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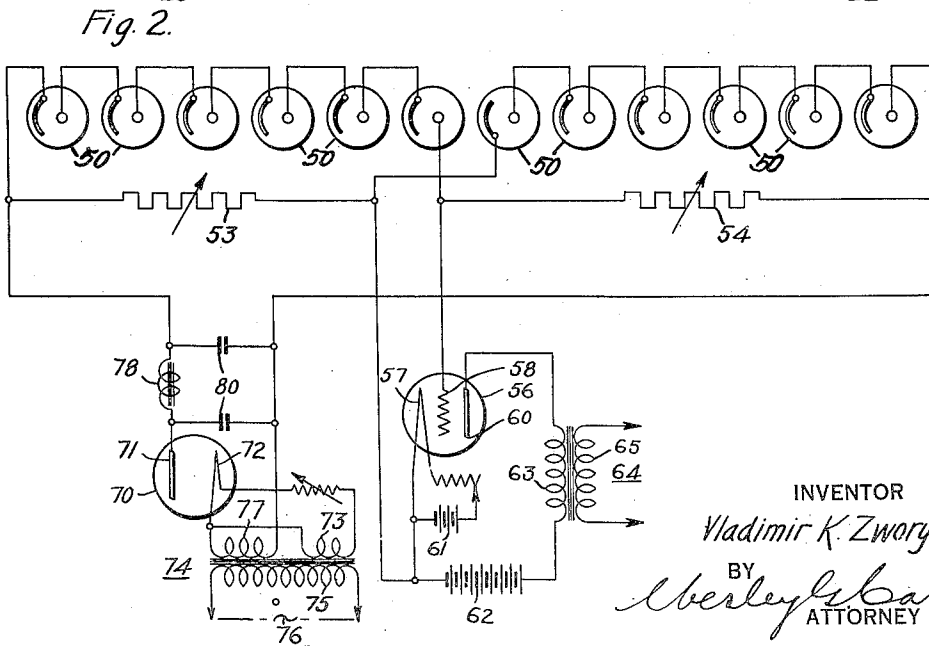
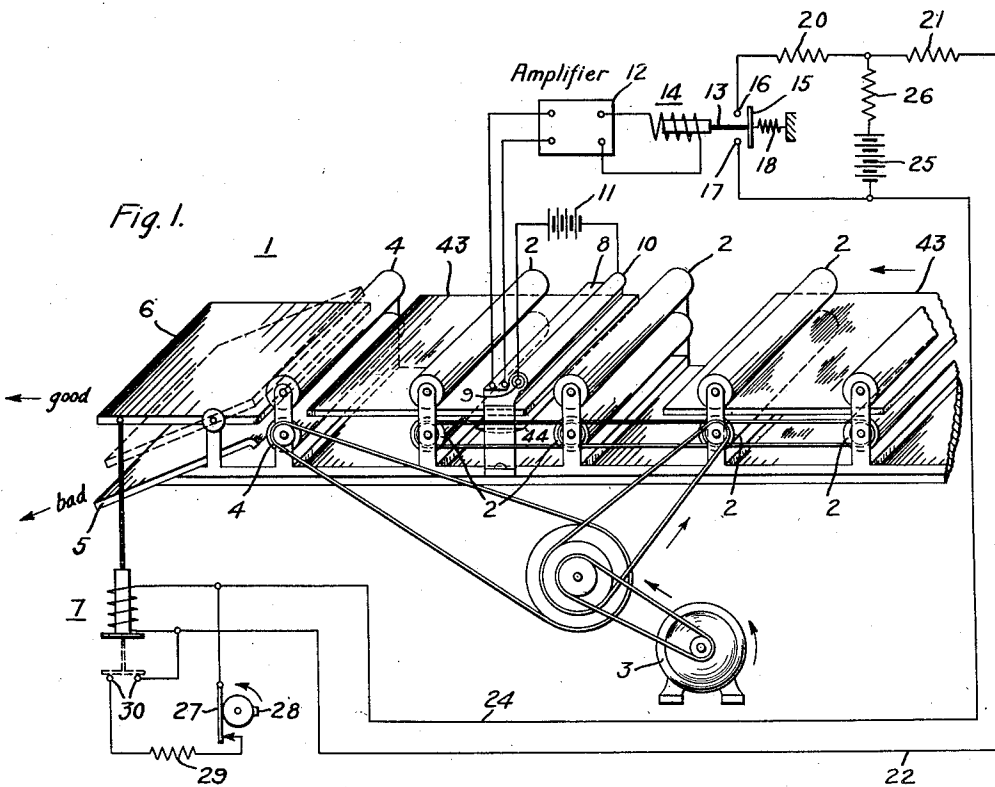
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1,922,188

INSPECTION DEVICE

Filed June 16, 1927

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 3.

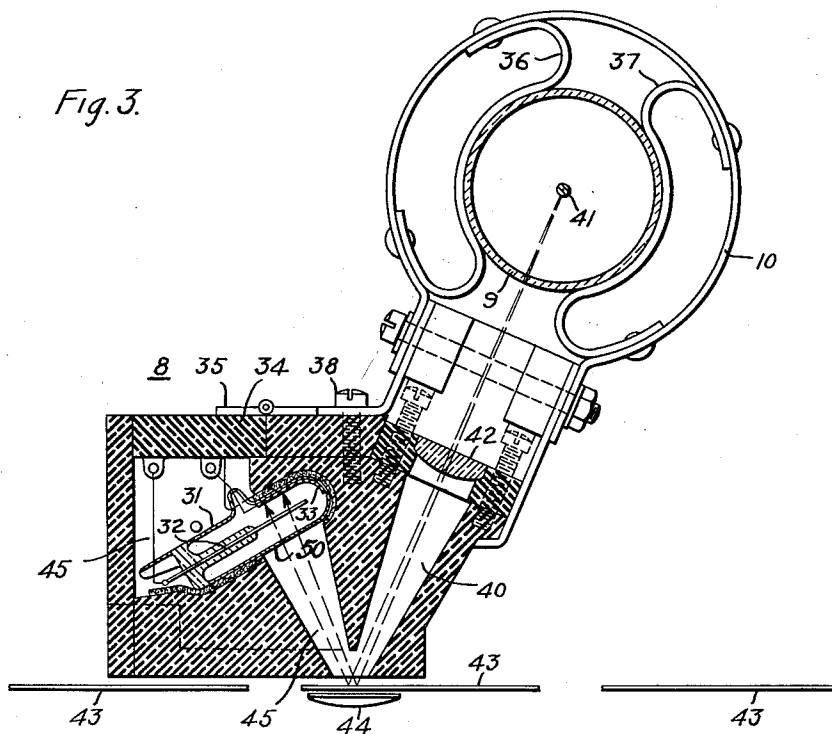
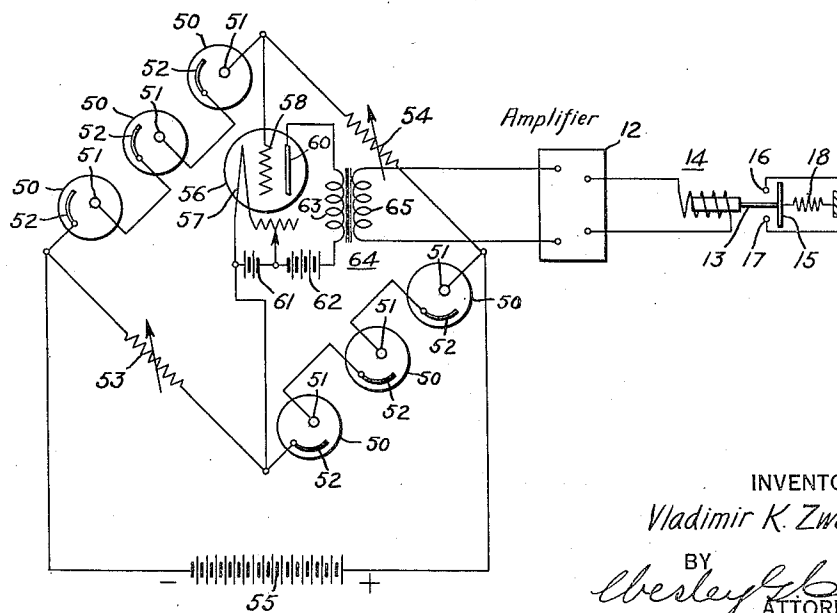


Fig. 4.



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INSPECTION DEVICE

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11 Claims. (Cl. 209—111)

My invention relates to inspection devices, and it has particular relation to devices designed to inspect the surfaces of planar articles and to reject such of said articles as have imperfections.

One object of my invention is to provide an inspection device that shall be responsive to the slightest imperfection in the surface of the article being tested.

Another object of my invention is to provide an inspection and sorting device that will classify the articles being tested according to their surface characteristics.

Another object of my invention is to provide an article-sorting device that shall be particularly suitable for the inspection and sorting of articles such as tin-plated sheets.

Another object of my invention is to provide an article-sorting device that shall be simple in construction and one that shall be sufficiently rugged to be used under conditions usually prevailing in tin-plate factories.

Another and more specific object of my invention is to provide a system of circuit connections whereby a plurality of photo-sensitive devices may be efficiently employed in an article-testing and sorting device.

In the manufacture of tin-plated or galvanized steel sheets, it is extremely important that the surfaces be entirely covered with tin or zinc. The presence of even the smallest imperfection in the plating, caused by grease or rust, is detrimental, inasmuch as it offers a point of attack to corroding agencies.

Heretofore, it has been customary to visually inspect each plated sheet after the final cleaning operation, and to manually sort the sheets into separate groups depending upon the presence or absence of imperfections in the plating. The sorting operation necessarily adds considerably to the cost of plating, and is not entirely satisfactory, inasmuch as it is dependent upon the skill and attention of a workman, or of a plurality of workmen.

In accordance with my present invention, I provide an inspecting and sorting device that is entirely automatic in action, and one which in no way depends upon the attentiveness or skill of the attendant. Specifically, my invention contemplates passing plated sheets beneath and adjacent to a plurality of photo-sensitive devices distributed along a line transverse to the motion of the sheets, the said devices being arranged to be illuminated by light reflected thereon by said sheet. Any change in the illumination of at least one of the photo-sensitive devices causes a change

in its electrical conductivity and this change in conductivity is relied upon to cause the energization of a relay that controls the classification of the sheet after it has passed beyond the illuminated zone.

Among the novel features of my invention are those particularly set forth in the appended claims. The invention in its generic aspect, however, as well as further objects and advantages thereof, will best be understood by reference to the following description of a specific embodiment thereof, taken in connection with the accompanying drawings, in which:

Figure 1 is a view, partly diagrammatic and partly perspective, illustrating a tin-plate-sorting machine comprising a preferred embodiment of my invention.

Figure 2 is a diagrammatic view of the circuit connections utilized when my invention is to be applied in situations where only alternating current is available.

Fig. 3 is a view, in cross-section, of a photo-electric-cell-holding device, illustrating the relation thereto of the light source.

Fig. 4 is a diagrammatic view of a circuit network designed to be utilized in situations where direct current is available.

Referring specifically to Fig. 1, a preferred embodiment of my invention comprises a device 1 in the nature of a conveyor. The conveyor embodies a plurality of rolls 2 which are belted together and arranged to be driven by a motor 3. In addition, a plurality of rolls 4 are provided which are driven at a higher rate of speed from the same motor, for a purpose which will later be described.

A chute 5 which leads to a receptacle for the receipt of rejected plates, is arranged immediately adjacent the last named pair of rolls. A tiltable table 6 is mounted above the chute 5 and is connected to the movable core of a solenoid 7.

A housing 8 containing a plurality of photo-electric cells arranged in a manner later to be described, is arranged parallel to the rollers and is supported a slight distance above a plane determined by the upper surfaces of the lower rollers.

A linear source of light 9 which may be a filament or a slot in a cylinder enclosing a glow tube, or the like, is supported within the rounded portion 10 of the housing 8 and is energized from a suitable battery 11. A thermionic amplifier 12 is connected to the photo cells contained in the housing, in a manner that will later be explained in detail, and the output circuit of this amplifier

is arranged to actuate the movable element 13 of a relay device 14.

The armature 15 of the relay device is associated with a pair of fixed contacts 16 and 17 and is biased to the open position by means of a spring 18.

A circuit connection may be traced from the contact 16 through a resistor 20, a second resistor 21, a conductor 22, the solenoid 7, a second conductor 24, and back to the fixed contact 17. A source 25 of potential, in series with a resistor 26 is connected in shunt to the circuit including the solenoid winding.

A second circuit is connected in shunt to the holding solenoid 7 and comprised therein is a movable contact device 27 associated with a rotatable cam 28, a fixed or variable resistor 29 and a plurality of contact devices 30.

The housing 8 comprises a box-like structure in which are mounted a plurality of photo cells and which also supports a linear light source. The construction of the housing will be more clearly apparent from a consideration of Fig. 3, which is a cross section therethrough taken along a line corresponding to the median line of one of the photo electric cells, supported therein.

As will be seen from Fig. 3, each individual photo cell, which comprises a container 31, an anode 32, and a photo-sensitive cathode 33, is supported in an inclined position, in the housing 8. The housing is provided with a movable lid 34 carried thereon by a hinge 35 which extends the length thereof in order that the individual photo cells may be easily placed therein or removed. The rounded portion 10 is provided with spring devices 36 and 37, between which the light source is supported, and is affixed to the housing 8 by a plurality of screws 38. The housing 8 is provided with a passageway 40 transverse thereto and parallel to the filament 41 of the lamp, a concentrating lens 42 being supported at the upper end of the said passageway.

The light from the filament 41 is concentrated on a plate 43 or other object having a reflecting surface and from it is reflected to the photo-sensitive cathode of the photo cell, as shown in Fig. 3.

In order that the device shall not function in the absence of a reflecting plate, a mirror 44 is provided immediately below the region at which the light from the filament is focused on the plate by the lens, this mirror serving to reflect light upon the photo-sensitive cathode 33 during the intervals between successive plates.

The specific manner in which the photo cell holding-device is constructed is not a part of the present invention, such invention being concerned mainly with the combination of a plurality of cells, a reflecting surface and a linear source of light. In one commercial embodiment of the invention in question, each individual cell is separated from the neighboring cell by a very thin partition 45 in order that it shall be influenced only by light being reflected from that portion of the plate below it and not by light reflected from points on the plate adjacent to neighboring cells.

It is, of course, possible to associate each individual photo cell with a separate thermionic amplifier, but, in practice, I have found it much more convenient to arrange the cells in groups, each group being in series and the said groups forming elements of a Wheatstone bridge.

A preferred circuit network and arrangement are illustrated in Fig. 4. A plurality of photo-electric devices 50, each having an anode 51 and

a photo-sensitive cathode 52 are so arranged that the anode of one device is connected to the cathode of a succeeding device. The cells are arranged in groups in the opposite arms of a Wheatstone bridge, in the remaining arms of which are incorporated variable-resistance devices 53 and 54. A source of potential 55 is connected across the network 57 and 58. A thermionic device 56 having a filament, a grid, and a plate 60, has the grid and the filament thereof connected to points conjugate to the points on the bridge to which the potential source 55 is connected. The thermionic device is provided with a source 61 of filament potential and a source 62 of plate potential, the latter being arranged to supply the plate through the primary 63 of an audio-frequency or other transformer 64. It is to be noted that the photo-electric devices 50 and the thermionic device 56 are so connected in the network that a change in degree of illumination impinging on any one of the photo-sensitive devices in either arm has the same predetermined influence on the output of the thermionic device. Thus a decrease in the illumination impinging on any one of the photo-electric devices 50 regardless of its position in the network results in an increase in the output of the thermionic device 56 while an increase in the illumination impinging on any one of the devices 50 results in a decrease in the output of the thermionic device.

The secondary 65 of the transformer is connected to the thermionic amplifying device 12 which may comprise a plurality of power tubes. The output circuit of the amplifier includes the relay winding shown in Fig. 1.

In order that the operation of the device illustrated in Fig. 1 may be made clear, the manner in which the circuit network shown in Fig. 4 operates will now be described. Assume first that the filament of the thermionic device 56 is energized and that the photo electric cells are being illuminated. The bridge may then be balanced by adjusting the variable resistors 53 and 54 until the grid attains the same potential as the filament.

If one of the photo electric cells now receives a lesser amount of illumination, the resistance of this cell will rise accordingly, and the resistance of the corresponding arm of the bridge will be increased by the same amount as the change in the resistance of the individual cell. If the cell should be completely darkened, the resistance of the arm containing it would be infinite, irrespective of the degree of illumination of the remaining cells. Any change in the resistance of at least one of the cells will accordingly, destroy the balance of the bridge, and the grid of the thermionic device will acquire a potential different from that of the filament thereof. The connections may be such that the potential may be increased in a positive direction or it may be made more negative. Irrespective of whether the grid is made more negative or more positive by the change in the balance of the bridge, the resulting change in the plate current of the thermionic device may be amplified, and, by a suitable arrangement of the amplifier, may be utilized to energize the winding of the relay 14.

The operation of the complete device will next be explained. By energizing the motor 3 the lower rolls 2 are caused to rotate in such manner as to draw between them and the upper rollers a plate, if the plate is presented to the opening therebetween. The plate, therefore, after it has once been presented to the opening between the

rollers at the right-hand end of the apparatus will pass through the machine from right to left. As the plate passes beneath the housing 8 containing the photo-electric cells and the linear source of light, it reflects the light from the said source to the cells. If the surface of the plate is free from rust, spots or imperfections, the light reflected to each of the cells will be substantially the same in amount.

10 If an imperfect place exists on the surface of the plate, the amount of light reflected therefrom will be less than the normal amount, and, as previously explained in connection with Fig. 4, the diminished illumination will destroy the balance of the network in which the photo cells are connected, permitting the amplifier 12 to function. The winding of the relay device 14, being accordingly energized, causes the armature 15 to move against the fixed contacts 16 and 17, thus momentarily completing the shunt circuit including the resistor 20.

The completion of the shunt circuit so de-energizes the solenoid that it releases the core thereof, which drops under the influence of gravity and completes a second shunt circuit, including the contacts 30. The resistor 29 in the second shunt or holding circuit, preferably has substantially the same value as the resistor 20, and, so long as the circuit including it is not broken, the solenoid is maintained in a partially de-energized state.

The dropping of the core of the solenoid 7 moves the table 6 to the dotted-line position and the plate, when it has passed through the last set of rollers at the left-hand end of the device, is thrown into a receptacle (not shown) designed to accommodate the rejected plates.

The last set of rollers is given a much higher speed than any of the rollers which feed the plates through the machine, in order that each plate may be completely clear of the machine before the following plate reaches the said last rollers.

The de-energization of the solenoid 7 is substantially instantaneous, and were it not for the further provision of the holding circuit, including the movable contact 27, the table 6 would continually oscillate from the dotted-line position to the full-line position. The resistor 29 in the shunt circuit, however, since it is substantially equal in magnitude to the resistor 20 in the circuit completed by energizing the relay 14, permits the solenoid 7 to be maintained de-energized until the shunt circuit is broken by the rotation of the cam 28 against the movable contact 27. The cam may be geared to an appropriate part of the machine, or it may be arranged to be actuated by the respective plates themselves after they have passed beyond the control of the last rollers. It is of course immaterial if the cam opens the holding circuit, so long as the solenoid 7 is energized, it merely being necessary to open it after a defective plate has passed out of the machine in order that the next plate, if perfect may be sent to the proper destination.

By reason of the provision of the shunting circuit, including the movable contact 27, the sorting table may be caused to be depressed only once for a defective plate, irrespective of the number of imperfections which the said plate may have. After having once been de-energized by the action of the relay 14 the solenoid 7 is unaffected by succeeding actuations of the amplifier 12.

The resistors 20, 21 and 26 in the actuating circuit are so chosen that there will be no excessive drain from the actuating battery.

Inasmuch as the relative polarity of the voltage source of Fig. 4 is immaterial, provided the network is properly balanced, such source may be, if desirable, replaced by a rectifier energized by alternating current. An arrangement suitable for energizing by alternating current is illustrated in Fig. 2.

A plurality of photo-electric cells are arranged in groups and are connected in the opposite arms of a Wheatstone bridge in the same manner as was explained in connection with Fig. 4. The resistors 53 and 54 are the same as those shown in Fig. 4.

The thermionic device is connected to the bridge in the manner illustrated in Fig. 4, the output circuit being arranged to be connected to a further amplifying device if necessary. A two-electrode rectifier device 70, comprising a plate 71 and a filament 72 is so arranged that the filament thereof is energized by a secondary winding 73 of a transformer 74, the primary 75 of which may be connected to a source 76 of commercial-frequency alternating current. Plate potential for the rectifier device, is supplied from an additional secondary winding 77 and the output circuit thereof, is so connected to the bridge at points conjugate to the points at which the thermionic device is connected. A choke coil 78 and a plurality of condensers 80 may be so arranged as to form a filter circuit in the output of the rectifier, although this is not absolutely necessary.

The most striking advantage of my invention lies in the fact that it is capable of quickly and automatically inspecting articles, such as tin plate, paper, cardboard, or the like which are capable of reflecting a certain amount of light. It is also possible to modify the device shown in order that fabrics or analogous materials may be inspected by light transmitted therethrough. In such a modification, the presence of a hole or an imperfect place would permit light to fall on the photo cells, and the resulting change in the conductivity could be utilized to give an audible indication and, at the same time, stop the machine. When once adjusted for the particular material being operated on, the device is substantially automatic in operation and requires only unskilled labor for its operation. By utilizing extremely small photo cells, for example, cells only a quarter or an eighth of an inch in diameter, and by arranging them closely adjacent one another, it is possible, by my invention, to construct a machine that will be responsive to extremely minute imperfections.

It will be noted that the operation of my invention is dependent on heterogeneities introduced into the sorting beam of light. By heterogeneities I mean of course irregularities in the quality of the beam of light as distinguished from irregularities in its geometric characteristics. Thus when an element of a beam of light changes in color or in intensity a heterogeneity can be said to have been introduced into the beam.

Although I have illustrated and described only a single specific embodiment of my invention, I am fully aware that many modifications may be suggested by those skilled in the art. My invention, therefore, is not to be limited except in so far as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. In an article-sorting device, a plurality of photo-sensitive cells in series, a source of light, means for causing articles to reflect said light to said photo cells, unitary amplifying means re-

sponsive to a variation in the illumination of any one of said cells to cause said articles to follow a predetermined path and means for causing said articles to follow another path when there is no variation in the illumination of said cells.

2. In an article-sorting device, a plurality of photo-sensitive cells in series, a source of light, means for causing articles to pass adjacent said cells and to reflect light thereon, unitary amplifying means responsive to a variation in the illumination of any one of said cells to cause said articles to follow a predetermined path after they have passed beyond said cells and means for causing said articles to follow another path after they have passed beyond said cells when there is no variation in the illumination of said cells.

3. In an article-sorting device, a plurality of photo-sensitive cells in series, a source of light, means for causing articles to pass adjacent to said cells and to affect the light reaching said cells from said source, unitary amplifying means responsive to a variation in the illumination of any one of said cells to cause said articles to follow a predetermined path after they have passed beyond said cells and means for causing said articles to follow another path after they have passed beyond said cells when there has been no variation in the illumination of said cells.

4. In article-sorting apparatus, a beam of radiant energy, means for directing said beam on a plurality of articles to be sorted, a plurality of groups of photo-sensitive cells to be energized by the beam emitted from said articles to be sorted the said groups being incorporated in a balanced circuit network and means, responsive to an unbalanced condition in said network as influenced by the condition of said cells, for sorting said articles.

5. In article-sorting apparatus, a beam of radiant energy, means for directing said beam on a plurality of articles to be sorted, a plurality of groups of photo-sensitive cells to be energized by the beam emitted from said articles to be sorted the said groups being incorporated in a balanced circuit network and means, responsive to an unbalanced condition in said network as influenced by the condition of said cells, for indicating a predetermined condition in certain of said articles.

6. In article-sorting apparatus, a plurality of groups of photo-sensitive cells, the cells of each group being connected in series, means for energizing said cells, means for subjecting said energizing means to the influence of articles to be sorted, a Wheatstone bridge, the arms of which include the said groups, a source of potential connected to said bridge, an amplifying device connected to said bridge conjugate to the connections of the potential source and means responsive to a variation in the condition of said amplifying device as influenced by a change in the condition of certain of said cells for sorting said articles.

7. In article-sorting apparatus, a beam of radiant energy, means for directing said beam on each of a plurality of articles to be sorted, a plurality of photo-sensitive cells to be energized by the beam emitted from each of said articles to be sorted, the said cells being incorporated in a balanced circuit network, and means, responsive to an unbalanced condition in said network as in-

fluenced by the condition of any one of said cells and independent of the particular cell, for sorting said articles.

8. In article-sorting apparatus, a beam of radiant energy, means for directing said beam on each of a plurality of articles to be sorted, a plurality of photo-sensitive cells to be energized by the beam emitted from each of said articles to be sorted, the said cells being incorporated in a balanced circuit network and means, responsive to an unbalanced condition in said network as influenced by the condition of any one of said cells and independent of the particular cell, for indicating a predetermined condition in certain of said articles.

9. In an article sorting device, a plurality of photo-sensitive cells in series, a source of light, means for causing articles to pass adjacent to said cells and to affect the light reaching said cells from said source, unitary amplifying means responsive to a variation in the illumination of any one of said cells to cause said articles to follow a predetermined path and means for causing said articles to follow another path when there has been no variation in the illumination of said cells.

10. In article sorting apparatus means for projecting a beam of radiant energy on an article to be sorted, a balanced net-work, an amplifier having input and output circuits, means for connecting said input circuit between opposite terminals of said net-work, a plurality of photo-sensitive devices, having cathodes and anodes, connected in opposite arms of said net-work, means for connecting the cathodes of one of the photo-sensitive devices in each arm to one of said opposite terminals, means for connecting the anodes of one of the photo-sensitive devices in each of said arms to the other of said opposite terminals, means for subjecting said photo-sensitive devices to the resultant radiation emitted by said article to be sorted and means responsive to variations in the output of said amplifier, as it is varied by variations in the radiation impinging on said photo-sensitive devices, for causing said article to follow one of a plurality of predetermined paths.

11. In article sorting apparatus means for projecting a beam of radiant energy on an article to be sorted, a balanced net-work, an electric discharge device having a control electrode and a plurality of principal electrodes, means for connecting said control electrode to one terminal of said net-work and a principal electrode to another terminal of said net-work, a plurality of photo-sensitive devices having cathodes and anodes connected in opposite arms of said net-work, means for connecting the cathodes of one of the photo-sensitive devices in each arm of said net-work to the terminal thereof to which said principal electrode is connected, means for connecting the anodes of one of the photo-sensitive devices in each of said arms to said conjugate terminal to which said control electrode is connected, means for subjecting said photo-sensitive devices to the resultant radiations emitted by said article to be sorted and means responsive to the variations in the power output between the principal electrodes of said electric discharge device, as it is varied by variations in the radiations impinging on said photo-sensitive devices, for causing said article to follow one of a plurality of predetermined paths.

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