Jan. 1, 1963 W. H. HUNTER 3,071,711

PHOTOELECTRIC ARTICLE DETECTOR APPARATUS

Filed March 14, 1960

Fig. 1

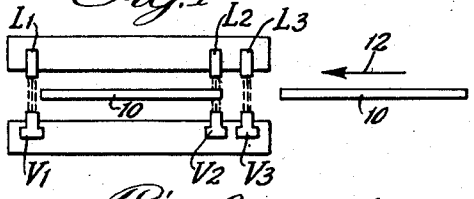


Fig. 2

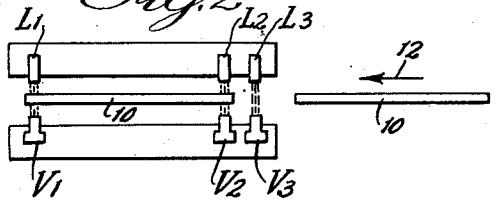
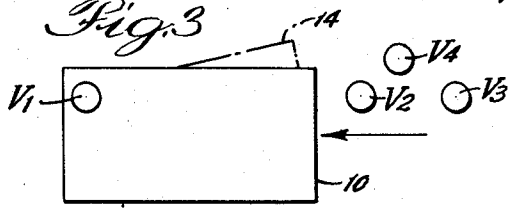


Fig. 3



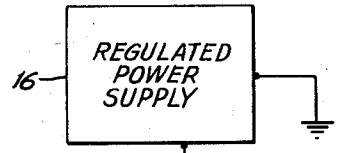


Fig. 4

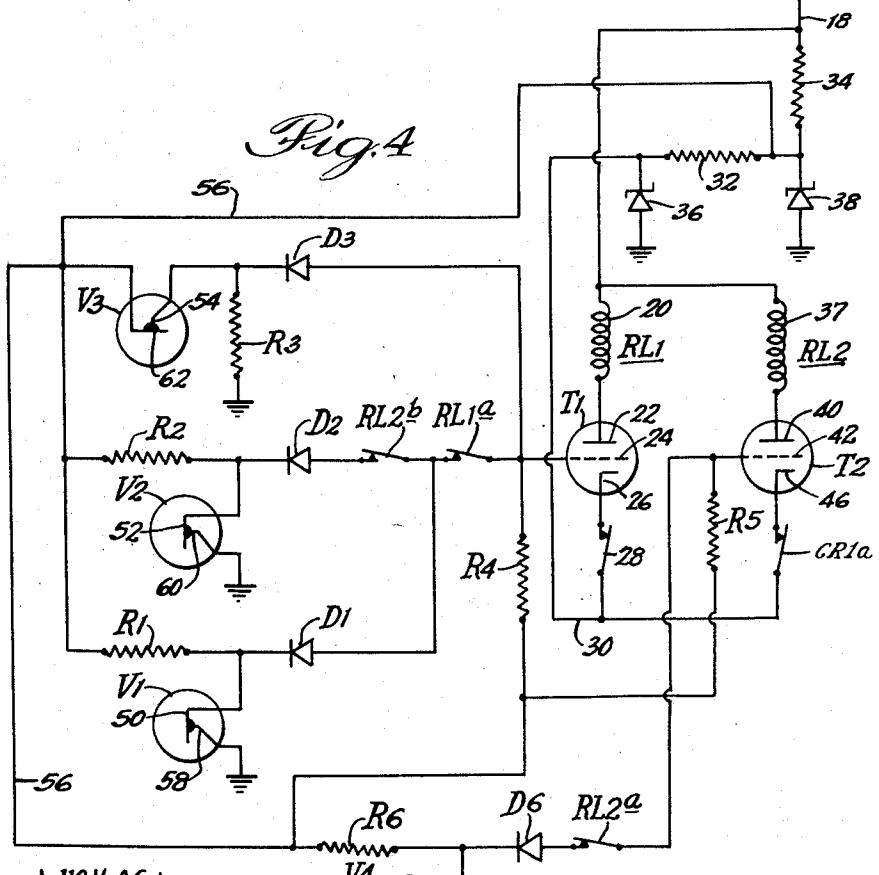
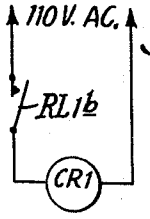


Fig. 5



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3,071,711

PHOTOELECTRIC ARTICLE DETECTOR APPARATUS

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9 Claims. (Cl. 317—130)

This invention relates generally to electronic control circuits and more particularly to a new and improved electronic control circuit for detecting off-size articles, such as magazines of improper length or width.

This invention is an improvement over the photo-electric article detector disclosed in United States Letters Patent 2,916,633 issued December 8, 1959. It often is desirable to provide automatic detection means for undersize or oversize articles after the assembly of such articles to reduce the expenditure of time and money required for final inspection, removal and re-assembly of the articles and to eliminate the problem of defective articles being placed into trade channels.

As pointed out in the above identified patent, this problem may be exemplified in the production of magazines having various portions of different sizes gathered together into a uniform assembly and placed edgewise in a conveyor track for transport to a stapling machine. If the magazine contents are not properly aligned prior to stapling and covering, the expense of removing and destroying the cover, removing the staples, properly aligning the magazine contents and re-introducing the magazine for binding is required. Thus, the advantages of detecting and removing an improperly aligned or off-size magazine before the binding process are obvious.

It is a general object of this invention to provide a new and improved electronic control circuit for detecting off-size articles.

It is a more specific object of this invention to provide electronic control means for detecting magazines of improper length or width so that such magazines may be removed from an automatic assembly and binding operation before the binding step takes place.

It is another object of this invention to provide new and improved electronic means which responds rapidly to the detection of misaligned pages in a magazine, book or the like, and which effects such detection without physically contacting such magazines or books such that the assembly and binding process therefor may be operated at a relatively high speed.

It is still another object of this invention to provide an improved control circuit for detecting off-size articles in which photojunction cells formed of semiconductor material, such as germanium, cadmium sulphide and cadmium selenide, are utilized in novel voltage dividing networks to control the operation of an article ejector apparatus.

It is a further object of this invention to provide improved electronic gauge means for detecting offsize articles which is characterized by its relatively high speed of operation, its efficiency, and its compact and relatively simple construction.

The above and other objects are realized in accordance with a specific illustrative embodiment of this invention wherein three photojunction cells are positioned in spaced relation to each other to detect the presence of offsize books or magazines among a number of such articles on a conveyor track as they are being transported to a stapling mechanism. In an embodiment of the invention adapted to detect over-length magazines, for example, two of the photojunction cells—which are referred to as the length gauge cells—are spaced from each other a distance greater than the maximum permissible length of the magazine so that only an over-length magazine will cause

the length gauge photojunction cells to be blocked from receiving light. A third photojunction cell—referred to as a timing and action cell—is positioned adjacent one of the length gauge cells to inhibit ejector action when the length gauge cells are blocked by two, rather than one, magazine.

In accordance with a feature of this invention, each photojunction cell is connected in a separate voltage dividing network, which, in turn, is connected through a suitable diode to the control of a discharge device in the ejector circuit. The discharge device is normally biased to its cut-off or non-conducting condition by the combined action of the three voltage dividing networks and is driven into conduction only by one specific combination of photojuction cell operation—namely, the two length gauge cells blcoked from light and the timing and action cell receiving light.

An additional feature of this invention comprises means for detecting over-wide magazines. In accordance with this feature a fourth photojunction cell, referred to as the width gauge cell, is positioned above the conveyor track an amount greater than the maximum permissible width of the magazine. The width gauge cell is connected in a separate voltage dividing circuit which, in turn, is connected to the control grid of a second discharge device. The second discharge device is normally non-conducting and is adapted to be driven into conduction in response to the light blocking of the width gauge cell by an over-wide magazine. The conduction of the second discharge device serves to disconnect the voltage dividing network of one of the length gauge photojunction cells from the biasing circuit of the first discharge device—an effect similar to that provided when this length gauge photojunction cell is in the light blocked condition. Accordingly, when the over-wide magazine is passed in front of the other length gauge photojunction cell to place it in a light blocked condition, the first discharge device is driven into conduction to operate the ejection apparatus.

These and other features which are characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and operation, together with further objects and advantages thereof, will best be understood by reference to the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a plan view of an illustrative sensing arrangement embodying the invention shown with a magazine of proper size;

FIGURE 2 is a plan view of the illustrative sensing arrangement embodying the invention shown with a magazine of excessive length;

FIGURE 3 is a simplified elevational view of an illustrative sensing arrangement embodying the invention shown with a magazine of excessive width; and

FIGURES 4 and 5 are electrical schematic diagrams of the circuitry forming one preferred embodiment of the invention.

Referring now to the drawing, and more particularly to FIGURES 1, 2 and 3 thereof, there is diagrammatically depicted the manner in which the spaced photojunction calls and their associated light sources serve to sense a plurality of articles being transported thereby and to detect those articles which depart from a desired size. In FIGURE 1, for example, the photojunction cells V1 and V2 are positioned to receive light from the light sources L1 and L2, respectively, when there is no article **10** being transported thereby to block the light rays. In one preferred embodiment of the invention the articles **10** may take the form of magazines which are transported edgewise on a suitable conveyor past the photojunction cells and the light sources to appropriate binding apparatus.

Advantageously, the photojunction cells V1 and V2

are spaced from each other a distance greater than the maximum permissible length of the magazines **10**. In addition, a third photojunction cell V3 advantageously is positioned adjacent cell V2 and is associated with the light source L3 positioned adjacent light source L2.

The magazines **10** are transported between the cells and their associated light sources, in the direction indicated by the arrow **12**, in FIGURE 1. When the magazines **10** do not exceed the predetermined maximum permissible length, either cell V1 or V2 may be blocked at any given time by a magazine **10** but these cells never are blocked simultaneously by a magazine of proper length due to the spacing between the cells V1 and V2.

FIGURE 2 illustrates the effect of an over-length magazaine **10** on the invention. It can there be seen that both of the photojunction cells V1 and V2 will be blocked simultaneously when an over-length magazine is transported thereby. It further will be noted that the spacing between the photojunction cells V2 and V3 is such with respect to the spacing between adjacent ones of the magazines **10** that the photo-junction cell V3 is not blocked from receiving light when a magazine **10** is being sensed for proper or excessive length by the photojunction cells V1 and V2.

In addition to providing this length sensing function, as described in greater detail below, the invention further comprises means for detecting magazines having a width in excess of a predetermined maximum permissible width. To this end, as illustrated in the diagrammatic showing of FIGURE 3, a fourth photojunction cell V4 is positioned at a height which is greater than the maximum permissible width of the magazines **10** as they are transported past the photojunction cells. Thus, if a magazine **10** is defective in that a portion thereof, such as the corner **14**, is out of alignment and extends from the top edge of the magazine, the photojunction cell V4 will be blocked from receiving light when the over-width corner portion **14** is transported thereby.

FIGURE 4 illustrates one specific illustrative embodiment of control circuit which provides the sensing and detecting functions described above with respect to FIGURES 1, 2 and 3. This illustrative circuit comprises a source of regulated D.C. voltage **16** having a D.C. voltage output at the power lead **18**, which in one specific embodiment of the invention had a value of up to 500 volts. The power lead **18** is connected through the winding **20** of relay RL1 to the anode of a normally non-conducting discharge device T1. The control grid **24** of discharge device T1 is connected to a biasing circuit which includes the resistor R4, and the cathode **26** of discharge device T1 is connected through the microswitch contacts **28** to the power lead **30**.

Power lead **30** advantageously is connected to the regulated power supply **16** through the voltage dropping resistors **32** and **34**, and in one specific embodiment of the invention, the power lead **30** had a D.C. voltage of 27 volts thereon. In accordance with a feature of this invention, a pair of Zener diodes **36** and **38** are connected between the respective terminals of resistor **32** and ground to provide additional voltage regulating action, and further to provide a safety feature in preventing the operating voltage from increasing to the point of possibly damaging the photojunction cells of the circuit.

The power lead **18** also is connected through the winding **38** of relay RL2 to the anode **40** of the normally non-conducting discharge device T2. The control grid **42** of discharge device T2 is connected to a biasing circuit, which includes the resistor R5, and the cathode **46** of discharge device T2 is connected through the control relay contacts **48** to the power lead **30**.

It is a feature of this invention that each of the photojunction cells V1, V2 and V3 is connected in a separate voltage dividing network that forms a part of the biasing circuit connected to the control grid **24** of the discharge device T1. Thus, the photojunction cell V1 is connected

at its electrode **50** to the junction of the resistor R1 and the diode D1. The photojunction cell V2 has its electrode **52** connected to the junction of the resistor R2 and the diode D2. The electrode **54** of photojunction cell V3 is connected to the junction of resistor R3 and the diode D3.

The photojunction cells V1 and V2 are connected in similar voltage dividing networks in that one terminal of their respective resistors R1 and R2 is connected to the power lead **56** which is returned to the junction of the voltage dropping resistors **32** and **34** at the power supply **16**. In one specific embodiment of the invention, the power lead **56** and a D.C. voltage of 43 volts applied thereon. The electrode **58** of cell V1 and the electrode **60** of cell V2 are connected to ground, and it can now be appreciated by those skilled in the art that the voltage present at the junction of the cell, diode and resistor of each of these voltage dividing networks is dependent upon the conducting or non-conducting condition of its respective photojunction cell.

The photojunction cell V3 has its electrode **62** connected to the power lead **56** and again it will be appreciated by those skilled in the art that the voltage at the junction of the V3 cell, resistor R3 and diode D3 is dependent upon the conducting or non-conducting condition of the cell.

The diode D1 is connected through the contacts RL1*a* of relay RL1 to the bias resistor R4, and the diode D2 is connected through the contacts RL2*b* of relay RL2 and the contacts RL1*a* of relay RL1 to the bias resistor R4. The diode D3 is connected directly to the bias resistor R4.

The over-width photojunction cell V4 is connected at its electrode **64** to ground and at its electrode **66** to the junction of resistor R6 and diode D6. The other terminal of resistor R6 is connected to the power lead **56**, and the other terminal of the diode D6 is connected through the contacts RL2*a* of relay RL2 to the control grid **42** of discharge device T2.

The operation of the circuit will now be described. The photojunction cells V1 and V2 are the gauge cells which detect the presence of over-length articles. The photojunction cell V3 serves as a timing and action cell. When the photojunction cells V1 and V2 are blocked from their light sources, due to an over-length magazine, and the photojunction cell V3 is receiving light from its light source, by being in between two successive magazines at the inspection point, then the bias on the discharge device T1 is such to cause it to conduct. This energizes the relay RL1 and serves to control any suitable magazine ejection mechanism which may be associated therewith to eject the defective magazine. One such ejection apparatus suitable for this purpose is disclosed in Sydney H. Dengle application, Serial No. 623,004, filed November 19, 1956.

As the magazines **10** are conveyed past the photojunction cells, various combinations of the conducting conditions of the cells take place. However, in accordance with a feature of this invention, only one particular combination of the conducting and non-conducting conditions of cells V1, V2 and V3 can effect the action of the detector and its associated ejector apparatus.

These various possible combinations are listed below, in which (X) indicates a cell in its light receiving condition and (—) indicates a cell in its light blocked condition.

Combinations	V1	V2	V3	Action
1	X	X	X	No.
2	X	X	—	No.
3	X	—	—	No.
4	X	—	X	No.
5	—	X	X	No.
6	—	X	—	No.
7	—	—	—	No.
8	—	—	X	Yes.

Photojunction cell V3 keeps the bias voltage on the control grid 24 of discharge device T1 at a low value when the cell becomes darkened by a magazine blocking its light source. Photojunction cells V1 and V2 tend to cause an increasing bias voltage on the control grid 24 of the discharge device T1 when both cells become darkened. A bias voltage increase on the control grid 24 of discharge device T1 due to the light blocking of the gauge cells V1 and V2 cannot take place, however, when cell V3 is darkened, since all three cells are connected to the control grid. Therefore, conduction of discharge device T1 cannot take place until cell V3 becomes light. If either one, or both, of the two gauge cells V1 and V2 are receiving light, the grid bias voltage is forced to remain at a low value. Thus, the conduction of device T1 and the subsequent ejection action can occur only during the time when cell V3 is receiving light and cells V1 and V2 are darkened.

When discharge device T1 conducts, relay RL1 is energized because of the increased current flow through the plate circuit of the discharge device. The energization of relay RL1 closes its contacts RL1*b*, shown in FIGURE 5, to energize the ejector control relay. The energization of relay RL1 also opens the contacts RL1*a* to disconnect the photojunction cells V1 and V2 from the bias circuit of discharge device T1 to insure that the latter conducts long enough to allow the ejector to operate. Advantageously, a cam may be provided on the ejector apparatus to open the microswitch 28 in the cathode circuit of the discharge device T1 momentarily to allow the circuit to reset.

The three diodes D1, D2 and D3 serve to prevent current from flowing toward the discharge device T1 from the cells. The resistor R4 acts as a grid biasing resistor which allows any one of the cells to hold the grid voltage of discharge device T1 at a low value regardless of what the conducting condition of the other two cells may be.

Those skilled in the art will appreciate that the type of cells used in the circuit depends somewhat on the kind of circuit performance desired and the type of light source used. Germanium photojunction cells have been used successfully in the circuit at speeds in excess of two magazines per second, although the circuit is capable of speeds many times greater than this, if necessary. Cadmium sulphide and cadmium selenide cells also may be used in the circuit, but the response to excitation would be slower than with the use of germanium cells.

The photojunction cell V4 is the gauge which is used to detect magazines of greater than a maximum permissible width. This cell normally receives light from its light source L4 and is blocked or darkened only when an over-width magazine is transported therebetween.

The discharge device T2 normally is biased to its nonconducting condition, and this bias is maintained as long as cell V4 is receiving light. However, the voltage at the control grid 42 of discharge device T2 is raised to a larger value when the cell becomes darkened. Discharge device T2 then conducts and coil 37 of the relay RL2 is energized as a result of the increased current flow through the plate circuit of device T2. The relay contacts RL2*a* of RL2 are opened to disconncet cell V4 and to hold device T2 at its high conduction level until the circuit is reset. The contacts RL2*b* of relay RL2 also open to disconnect cell V2 from the bias circuit of device T1 in the length detector. This allows the magazine to move downstream and to be ejected at the point where the magazine just darkens photojunction cell V1. The ejection control relay CR1, which is energized in response to the conduction of device T1 and the energization of relay RL1, opens the cathode circuit of the discharge device T2, at the relay contacts CR1*a* to reset the top edge detector.

It can be seen that cell V4 is connected in a voltage dividing network similar to the networks of cells V1 and V2. The resistor R5 forms one part of the network and the cell V4 forms the other part. The diode D4 prevents current from flowing toward device T2 from the cell V4. The resistor R6 serves as a grid biasing resistor which allows small charges through it to cause a large voltage charge on the control grid of device T2.

FIGURE 3 shows a magazine with a corner 14 sticking out just after it has been detected by cell V4 in the top edge detector. This magazine is shown in the ejection position. The cell V2 in the length detector has been disconnected by the action of the top edge detector, in the manner explained heretofore. The magazine is shown darkening cell V1; therefore, the magazine will be ejected because cell V3 of the length detector is still receiving light from its light source.

While there has been shown and described a particular embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and, therefore, it is intended in the appended claims to cover all such changes and modifications as fall within hte true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The improvement of apparatus for checking articles and for detecting over-length articles thereamong comprising a plurality of light-responsive photojunction cells positioned along the path of travel of the articles to be checked; said photojunction cells including a first cell, a second cell spaced from said first cell a distance greater than the maximum permissible length of said articles and a third cell spaced from said first cell a distance smaller than the spacing between adjacent ones of said articles; a source of D.C. voltage; a plurality of separate voltage dividing networks, each comprising one of said photojunction cells in series with separate resistance means, connected between the terminals of said source of D.C. voltage; a normally inoperative control device adapted to be operated in response to the detection of an over-length article; and means connecting the common terminal of the photojunction cell and the resistance means in each voltage dividing net work to said control divice for causing the latter to operate only when said first and said second cells are in a light-blocked condition due to the presence of an off-size article adjacent thereto and said third cell is in a light-receiving condition due to the absence of an article being adjacent thereto.

2. The improvement of apparatus in accordance with claim 1 further comprising a fourth voltage dividing network formed of a fourth photojunction cell and a fourth resistance means connected in series across the terminals of said source of D.C. voltage; a second normally inoperative control device adapted to be operated in response to the detection of an over-wide article, and means connecting the common terminal of said fourth photojunction cell and said fourth resistance means to said second control device to cause the latter to operate when said fourth photojunction cell is in a light-blocked condition due to the presence of an over-wide article adjacent thereto.

3. The improvement of apparatus for checking articles and for detecting off-size articles thereamong comprising a plurality of light-responsive photojunction cells, each connected in series with a separate resistance element to form a voltage dividing network, there being a separate one of said voltage dividing networks for each photojunction cell; a normally non-conductive discharge device adapted to conduct in response to the detection of an off-size article; and biasing means connecting the common terminal of the photojunction cell and the resistance means in each voltage dividing network to said discharge device for causing the latter to conduct only when two of said photojunction cells are in a light-blocked condition due to the presence of an off-size article adjacent thereto and a third photojunction cell is in a

light-receiving condition due to the absence of an article being adjacent thereto.

4. The improvement of apparatus for detecting off-size articles comprising a plurality of spaced apart, light-responsive photojunction cells, each connected in series with a separate resistance element to form a separate voltage dividing network; a first normally non-conducting discharge device adapted to conduct in response to the detection of an over-length article; means connecting the common terminals of three of said photojunction cells and the resistance means to a biasing circuit for said first discharge device for causing the latter to conduct only when two of said photojunciton cells are in a light-blocked condition due to the presence of an over-length article adjacent thereto and a third photojunction cell is in a light-receiving condition due to the absence of an article being adjacent thereto; a second normally non-conducting discharge device adapted to conduct in response to the detection of an over-wide article; and means connecting the common terminal of a fourth photojunction cell and a fourth resistance means to a biasing circuit for said second discharge device for causing the latter to conduct only when the fourth photojunction cell is in a light-blocked condition due to the presence of an over--wide article adjacent thereto.

5. The improvement of apparatus for detecting off-size magazines comprising a plurality of light-responsive photojunction cells positioned along a conveyor track for the magazines; said photojunction cells including a first cell, a second cell spaced from said first cell a distance greater than the maximum permissible length of said magazines, a third cell spaced from said first cell a distance smaller than the spacing between adjacent ones of said magazines, and a fourth cell spaced from said track a distance greater than the maximum permissible width for said magazines; a source of D.C. voltage; a plurality of separate voltage dividing networks, each comprising one of said photojunction cells and separate resistance means, connected between the terminals of said source of D.C. voltage; biasing means connecting the common terminal of the photojunction cell and the resistance means in the voltage dividing networks of said first, second, and third cells to a first normally non-conducting discharge device for causing the latter to operate only when said first and said second cells are in a light-blocked condition due to the presence of an over-length magazine adjacent thereto and said third cell is in a light-receiving condition due to the absence of a magazine being adjacent thereto, and biasing means connecting the common terminal of the photojunction cell and resistance means in the voltage dividing network of said fourth cell to a second normally non-conducting discharge device for causing the latter to conduct only when said fourth cell is in a light-blocked condition due to the presence of an over-length magazine adjacent thereto.

6. The improvement of apparatus in accordance with claim 5 further comprising switch means connected to the biasing means of said first discharge device and responsive to the conduction of the latter for disconnecting the first and second cells from said first discharge device.

7. The improvement of apparatus in accordance with claim 5 further comprising switch means connected to the biasing means of said second discharge device and responsive to the conduction of the latter for disconnecting the fourth cell from said second discharge device.

8. The improvement of apparatus for detecting off-size magazines comprising a plurality of light-responsive photojunction cells positioned adjacent a conveyor track for said magazines; two cells being over-length magazine sensing cells and a third cell being a timing cell, a first normally inoperative discharge device, circuit means connecting said three photojunction cells to a bias circuit for controlling the operation of said first discharge device, said circuit means including separate voltage dividing impedance means connected in circuit with each cell, an article ejector control relay responsive to the conduction of said first discharge device, a source of regulated D.C. voltage connected to said cells, said bias circuit and said first discharge device whereby only the combination of the blocked condition of said two cells together with the unblocked condition of the third cell reduces the bias on said first discharge device sufficiently to permit the latter to conduct, thereby causing said relay to be energized for enabling over-length magazines to be ejected, a second normally inoperative discharge device, circuit means connecting a fourth cell, adapted to sense over-wide magazines, to a bias circuit for controlling the operation of said second discharge device, said circuit means including separate voltage dividing impedance means connected in circuit with said fourth cell, and means connecting said source of regulated D.C. voltage to said fourth cell, said bias circuit and said second discharge device whereby the blocking of the fourth cell by an over-wide magazine reduces the bias on said second discharge device sufficiently to permit the latter to conduct.

9. The improvement of apparatus in accordance with claim 8 further comprising switch means responsive to the conduction of said second discharge device for disconnecting one of said two over-length magazine sensing cells from said first discharge device, whereby the blocking of the other over-length magazine sensing cell by the over-wide magazine causes said first discharge device to conduct to energize the magazine ejection relay.

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