

J. H. BURNSIDE, 2D

8 Sheets-Sheet 1

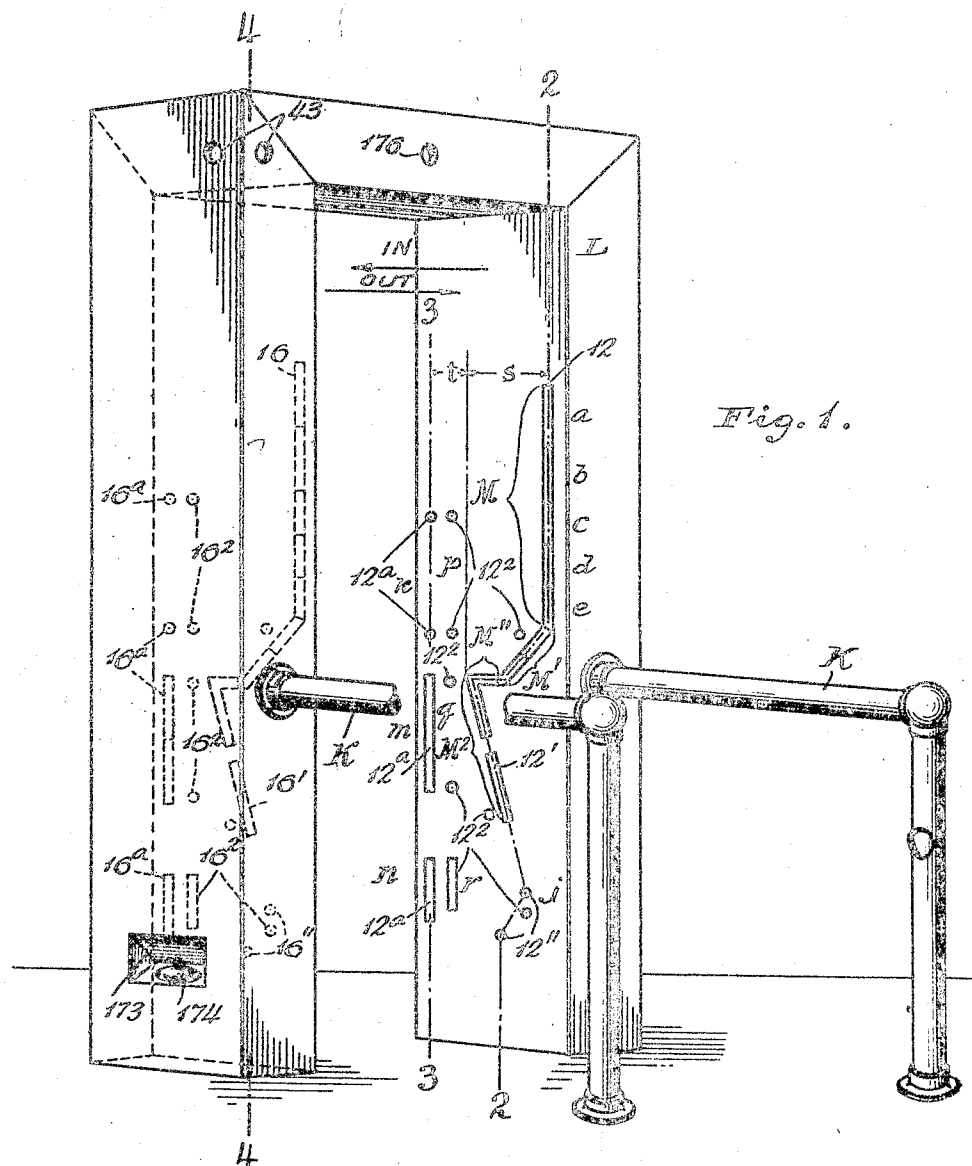


Fig. 1.

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June 8, 1937.

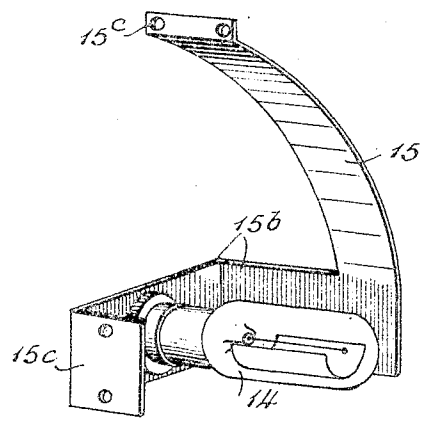
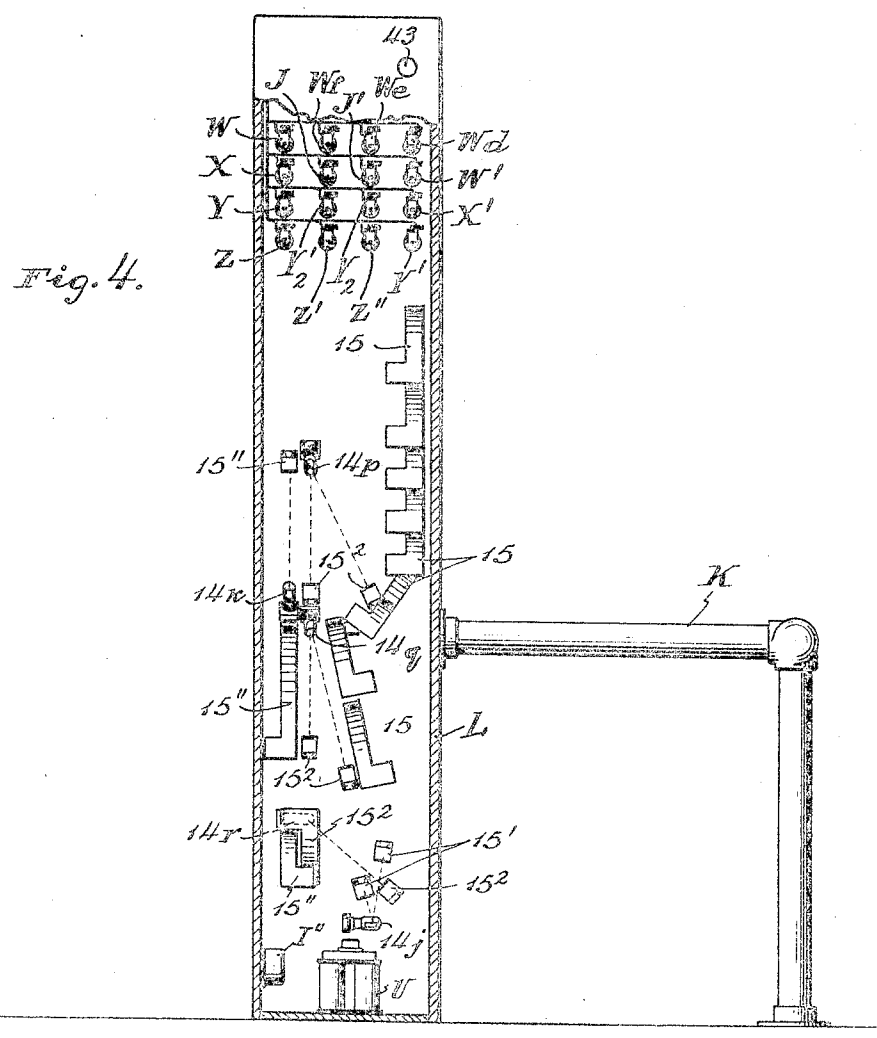
J. H. BURNSIDE, 2D

2,082,941

COUNTING APPARATUS OPERATED BY RADIANT ENERGY

Filed June 30, 1933

8 Sheets-Sheet 3



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COUNTING APPARATUS OPERATED BY RADIANT ENERGY

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8 Sheets-Sheet 4

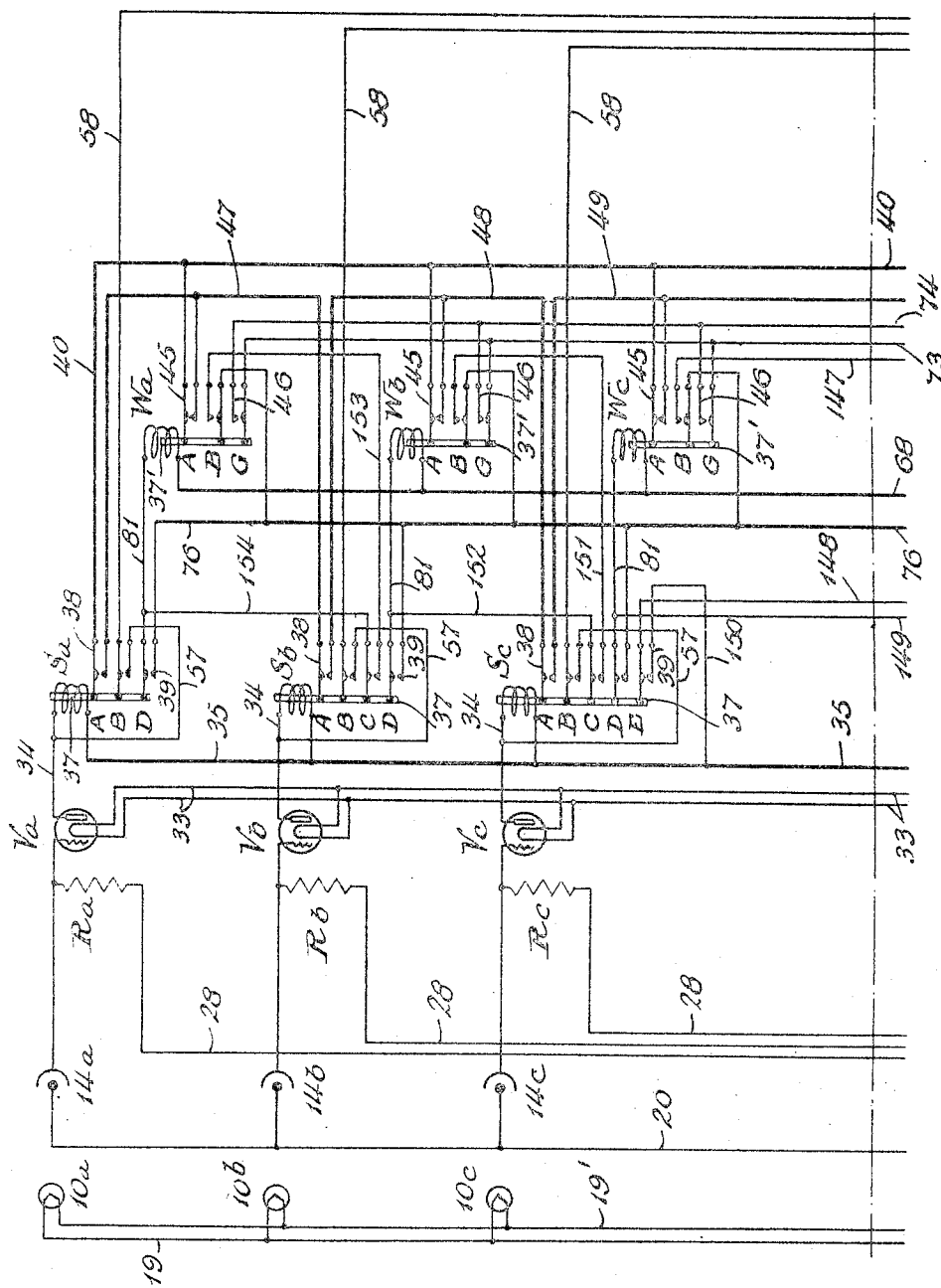


Fig. 5.

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COUNTING APPARATUS OPERATED BY RADIANT ENERGY

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8 Sheets-Sheet 5

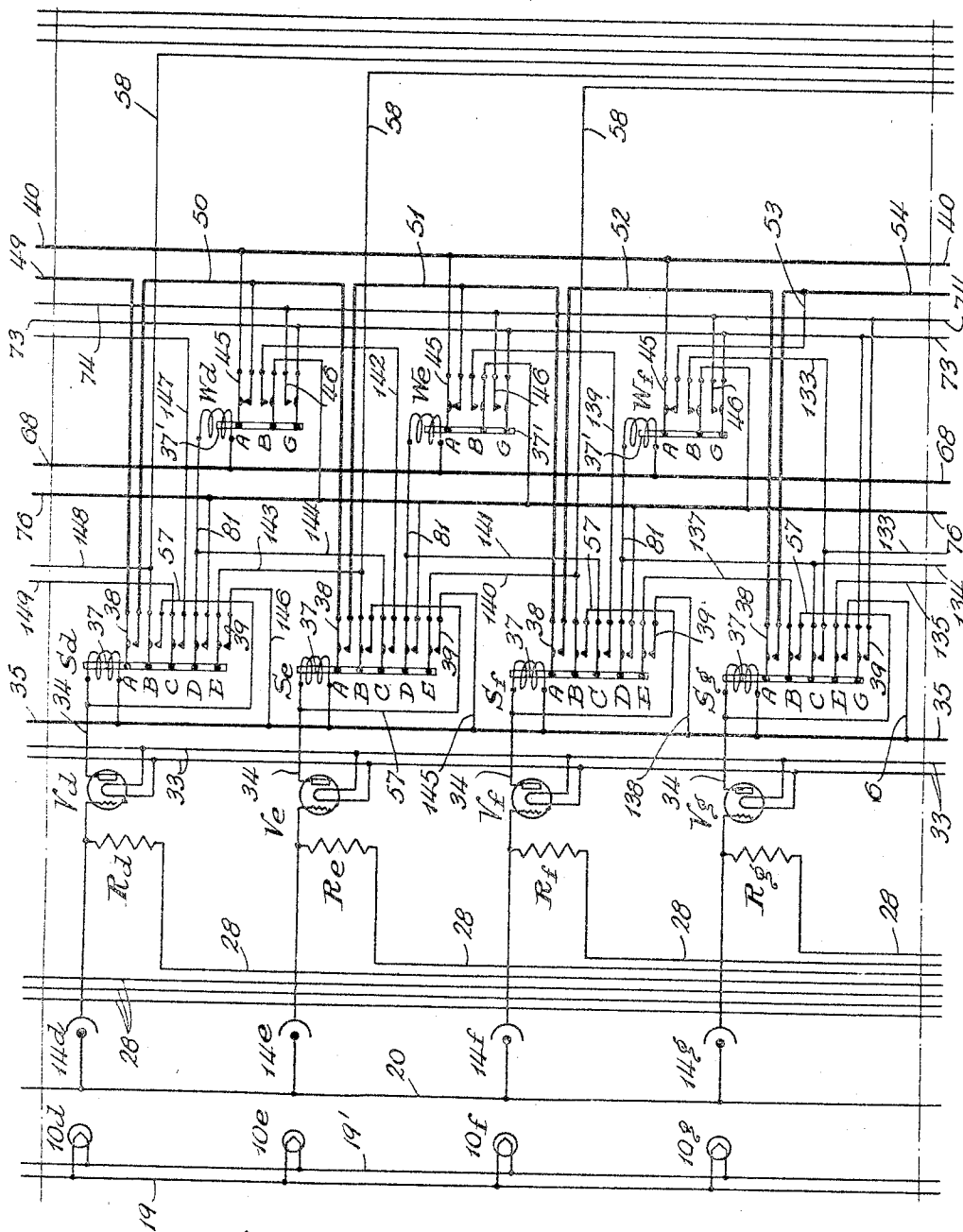


Fig. 6.

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COUNTING APPARATUS OPERATED BY RADIANT ENERGY

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8 Sheets-Sheet 6

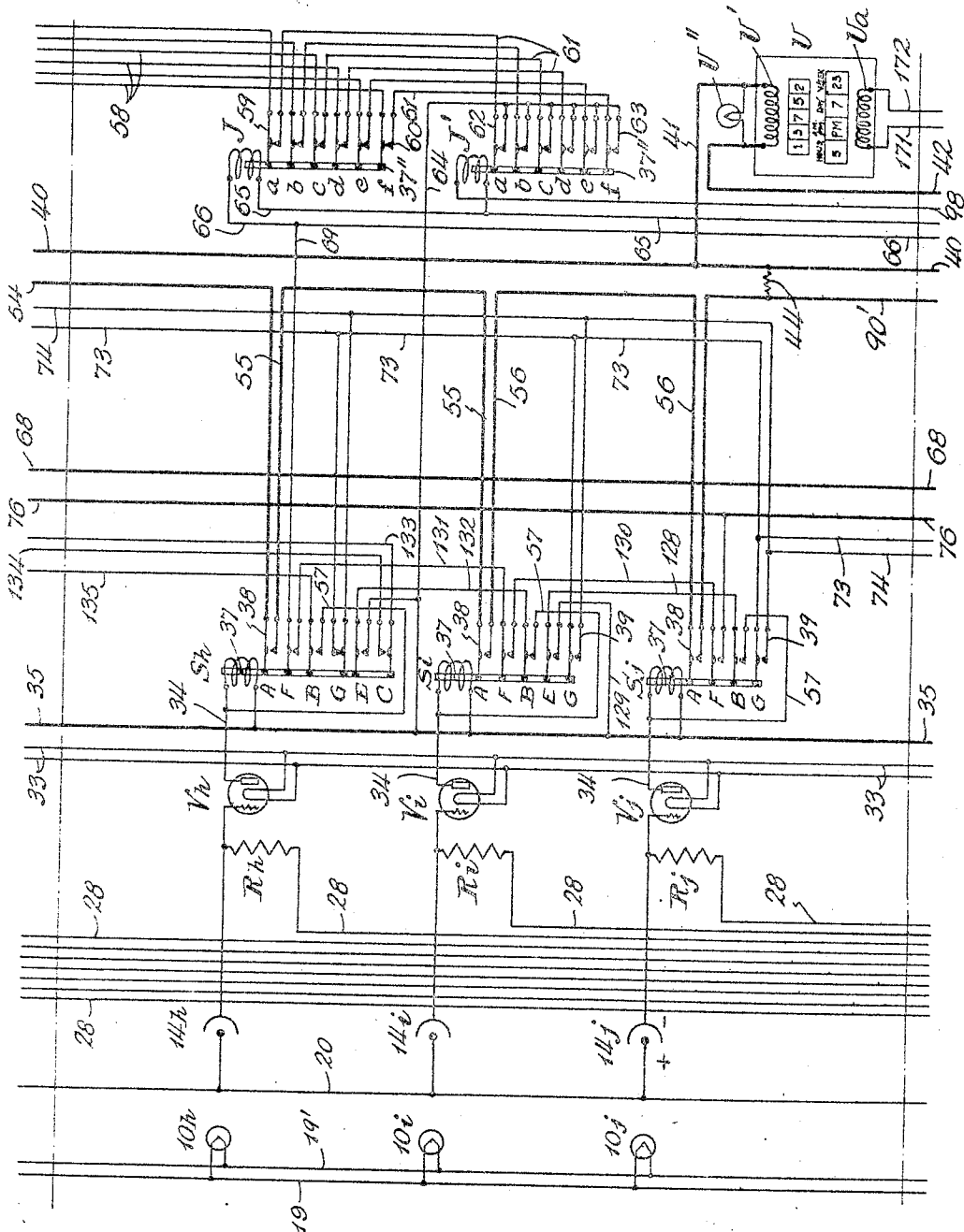


Fig. 7.

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COUNTING APPARATUS OPERATED BY RADIANT ENERGY

Filed June 30, 1933

8 Sheets-Sheet 7

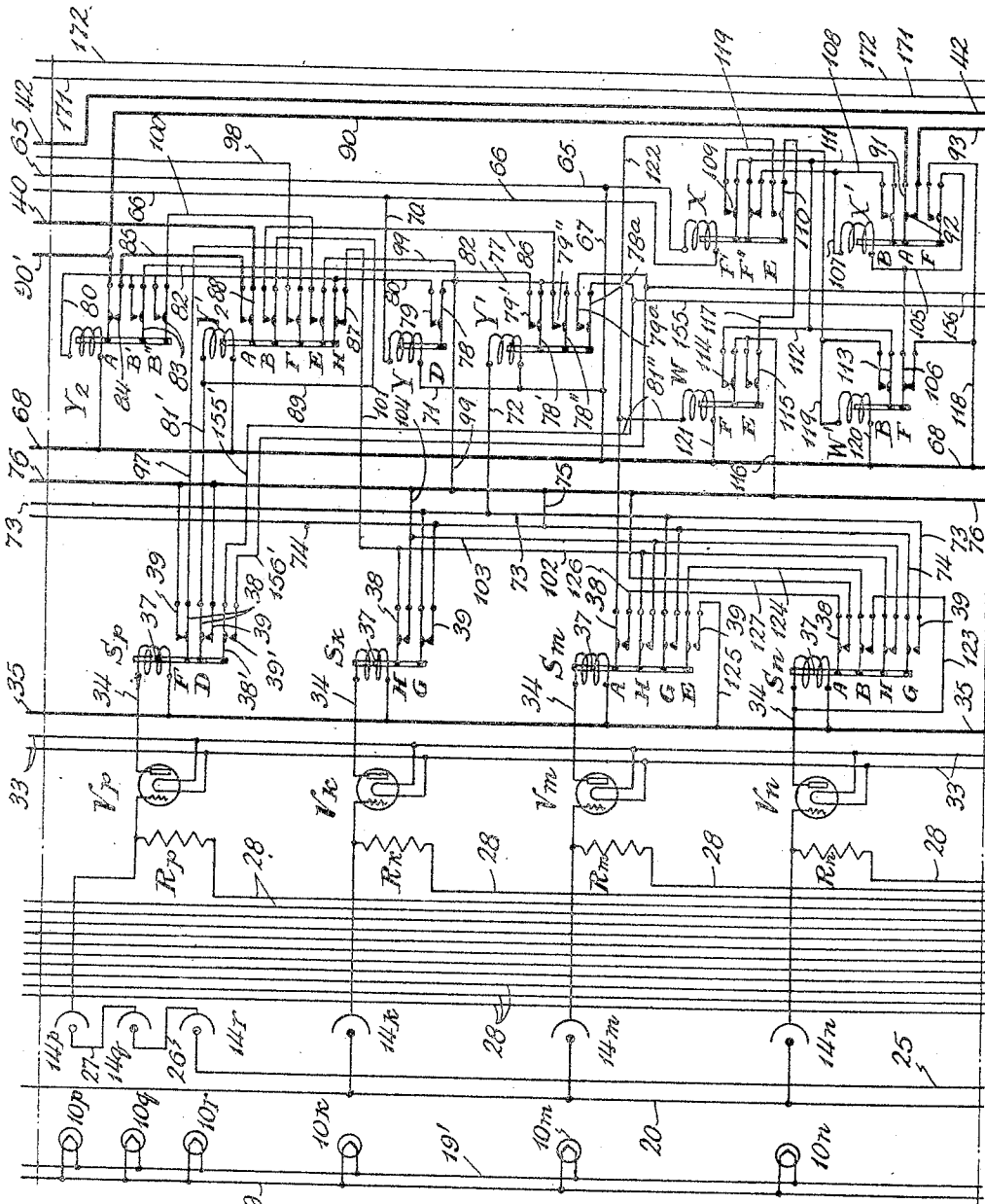


Fig. 8.

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COUNTING APPARATUS OPERATED BY RADIANT ENERGY

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8 Sheets-Sheet 8

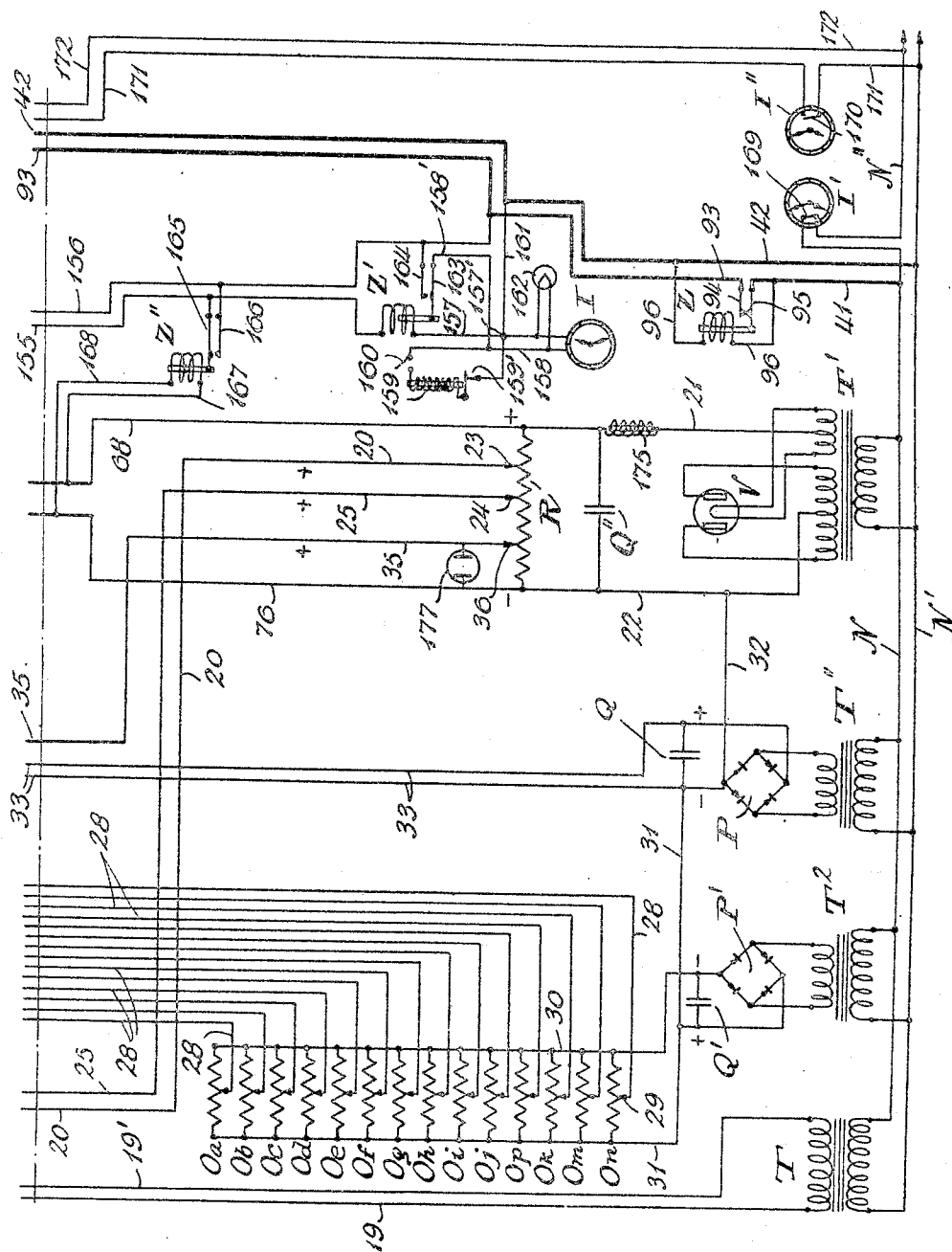


Fig. 9.

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UNITED STATES PATENT OFFICE

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COUNTING APPARATUS OPERATED BY
RADIANT ENERGY

James H. Burnside, 2nd, New York, N. Y.

Application June 30, 1933, Serial No. 678,367

5 Claims. (Cl. 250—41.5)

My invention relates to counting apparatus operated by light or other radiant energy, particularly such as are intended for counting persons entering a theatre, meeting hall, or the like.

Among the objects of my invention is the provision of an apparatus of this type which will furnish an accurate count of all persons passing through the entrance in a predetermined direction. Certain features of my invention insure the accuracy of the count notwithstanding irregularities such as may be due to differences in the stature or girth of the persons to be counted, or to the way in which such persons may hold or move their arms, or to articles carried by such persons, or to persons following one another very closely, or to attempts of persons to pass through uncounted, as by jumping or crawling through. Another feature of my invention causes the counting apparatus to be thrown out of action whenever a person passes through the entrance in the direction opposite to that which may be called the counting direction; thus, generally it will be desired to count only the persons which pass in through the entrance, and not any persons which may pass out the same way.

A satisfactory typical embodiment of my invention will now be described in detail with reference to the accompanying drawings. While this embodiment contains various features or devices used in conjunction with each other, I desire it to be understood that in certain cases, some of these devices or features might be omitted without sacrificing the advantages obtained by the provision of the other features. Furthermore, it will be understood that I do not wish to limit myself to the exact constructions, arrangements, and connections illustrated and described, but that various modifications may be made without departing from the nature of my invention as set forth in the appended claims.

In the drawings, Fig. 1 is a perspective view showing the doorway through which the persons to be counted are intended to pass; Figs. 2, 3, and 4 are sections substantially on the lines 2—2, 3—3, and 4—4 respectively of Fig. 1, the section line 2—2 being laid longitudinally of the irregular opening 12 and of the opening 12', as well as through the openings 12"; Fig. 4a is a detail perspective view showing a photoelectric cell and a reflector associated therewith; Figs. 5 to 9 inclusive together constitute a diagram of the parts and their electrical connections, Fig. 5 being the uppermost section of this diagram, Fig. 6 being the downward continuation of Fig. 5 and so forth, Fig. 9 being the lowermost section;

the dotted horizontal lines at the bottom of Figs. 5 to 8 inclusive and at the top of Figs. 6 to 9 inclusive indicate corresponding points of adjacent diagram sections.

Referring particularly to Figs. 1, 2, 3, 4, and 4a, I have shown an entrance to a theatre or like building, with parallel horizontal rails K leading to the opening in the door jamb L, said opening being relatively narrow so as to prevent two persons walking abreast, and compel all persons to enter through the door in single file. Preferably even the distance between the rails K is such as to compel the people to form a line in single file as they approach the doorway. The door jamb L is hollow and contains the several parts of my improved counting apparatus.

At one side of the doorway, the jamb contains devices for projecting rays or beams of radiant energy across the doorway, while on the other side the jamb contains devices sensitive or responsive to such radiant energy, and controlling the counting mechanism proper. Such rays or beams are projected at different levels, and are preferably located at such short distance apart (say about 2 inches) that together they will constitute a practical approximation to an upright sheet of radiant energy. The upper limit of such sheet may, for instance, be at a level of about 5 feet 6 inches from the floor, and the lower limit at a level of about 2 feet 6 inches. In the drawings, I have shown incandescent electric lamps as the source from which beams or rays of radiant energy proceed, and in the particular embodiment illustrated there are nine groups or banks of such lamps at different levels, said groups being designated as 10a to 10i respectively, to form the upright sheet of radiant energy (light) referred to above. At a distance below the lower edge of such sheet (say about 20 inches from the floor), I have indicated another group or bank of incandescent lamps 10j. The ten groups 10a to 10j together form what I term the "counting line", that is, the set of lamps (projectors of radiant energy) which causes the counting mechanism to operate. While each of the banks or groups contains more than one lamp (Fig. 2 showing two lamps in some groups, and three in others), each group has been represented by a single lamp in the diagrammatic Figs. 5, 6, 7, 8, in order to simplify illustration.

The light from the lamps is thrown across the door opening by suitable directing, focusing, or concentrating devices, for instance lenses 11, one for each lamp, the inner wall of the jamb having openings or windows through which the

light may pass. Fig. 2 shows a single opening 12 for the eight groups of lamps 10a to 10h which form all but the lowermost portion of the sheet of light, a separate opening 12' for the group 10i which forms the lowermost portion of said sheet, and separate openings 12'' for each of the lamps of the lower group 10j. In each of the openings 12, 12', 12'' I have shown a pane of ruby glass 13, 13' or 13'' respectively, the purpose being to render the beams of light less noticeable to the eye, although they are fully efficient to influence the light-responsive devices located on the other side of the door opening.

These light-responsive devices consist of photoelectric cells of any well-known or approved construction. There are ten photoelectric cells 14a to 14j, one for each of the lamp groups 10a to 10j respectively. In the construction illustrated, the rays or beams of light focused by the lenses 11 do not reach the photoelectric cells directly, but are first thrown on reflectors 15 or 15' respectively. The reflectors 15 are shown as of parabolic shape, there being nine reflectors 15, one for each of the photoelectric cells 14a to 14i (the two reflectors for the cells 14j and 14g are shown as a unit), while two reflectors 15' are employed (one for each of the lamps 10j) in connection with the photoelectric cell 14j. The light-sensitive surfaces of the photoelectric cells are placed at the foci of the respective reflectors. Any suitable detail construction may be employed for the photoelectric cells and the reflectors associated therewith. According to Fig. 4a, a unitary bracket 15b may be used to support both the photoelectric cell 14 and the corresponding reflector 15, said bracket having two flanges 15c perforated to receive screws for fastening it to the inner wall of the door jamb. The photoelectric cells and the reflectors are located within the hollow jamb L, behind openings 16, 16', 16'', which may contain panes 17, 17', 17'' of ordinary clear glass, to exclude dust etc. and to protect the apparatus against tampering. The openings 16, 16', 16'' correspond to the openings 12, 12', 12'' in shape and location, and preferably also in size. In the openings 16, 16' which receive a plurality of beams of light, I prefer to provide partitions or shields 18 the planes of which are horizontal, that is to say, parallel to said beams, and located between adjacent beams, as shown in Fig. 2. These shields will prevent any stray light flux from affecting the photoelectric cells 14a to 14i.

While the lamps 10a to 10j are mostly located at different levels, they are not all vertically one above the other, but I have adopted the irregular arrangement shown in Fig. 1, which has certain special advantages explained below. The upper portion M of the "counting line" (the five groups 10a to 10e) has its lamps vertically one above the other. Then follows a portion M' which is inclined downwardly and toward the rear or inner end of the doorway, that is to say, in the direction in which the persons walk through when being counted. In this portion M' (formed by the group 10f and all but the lower end of group 10g), the lamps are not only at different levels, but at different distances from the end or face of the jamb L. A short horizontal portion M'' (formed by the lower end of group 10g and the upper end of group 10h) contains lamps located at the same level, but at different distances from the face of the jamb. This portion M'' extends from the lower end of the portion

M' rearwardly (toward the left in Fig. 1) to the upper end of a portion M² composed of the group 10i and all but the upper end of group 10h. This portion M² is inclined downwardly and forwardly (toward the right in Fig. 1), and the lamps therein are arranged correspondingly, that is, not only at different levels but at different distances from the face of the jamb. Fig. 1 also shows that the upper opening 12'' is located in the continuation of the lower portion M² of the "counting line", while the lower opening 12' is somewhat to the rear of said upper opening.

Near the inner or rear end of the doorway, I have indicated (see particularly Fig. 3) another set of lamp groups 10k, 10m, 10n, the lamps of these groups being one vertically above the other and together constituting what I term the "free line", since the lamps of this set are intended to render the lamps of the "counting line" inoperative for counting purposes whenever a person passes through the entrance in the direction marked Out in Fig. 1. This will be fully explained below in describing the operation of the invention. The lamps of the "free line" are located on the same side of the jamb L as those of the "counting line", and in connection with the lamps of groups 10k, 10m and 10n I have shown lenses 11', openings 12a in the jamb, and ruby panes 13a in said openings, corresponding to the lenses 11, openings 12, 12', 12'' and ruby panes 13, 13', 13'' used in connection with the counting line. In the same manner as described with reference to the lamps of the counting line, those of the "free line" groups 10k, 10m, 10n throw their light across the doorway through clear panes 17a set in openings 16a on the other side of the jamb and with the aid of reflectors 15'' (some of which have shields 18' of the character described above) upon the light-sensitive surfaces of photoelectric cells 14k, 14m, 14n respectively.

In an intermediate position, that is to say, substantially to the rear of the counting line but forward of the free line, I have located still another set of lamp groups and adjuncts, which together constitute what I term a "trip line", for reasons that will appear from the description of the operation as given below. The lamps of this tripping line are arranged in three groups 10p, 10q, 10r at different levels, each group being of substantially triangular outline, one lamp of each group being forward of the others (to the right in Fig. 1), such other lamps of the groups 10p, 10q and 10r being located one vertically above the other. These lamps are on the same side of the jamb L as the other lamps referred to above, and the light from the lamps of the trip line is directed by lenses of the same character as the lenses 11, 11' through openings 12³, containing ruby panes of the same character as the panes 13, 13', 13'', 13a, horizontally across the doorway into openings 16³, containing clear panes of the same character as the panes 17, 17', 17'', 17a. The light thus reaches reflectors 15³, one of which is shown as a parabolic reflector (Fig. 4) and the opening 16³ adjacent to which said reflector is located, is provided with shields of the character described above in connection with the shields 18, 18'. The reflectors throw the light upon the light-sensitive surfaces of three photoelectric cells 14p, 14q and 14r respectively (one for each group of lamps). The lamp groups 10p, 10q and 10r are shown only in the diagrammatic view Fig. 3, but it will be understood that these lamps and their adjuncts will be of the same general character as explained

above in connection with Figs. 2 and 3, so that with the aid of Figs. 1 and 4 and in view of the analogy of the arrangement with that shown in Figs. 2 and 3, the illustration is thought sufficient to make the parts of the "trip line" readily intelligible.

In Figs. 1 and 2, I have shown the openings 12, 12', 12'', 12a, 12b, on one side of the jamb, and the corresponding openings 16, 16', 16'', 16a, 16b, on the other side of the jamb. It will be understood that the lamps, reflectors and other parts described above but not shown in Fig. 1 are located adjacent to the respective openings. For the sake of easier understanding, I have added at the right hand portion of Fig. 1 reference characters indicating the position of the particular groups of lamps located adjacent to the respective openings.

The filaments of the incandescent lamps in the several groups 10a to 10r are connected in parallel to bus wires 19, 19' receiving an electric current from any suitable source, for instance alternating current from the secondary of a transformer T the primary of which is connected to the conductors or mains N, N', for instance of an ordinary electric circuit supplying alternating current of 110 volts and 60 cycles. The anodes of the photoelectric cells 14a to 14r are indicated by small circles in Figs. 5, 6, 7, 8 and the anodes of the cells 14a to 14n are connected to a bus wire 20 connected with the positive terminal of any suitable source of direct current. As such source, I may employ a vacuum-tube rectifier V which receives alternating current from the secondaries of a transformer T' energized by the mains N, N', and delivers the rectified current through positive and negative conductors 21 and 22 respectively. The positive bus wire 20 is connected with a tap 23 on a resistor R which connects the conductors 21 and 22. Another tap 24 on said resistor supplies positive potential through a wire 25 to the anode of one of the photoelectric cells of the trip line, for instance the cell 14r. The cathode of this cell (the cathodes being indicated by semi-circles) is connected by a wire 26 with the anode of another cell (14q) of the trip line, and a similar wire 27 connects the cathode of such second cell with the anode of the third cell (14p). The cathodes of the photoelectric cells 14a to 14p are connected to the grids of vacuum tube amplifiers Va to Vp respectively and to one terminal of the grid leak resistors Ra to Rp of such amplifiers. The other terminals of these grid leak resistors are connected by wires 28 with taps 29 on bias resistors Oa to Op respectively, the ends of said resistors being connected by wires 30, 31. From the wire 31 a wire 32 leads to the negative conductor 22 of the rectifier V. Thus a negative potential is supplied from said rectifier to the cathodes of all the photoelectric cells 14a to 14r.

The filaments of the amplifier tubes Va to Vp are supplied with direct current through bus wires 33, from any suitable source, for instance a dry rectifier P, a shunt condenser Q being connected with said wires. This rectifier is energized by a transformer T''.

The wires 30, 31 are connected with a shunt condenser Q' and with positive and negative terminals respectively of another source of direct current, for instance a dry rectifier P' energized by a transformer T². Thus a negative potential (relatively to the tube filaments) is applied to the grid of each amplifier tube through the grid

leak resistors Ra to Rp and the bias resistors Oa to Op.

The plates of the amplifier tubes Va to Vp are connected by wires 34 with one end of the coils of relays Sa to Sp, the other ends of said coils being connected with a voltage bus wire 35 connected to a tap 36 on the resistor R of the rectifier V. A positive potential of proper value is thus applied to the plates of the amplifier tubes Va to Vp.

The movable cores 37 of the relays Sa to Sn are connected with movable switch members 38 which are adapted to engage the respective stationary contacts 39. The number of switch members and contacts varies in the several relays, as explained below, and to facilitate the reading of the drawings I have applied like indices (A to H) to switch members and contacts which have similar circuit connections. Under normal conditions, that is to say, when the light beams thrown across the doorway are unobstructed, the current flowing through the coils of the relays Sa to Sp is strong enough to raise all the switch members 38 of the relays Sa to Sg, Si, Sj, Sk, Sm, and Sn out of engagement with the respective contacts 39, while as to the relays Sh and Sp, some of their switch members 39 in their raised position will engage the respective contacts, and others will be out of engagement therewith.

The relay Sa has three switch members 38 and three contacts 39, with the indices A, B and D respectively. The relay Sb has four such switch members and four such contacts, with the indices A, B, C and D respectively. Each of the four relays Sc, Sd, Se and Sf has five switches with their respective contacts, designated by the indices A, B, C, D and E. The relay Sg likewise has five switches and contacts, but their relation to the circuit is different from those of the four relays just mentioned, as is indicated by the indices A, B, C, E and G respectively. The relay Sh has six switches and contacts designated by the indices A, F, B, G, E and C respectively. The relay Si has five switches and contacts designated by the indices A, F, B, E and G respectively. The relay Sj has four switches and contacts designated by the indices A, F, B and G respectively. These are the relays associated with the counting line, and may be termed the counting control relays.

The relay Sk has two switches and contacts, designated by the indices H and G respectively. The relay Sm has four switches and contacts, designated by the indices A, H, G and E respectively. The relay Sn has four switches and contacts designated by the indices A, B, H and G respectively. These three relays Sk, Sm and Sn are associated with the free line, and may be termed the free control relays.

Finally, the relay Sp associated with the trip line has two switches with their respective contacts, designated by the indices F and D, respectively, and also an additional switch 38' with its contact 39'. This relay I term the trip control relay.

The switch member 38A of the relay Sa is connected by a bus wire 40 with one terminal of the actuating coil U' of the electrically operated counting device U, which may be a register or a recorder, but preferably combines both functions. Since devices of this class, operated by electrical impulses, are well-known in the art, I have not deemed it necessary to show the details of the counting mechanism proper. The coil U' is adapted to receive current from the mains N, N'

through wires 41, 42 one of which (42) is connected with the coil permanently, while the connection of the other wire (41) with said coil through the bus wire 40 is controlled by switches, in the manner set forth hereinafter. A tell-tale lamp U'' shunted across the coil U', is designed to flash whenever a current impulse passes through said coil to operate or "step" the counting mechanism. This lamp is visible through openings or windows 43 at the top of the jamb L. A resistor 44 is shunted across from the wire 40 to a wire 90' referred to below.

The wire 40 is also connected, as shown, with movable switch members 45 (bearing the index A) of another set of relays Wa, Wb, Wc, Wd, We and Wf (which I term power relays). These relays are similar to those described above, each of them having a coil, a movable core 37' connected with all the switch members of the particular relay, and stationary contacts 46, some of the switch members 45 when raised being in engagement with the respective contacts, and others in engagement with their contacts when lowered. Each of these six relays Wa to Wf has three switch members 45 and three contacts 46, bearing the indices A, B and G respectively. The contact 46A of the relay Wa is connected by a wire 47 with the contact 39A of the relay Sa and also with the switch member 38A of the relay Sb. The contact 46A of the relay Wb is connected by a wire 48 with the contact 39A of the relay Sb and also with the switch member 38A of the relay Sc. Similarly, a wire 49 connects the contact 46A of the relay Wc with the contact 39A of the relay Sc and with the switch member 38A of the relay Sd. A wire 50 connects the contact 46A of the relay Wd with the contact 39A of the relay Sd and with the switch member 38A of the relay Se. A wire 51 similarly connects the contact 46A of the relay We with the contact 39A of the relay Se and with the switch member 38A of the relay Sf. The contact 39A of the relay Sf is connected by a wire 52 with the switch member 38A of the relay Sg. Wires 53, 54 connect the contact 46A of the relay Wf with the contact 39A of the relay Sg and with the switch member 38A of the relay Sh. A wire 55 connects the contact 39A of the relay Sh with the switch member 38A of the relay Si. Another wire 56 connects the contact 39A of the relay Si with the switch member 38A of the relay Sj. The contact 39A of this relay Sj is connected by a wire 90' with the wire 90 referred to below.

The contact 39B of each of the ten relays Sa to Sj is connected by a wire 57 to the wire 34 associated with the same relay. The switch member 38B of each of the six relays Sa to Sf is connected by individual wires 58 to the switch member 59a to 59f respectively of a locking relay J. The stationary contacts 60a to 60f co-operating with said switch members are connected by individual wires 61 with the six switch members 62a to 62f respectively of another locking relay J' the stationary contacts 63a to 63f of which are all connected, by the same wire 64, to the bus wire 35.

The general construction of the locking relays J and J' is the same as that of the other relays described above; that is to say, each of the relays J and J' has a coil which when energized fully will draw the core 37'' in such a direction (upwardly as illustrated) as to hold all the switch members 59a to 59f or 62a to 62f respectively of that relay out of engagement with the contacts 60a to 60f or 63a to 63f of the same relay, each core being connected operatively with all the movable switch members of the respective relay.

One terminal of the coil of each locking relay J, J' is connected by a wire 65 to one terminal of the actuating coil of another relay X (which I term the free control relay), the other terminal of said actuating coil being connected by a wire 66 to the second terminal of the coil of the locking relay J. The wire 65 is connected by a wire 67 with a voltage bus wire 68 receiving current from one terminal of the rectifier V. The wire 66 is connected by a wire 69 with the switch member 38F of the relay Sh, and by a wire 70 with one end of the actuating coil of a relay Y (which I term the trip set driver relay), the other end of said coil being connected with the wire 67 by a wire 71. The latter is also connected with one end of the actuating coil of a relay Y' (which I term the trip lock relay), the other end of which is connected by a wire 72 with a wire 73. The latter is connected with the switch members 38G of the counting control relays Sg, Si, Sj, Sk, and Sm, with the contact 39C of the relay Sh, the contact 39G of the relay Sn, and also with the switch members 45G of the six power relays Wa to Wf. The switch member 38G of the relay Sn is connected by a wire 74 and suitable branch wires, with the contacts 39G of the relays Sg, Si, Sj, Sk and Sm, with the switch member 38C of the relay Sh, the switch member 38G of the relay Sn, and also with the contacts 46G of the six power relays Wa to Wf. From the wire 74 a wire 75 leads to a voltage bus wire 76 receiving current from the other terminal of the rectifier V.

The bus wire 76 is also connected, by suitable branch wires, with the contacts 39D of the six relays Sa, Sb, Sc, Sd, Se, Sf, with the switch members 45B of the six relays Wa to Wf, as well as with the contact 39F of the relay Sj, the contacts 39D and 39F of the relay Sp, the contacts 39H of the relay Sk and the contact 39A of the relay Sn.

A wire 77 connects the switch member 78 of the relay Y with two switch members 78', 78'' of the relay Y'. The stationary contact 79 of the relay Y is connected by a wire 80 with one end of the actuating coil of a relay Y2, the other end of such coil being connected with the bus wire 68.

This wire 68 is also connected with one end of the actuating coil of each of the relays Wa to Wf, and also with one end of the actuating coil of relays Y2', Y, Y', W, and W'. The other ends of the coils of the relays Wa to Wf, are connected by wires 81, with the switch members 38D of the relays Sa to Sf. The other end of the coil of the relay Y2' is connected by a wire 81' with the switch member 38D of the relay Sp, and the other end of the coil of the relay W is connected by a wire 81'' with the switch member 38A of the relay Sm.

The stationary contact 79' of the relay Y' is connected by a wire 82 with the switch member 83B' of the relay Y2. The contacts 84B' and 84B'' of this relay Y2 are connected with the wire 80. The stationary contact 79'' of the relay Y' is connected by a wire 86 with the stationary contact 87B of the relay Y2'. The corresponding switch member 88B of the relay Y2' is connected by a wire 89 with the wire 81' which connects the actuating coil of this relay with the switch member 38D of the relay Sp.

The relay Y2' has four additional pairs of switch members and corresponding contacts, these pairs being denoted by the indices A, F, E and H respectively. The switch member 88A of 75

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this relay is connected to the wire 40, while the corresponding contact 87A is connected by a wire 85 with the contact 84A of the relay Y₂. The switch member 83A co-operating with the contact 84A is connected with a wire 90 leading to the switch member 91A of a relay X' which I term the free set relay. From the corresponding contact 92A of the relay X' a wire 93 leads to the contact 94 of a relay Z which I term the power time delay relay. The switch member 95 of this relay is connected by the wire 41 to the line wire N. The actuating coil of the relay Z is connected by wires 96 in a shunt between the wires 41 and 42.

The switch member 88F of the relay Y₂' is connected by a wire 97 with the switch member 38F of the trip line relay S_p; the contact 87F co-operating with said switch member 88F is connected by a wire 98 with that end of the actuating coil of the locking relay J' which is opposite to the end connected with the wire 65. The switch member 88E of the relay Y₂' is connected to the bus wire 76 by a wire 99, while the corresponding contact 87E is connected by a wire 100 to the switch member 83B'' of the relay Y₂. The switch member 88H of the relay Y₂' is connected with the wire 80, while the corresponding contact 87H is connected by a wire 101 with the switch member 38H of the relay S_k.

From the wire 101 a branch wire 102 leads to the switch members 38H of the relays S_m and S_n. The contacts 39H of the three relays S_k, S_m, S_n are connected by a wire 103 from which a branch wire 104 leads to the bus wire 76.

The switch member 91F of the free set relay X' is connected by a wire 105 with the contact 106F of the relay W' (which I term the free power relay) and with one end of the actuating coil of the relay X', the other end of said coil being connected by a wire 107 with a wire 108 which connects the contact 92B of the relay X' with the contact 109F'' of the free control relay X. The corresponding switch member 91B of the relay X' is connected by a wire 111 with the switch members 110F' and 110F'' of the relay X. A branch 112 connects the wire 111 with the switch member 113B of the free power relay W' and with the contact 114F of the relay W, which I term the free master relay. The switch member 115F and the contact 114E of the relay W are connected with the bus wire 76 by a wire 116. A wire 117 connects the switch member 115E of the relay W with the switch member 110E of the relay X. The contact 92F of the relay X' is connected by a wire 118 with the bus wire 68 and also with the switch member 113F of the relay W'. A wire 119 connects the contact 109F'' of the relay X with the contact 106B of the relay W' and with one of the actuating coils of said relay W'. The other end of said coil is connected with the bus wire 68 by a wire 120. The actuating coil of the relay W has one end connected, by a wire 121, with the bus wire 68, the other end of such coil being connected, as stated above, with the switch member 38A of the relay S_m by the wire 81'', from which a branch 122 leads to the contact 109E of the relay X.

The contact 39B of the relay S_n is connected by a wire 123 with the wire 34 connecting the actuating coil of said relay with the plate of the corresponding amplifier tube V_n. The corresponding switch member 38B of the relay S_n is connected by a wire 124 with the switch member 38E of the relay S_m. The corresponding contact 39E of the relay S_m is connected by a wire 125

with the bus wire 35. A wire 126 connects the contact 39A of the relay S_m with the switch member 38A of the relay S_n. The corresponding contact 39A of the relay S_n is connected by a wire 127 with the bus wire 76.

The switch member 38B of the relay S_j is connected by a wire 128 with the switch member 38E of the relay S_i; the corresponding contact 39E of the relay S_i is connected with the bus wire 35 by a wire 129. A wire 130 connects the switch member 38F of the relay S_j with the contact 39F of the relay S_i, and the corresponding switch member 38F of the relay S_i is connected with the contact 39F of the relay S_h by a wire 131. The switch member 38B of the relay S_i is connected by a wire 132 with the switch member 38E of the relay S_h; the corresponding contact 39E of the relay S_h is connected with the wire 64 and through it with the bus wire 35.

The switch member 38C of the relay S_h is connected by a wire 133 with the contact 39C of the relay S_g and with the contact 46B of the relay W_f. A wire 134 leads from the contact 39C of the relay S_h to the switch member 38C of the relay S_g and to that wire 81 which is connected with the switch member 38D of the relay S_f. The switch member 38B of the relay S_h is connected by a wire 135 with the switch member 38E of the relay S_g, and the corresponding contact 39E of the relay S_g is connected by a wire 136 with the bus wire 35.

The switch member 38B of the relay S_g is connected by a wire 137 with the switch member 38E of the relay S_f. The corresponding contact 39E of the relay S_f is connected with the bus wire 35 by a wire 138. From the contact 39C of the relay S_f a wire 139 leads to the contact 46B of the relay W_e.

The switch member 38B of the relay S_f is connected by a wire 140 with the switch member 38E of the relay S_e, and the switch member 38C of the relay S_f is connected by a wire 141 with the switch member 38D of the relay S_e, through the corresponding wire 81. From the contact 39C of the relay S_e a wire 142 leads to the contact 46B of the relay W_d.

The switch member 38B of the relay S_e is connected by a wire 143 with the switch member 38E of the relay S_d, and the switch member 38C of the relay S_e is connected by a wire 144 with the switch member 38D of the relay S_d, through the corresponding wire 81. The contact 39E of the relay S_e is connected with the bus wire 35 by a wire 145. Similarly, a wire 146 leads from the contact 39E of the relay S_d to the bus wire 35. From the contact 39C of the relay S_d a wire 147 leads to the contact 46B of the relay W_c.

The switch member 38B of the relay S_d is connected by a wire 148 with the switch member 38E of the relay S_c, and the switch member 38C of the relay S_d is connected by a wire 149 with the switch member 38D of the relay S_c, through the corresponding wire 81. The contact 39E of the relay S_c is connected with the bus wire 35 by a wire 150. A wire 151 connects the contact 39C of the relay S_c with the contact 46B of the relay W_b.

The switch member 38C of the relay S_c is connected by a wire 152 with the switch member 38D of the relay S_b, through the corresponding wire 81. A wire 153 extends from the contact 39C of the relay S_b to the contact 46B of the relay W_a. A wire 154 connects the switch member 38C of the relay S_b with the switch member 38D of the relay S_a, through the corresponding wire 81.

The trip lock relay Y' has a third switch

member 78a and a third stationary contact 79a co-operating therewith, said switch member and contact being connected with wires 155 and 156 respectively. These wires are connected, by wires 155' and 156' respectively, with the switch member 38' and the contact 39' respectively of the relay Sp. The switch member 78a is connected by the wire 155 with one end of the actuating coil of a relay Z', which I term the alarm time delay relay, the other end of said coil being connected by a wire 157 with one contact of an alarm time clock I, the other contact of such clock being connected by a wire 158 with one end of the actuating coil of a buzzer 159, a manually operatable switch 160 being preferably included in said connection. The interrupter of the buzzer 159 is indicated at 159', and the stationary contact of such interrupter is connected by a wire 161 with the wire 42. The alarm time clock I may be of any well-known or approved construction, to bring its two contacts into or out of engagement at predetermined hours as desired. A trouble lamp 162 is shunted across the wires 157, 158. The wire 158 is connected by a branch 158' with the movable switch member 163 of the relay Z', the stationary contact 164 of which is connected with the wire 156.

The wires 155, 156 are also connected with the switch member 165 and the contact 166 respectively of a relay Z'', which I term the no-voltage relay. The actuating coil of this relay has its ends connected by wires 167, 168 with the wires 68 and 76 respectively.

At I' I have indicated an "off-on clock" with a switch 169 controlling a gap in the line wire N, while I'' designates a "date clock" with a switch 170 controlling a gap in a wire 171 which leads to one end of the actuating coil Ua of a time indicator of any suitable construction, preferably located adjacent to the counting device U, the other end of said coil being connected to the line wire N' by a wire 172. The indications of said device U and of the time indicator may be inspected through a window 173 in the jamb L, preferably with the aid of a lens 174.

A condenser Q'' may be shunted between the bus wires 68 (21) and 76 (22), ahead of the resistor R, and a choke coil 175 included in the connection of the wires 21, 68, on the transformer side of the said condenser shunt.

The trouble lamp 162 is visible through an opening or window 176 in the door jamb L, while the tell-tale lamp U'' is visible through the openings or windows 43.

The operation is as follows: To bring the apparatus into readiness for operation, the switch 169 must first be closed. This might, of course, be done manually at the proper times, but I prefer to have the switch 169 operated automatically by clockwork, such as the off-on clock I' which may be of any suitable construction to open and close the switch 169 at the particular times desired. Assuming that the switch 169 has been closed, the primaries of the four transformers T, T', T'' and T² will receive current from the line N, N'', N'. The following operations will then take place simultaneously: (1) From the secondary of the transformer T alternating current will be supplied through the wires 19, 19' to light all the lamps 10a to 10r which throw beams of light across the doorway, said beams being directed on the respective photo-electric cells 14a to 14r, thus reducing the internal resistance of said cells. (2) The transformer T' has two secondaries, one of which supplies current

to the filament of the rectifier V, while the other supplies current to the plates of said rectifier. From the midpoints of said two secondaries, rectified current is supplied through the wires 21, 22 to the resistor R and the wires 68, 76 respectively. From the tap 23 of the resistor R, positive potential is applied to the anodes of the photoelectric cells 14a to 14n through the bus wire 20, while a positive potential is applied to the anodes of the photoelectric cells 14p, 14q and 14r from the tap 24 of the resistor R through the wire 25 and the series-connecting wires 26, 27. Current will thus flow from the resistor R to the anodes of the photoelectric cells through the wires 20, 25, 26, 27, then through the cells and from the cathodes of the cells 14a to 14p inclusive through the respective grid leak resistors Ra to Rp and the wires 28, the taps 29 of the bias resistors Oa to Op, and the wires 31, 32 to the negative terminal of the rectifier V and resistor R. (3) The alternating current from the secondary of the transformer T² is transformed into direct current in the rectifier P', and from the negative terminal of said rectifier a connection is made through the wire 30, the bias resistors Oa to Op, the wires 28, and the grid leak resistors Ra to Rp to the grids of the amplifier tubes Va to Vp, thus imparting to the grids of said tubes a negative potential relatively to the filaments of such tubes. (4) The alternating current delivered by the secondary of the transformer T'' is transformed into a direct current by the rectifier P, and said direct current is supplied by the wires 33 to the filaments of the amplifier tubes Va to Vp. (5) From the tap 36 of the resistor R positive potential is supplied through the bus wire 35, the actuating coils of the counting control relays Sa to Sp and the wires 34, to the plates of the amplifier tubes Va to Vp. All the plate circuits of these tubes are of the same character, so that it will suffice to trace one of them. For instance, the plate circuit of the tube Vn is as follows: From the tap 36 of resistor R to wire 35, actuating coil of counting control relay Sn, corresponding wire 34, plate of amplifier tube Vn, filament of said tube, and through the negative wire 33, wires 32 and 22 back to the negative end of resistor R.

It is well known that the resistance of a photoelectric cell decreases with an increase in the amount of light falling thereon. The photoelectric cells of my apparatus have a minimum resistance when the full amount of light intended for each cell is directed thereon. Under these conditions, the amount of current in the plate circuit will be at a maximum, that is to say, the actuating coil of the respective counting control relay Sa to Sp will be energized fully. This will result in the respective cores 37 being in their raised position whenever the light beams from the respective lamps 10a to 10p pass without interruption across the doorway to the respective photoelectric cells.

The raising of the cores 37 will cause all the switch contacts to be opened in the counting control relays Sa to Sg inclusive and also in the relays Si, Sj, Sk, Sm and Sn. In the counting control relay Sh, however, the raised position of the core 37 will cause the switch contacts to be opened only at A, F, B and E, while in such position of the core the switch contacts will be closed at G and C. In the counting control relay Sp, the raised position of the core 37 will open the switch contact at 38', 39' and at D, but close at F. The drawings show the contacts of the count-

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ing control relays in the normal condition corresponding to the raised position of the respective cores 37.

The cores 37' of the power relays Wa to Wj are normally in their lower position, as shown, thus closing all the switch contacts of these relays at A while opening their contacts at B and G. The cores of the relays W, W', J, J', X, X', Y, Y', Y₂, Y₂', Z, Z' are initially in their lower position, thus opening all the contacts of W, Y, Y', Z and Z', and closing all the contacts of J, J' as to W', closing the contact at F and opening the contact at B; as to X, closing the contact at F'' and opening the contacts at F' and E; as to X', closing the contact at A and opening the contacts at B and F; as to Y₂, opening the contacts at B', B'' and closing the contact at A; as to Y₂', closing the contact at H and opening the contacts at A, B, F, and E. Since a circuit is closed from the positive end of resistor R through wires 68, 167, the actuating coil of the no-voltage relay Z' and the wires 168, 76 to the negative end of the resistor R, the core of said relay is normally in the upper position, breaking the contact between 165 and 166. Whenever the switch 169 is closed, the wire 41 becomes energized by connection with the live portion N'' of the line wire N and a circuit is closed from such live portion through the switch 169, the wires 41 and 96, and the actuating coil of the power time delay relay Z to the wire 42 and the other line wire N'. This will cause a slow upward movement of the core of the relay Z, bringing the switch member 95 into engagement with the contact 94 and keeping it in such engagement as long as the switch 169 is closed. Thus, as long as the core of the relay Z is in the upper position, the wire 93 will remain in conductive connection with the live portion N'' of the line wire N. The circuit closing movement of the switch member 95 will be relatively slow, the coil and core of the relay being constructed to obtain this result. It will be understood that as soon as the clock I' causes the switch 169 to open, the relay Z will become deenergized, thus interrupting the connection between the wire 93 and the wire 41, which latter, of course, at substantially the same time, is disconnected from the live portion N'' of the line wire N.

Therefore, as soon as the switch 169 and the switch 94, 95 have been closed as described above, the cores of the several relays will be in the positions illustrated (upper position for the cores of relays Sa to Sp, Z and Z', and lower position for the cores of the other relays) and the following contacts will be the only ones in the closed position: Relay Sh, at G and C; relays W' and Sp, at F; all the contacts of relays J, J', and Z; relay X, at F''; relay X', at A; relay Y₂, at A; relay Y₂', at H; and each of the power relays Wa to Wj, at A.

Now suppose that the light beam striking one of the photoelectric cells (say the cell 14a) is interrupted entirely, the resistance of such cell will increase, thereby reducing the flow of current through the corresponding grid leak resistor Ra, resulting in a decrease of the voltage drop across such resistor. This voltage drop is impressed between the grid and the filament of the amplifier tube Va, in a polarity opposite to the normal negative bias potential supplied by the transformer T² as described above. Therefore, when the voltage drop across the resistor Ra is reduced, the resultant grid potential existing in the tube Va between the grid and the negative end of the filament increases, causing

the grid to become more negative. This results in a decrease of the plate current flowing through the tube Va, and consequently there is a decrease in the strength of the current flowing through the actuating coil of the relay Sa connected in the plate circuit of said tube. Such a reduction of the current energizing the coil of the relay Sa will permit the corresponding core 37 to drop to its lower position in which the three pairs of contacts of said relay are closed. The closing of the contacts of the relay Sa at D will cause the actuating coil of the power relay Wa to be energized, since current from the rectifier V will flow through the wires 21, 68, the actuating coil of the relay Wa, the wire 81, the switch member 38D and the contact 38D of the relay Sa and the wires 76, 22 back to the rectifier. The energizing of the actuating coil of the relay Wa will cause its core 37' to rise thereby breaking the contact at A, but establishing contacts at B and G. This, however, will be insufficient to complete any further circuits, for the reasons explained below.

It will be noted that all the pairs of contacts marked A on the ten relays Sa to Sj of the counting line are in series connection by means of the wires 47 to 56, with the bus wire 90', 90, 93, 41. With the switches 169 and 94, 95 closed, there is normally a live condition from the wire 41 to the wires 93, 90 (since the relay X' has a closed contact at A) and 90'. It will be obvious that if only the relay Sa has its core 37 in the lowered position, no circuit will be completed at the contact A, for the reason that there are open gaps at the contacts A of the relays Sb to Sj inclusive. In order that a circuit be completed when the core 37 of the relay Sa is in its lower position, it is necessary that the cores of the relays Sb to Sj inclusive be likewise in their lower position, or in other words, that the beams of light affecting the corresponding photoelectric cells 14b to 14j be likewise interrupted. If this is the case, the cores of all ten relays Sa to Sj will be in their lower position, and a circuit will be closed as follows: Line N, wire 41, switch member 95, contact 94, wires 93, 90, and 90', contact A of relay Sj, wire 56, contact A of relay Si, wire 55, contact A of relay Sh, wire 54, contact A of relay Sg, wire 52, contact A of relay Sf, wire 51, contact A of relay Se, wire 50, contact A of relay Sd, wire 49, contact A of relay Sc, wire 48, contact A of relay Sb, wire 47, contact A of relay Sa, wire 40, one terminal of the actuating coil U' of the counting mechanism U, the other terminal of said coil, wire 42, and line wire N'. In this case therefore the coil U' will be energized to give a counting mechanism U. At the same time the tell-tale lamp U'' will flash thus giving the attendant a visible indication that this part of the apparatus has functioned properly.

Now let us assume that the person entering through the doorway is not tall enough to interrupt entirely the beam of light affecting the photoelectric cell 14a, but tall enough to interrupt all the other beams of light belonging to the counting line, that is to say, the beams which affect the photoelectric cells 14b to 14j inclusive. In this case the core 37 of the relay Sa will remain in its upper position, breaking the contact D, but the cores 37 of the relays Sb to Sj inclusive will be in their lower position. As a result, the actuating coil of the power relay Wa will receive no current and will therefore maintain a contact at A, whereas the actuating

coils of the power relays Wb to Wf will receive current through the connections which one end of each of such coils has with the bus wire 76, through the closed contact D of the associated counting line relay and the wire 81, while the other end of such coil is connected directly with the bus wire 68. The cores 37' of the power relays Wb to Wf will therefore be in the raised position, interrupting the contacts A of said relays. A circuit will therefore be closed as follows: Line N, wire 41, switch member 95, contact 94, wires 93 and 90', contact A of relay Sj, wire 56, contact A of relay Si, wire 55, contact A of relay Sh, wire 54, contact A of relay Sg, wire 52, contact A of relay Sf, wire 51, contact A of relay Se, wire 50; contact A of relay Sd, wire 49, contact A of relay Sc, wire 48, contact A of relay Sb, wire 47, contact A of relay Wa, wire 40, one terminal of the actuating coil U' of the counting mechanism U, the other terminal of said coil, wire 42, and line wire N'. The counting mechanism will thus again receive an impulse, even though there has been no change in the condition of the relays Sa and Wa.

Similarly, if a still shorter person should enter the doorway and fail to intercept the beams of light which affect the photoelectric cells 14a and 14b, a similar operation would take place, the cores of the relays Sa, Sb, Wa, Wb remaining in their original position, while the cores of the relays Sc to Sj and Wc to Wf would assume the reverse position to that shown in the drawings. The current in this case after reaching the wire 48 in the circuit just referred to above, would not continue on to the wire 47 (since there would be a gap at the contacts A of the relay Sb), but would pass from the wire 48 through the contacts A of the power relay Wb to the wire 40, continuing from there to the line N' in the same way as described above. A similar operation would take place if the person was still shorter, so that the uppermost beam of light intercepted would be the one affecting the photoelectric cell 14d, 14e or 14f; in these cases the closed contacts A of the power relays Wc, Wd and We respectively, would become operative to connect bus wire 40 with the wires 50, 51 or 52 respectively, and through the closed contacts A of the relays Se, Sf and Sg respectively with the wire 54 and thence by the closed contacts A of the relays Sh, Si and Sj with the bus wire 90', 90 and ultimately with the line wire N'.

Should the person be of such small stature as to intercept only the beams which affect the photoelectric cells 14h, 14i and 14j, the operation of the counting mechanism will take place in substantially the same manner as before, but the circuit will be slightly different, namely as follows: Line N, wire 41, switch member 95, contact 94, wires 93, 90, and 90', contact A of the relay Sj, wire 56, contact A of relay Si, wire 55, contact A of relay Sh, wires 54, 53, contact A of power relay Wf, wire 40, one terminal of the actuating coil U' of the counting mechanism U, the other terminal of said coil, wire 42, and line wire N'.

Should the body be so short as to intercept only the beams affecting the photoelectric cell 14i and 14j, or only the beams affecting the cell 14j, this will not cause an operation of the counting mechanism, for the reason that in the case first mentioned a gap will remain between the wires 54 and 55 at the A contact of the relay Sh, and in the second mentioned case, in addition to said gap, another gap, between the wires 55 and 56, at the A contact of the relay Si. Of

course, if the body is so short as not even to intercept the beam affecting the photoelectric cell 14j, a gap will remain between the wires 90' and 56 at the A contact of the relay Sj and thus there can be no operation of the counting mechanism. However, the beam of light affecting the photoelectric cell 14h is placed at a level low enough (say three feet from the ground) to be interrupted even by the passage of any child of such age as to be admitted to the theatre or like place under the rules governing admission. The apparatus will therefore count all admissible persons which enter through the doorway irrespective of the stature of such persons.

It will be noted that all the contacts marked A on the power relays Wa to Wf are connected in shunt to the power bus line 40 at points below those where such line is connected with the A contacts of the corresponding counting control relays Sa to Sf.

Each of the relays Sd to Sj inclusive, once it has closed its contacts by reason of the respective photoelectric cell being rendered dark, is locked in this closed position by the relay Sc to Si respectively next above it. For example, if the core 37 of the relay Sd has taken its lower position so as to close the contacts of said relay, it will be locked in this position by the action of the relay Sc. Similarly, if the core 37 of the relay Se is in its lower position, it will be locked by the action of the relay Sd. This is accomplished by an auxiliary contact on each relay so connected as to short circuit the actuating coil of the next relay below through one of its own contacts. For example, when the relays Sc and Sd are in the condition in which their contacts are closed, a positive potential is applied to the plate of the tube Vd from the voltage bus line 35 by means of the wire 150, the closed E contact of the relay Sc, the wire 148, the contact B of the relay Sd, and the wires 57, 34. This circuit forms a shunt around the actuating winding of the relay Sd, rendering it unresponsive to changes in the light thrown on the corresponding photoelectric cell 14d. Similarly, if the relays Sd and Se are in the condition in which their contacts are closed, a positive potential will be applied to the plate of the vacuum tube Ve from the voltage bus line 35 through the wire 146, the contact E of the relay Sd, the wire 143, the contact B of the relay Se and the wires 57, 34 associated with the relay Se and the tube Ve. This will form a shunt circuit around the actuating coil of the relay Se. It should be observed, however, that there is no interlocking action as regards the relays which are located above the relay Sc; that is to say, the relay Sc can not be locked in the contact-closing position by the relay Sb, nor can the latter be locked in the contact-closing position by the relay Sa.

Therefore each of the relays Sd to Sj, once it has taken the position in which its contacts are closed, will remain closed if the relay next above it is closed, regardless of whether its associated photoelectric cell is light or dark, until the relay next above it is restored to the contact-opening position, thereby releasing the interlock. It will be obvious that by means of such interlock, any one of the relays Sc to Si may hold all of the relays (Sd to Sj) below it closed once they have been closed owing to the interruption of the light beams focused on their respective photoelectric cells.

Each of the power relays Wa to Wf can be locked by the counting control relay next below

it. That is to say, when the relay *Wa* is in such a position that its contact *A* is open and its contacts *B* and *G* closed, said relay can be locked in this position by the relay *Sb*, and similarly as to the other power relays. The locking of the power relays is accomplished by short circuiting the *D* contacts of the corresponding counting control relays *Sa* to *Sf* respectively. For example, if the actuating coil of the relay *Wa* is energized (by the closure of the *D* contact of the relay *Sa*) the *A* contact of the relay *Wa* will be opened and its *B* and *G* contacts will be closed, as has been explained above. Now, if the contacts of the relay *Sb* are closed, the relay *Wa* will be locked in this energized position, whether or not the contact *D* on the relay *Sa* remains closed, because a voltage is applied from the voltage bus line 76 through the *B* contacts of the power relay *Wa*, then through the wire 153 to the *C* contacts of the relay *Sb* and then by the wires 154, 81 to the actuating coil of the relay *Wa*. Relay *Wa* will remain in this energized condition until both relays *Sa* and *Sb* resume the position in which their contacts are open.

A separate individual lock is provided on the relays *Sa* to *Sf*. When any one of these relays is closed (by reason of its associated photoelectric cell being rendered dark), it will be locked in a contact-closing position by the relay *J*. This locking action is accomplished by short circuiting the actuating coil of the respective relays *Sa* to *Sf*. For example, it has been stated that the contacts of the relays *J* and *J'* are normally closed, that is to say, when their actuating coils are not energized. Therefore, if for instance the relay *Sa* is in the condition in which its contacts are closed, a positive potential will be applied to the plate of the vacuum tube *Va* from the voltage bus line 35 through the wire 64 to the contacts *a* of the locking relay *J'*, the corresponding wire 61 to the contacts *a* of the locking relay *J*, then by means of the corresponding wire 58 to the *B* contacts on the relay *Sa* and then by the corresponding wires 57 and 34 to the plate of the tube *Va*. The circuit just described forms a shunt around the actuating coil of the relay *Sa*. This relay will now remain closed whether or not the corresponding photoelectric cell 14a is light or dark, until the locking relay *J* is operated to open all of its contacts, whereby the individual locks will be released and any of the *Sa* to *Sf* relays which may have been locked in this manner, will be permitted to return to their contact-opening position if the respective photoelectric cells 14a to 14f receive the full amount of light.

The locking relay *J* is operated when all three relays *Sh*, *Si* and *Sj* are in the contact-closing position; a voltage is then applied from the voltage bus line 76 through the *F* contact on relay *Sj*, wire 130, the *F* contact on relay *Si*, wire 131, the *F* contact on relay *Sh*, wires 69 and 66 to the actuating coil of the locking relay *J* and then through the wire 65 etc.

By the connection and interlocking arrangement of the relays described above I insure the result that only one relay at a time will control the counting mechanism. This controlling relay may be any one of the relays *Sa* to *Sh* inclusive, depending on the maximum height of the body passing through the doorway. The controlling relay will always be the highest relay to operate. Furthermore, control of the counting mechanism, once its actuating coil *U'* has been energized, may be passed upward from one

of said relays to another without interrupting the current through said coil. For example, let us assume that all the relays *Sj*, *Si*, *Sh*, *Sg* and *Sf* have their cores 37 in their lower position; in this case, the relay *Sj* will be in control of the counting mechanism, since the current to operate said mechanism is forced to flow through the *A* contacts of the highest *S* relay which has its core in the lower position (providing, of course, that all the relays below said relay, down to and including the relay *Sj*, have their cores 37 in their lower position). As has been described above, in this case the current will pass up as far as the *A* contacts of the relay *Sj* and then through the wire 51 to the *A* contacts of the relay *We* to the bus line 40. If now the relay *Se* should be operated in such a way as to lower its core 37 and close its contacts, this will, at the contacts *D*, close a circuit through the actuating coil of the relay *We* and raise the core 37' of said relay so as to open the contacts at *A* and close the contacts at *B* and *G*. The current through the actuating coil *U'* will now flow through the *A* contacts of the relays *Sj*, *Si*, *Sh*, *Sg* and *Sf* as before, but since the *A* contacts of the power relay *We* are now open, the current will be compelled to flow through the closed *A* contacts of the relay *Se* and then by way of the wire 50, through the *A* contacts of the power relay *Wd*, through the bus line 40 and back to the actuating coil *U'*. During the change of control from *Sj* to *Se*, the current through the coil *U'* was not interrupted. As all the contacts of the relay *Se* close simultaneously, the power relay *We* could not be operated to close its *A* contact before the *A* contact of the relay *Se* was closed. There was therefore no open circuit along the bus line 40 to interrupt the current, and as the current through the coil *U'* was not interrupted, the shifting of the control from one relay to the next above would not cause another count to be registered.

As has been explained above, all the relays from the relay *Sj* upward which are at the time below the *S* relay controlling the counting mechanism, are locked in the closed position (core 37 lowered) by means of the interlocking connections set forth and therefore can not operate, whether their respective photoelectric cells be light or dark, until this interlock is released by opening the contacts of the controlling relay. Therefore, until the contacts of the controlling relay are opened, the current flowing through the coil *U'* can not be interrupted; in other words, it is impossible for another count to be registered until after the contacts of the controlling relay have been opened. For example, let us assume that all the relays from *Sj* upward to *Sd* (both inclusive) have their cores 37 in the lower position, it will be understood that this places the relay *Sd* in control of the counting mechanism and of the locks on all the said relays below it (*Se* to *Sj*). The current energizing the coil *U'* will now flow through the *A* contacts of the relay *Sd*. If now the contacts of this relay are opened (core in the upper position) by reason of its photoelectric cell 14d receiving the full amount of light, the current through the coil *U'* will be interrupted. Since, as explained above, the *A* contact of the power relay *Wd* is now opened and is locked in this position by the relay *Se*, control of the counting mechanism will remain at the relay *Sd* and will not be transferred to *Se*, and if the core 37 of the relay *Sd* is again caused to drop, its *A* contacts will again close the circuit along the bus line 40, permitting another current

impulse to flow through the coil U' and thus register a second count. If, however, the core 37 of the relay Sd is not again brought to the lower position, but if instead of this the core 37 of the relay Se is raised (by reason of the photoelectric cell 10e receiving the full amount of light), then the lock which has been holding the relay Wd in said position is released, permitting the A contact of Wd to close and thereby placing a shunt across the bus line 40. From this moment on, the counting mechanism will be controlled by the relay Se and if the core 37 of such relay is brought to its lower position, current will flow through the coil U' and register another count.

If, however, after the core 37 of the controlling relay has moved to its lower position, thereby opening the circuit along the bus line 40 and interrupting the flow of current through the coil U' of the counting mechanism U, the relays below the controlling relay are permitted to open individually in succession (owing to the interlocking system, this is the only way in which they can open), then the circuit along the bus line 40 will not be closed again, so that no additional count will be registered. When I say that the relays will open, I mean that their cores 37 will move to their upper position.

It will be understood that the system described above provides means for controlling a counting mechanism through the medium of a plurality of light beams and of photoelectric cells. The arrangement is such that only one photoelectric cell at a time can control the counting mechanism, the lowest cell which can thus become the controlling cell, being the cell 14h, while the highest cell which can become the controlling cell is the one designated 14a. Whenever a body passes through the doorway, the highest photoelectric cell which is thereby rendered dark, will be the one that will control the counting mechanism at that time. However, owing to the operation as described, this cell can control the counting mechanism so as to cause it to register one count, only after all the photoelectric cells of the counting line (14a to 14j) which are below this controlling cell, have been rendered dark. Once the photoelectric cells below the controlling cells have been rendered dark, they are all so governed by the controlling cell that they are not capable of interrupting the above mentioned control of the counting mechanism, if any of said lower cells should become light; obviously, an error by double count could occur if the temporary lighting of any of such lower cells interrupted the control exerted by the controlling cell on the counting mechanism. It is immaterial in which order the photoelectric cells are rendered dark by a body entering through the doorway; in every case, the highest photoelectric cell to be rendered dark by the passage of such a body is the only cell which can control the counting mechanism and cause it to register a count. As has been explained above, should a lower photoelectric cell be rendered dark, and thereby placed in control of the counting mechanism, this control can be shifted upward from one photoelectric cell to another after the body passes in through the doorway, until the highest photoelectric cell to be rendered dark by such a body is reached, such shifting taking place without opening the counting circuit so that the count will be effected only when the body has intercepted the beam of light affecting the highest photoelectric cell. After such a body has passed beyond the highest photoelectric cell darkened by the passage of such body (the con-

trolling cell at that time) so that said cell will again become light and cause the counting mechanism to effect a count, the order in which the lower photoelectric cells become light will have no effect on the counting mechanism.

As explained, once the highest photoelectric cell to be rendered dark by a given body has become light, the counting circuit along the bus line 40 has been opened, and can be closed again only when the same photoelectric cell is again rendered dark, or by permitting the next lower photoelectric cell to become light and then again causing this cell to become dark. For example, once the circuit along the bus line 40 has been opened, interrupting the current which passes through the counting mechanism coil U', control passes down from one photoelectric cell to the next below as these cells become light. The circuit can then be closed again only by darkening again a photoelectric cell which has been dark and then has been permitted to become light, thereby starting an upward shift of the control. This would be the case if two bodies passed through the doorway in single file but so close together as to present a silhouette unbroken between them except in the region of the heads or necks.

The system described above will provide an accurate count of all admissible persons entering through the doorway, provided they are caused to pass through the doorway in single file or approximately so. This result is accomplished by giving a proper width to the doorway and by a proper spacing of the rails K. As has been explained above, every person will be counted whether short, medium or tall, the beam of light which affects the photoelectric cell 14h being placed at such a height from the ground as to be intercepted even by a child of admissible age.

The irregular arrangement of the opening 12 and the shape of the sheet of light which is thrown across the doorway through said opening, are of considerable importance in securing an accurate operation. When a person enters through the doorway, the number of light beams that will be interrupted and the sequence in which they will be interrupted, depends not only on the height or stature of such body, but on its posture, whether the person be in erect position or bending forward etc. Assuming the body passing the doorway to be erect and tall enough to interrupt the highest light beams, that is to say, those focused on the photoelectric cell 14a, the light beams passing through the vertical upper portion M of the long irregular opening 12 will be interrupted first, and as these light beams are focused on the photoelectric cells 14a, 14b, 14c, 14d and 14e, the corresponding relays Sa, Sb, Sc, Sd, Se will close (lowering their cores 37) and will be locked in this position by the relays J and J'. As such body proceeds through the doorway, the light beams passing through the openings 12'' will be interrupted next, closing the relay Sj. As the body continues to pass through the entrance, the light beams issuing from the portions M', M'', M² will be interrupted next, closing the relays Sf, Sg and Si. It should be noted that when the body has proceeded thus far, all the light beams passing through the opening 12 have been interrupted except those at the rear-most point of the said opening, that is, the point where the portion M'' joins the portion M². This junction point will be the last portion of the opening 12 to be rendered dark by the passage of the body. Since the light beams passing through the opening 12 at this junction point are focused on

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the cell 14h, all the photoelectric cells in the counting line (14a to 14j) will have been rendered dark, and all the relays of the counting line except the relay Sh will be closed and locked in this position. Now, when the body entering through the doorway interrupts the light beams at the junction point of the portions M' and M², the photoelectric cell 14h will be rendered dark, causing the relay Sh to close. Its A contacts will then complete the circuit along the bus line 40 and cause the counting mechanism to operate, to register or record a count. Simultaneously, a circuit is closed from one side of the voltage bus line 76 through the F contacts of the relays Sj, Si and Sh, and then through the wire 69 to the bus line 66. When this bus line is energized, current will flow through the actuating winding of the locking relay J, opening all of its contacts, and immediately releasing the locks on the counting line relays Sa, Sb, Sc, Sd, Se and Sf. Now, as the body proceeds farther, permitting the photoelectric cell 14a (which we will assume to be the controlling cell in this case) to become light, the relay Sa will open, opening the circuit along the bus line 40 and causing the counting mechanism U to effect one count.

It will be understood that the registering or recording of one count by the counting mechanism U does not take place until the circuit including the actuating coil U' of said mechanism is opened, which occurs when the controlling photoelectric cell becomes light again.

As the body entered the doorway, the photoelectric cells 14a to 14g were rendered dark, causing the corresponding relays Sa to Sg to become closed and locked in this closed position. Similarly, the lower photoelectric cells 14i and 14j were rendered dark and their relays Si and Sj were closed. The actuating coil of the counting mechanism, however, was not energized until the light beams passing through the opening 12 at the junction of the portions M' and M² were interrupted, causing the relay Sh to close.

If a child or other short person enters through the doorway, the action will be substantially as described above except that some of the photoelectric cells at the upper portion of the apparatus will not be rendered dark and their relays will not come into play. Let us assume, for example, that a person passing through the doorway is only tall enough to interrupt the light beams focused on the cell 14e, but not those on the higher cells 14a to 14d. In this case, the photoelectric cells 14e, 14f and 14j will be rendered dark first, causing their associated relays Se, Sf and Sj to be closed and locked. Next the photoelectric cells 14g and 14i would be rendered dark, closing and locking the corresponding relays Sg and Si. This will almost close the circuit along the bus line 40, leaving a gap at one place only, namely, the A contact on the relay Sh which as yet has not been operated. All the relays above Se are open, since their respective photoelectric cells have not been rendered dark, and as the contacts on the relay Sd are open, the power relay Wd has not operated and therefore its A contacts are closed, effectively short circuiting the A contacts of all the relays above Sf.

When during the further inward movement of the body the light beams are interrupted at the rearmost point of the opening 12 (junction of the portions M' and M²), the photoelectric cell 14h is rendered dark, causing the relay Sh to close the circuit along the bus line 40 and energize the bus line 66 as explained above, thus operating the

counting mechanism and simultaneously the locking relay J, whereby the locks on the relays Sc and Sj are released. As the body continues to pass inward, the photoelectric cell 14e (which in this case is the controlling cell) will be rendered light and the relay Se will open, reopening the circuit along the bus line 40 and thereby completing the count.

In the event of the passage through the doorway of a child only tall enough to darken the photoelectric cell 14h, and none of the cells above, the lower photoelectric cells 14j and 14i will be rendered dark first, closing the relays Sj and Si respectively. Should then the photoelectric cell 14j become light again, the relay Sj can not open since it is locked by the relay Si. When the child has advanced far enough to interrupt the light beams focused on the cell 14h, the relay Sh will close, completing the actuating circuit of the counting mechanism U along the bus line 40, because as the relay Sj has not operated, the A contact on the power relay Wf is closed, short circuiting all the A contacts on the counting line relays above Si. As the relay Si is locked in a closed position by the relay Sh, the circuit along the bus line 40 will remain closed until the photoelectric cell 14h becomes light, opening the relay Sh and completing the count.

With the arrangement described employing a plurality of light beams, photoelectric cells, and relays, together with the interlocking system set forth, there is no possibility of overcounting, that is, registering or recording more than one count for a single person. For example, let us assume that a person entering through the doorway and carrying an object such as an umbrella, a hat etc., holds such object extended forward. It is impossible to prevent such objects for interrupting some of the light beams; however, the shape and the dimension of the lower portion M² of the opening 12 and of the openings 12', are such that any object of the character just mentioned will not be able to interrupt enough light beams in the proper sequence to effect a count in the mechanism U. A child, however, has sufficient dimension to cause the counting mechanism to operate.

My improved arrangement also guards against a wrong count in cases like the following: Assume that a person passing through the doorway carries an overcoat on his arm and extends it forward in such a way that light may pass between this overcoat or similar object, and the person's body. An object of this size would be able to interrupt enough light beams in the proper sequence to operate the counting mechanism. However, as has been explained above, the light beams passing through the opening 12 at the junction point of the portions M' and M² must be interrupted before the counting mechanism can be operated. The distance s by which said junction point lies to the rear of the portion M of the opening 12, is such that when the overcoat or other object interrupts the light beams at said junction point, some portion of the person's body, generally the extended arm holding said object, will have interrupted some of the light beams along the portion M of the opening 12. The photoelectric cell upon which these light beams are focused will be rendered dark, closing the contacts of the respective S relay and thus placing this relay in control of the counting mechanism. Now, inasmuch as all the photoelectric cells of the counting line below this point have been rendered dark by the passage of the

overcoat or other object, all the relays below the controlling relay will be closed, and locked in this position by the controlling relay. As the person proceeds through the doorway, the lower photoelectric cells are rendered light by the light beams passing between the object and the body. The corresponding S relays, however, can not re-open and thus open the counting mechanism circuit, since the controlling relay maintains an interlock for the closed relays. As the person proceeds still farther, control passes from one photoelectric cell to another as has been explained above, until such control passes to the cell corresponding to the highest beam interrupted by the body, when the operation of the counting mechanism to effect one count will be completed. Therefore, even though the lower photoelectric cells have been rendered dark and then light twice during the passage of the body (with the overcoat), only a single count will be effected in the mechanism U. The result would be the same if instead of holding an object in front of him, the person should hold such object to his rear.

The system herein disclosed also guards against the possibility of undercounting, that is, registering a single count for the passage of more than one person through the doorway. For example, assume that two or more persons are entering through the doorway in single file but as close together as possible, perhaps with the intent of defeating the correct operation of the apparatus by causing two or more persons to count as only one. It will be found in practice that some light will be able to pass between these bodies in the region of the head or neck, and possibly in the region of the feet. As the persons proceed through the doorway, the first body will render a sufficient number of photoelectric cells dark in the proper sequence to operate the counting mechanism U and effect one count. As the bodies proceed farther, the light beams that pass between two bodies in the region of the head will render the controlling photoelectric cell light, thus opening the recorder circuit and completing the first count in the manner set forth above. If the two persons are of approximately the same height, the second body will, as it proceeds, interrupt the same light beams and again close the counting mechanism circuit, effecting a second count. If, however, one of the persons is considerably taller than the other, the action is as follows: Assuming the first person to be tall enough to interrupt the light beams focused on the photoelectric cell 14a, and the second person to be only tall enough to interrupt the light beams focused on the photoelectric cell 14e, the tall person will operate the counting mechanism and effect one count as explained above. Then, as the tall person proceeds, the photoelectric cells from 14a downward will become light in succession owing to the beams of light which pass between the bodies in the region of the head or neck of the smaller person, thus opening the respective S relays and passing control of the counting mechanism downwardly from one photoelectric cell to the other. When during this operation the photoelectric cell 14e is finally rendered light by the light beams passing between the two bodies, the relay Se will open, and the lock it holds on the relay Wd (by means of the C contact of relay Se and the B contact of relay Wd) is released, whereby the A contact on the relay Wd will be caused to close, short circuiting all the A contacts along the bus line 40 above this point and thereby placing the relay Se

and the photoelectric cell 14e in control of the counting mechanism. As the two persons then proceed farther through the doorway, the smaller person will interrupt the light beams focused on the cell 14e, and since this cell is now in control of the counting mechanism, a second count will be effected when this cell is rendered dark. The action will be practically the same if the position of the two persons is reversed, that is, if the shorter person precedes the taller.

It is one of the objects of the apparatus illustrated that only the persons entering through the doorway should be counted, and not those passing out through the doorway. In other words, the count may be termed a uni-directional count. For the purpose of preventing the counting mechanism from being operated by persons which pass out through the doorway, I have provided the lamp groups 10k, 10m and 10n constituting the free line, and the instrumentalities controlled by the light beams proceeding from said three lamp groups. It will be evident from Fig. 1 that a person passing out through the doorway will interrupt the light beams of the free line (beams emitted through the openings 12a) before interrupting the light beams of the counting line (beams emitted through the openings 12, 12', 12''). It should be noted that a person entering through the doorway can not interrupt a sufficient number of the light beams emitted through the free line openings 12a to render the counting line inoperative before a count has been effected by the said person having interrupted the proper number of light beams emitted through the openings 12, 12' and 12''. If, however, the person is passing through the doorway in the direction marked Out, the interruption of the light beams of the free line will render the counting line temporarily inoperative to effect a count; this operation is obtained by means of the switching relays W (free master relay), X (free control relay), W' (free power relay), and X' (free set relay). The relay W is operated by voltage applied to its actuating coil through the wire 121 from the bus line 68, through the wire 81'' and the A contacts on the relays Sm and Sz, when the latter are closed. The relay X is operated when the bus line 65, 66 is energized by the closure of the F contacts on the relays Sh, Si and Sj. When no current is flowing through the actuating coil of the relay X, its contacts F' and E are open, and its contact F'' is closed. The relay W' is operated when a voltage is applied to its actuating coil from the voltage bus line 76 through the wire 116, the F contact of the relay W, the wires 112, 111, the F' contact of relay X and the wire 119. Therefore, if the F contact on the relay W and the F' contact on the relay X are both closed, a current will flow through the actuating coil of the relay W', closing its B contact and opening its F contact. The relay X' is operated when a voltage is applied to its actuating coil from the voltage bus line 76, through the wire 116, the F contact of relay W, wires 112, 111, the F'' contact of relay X, and the wires 108, 107. The other end of the actuating coil of the relay X' is connected with the voltage bus line 68 through the F contact of the relay W'. Therefore, in order that current may flow through the actuating coil of the relay X', it is necessary that the F contact of relay W, the F'' contact of relay X and the F contact of relay W' all be closed. When current flows through the actuating coil of relay X', its A contact will open and its B and F contacts will close. The A con-

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tact of relay X' is connected with the wire 90, 90', which in the manner described above is connected in the circuit of the actuating coil U' of the counting mechanism U. Therefore, if the A contact of the relay X' is open, no power is available in said circuit to energize said actuating coil U', and no count would be effected even though certain other gaps in the circuit of said actuating coil were closed by a body rendering the proper photoelectric cells dark.

When during the passage of a person through the doorway in the direction marked In, the relay Sh is finally closed in the manner explained above, the bus line 66 is energized, operating the relay X to open its F'' contact and close its F' and E contacts. The relay X will remain in this position until light is permitted to reach the photoelectric cell 14h. The dimension t (by which the openings 12a of the free line are to the rear of the rearmost point of the opening 12 of the counting line) is chosen to be smaller than the front-to-rear dimension of a person passing through the doorway. Thus, a person entering through the doorway will interrupt the light beams of the free line (emitted through the openings 12a) before clearing the light beams which are emitted at the rearmost point of the opening 12. Therefore, the relay W will be operated, closing its contacts, before the F'' contact on the relay X again closes. When the light beams of the free line are interrupted, the photoelectric cells 14k, 14m and 14n are rendered dark, operating the relays Sk, Sm and Sn, which in turn operate the relay W as explained above. Now, when the F' contact of the relay W is closed, the relay W' operates, closing its B contact and opening its F' contact. The relay X' could not operate to open its A contact and interrupt the supply of voltage to the counting mechanism, since the F'' contact of relay X was open, breaking the circuit to its coil. As the body proceeds in the direction marked In, the photoelectric cell 14h is rendered light and therefore the relays Sh, Si and Sj will be opened, breaking the circuit to the bus line 65, 66 and interrupting the current through the coil of the relay X, thus causing its F' contact to open and its F'' contact to close. When this F'' contact closes, the relay X' still can not operate, since the F' contact on the relay W' is now open, breaking the circuit to the other side of its actuating coil. The relay W' will remain locked in this position, preventing the relay X' from operating, until the contacts on the relay W are opened by rendering the photoelectric cell 14m light. This lock is established by the B contact on the relay W', which forms a shunt across the F' contact of the relay X. Therefore, a body has passed through the doorway in the direction marked In and has effected one count.

Now, when a person proceeds through the doorway in the direction marked Out, such person will first render the photoelectric cells 14k, 14m and 14n dark, closing the contacts on the relays Sk, Sm and Sn, which in turn cause the relay W to close its contacts. As the E contact on the relay W' and the F'' contact on the relay X are normally closed, the relay X' will now operate to open its A contact and close its B and F' contacts. If the person passing out through the entrance proceeds farther, the photoelectric cells along the counting line will be rendered dark, closing gaps in the circuit along the bus line 40; the counting mechanism, however, will not operate, since the A contact on the relay X' is open

and therefore no power is available to operate the counting mechanism. When the photoelectric cells 14h, 14i and 14j are all rendered dark by the passage of the body, the bus line 65, 66 will be energized, operating the relay X to open its F'' contact and close its F' and E contacts. The closing of this F' contact will cause the relay W' to operate, opening its F' contact. The current through the actuating coil of the relay X', however, has not been interrupted, because its B contact is closed, forming a shunt around the F'' contact of the relay X; likewise, the F' contact of the relay X' is closed, forming a shunt around the F' contact of the relay W'. The relay X' will remain in this position and prevent the operation of the counting mechanism, until the relay W operates to open its contacts. As the person proceeds still farther through the doorway on his way out, the photoelectric cells Sk, Sm and Sn are rendered light; the relay W, however, does not open, because a voltage is supplied to its actuating coil from the voltage bus line 76 through the wire 116 to its E contact, then through the wire 117 to the E contact of the relay X and then by the wires 122 and 81'' to the actuating coil of the relay W. The relay W will remain in this position until the photoelectric cell 14h is rendered light, interrupting the current through the coil of the relay X and causing its E contact to be opened, thereby releasing the lock on the relay W. Therefore, the passage of a person through the doorway in the direction marked Out will not cause the counting mechanism to effect any count.

I have explained that the apparatus described above will effect a correct count of all persons entering through the doorway irrespective of the stature or shape of such persons (as long as such stature is at least that of a small child tall enough to interrupt the light beams affecting the photoelectric cell 14h); one condition is, however, that such persons shall pass through the entrance in single file or approximately so, and this result is insured by the proper width of the doorway and by the proper spacing of the rails K. Further features of my invention guard against the possibility of a person bending extremely low or perhaps crawling on hands and knees so as to pass under the light beams which affect the photoelectric cell 14h and thus entering through the doorway without effecting a count. I have also explained above that with the operation so far described, a person entering through the doorway and failing to render the cells 14i or 14j dark, would fail to effect a count. These two photoelectric cells are so placed that they will normally be rendered dark; however, there is a possibility of a person jumping over the light beams affecting these cells and thus passing through the entrance without effecting a count.

To guard against these possibilities, I have provided the lamp groups 10p, 10q and 10r constituting the trip line and the instrumentalities which are controlled by the beams emitted by said lamp groups. These light beams have been so arranged as to make it impossible for a person, regardless of posture, to enter through the doorway without interrupting at least the light beams affecting one of said lamp groups. As has been set forth above, the photoelectric cells 14p, 14q and 14r belonging to the trip line are connected in series. In view of this connection the potential applied to these cells by means of the wire 25 must be made about three times as high as that supplied to the other photoelectric cells,

so that, notwithstanding the equal division of the voltage among the cells 14p, 14q and 14r, each of these cells may receive about the same voltage as the cells 14a to 14n. If any one or more of the photoelectric cells of the trip line are rendered dark, the total current passing through the resistor Rp will decrease, increasing the negative bias potential applied to the grid of the vacuum tube Vp, and decreasing its plate current, thereby operating the relay Sp to open its F contact and to close its D contact (as well as contact between 38' and 39'). These three auxiliary photoelectric cells of the trip line and the parts associated therewith constitute a tripping system which operates to effect a count only in the event that a person has entered through the doorway in either one of the unusual positions mentioned above and has not been counted by the action of the light beams of the regular counting line. In those cases where the person has entered through a doorway in such a posture as to be counted through the medium of the regular counting line, the tripping system is automatically taken out of operation. This is effected in the following manner: Four switching relays are employed in connection with the tripping system, namely, the trip set relay Y2, the trip set driver relay Y, the trip master relay Y2' and the trip lock relay Y'. When the relays Sh, Si and Sj are closed, the bus line 65, 66 and the relay Y are energized to close the D contact of said relay. The relay Y serves only as a driver to operate the relay Y2. Therefore when the contact of the relay Y is closed, a voltage is applied from the bus line 76 through the wire 99 to the contact of the relay Y, and then through the wire 80 to the actuating coil of the relay Y2. When the said coil is energized, the A contact of relay Y2 will be opened and its contacts B' and B'' will close. The relay Y2' is controlled by the D contact on the relay Sp, and when this contact is closed, the coil of the relay Y2' will be energized to open its H contact and close its A, B, F and E contacts. The relay Y' is operated from the bus line 73 which is connected to the G contacts of every relay directly controlled by a photoelectric cell except the relay Sp. Owing to the arrangement of the connections, if any photoelectric cell in the entire system except the photoelectric cells 14p, 14q, 14r is dark, a G contact is closed, short circuiting the bus line 73 and thus applying a voltage to the actuating winding of the relay Y', to close all the contacts of said relay. Since the A contacts on the relays Y2 and Y2' are in series with the bus line 90 and 40, it follows that when the A contacts of the relays Y2 and Y2' are both closed, a circuit will be closed along the bus line 90 and 40, short circuiting the main bus line of the counting mechanism between the wires 90, 90' on the one hand and the wire 40 on the other hand and causing the counting mechanism to operate.

As has been stated above, a person entering through the doorway will interrupt some of the light beams emitted through the openings 12, 12', 12'' before interrupting those which are emitted through the openings 12² of the trip line. In the normal operation, that is to say, when the count is effected by means of the regular counting line, the bus line 65, 66 will be energized as described above, thus operating the relay Y, which in turn operates the relay Y2, opening its A contact and closing its B' and B'' contacts. When the A contact on the relay Y2 is open, the circuit along the bus line 40 can not be closed and therefore the

photoelectric cells 14p, 14q, 14r can not operate the counting mechanism. As the relay Y' is now closed (because of any photoelectric cell in the system being dark), the relay Y2 will be locked in this position, and will remain so locked until every photoelectric cell in the entire system has been rendered light. This lock is established by a potential applied from the voltage bus line 58 through the wires 99 and 77 to the switch member 78' of the relay Y', the contact 79' of said relay, the wire 82, the contact B' of the relay Y2 and through the wire 90 to the actuating coil of said relay. As the person proceeds farther inward through the doorway, one or more of the photoelectric cells 14p, 14q, 14r will be rendered dark, operating the relay Sp which in turn operates the relay Y2' to open the H contact of said relay and close its A, B, F and E contacts. The counting mechanism, however, will not be operated when the A contact of the relay Y2' closes, because the A contact of the relay Y2 is open. An additional lock is now placed on the relay Y2 by the relay Y2', since another circuit is closed from the voltage bus line 76 to the actuating coil of the relay Y2, through the wire 99 to the E contact of the relay Y2' and then through the wire 100 to the B'' contact of the relay Y2. As the person entering through the doorway emerges therefrom, all of the photoelectric cells become light, permitting the contacts of the relay Y' and the E contacts of relay Y2' to open, thereby releasing the locks on the relay Y2 and permitting the core of the latter to return to its normal position.

If now a person should enter through the doorway, but not in the normal way, that is to say, jump or crawl instead of simply walking through, and thereby prevent the counting mechanism from being operated by the photoelectric cells of the regular counting line, such person can not avoid interrupting the light beams focused upon at least one of the photoelectric cells 14p, 14q, 14r of the tripping system, and as explained above, these cells are connected in series and therefore if any one of them is rendered dark, the relay Sp will operate, closing its D contacts, which in turn will energize the relay Y2', to open its H contact and close its A, B, F and E contacts. If the regular counting line has not been operated, the bus line 65, 66 has not been energized and therefore the relay Y2 remains in its normal position, with its A contact closed. When the A contact of the relay Y2' closes, the circuit along the bus line 40 will be closed and the counting mechanism U will operate to effect a count. The relay Y2' will now remain in this position, holding the circuit along the bus line 40 closed, until every photoelectric cell in the entire system becomes light. As the person, in entering through the doorway, will have darkened one or more of the photoelectric cells, the relay Y' will have operated, closing its contact at 78'', 79'' and thereby placing a lock on the relay Y2' by applying a voltage to the actuating coil of said relay Y2' through a circuit extending from the bus line 76, through the wire 99, to the contact 78'', 79'', and the wire 86 to the B contact of the relay Y2' and then by means of the wire 89 back to the actuating coil of the relay Y2'. When the person passes out of the doorway, all the photoelectric cells become light, permitting the contacts on the relay Y' to open, thus releasing the lock on the relay Y2'. When the A contact on the relay Y2' opens, the circuit along the bus line 40 is opened, interrupting the passage of current through the counting mechanism U and completing the count. A per-

son therefore has passed through the doorway in the direction marked In without having operated the regular counting system, but owing to the addition of the tripping system such person has nevertheless caused a count to be effected.

As has been pointed out above, the relays above the relay *Sf*, when such relays are closed by rendering their respective photoelectric cells dark, will be locked in this position until the relays *Sh*, *Si* and *Sj* are all closed, to open the relay *J* and thereby release the locks just mentioned. It would be possible for a person, by jumping through the doorway, to close one or more of the relays above *Sf*, locking the same, and then, without darkening the photoelectric cells *14j* or possibly *14i*, pass out of the doorway in the direction marked In; in so doing, however, the person will have rendered dark the photoelectric cells *14p* or *14q*, thereby closing the A contact on the relay *Y2'* and causing an operation of the counting mechanism U. In this case, however, the said mechanism will remain closed if some means is not provided to release the locks on the relays above *Sf*. As explained above, the counting mechanism circuit along the bus line 40 is held closed by the relay *Y2'*, which is locked by the relay *Y'*, which in turn is locked in closed condition by those relays above *Sf* which are locked in the closed condition, holding a G contact closed on the bus line 73. It is the function of the auxiliary relay or locking relay *J'*, the contacts of which are in series with those of the relay *J*, to release the locks on the relays above *Sf* when the person passes on, permitting the photoelectric cells *14p*, *14q*, *14r* of the trip line to become light. When all of these three cells have become light, the F contact on relay *Sp* will close, applying a voltage from the voltage bus line 76, through the wire 97, to the F contact on the relay *Y2'* and then by means of the wire 98, to the actuating coil of the relay *J'*. When this coil is energized, all the contacts of relay *J'* will open, thereby releasing the locks on all the S relays above *Sf*. If now all of the photoelectric cells in the system are light, the contacts of relay *Y'* will open, releasing the locks on relay *Y2'* and thus opening the circuit of the counting mechanism U along the bus line 40. Furthermore, when the F contact on the relay *Y2'* opens, the voltage applied to the actuating coil of the relay *J'* is interrupted, thus permitting the contacts of said relay to return to their normal closed position.

The light beams focused on the photoelectric cells *14p*, *14q*, *14r* of the trip line are so arranged with respect to the regular counting light beams passing through the openings 12, 12', 12'' that any object carried by a person and extended forward, normally will not render these cells dark before the person interrupts a sufficient number of light beams to operate the counting line. It is, however, in some instances possible for a person carrying a very large object, to render one of the three photoelectric cells of the trip line dark first, thereby causing an operation of the counting mechanism. This, however, will not result in a double count when the body of the person finally interrupts the counting light beams, since the circuit of the counting mechanism is locked closed by the relay *Y2'* which in turn is locked by the relay *Y'*. The circuit of the counting mechanism will remain locked until the photoelectric cells *14h*, *14i* and *14j* are rendered dark, closing the circuit to the counting mechanism along the bus line 40 and

simultaneously energizing the bus line 65, 66. As explained above, when the bus line 65, 66 is energized, the relay *Y2* will operate to open the circuit along the bus line 40. Control of the counting mechanism has therefore been shifted from the tripping system to the regular counting system without interrupting the circuit of the counting mechanism, and thus but a single count will be registered.

It will be obvious that the tripping system must be prevented from operating the counting mechanism when a person passes through the doorway in the direction marked Out. This is accomplished by means of the H contacts on the relays *Sk*, *Sm* and *Sn*. Fig. 1 shows clearly that the arrangement of the openings 12' of the trip line with respect to the openings 12a of the free line, is such that a person passing through the doorway in the direction marked Out, will interrupt the light beams emitted from the free line openings 12a before interrupting those which are emitted through the openings 12' of the trip line. When the body of the person interrupts the light beams focussed on any one of the photoelectric cells *14k*, *14m* or *14n*, the corresponding relay *Sk*, *Sm* or *Sn* will operate to close its H contact. As these H contacts of the three relays *Sk*, *Sm*, and *Sn* are all in shunt on the bus line 102, 103, it follows that when any one of these contacts is closed, a voltage will be applied from the bus line 76 through such H contact and the wire 101 to the H contact of the relay *Y2'* which is normally closed, and then by means of the wire 80 to the actuating coil of the relay *Y2*. As has been explained above, operation of the relay *Y2* will cause its A contact to open, thus preventing any of the photoelectric cells *14p*, *14q*, *14r* of the trip line from controlling the counting mechanism. The relay *Y2* will remain locked in this condition by the action of the relay *Y'* and, as previously explained, the latter relay will continue to hold this lock until every photoelectric cell in the entire system has been rendered light.

Should a failure result anywhere in the system, both an audible and visual alarm will be given by the buzzer 159 and the trouble lamp 162 respectively. This alarm arrangement is energized from the power bus line 93 when the contacts of the alarm time delay relay *Z'* are closed. This relay may be energized from the power bus line 93, through the wires 155, 166, the switch member 78a of the relay *Y'* and the corresponding contact 78a of said relay, such switch member and contact coming into engagement when the relay *Y'* is energized; the relay *Z'* will also be energized when the switch member 165 engages the contact 166 upon the de-energization of the no-voltage relay *Z''*, or when the switch member 38' of the relay *Sp* engages the contact 39', as explained below. Normally, there is a gap between 165 and 166. If current is supplied to the actuating coil of the relay *Z'* in one of the ways just mentioned, the core of said relay and the switch member 163 will rise slowly until contact is established between 163 and 164, thereby closing the alarm system circuit, it being understood that the manually operated switch 160 will normally be kept closed, since as a rule it will be desired to have the buzzer 159 operate whenever the alarm system circuit is closed. Whenever the switch 163 engages the contact 164, upon the energizing of the relay *Z'*, the following alarm system circuit will be closed: Line wire N, wire 41, switch 95, contact 94, wires 93 and 156, con-

tact 164, switch 163, wires 158' and 159, dividing from the latter in two shunt branches one of which includes the switch 160 and the buzzer 159 with its interrupter 159', while the other branch includes the trouble lamp 162 and the connections to the clock I; the two shunts or branches then come together against the junction point 157', from which the circuit is completed through the wires 161 and 42 to the line wire N'. Even if the switch 160 is in the open position illustrated, the trouble lamp 162 will receive current upon the switch member 163 engaging the contact 164, although the buzzer 159 would not be operated in this case. The rate at which the switch member 163 will rise is adjustable over wide limits by suitable means of any well-known or approved character. I employ a time delay relay at Z' so that the alarm system circuit may be closed at 163, 164 only if the energizing of said relay continues for a length of time, but will not be closed when the coil of the relay Z' receives current only for a short time, as it will when the relays Y' or Sp, during the normal operation of the apparatus, establish a temporary connection between the wires 155 and 156 at 18a, 19a, or 38', 39' respectively. The relay Z' therefore prevents the alarm (lamp 162, or lamp 162 and buzzer 159) from being operated during the normal passage of a person or persons through the doorway. The relay Z' is connected across the bus lines 68 and 76 and will therefore have its contacts remain in the open position as long as a proper supply of current reaches said bus lines from the rectifier V which, as explained, also supplies current to the photoelectric cells, to the plates of the amplifying vacuum tubes and to various relays. Should anything go wrong with this source of current supply, the circuit will be closed by the contact of 165 with 166 and an alarm will be given by the trouble lamp 162 and also, if the switch 160 is closed, by the buzzer 159. After the attention of the attendant has been called by the sounding of the buzzer, he will generally open the switch 160, so that the patrons of the theatre will not be disturbed. With this alarm system, I have also connected the clock I which will be so constructed (in any well known or approved manner) that normally it will not be running, but will start running whenever current is supplied thereto in the event of the energizing of the trouble lamp 162, and will keep running as long as the alarm system operates. The clock I therefore will indicate the length of the time during which the failure has continued.

Should any one of the lamp groups or of the photoelectric cells or of the amplifier tubes, or of the relays connected with such amplifier tubes excepting those in the tripping system, burn out or otherwise become inoperative, the relay Y' will operate to close the contact between 18a and 19a and thus energize the alarm time delay relay Z' to operate the alarm system as explained. If, for example, the group of lamps 10b should burn out, the photoelectric cell 14b will be rendered dark, decreasing the plate current through the vacuum tube Vb, thereby closing the relay Sb. This in turn will operate the relay Wb, closing its G contact and operating the relay Y' as explained previously. Likewise, if the photoelectric cell 14b should become defective, the current through this cell will decrease, causing in turn a decrease of the plate current through the vacuum tube Vb which will close the relay Sb and cause the further operations as before. Should

the filament of the vacuum tube Vb burn out, its plate current will cease, closing the relay Sb and initiating the same results as before. The action will be the same in the case of any of the other voltage sources, lamps, photoelectric cells, vacuum tubes and relays, excepting the lamps, photoelectric cells and vacuum tubes which form part of the tripping system. These latter will operate the relay Sp instead of the relay Y' and will cause the alarm system to be brought into action in the following way: If any one of the lamp groups 10p, 10q, 10r should burn out, or if any of the photoelectric cells 14p, 14q, 14r should become defective, or if the filament of the vacuum tube Vp should burn out, the plate current flowing through said vacuum tube will either decrease or cease; in either event the core 37 of the relay Sp will drop (since the actuating coil of said relay will receive either a weakened current or no current at all), and the switch member 38' will engage the contact 39' to close the alarm circuit as follows: Line main N', clock I' and its switch 169, main portion N', wire 41, switch member 95, contact 94, wires 93, 156, 156', contact 39' and switch member 38' of relay Sp, wires 155', 155, actuating coil of relay Z', and through wires 157, 161 and 42 to the other line main N'.

When the counting system is first placed in operation by applying voltage to it, a certain time (generally a few seconds) is required for the filaments of the vacuum tubes to warm up. During this time no plate current flows through the vacuum tubes, and therefore all the relays Sa to Sj and Sp will be closed, closing the circuit along the bus line 40, so that a count would be effected by the counting mechanism U if voltage were available. It is the function of the time delay relay Z to prevent the operating voltage from reaching the counting mechanism or the alarm system 159, 162, until all the vacuum tubes, rectifiers, relays, etc. are in operating condition. A ballast tube 177 is connected across the wires 35 and 76 to maintain a proper regulation of the voltage supplied to the vacuum tube plates when the coils of the S relays are short circuited, as described, by the interlocking system.

The electrically wound time clock I' is provided to put the entire system into or out of operation at predetermined times. The date clock I'' will close the switch 170 at proper times (for instance, once every hour) to supply current through the wires 171 and 172 to the coil Ua associated with the time indicator. This coil Ua by mechanism of any well known or approved type will cause time indications such as those of the day, week and hour to be changed at the proper times. In Fig. 7, the indicator of the counting mechanism and the time indicator have been shown as adjacent to each other and located in the same casing, for the sake of convenience; these instrumentalities might, of course, be separate from each other. The time indicator may be simply a register, as illustrated, or it might be a recorder, printing the time indications on a record sheet or the like at regular intervals or whenever desired, or it might be a combined register and recorder. Any well known or approved construction may be employed for the time indicator.

In Fig. 2, I have indicated at the top how some of the relays, rectifiers and other parts of the apparatus might be placed within the hollow jamb; of course, the relative location of these

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parts within the structure is immaterial to my invention and as long as the parts co-operate to produce the results set forth, they may be located in any convenient arrangement.

- 5 I have stated above that certain operations are to occur only when the light beam striking one of the photoelectric cells is interrupted entirely; in other words, such operation is not to occur if the light beam is interrupted only partially, this
10 applying particularly to those cells which receive light from a plurality of lamps. I do not, however, wish to restrict myself to this operation, because it is perfectly possible to operate the device even when the light beam striking one of
15 the photoelectric cells is interrupted only partially; all that is required in such instance is a corresponding adjustment of the respective bias resistor O.

I claim:

- 20 1. In a system for counting bodies moving along a predetermined path, means for projecting radiant energy across said path at two definite lines, one in advance of the other, said lines of projected radiant energy approaching each other
25 at one portion, separate means responsive to radiant energy, located in the paths of the respective lines of projected radiant energy, a counting device operated by changes in the condition of the means responsive to radiant energy located
30 in the path of one of said lines of projected radiant energy, when a body moving along said path in a predetermined direction intercepts radiant energy projected at said line, and means for preventing the operation of said counting device
35 when a body moves along said path in the opposite direction, said last-mentioned means being operated by changes in the condition of the means responsive to radiant energy located in the path of the other of said lines of projected radiant
40 energy, and additional means for projecting radiant energy across the path of the bodies, between the said two lines, both above and below their portion of closest approach, additional means responsive to radiant energy, located in
45 the path of the radiant energy thus projected between said two lines, and an operative connection between said last mentioned means and the counting device to cause the latter to be operated in the event that a body moving in said predetermined direction should fail to cause an operation
50 of such device at the passage of such body across said first-mentioned line

2. In a system for counting bodies moving along a predetermined path, means for projecting
55 radiant energy across said path at two definite upright lines, one in advance of the other, said lines of projected radiant energy approaching each other at one portion, separate means responsive to radiant energy, located in the paths
60 of the respective lines of projected radiant energy, a counting device operated by changes in the condition of the means responsive to radiant energy located in the path of one of said lines

of projected radiant energy, when a body moving along said path in a predetermined direction intercepts radiant energy projected at said line, and means for preventing the operation of said counting device when a body moves along said
5 path in the opposite direction, said last-mentioned means being operated by changes in the condition of the means responsive to radiant energy located in the path of the other of said lines of projected radiant energy, and additional means
10 for projecting separate beams of radiant energy across the path of the bodies, at different points of a "trip" line located between said two lines, separate additional means responsive to radiant energy, located in the path of the several beams
15 of radiant energy thus projected between said two lines, relays associated with the several responsive means of said trip line, and an operative connection between the said relays and the counting device to cause the latter to be operated in the event that a body moving in said predetermined direction should fail to cause the operation of such device at the passage of such body across said first-mentioned line.

3. In a system for counting bodies moving along a predetermined path, means for projecting radiant energy across said path at different points
25 along three definite lines one of which, constituting a "trip" line, is located between the other two, constituting a "counting" line and a "free" line respectively, separate means responsive to radiant energy located in the path of radiant energy passing through said different points of
30 said three lines, a counting device operated by changes in the condition of the means, responsive to radiant energy, associated with points of said counting line, when a body moving along said path in a predetermined direction intercepts
35 radiant energy projected at said line, means controlled by the several means, responsive to radiant energy, associated with the free line, for preventing the operation of the counting device when a body moves along said path in the opposite direction, and means controlled by the several means, responsive to radiant energy, associated with the trip line, for causing an operation
40 of the counting device in the event that a body moving in said predetermined direction should fail to cause an operation of such device at the passage of such body across the said counting line.

4. A system according to claim 3, in which the means for projecting radiant energy at the trip line are arranged to project such energy at points
55 some of which are closer to the counting line than others.

5. A system according to claim 3, in which the means for projecting radiant energy at the trip line are arranged to project such energy at points in such relation to each other as to lie substantially on the outlines of triangles.

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