Jan. 30, 1951 I. GHERTMAN 2,539,995

SORTING MACHINE

Filed Feb. 11, 1947 4 Sheets-Sheet 1

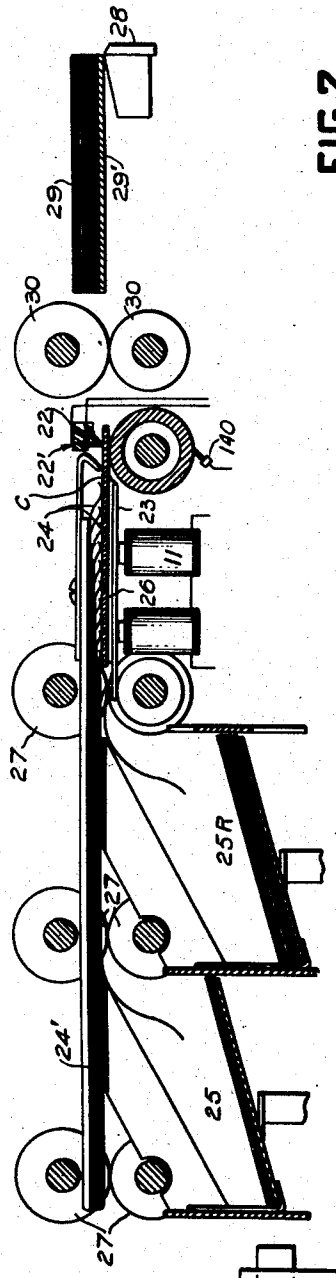

FIG. 1.

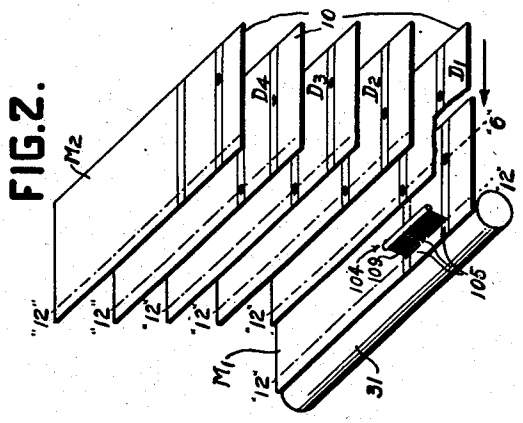

FIG. 2.

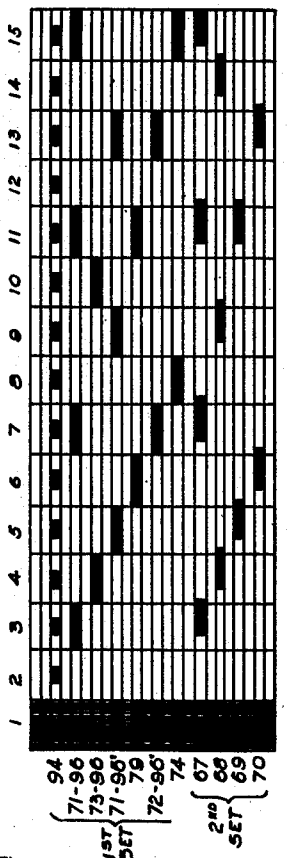

FIG. 3.

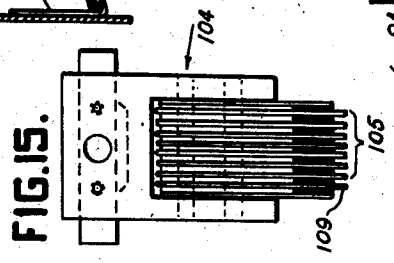

FIG. 15.

INVENTOR,
Ioino Ghertman.
BY
Edward R. Bounds
AGENT

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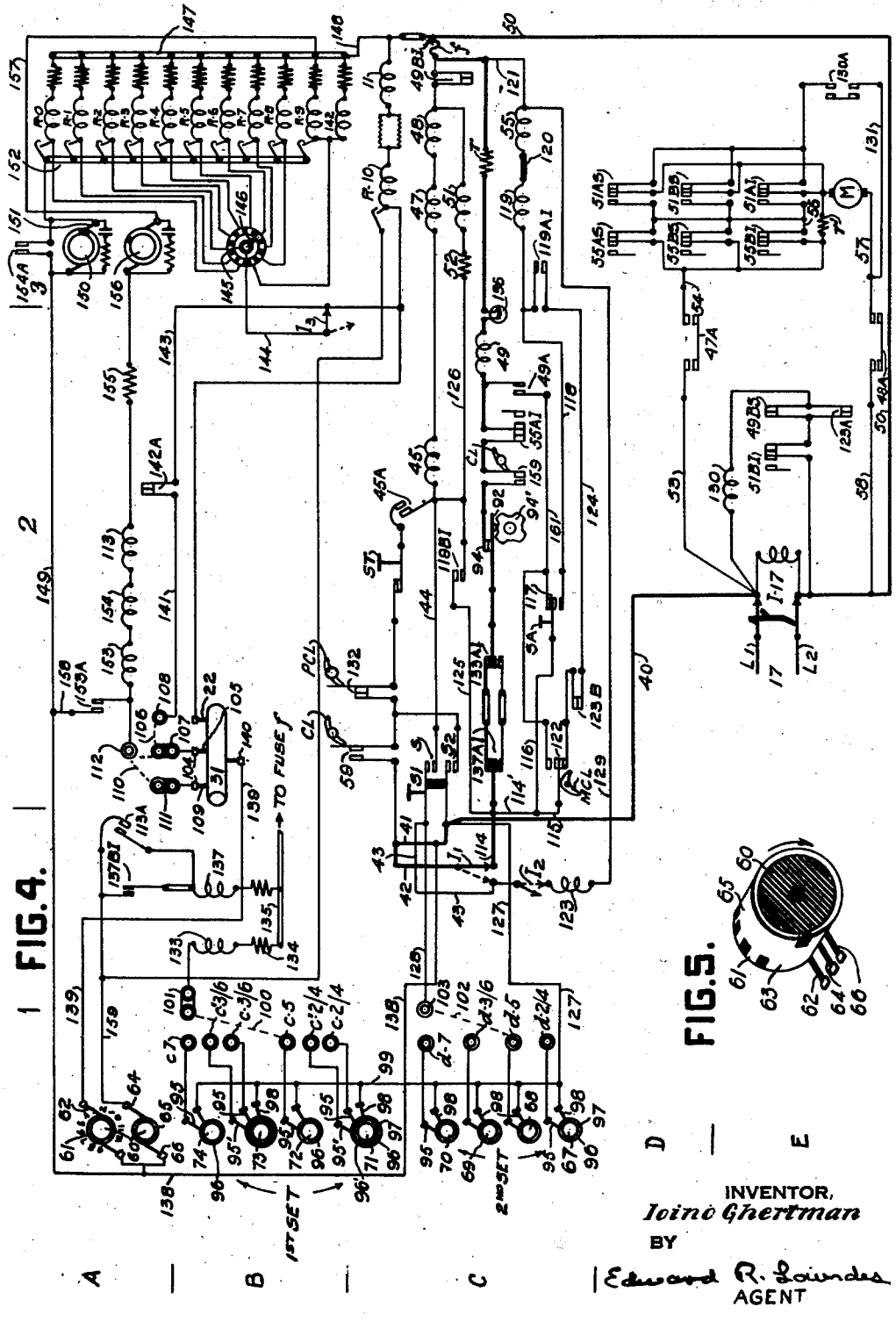

FIG. 4.

FIG. 5.

INVENTOR,
Ioino Ghertman
BY
Edward R. Lounder
AGENT

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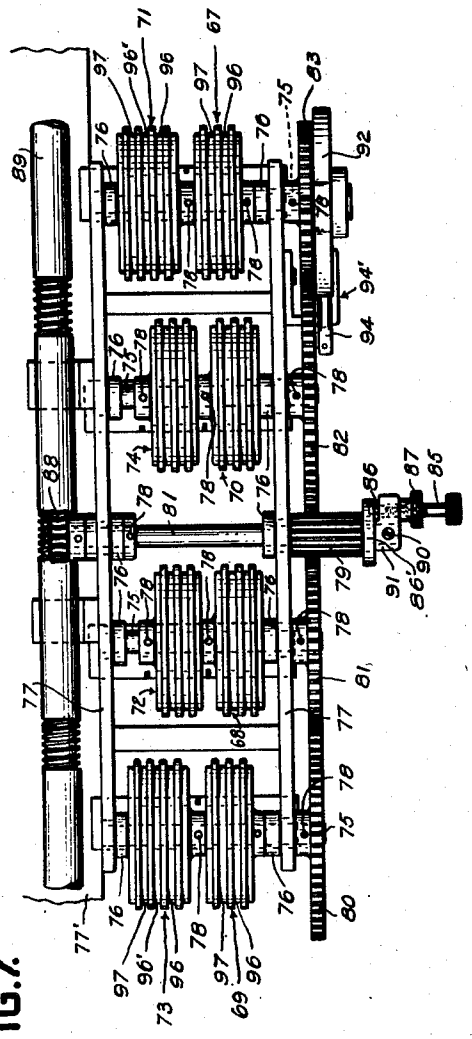

FIG. 7.

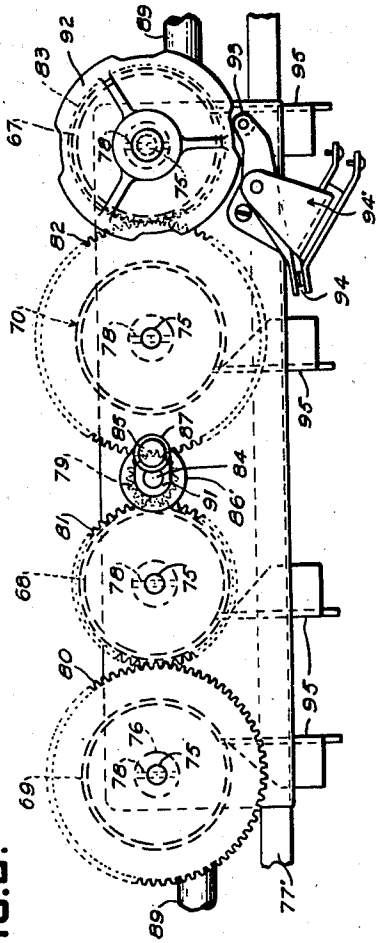

FIG. 6.

INVENTOR,
Ioino Ghertman.
BY
Edward R. Bowndes
AGENT

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FIG.10.

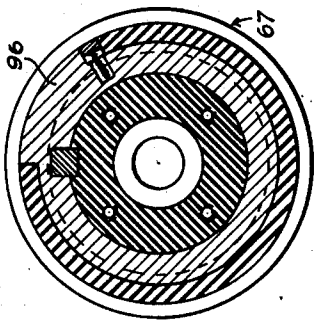


FIG.14.

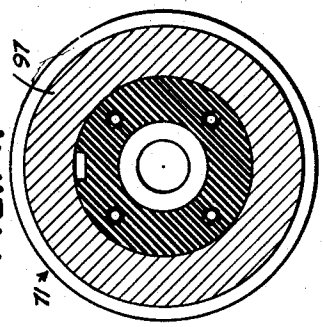


FIG.13.

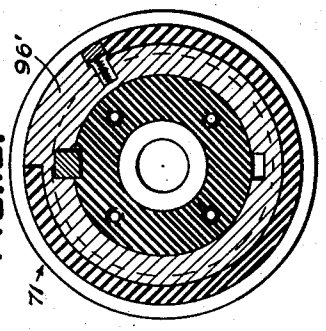


FIG.9.

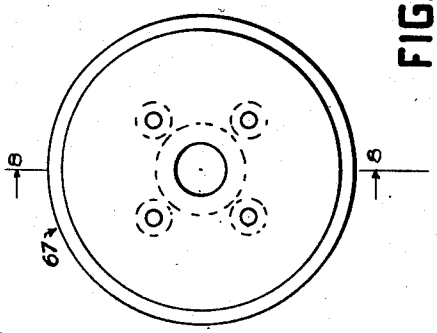


FIG.12.

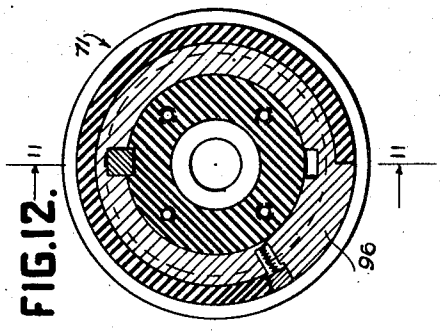


FIG.8.

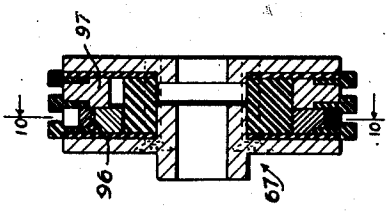
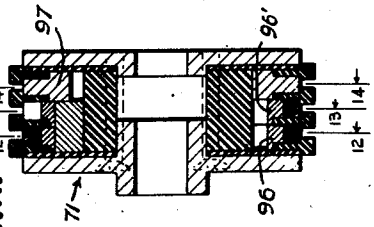


FIG.11.



INVENTOR.
Ioino Ghertman.
BY
Edward R. Lounder
AGENT

Patented Jan. 30, 1951

2,539,995

UNITED STATES PATENT OFFICE

2,539,995

SORTING MACHINE

Ioino Ghertman, Saint-Mande, France, assignor to International Business Machines Corporation, New York, N. Y., a corporation of New York

Application February 11, 1947, Serial No. 727,891
In France December 23, 1943

Section 1, Public Law 690, August 8, 1946
Patent expires December 23, 1963

3 Claims. (Cl. 209—110)

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The present invention relates to improvements in card controlled machines of the type which are adapted to sort record cards, such as are used to control the operation of the well-known Hollerith type of tabulating machine. The invention is designed as an improvement over the sorting machine shown and described in the patent to C. D. Lake, No. 2,000,237, dated May 7, 1935. Sorting machines of this type are capable of directing toward individual card receiving pockets groups of cards in which the component individual cards are arranged in a predetermined order. More specifically, in certain classes of work, each group of cards is preceded by a main control card or "first master card" which is perforated in a selected field with data for controlling the selection of the pocket which is to receive the entire group. Following the first master card are a variable number of "detail cards." The last card in each group is a "second master card" and this card is so designed as to restore the setting of the machine for a new selection by the first master card of the next succeeding group. Stated otherwise, such a machine will direct toward the selected pocket all cards of a certain group including the first master card and the last card according to perforations made in a special sorting column in the first master card and independently from perforations made in the corresponding columns of the detail cards. The last card of each group will follow its predecessors to the same pocket but in so doing will set up the machine for a new selection to be made according to the perforations made in the sorting column of the first master card of the succeeding group. For example, if the first master card of a particular group contains a perforation "6" in its sorting column, this card will be directed toward the "6" pocket of the sorting machine and all detail cards which follow will also be directed toward this same pocket, regardless of whether perforations 1, 2, 4, 6 or any other perforations appear in their corresponding column. If the master card of the next succeeding group contains a perforation "8" in the sorting column, as soon as this perforation presents itself under the analyzing brush of the sorter this latter card will be directed toward the "8" pocket, as well as all other detail cards which follow it in the same group. This procedure will continue throughout the entire sorting operation.

In certain classes of work, each group of cards will comprise an equal number of cards. However, due to inadvertence, negligence or other

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contingencies, the number of cards in a group may occasionally vary from the required number due to the absence of a master card or of one or several detail cards. If, for instance, the number of detail cards following each master card amounts to four (which corresponds to a group of five cards including the master card), and if a master card is missing from the group, the group of four cards being without a master card to control it will automatically follow the preceding group and, under the influence of the master card in that group, will proceed to a pocket not intended for it. In such an instance, the group will then contain nine cards, four of which should have been directed to another pocket. In machines of the type shown in the Lake patent, the operator is unable to determine when such a mistake has occurred and the machine will continue to operate until the end of the sorting operation. If one or more detail cards are missing from a group, the remaining cards of the group will obviously be forwarded to the proper pocket but the operator will have no means of determining whether such a group is deficient in its number of cards. The difficulty of remedying such errors is quite obvious.

The present invention is designed to overcome the above noted limitations that are attendant upon machines of the type described in the above identified Lake patent. The various electrical instrumentalities and circuits employed herein offer to such a machine a flexibility that has not been previously contemplated. Principal among the advantages afforded by the present invention is the provision of a control device which goes into operation whenever an error in the original group of the cards results in a surplus or deficiency in the number of cards in a particular group. This control device not only warns the operator of the presence of such an error, but also serves to automatically stop the machine at a suitable point in the machine cycle to permit the operator to remedy or otherwise take note of the error.

One principal point of difference between the machine shown in the Lake patent and the present modified form thereof resides in the manner in which the detail cards are distinguished from the master cards. In the patented machine, the groups of cards are arranged with the first master card having a cut corner in what is termed the lower left corner. This card is also perforated in the selected field with data for controlling the selection of the pocket to receive the entire group. Following the first master card

are the detail cards which have their upper left corners cut. The last card in each group or the second master card is formed with four square corners. The present apparatus employs other means for differentiating the master cards from the detail cards and the cut-off corners of the various cards are replaced by special perforations which appear in either the detail or the master cards. To accommodate this, use is made of an analyzing device, the purpose of which is to detect the presence or absence of these perforations instead of detecting the presence or absence of the cut-off card corners.

One of the features of the present invention resides in the use of commutators arranged in such a manner as to send into the control circuits successive current impulses, the frequency of which depends upon the number of detail cards which ordinarily must follow each master card and which is equal to the frequency of occurrence of the group of cards, i. e., how often their representative master card passes under the analyzing brushes of the sorting machine. As a result of this, if a master card or one or several detail cards are missing, due to an error, the fact is detected by a control and signal circuit including a set of two-way, three-blade contacts, whose medial blades are moved in the same direction for the purpose of establishing a particular circuit, one of the three blade contacts being controlled by a special perforation detector relay device, the purpose of which is to distinguish the detail cards from the master cards, while the other contact is controlled by a relay device which is excited by one of the commutators in accordance with the frequency of occurrence of the groups of cards. The first circuit induces the sending of current to a signal light to attract the attention of the operator, while the second circuit sends an impulse of current to a relay, the excitation of which effects the immediate stopping of the machine by means of a strong braking action to overcome the inertia of the machine. This braking of the machine is effected by a direct short-circuiting of the motor armature to prevent coasting of the machine into the next cycle. The operation of the present improved machine is characterized by an initial phase during which the commutators, which are selected according to the frequency of occurrence of the groups of cards, have their current distribution periods automatically synchronized with the period of occurrence of the master cards under the analyzing brushes which analyze, on the one hand, the special perforations employed to distinguish detail cards from master cards and, on the other hand, the perforations made in the sorting column of each detail card or each master card. In this initial or preparatory phase the machine functions at relatively low speed and stops automatically at a point in the cycle which is close to point "9," this latter point constituting the origin of the operation cycles which constitute the second phase of machine operation.

During the second phase the machine proceeds at normal speed and sorting and control are effected as long as each group contains the proper number of cards and there are no detail or master cards missing. As soon as an error is detected, as evidenced by a lighting of the signal lamp, the machine will automatically stop at or near the "9" point in the cycle and the operator may then take the cards out of the magazine, as well as any card or cards already passed to the improper card pockets.

The commutators referred to above are for the purpose of detecting errors and are arranged in two sets. The rotors of each set are integrally connected with each other in pairs in such a way that a commutator of the first set establishes the control circuits and effects immediate stopping of the machine in case of a mistake, while the commutator associated with the second set serves to prepare the control circuits by insuring a starting of the machine at the desired point of the cycle.

The present invention has been illustrated in connection with a standard type of sorting machine and the one best selected for illustrative purposes is that shown and described in the above mentioned Late patent.

Other objects and advantages of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a fragmentary side elevational view, partly in section, showing certain characteristic parts of a sorting machine, together with the electrical connections leading thereto.

Fig. 2 is a diagram showing the order of arrangement of several cards of a representative group and also showing the manner in which they are electrically sensed for sorting purposes.

Fig. 3 is a diagrammatic time chart showing the duration of the various current impulses involved in a control and signal circuit.

Fig. 4 is an electrical diagram of the apparatus comprising the present invention showing its association with a sorting machine.

Fig. 5 is a perspective view, diagrammatic in its representation, of a commutator employed in connection with the present invention.

Fig. 6 is a side elevational view showing a plural commutator assembly employed in connection with the present invention.

Fig. 7 is a plan view of the instrumentalities shown in Fig. 6.

Fig. 8 is a sectional view taken substantially centrally through a two-brush commutator employed in connection with the present invention. This view is also a sectional view taken substantially along the line 8—8 of Fig. 9.

Fig. 9 is an end view of the commutator shown in Fig. 8.

Fig. 10 is a sectional view taken substantially along the line 10—10 of Fig. 8.

Fig. 11 is a sectional view taken substantially centrally through a three-brush commutator employed in connection with the present invention. This view has been taken along the line 11—11 of Fig. 12.

Fig. 12 is a sectional view taken substantially along the line 12—12 of Fig. 11.

Fig. 13 is a sectional view taken substantially along the line 13—13 of Fig. 11.

Fig. 14 is a sectional view taken substantially along the line 14—14 of Fig. 11.

Fig. 15 is a front view of an eight-brush holder employed in connection with the present invention.

In all of the above described views like characters of reference are employed to designate like parts throughout.

Before proceeding with a description of the present invention, the sorting machine with which the invention is associated will be briefly

explained as to its general principles. Fig. 1 shows the essential parts of an electrically controlled sorting machine in which the sorting of the record cards is accomplished through the medium of a sorting magnet 11 under the control of a brush relay R—10 (see Fig. 4) which, in conjunction with the sorting magnet, is in the circuit with the sorting brush 22 and, with the sorting magnet 11, receives exciting current from a source 17 as soon as a perforation is encountered in the card column undergoing analysis. According to the point of time at which the energization of the sorting magnet takes place, the armature 23 upon which the ends of the tongues 24 of the guide blades 24' leading to the card receiving pockets 25 rest determines the destination of the particular card being analyzed.

The ends of the tongues 24 are spring pressed downwardly upon the armature 23 by their own weight and resiliency so that during the card analyzing cycle the record card is guided between the ends of the tongues 24 and the armature 23, with the result that upon energization of the sorting magnet 11 only as many tongues 24 are lowered by the armature as do not overlie the record card, while the remaining tongues are maintained elevated by the card itself. Toward this end, there is provided a fixed bar 26 parallel to and on a level with the armature 23 when in its normal position and which is arranged to support the record card after the armature has been lowered. It is to be noted also that the time of energization of the sorting magnet 11 depends upon the position of the perforation in the card column. Inasmuch as each column presents twelve index point positions, the cards may be guided selectively into any one of the twelve sorting pockets 25. Because of the downward movement effected upon the tongues 24 by energization of the sorting magnet 11, these tongues are disengaged from the card and define a gap between the last tongue supported on the record card and the next adjacent tongue which has been lowered along with the armature 23. Into this gap the record card 10 is conveyed and thereafter it is guided toward its corresponding pocket by means of the usual feed rollers 27. In the event that there is no perforation in the card column undergoing analysis, the magnet 11 will not be energized and the card will pass beneath all of the tongues 24 and will be guided to a thirteenth pocket 25R, commonly referred to as the "reject" pocket. The card feeding mechanism comprises a horizontally reciprocable picker 28 which feeds the cards one at a time from the bottom of a stack 29 to a pair of feed rolls 30 which introduces the card between the brush 22 and contact roller 31.

Fig. 4 is an electrical diagram of the apparatus comprising the present invention showing its operative electrical association with a sorting machine. Preparatory to a description of the operation of the apparatus, as portrayed in this figure, the following table is presented to facilitate the location of the various electrical contacts employed and the controlling instrumentalities for these contacts, whether the same be in the form of a relay magnet or in the form of a mechanical instrumentality, as for example, a cam, a card stop lever, a pocket stop lever or the like. Fig. 4 has been subdivided into fifteen components or sections, the location of any one of which may be readily determined by reference to the alphabetical horizontal divisions along the left-hand margin of the figure and to the numerical vertical divisions along the upper edge of the figure. Thus, for example, a contact group 130A, the function of which will subsequently be described, may be located in subdivision E3 of the drawing. The table is divided into two columns, the first column containing reference numerals pertaining to relay magnets or mechanical control devices for the various contacts, and the second column containing reference numerals pertaining to the contacts themselves. The parenthetical inserts refer to the locations of the various parts.

Controlling relay magnets or mechanical instrumentalities	Contacts
45 (C2)	45A (C2).
47 (C3)	47A (D2).
48 (C3)	48A (E2).
49 (C2)	49A (C2)—49BI (C3)—49BS (E2).
51 (C3)	51AS (D3)—51AI (E3)—51BI (E2)—51BS (D3).
55 (C3)	55AI (C2)—55AS (D3)—55BI (E3)—55BS (D3).
94' (C2) (Cam)	94 (C2).
113 (A2)	113A (A1).
119 (C3)	119AI (C3)—119BI (C2).
123 (C1)	123A (E2)—123B (C2).
130 (E2)	130A (E3).
133 (B1)	133AI (C2).
137 (B1)	137AI (C2)—137BI (A1).
142 (C3)	142A (B2).
CL (Card Lever) (C2)	59, 159 (C2).
MCL (Magazine Card Lever) (C2).	122 (C2).
PCL (Pocket Card Lever) (C2).	132 (C2).
11 (Sort Magnet) (C3)	
S1 (Start Key) (C2)	S (C2)—S2 (C2).
R-0 to R-3 (A3)	
R-4 to R-9 (B3)	
R-10 (C3)	
SA (C2)	117 (C2).

Referring now to Fig. 4, when the machine is to be used as a standard sorter the manually controlled switch I_1 is reversed from the position in which it is shown in Fig. 4, while the manually controlled switch I_3 is opened. The manually controlled switch I_2 is allowed to remain closed and in this manner all special circuits designed for operation of the present invention are completely eliminated. When the switch I—17 is closed, the machine is conditioned to operate as a standard sorter after cards have been introduced into the card receiving bin or magazine 29'.

Upon depression of the start key S_1, current issues from the source 17 through line wire L_1, main switch I—17, leads 40, 41, 42, switch I_1 (reversed), lead 43, contacts S of start key S_1, lead 44, relay magnets 45, 47, 48, contacts 49BI (normally closed while the machine operates as a standard sorter), fuse *f*, lead 50, switch I—17, line wire L_2 to the source 17. A resistance dampened relay magnet 51 is arranged in parallel with the magnets 45, 47 and 48, and becomes energized simultaneously therewith.

Energization of the magnets 47, 48 and 51 causes actuation of their respective contacts, thus conditioning the sorting machine motor M for operation as soon as the starting key S_1 has been depressed. The motor circuit extends from the source 17 through lead 53, contacts 47A (now closed), lead 54, contacts 55AS, 55BS, 55BI (arranged in parallel and in their normal positions), lead 56, contacts 51AS, 51BS, 51AI (arranged in parallel and now reversed), armature of the motor M, lead 57, contacts 48A (now closed), and lead 58 to the source. It will be understood that the motor M serves to drive the picker mechanism 28 to advance the cards toward the rolls 30 which are themselves also driven by the motor.

Upon displacement of the cards, the usual card lever contacts 59 become closed to establish a holding circuit for the relay magnets 45, 47, 48 and 51 so that energization of these magnets is maintained as long as cards continue to pass through the machine. After the last card has passed under the brush 22 and the card lever contacts 59 are opened, the relay magnets 45, 47, 48 and 51 become deenergized.

Similarly, depression of the stop key ST will break the circuit through the relay magnets just described and under either of the conditions just recited the motor will become deenergized and upon so doing its momentum, together with the momentum of the various machine instrumentalities involved, will cause the machine to coast gradually to a stop, this coasting operation lasting through a few normal card cycles.

In order to insure satisfactory operation of the machine, it is necessary that the sorting magnet remain energized from the moment at which energization takes place until the last index point position in the card column has passed beneath the brush. The winding of the brush relay magnet R—10 is connected in series with the sorting magnet 11 and is simultaneously energized therewith as soon as a perforation is encountered in the card column being analyzed, the position of this perforation corresponding to the positioning of the contact segments 61 of a commutator 60 (see also Fig. 5). The commutator 60 is of a conventional type and is found in use in connection with sorters of the type shown and described in the above mentioned patent to Lake. This commutator 60 includes twelve segments which cooperate with a brush 62 and a metallic ring 63 which in turn cooperates with a brush 64. The ring is electrically connected to the contact segments 61 and to a commutator segment 65 which cooperates with a brush 66. In Fig. 4 the commutator 60 has been separated into its component parts schematically to render the disclosure more clear. The commutator 60 is synchronized with the speed of passage of cards through the machine and moves its segments 61 past the brush 62, one for each index point position of the card. As a result, each index point position of the card corresponds to a predetermined contact segment 61. The commutator segment 65 is designed to maintain the brush magnet R—10 and the sorter magnet 11 energized until the last index point position of each card has passed under the brush 22.

The foregoing outlines in a general way the usual operation of a sorting machine for ordinary sorting purposes when the apparatus comprising the present invention is inoperative and not in the circuit.

The functioning of the machine according to the present invention will now be set forth in detail, but first it is deemed advisable to note that differentiation between the master cards and the detail cards may be effected by a method which makes use of a special perforation (see Fig. 2) in the "12" position of the detail cards in a column other than one of the usual sorting columns. The master cards carry no such "12" perforation in the corresponding column and thus they may be distinguished from the detail cards.

The cards are arranged in the stack 29 in the card feed magazine 29' in such a manner that the "12" positions lead the card in passing to the rollers 30 and sorting brush 22.

In addition to the standard conventional commutator 60 two sets or groups of additional commutators are provided for the purpose of controlling the number of detail cards which are to follow each master card in any particular instance. These two sets of commutators have been labeled accordingly in Fig. 4. These latter commutators additionally control at the same time the synchronization of various control circuits, as well as work circuits, which are designed to direct the master card and the detail cards following it to the proper sorting box selected by the master card.

Each commutator assembly includes four commutators, the commutators of the first set being designated at 71, 72, 73 and 74, and the commutators of the second set being designated at 67, 68, 69 and 70. These various commutators are shown in detail in Figs. 6 to 14 inclusive and their operating schedule is shown in Fig. 3.

In the example selected to illustrate the invention, the two sets of commutators permit control of a maximum group of seven cards, of which one card is the master card and the six cards following it are the detail cards. By such an arrangement, the control capacity of the device comprising the present invention is related to the verification of a group of cards including a master card followed by not more than six detail cards. It is possible, according to the invention, to control a smaller group of cards, as for example, a group containing one master card followed by the next one detail card and not more than six such cards. It will be understood, however, that in an instance where it is desired to employ more than six detail cards a larger number of commutators will have to be employed and suitable electrical connections provided therefor, all within the scope of the present invention.

The present invention is predicated upon the theory that the various commutators are arranged to emit current impulses to the various circuits they control every $1/n$ of a cycle when there are n cards in a group and it is desired to ascertain that none is missing. Toward this end, each commutator comprises a brush cooperating with a series of contact segments mounted on a rotor revolving at $1/n$ revolution per cycle. These rotors are driven by means of suitable reduction gears from a shaft which in turn is driven under the control of the motor M and which makes one revolution for each card cycle.

The above mentioned commutators are mounted in pairs, each pair being secured to a shaft 75. The pairs of commutators are as follows: 69, 73; 68, 72; 70, 74; and 67, 71. The shafts 75 are mounted in bearings 76 carried by side flanges 77 secured to the main frame 77' of the machine. Each shaft 75 has pinned thereto as at 78 a gear meshing with the gear or gears of the commutator or commutators next adjacent it. These gears, all meshing together, are driven from a pinion 79 which is suitably driven from the motor M at a rate of one revolution per card cycle. The various gears constitute a gear train 79, 80, 81, 82, 83 (see Figs. 6 and 7).

The pinion 79 is capable of free turning movement on its supporting shaft 84 when the machine is operated as a standard sorter, but is capable of being locked to the shaft when the apparatus is operated according to the present invention. Toward this end, a clutch screw or catch pin 85 is designed to releasably cooperate with a cavity 86 formed in a shoulder 86' integrally formed with the pinion 79. A knurled nut 87 is employed to lock the catch pin 85 in its operative or its inoperative position in or out of

the cavity 86. The shaft 84 is adapted to be driven by a worm gear connection 88 from a shaft 89 which in turn is suitably driven from the motor M.

The catch pin 85 projects through a block 91 which is capable of being pinned to the shaft 84 by means of a set screw 90. When it is desired to operate the machine as a standard sorter, the set screw 90 may be loosened to disconnect the block 91 from the shaft 84.

Still referring to Figs. 6 and 7, the shaft 75 which carries the commutators 67 and 71 also carries a cam 92 having four lobes formed thereon cooperating with a roller 93 forming a part of a cam controlled contact assembly 94' including contacts 94. The contacts 94 are situated in the control and signal circuit shown in full heavy lines in Fig. 4 and these contacts are adapted to become closed briefly once during each machine cycle as portrayed in Fig. 3. The nature of the pinion 79 and gears 80, 81, 82 and 83 is such that the gears 80 to 83 inclusive make 1/6, 1/5, 1/7 and 1/4 of a revolution respectively for each complete revolution of the pinion 79 and, under such conditions, commutators 67 and 71 under the control of the gear 83 emit an impulse every fourth cycle of machine operation, this impulse being maintained for a full cycle.

Commutators 70 and 74 under the control of the gear 82 send out an impulse every seven cycles of machine operation. Commutators 68 and 72 under the control of the gear 81 become effective every five cycles, and, finally, commutators 69 and 73 under the control of the gear 80 become effective every six cycles. The diagram of Fig. 3 clearly shows the distribution of current impulses from the various commutators during a prolonged period of machine operation. The impulses sent out by the various commutators are transmitted through brushes 95 cooperating with segments 96 (see Figs. 4, 6 and 8 to 14 inclusive) electrically connected to rings 97 associated with brushes 98 connected together in common as at 99.

Each commutator includes a single segment 96 and a single brush 95, as well as a complete annular ring 97 cooperating with a brush 98, but an exception is made in the case of commutators 71 and 73. The commutator 71 includes two segments 96 and 96' cooperating with respective brushes 95 and 95'. The extent of the segments 96 and 96' determines the duration of the impulses emitted by this commutator. The commutator 73 also comprises two segments 96 and 96' with cooperating brushes 95 and 95'.

The brushes 95 and 95' of the first set of commutators 71 to 74 inclusive have plug board jacks C and C' respectively, capable of being connected by a plug connection 100 to jacks 101. Similarly, the brushes 95 of the second set of commutators 67 to 70 inclusive have plug board jacks D capable of being connected by connections 102 to a jack 103. The connections thus made, as shown in Fig. 4, enable the apparatus, as will appear presently, to be prepared for a control action corresponding to a predetermined frequency of occurrence of a group of cards.

In preparing the machine for operation, the brush holder 22' is first removed from the machine and replaced by a brush holder 104 (see Figs. 4 and 15) which is equipped with eight brushes capable of analyzing simultaneously eight card columns. Of the eight brushes, seven of them, hereinafter referred to as selection brushes 105, are employed to selectively analyze the various orders of a number, i. e. according to whether sorting is performed in the units, tens or hundreds, etc., columns of the cards. The other brush, hereinafter referred to as the detection brush 109, analyzes the column containing the "12" perforation that distinguishes the detail cards from the master cards. The selection brushes 105 are capable of being connected by means of a plug connection 106 to the circuit of the sorting magnet 11. The plug connection 106 connects the plugs 107 and 108, as shown in Fig. 4. The detection brush 109 controls the corresponding circuit by means of a plug connection 110 placed between jacks 111 and 112. As will be described presently, this brush 109 controls the circuit containing a detection relay magnet 113 which becomes energized each time a "12" perforation in a detail card passes under the brush 109. In the absence of such a perforation, the passage of a master card beneath the brushes indicated and the above mentioned circuit is interrupted.

According to the number of cards included in each group of cards passing through the machine, the following connections are established:

Number of Cards per Group (One master card and the detail cards following it)	Connections to be made
7	101 to *c*—7 and 103 to *d*—7.
6	101 to *c*—3/6 or *c'*3/6 and 103 to *d*—3/6.
5	101 to *c*—5 and 103 to *d*—5 (Connections represented by Fig. 4).
4	101 to *c*—2/4 or *c'*2/4 and 103 to *d*—2/4.
3	101 to *c*—3/6 and *c'*3/6 and 103 to *d*—3/6.
2	101 to *c*—2/4 and *c'*2/4 and 103 to *d*—2/4.

It is to be noted that the labeling adopted in Fig. 4 to designate the jacks C, C', and D reveals by the alphabetical portion thereof the particular commutator under consideration and, by the numerical portion thereof, the control possibilities of each of these commutators. For instance, contact jack *c'*—2/4 connected to the brush 95' of the commutator 71 may be used to control groups of two cards or of four cards. Similarly, contact jack *c*—3/6 connected to brush 95 of commutator 73 may be used to control groups of three or six cards. Likewise, jack *c*—7 connected to commutator 74 may control a group of seven cards.

After the selected connections have been made and before the cards have been introduced into the machine, it is necessary to synchronize the frequency of feed of the first master cards M_1 (see Fig. 2) with the frequency with which the segments 96 pass under the analyzing brushes 95. Accordingly, an auxiliary starting button SA is provided and this button is employed for the purpose of automatically setting the machine in its starting position in which the first card feed cycle corresponds to the feeding of the first master card. Upon depression of the auxiliary starting button SA prior to introduction of the cards into the magazine 29', a circuit is established from the source through the switch I—17, leads 40, 41, 42, switch I_1, leads 114, 114', 116, button SA, contacts 117 (now reversed), lead 118, relay magnet 119, bar 120, relay magnet 55, lead 121, fuse *f*, and lead 50 to the source. Upon energization of the magnet 119, contacts 119AI and 119BI become closed. Closure of the contacts 119AI establishes a holding circuit for the relays 119 and 55 which remains effective after

the button SA has been released. This holding circuit exists from the source 17 through switch I—17, leads 40, 41, 42, switch I_1, leads 114, 114', 155, magazine card lever contacts 122 (normal), normally closed contacts 123B, lead 124, contacts 119AI (now closed), magnets 119 and 55, lead 121, fuse *f* and lead 50 to the source. Closure of the contacts 119BI causes energization of the relay magnet 51 through a circuit leading from the source through leads 40, 41 and 42, switch I_1, leads 114, 125, contacts 119BI (now closed), lead 126, resistance 52, relay magnet 51, normally closed contacts 49BI, fuse *f*, and lead 50 to the source.

The magnet 45, as well as the magnets 47 and 48, are arranged in a parallel circuit with the magnet 51 and are energized simultaneously therewith. Therefore, the associated contacts 47A and 48A are closed. On the other hand, the contacts 55AS, 55BS and 55BI become reversed under the effect of energization of the magnet 55. This also applies to the contacts 51AS, 51BS and 51AI, all of which fall under the influence of the magnet 51 and as a result the starting circuit of the motor M becomes opened. This motor circuit prior to becoming open exists from the source through lead 53, contacts 47A, lead 54, resistance *r*, motor armature M, lead 57, contacts 48A and lead 58 to the source. Inasmuch as the resistance *r* is disposed in the motor armature circuit, the latter commences to rotate slowly until the commutators are in the correct selected position in accordance with the frequency of occurrence of the master cards.

If, for example, each group is to contain the five cards including the master card M_1, followed by four detail cards D_1, D_2, D_3, D_4, and the connections illustrated in Fig. 4 have been previously made, i. e. plug board jacks 101 and 103 were connected respectively to jacks *c*—5 and *d*—5, under such conditions commutator 72 in the first set and commutator 68 in the second set will constitute the controlling instrumentalities.

Stopping of the machine is induced by a damping current impulse sent out from the commutator 68 whose segment 96 is in engagement with its corresponding brush 95 and also from commutator 72 of the first set whose segment 96 is likewise in engagement with its respective brush 95. To effect this, obviously, the rotors of both commutators are keyed on the shaft 75 with approximately the same relative setting. This damping is directed as follows: source 17, leads 40, 127, common connection 99, brush 98 of commutator 68, ring 97, segment 96, brush 95 (adjustment position on segment 96), jack *d*—5, plug connection 102, jack 103, leads 128, 43, switch I_2 (closed), relay magnet 123, leads 129, 121, fuse *f* and lead 50 to the source.

Establishment of the above circuit causes energization of the magnet 123 and closing of controlled contacts 123A and opening of controlled contacts 123B. This produces deenergization of magnets 119 and 55 and the interruption of current in the former magnet causes opening of the contacts 119BI and consequent deenergization of magnets 45, 47, 48 and 51 whose holding circuit is now open. Deenergization of the magnet 51 allows contacts 51BI to become closed, and therefore, due to the simultaneous closing of contacts 51BI and 123A, relay magnet 130 is energized through the following circuit: source 17, relay magnet 130, contacts 123A, contacts 51BI, to the source.

Energization of the magnet 130 induces closing of contacts 130A and since the magnet 51 has been deenergized due to opening of the contacts 119BI, the motor armature is directly short-circuited by a circuit existing from the lead 57 through the armature, through contacts 51AS, 51BS and 51AI, through contacts 130A and lead 131, back to the lead 57. Due to such direct short-circuiting of the armature, a strong braking action is applied, thus stopping the motor almost instantaneously due to the formation of damping currents. The machine thus stops at a point in the cycle located slightly ahead of the point "9" which corresponds to the arrival of the card determining position "12" under the brushes 105 and 109. Cards may then be introduced into the magazine 29' with their "12" perforations directed toward the rollers 30 and with the master cards at the bottom of each group so that these cards will be the first to be analyzed in each group.

During the first cycle of operation of the machine, the first master card passes under the brushes 109 and 105 and during this cycle index point position "12" arrives under the brush 109 when the contact segment of each commutator 68 and 72 is still in engagement with the reading brushes 95.

It will now be shown how differentiation between master cards and detail cards is accomplished and how the sorting control therefor is effected. The preparatory phase of operation having been accomplished, as described above, the machine is then ready for the next or starting phase. It is to be noted first that as soon as the cards are placed in the magazine 29' the magazine card lever contacts 122 become reversed under the control of magazine card lever MCL.

Upon depression of the starting key S_1, and consequent closure of the contacts S and S2 controlled thereby, relay magnets 45, 47, 48 and 51 become energized through a circuit leading from the source 17 through leads 40, 127, common wire 99, brush 98, ring 97, segment 96, brush 95 of commutator 68, plug *d*—5, connection 102, jack 103, lead 128, starting contacts S, lead 44, magnet 45, magnets 47, 48 (and at the same time magnet 51 in parallel therewith), contacts 49BI (normally closed), fuse *f* and lead 50 to the source. A holding circuit for these last mentioned magnets is established upon release of the starting key. This holding circuit passes through contacts 45A, contacts of the stop button ST, pocket stop contacts 132 (normally closed and opened under the control of card lever PCL when any one of the sorting pockets is filled to capacity), card lever contacts 59 (or through contacts S2 if card lever contacts are not yet closed), leads 41, 40 to the source. This circuit is maintained in effect until all the cards in the magazine 29' have passed through the machine or until an error is encountered, in which case the machine is brought to stop in a manner that will be set forth hereinafter.

Energization of the magnets 47, 48 and 51 induces closing of their respective contacts 47A, 48A and transfer of the contacts 51AS, 51BS and 51AI. Since the relay magnet 55 is deenergized, contacts 55AS, 55BS and 55BI are closed and thus the resistance *r* in the motor circuit is shunted and the motor proceeds at full speed inasmuch as the main motor circuit is established. This motor circuit exists from the source through lead 53, contacts 47A, lead 54, contacts 55AS, 55BS, 55BI, lead 56, contacts 51AS, 51BS, 51AI, motor arma-

ture M, lead 57, contacts 48A and lead 58 to the source.

During the first cycle of operation of the machine, a first control circuit leading through the relay magnet 133 is established by the commutator 72. The circuit leads from the source 17, leads 40, 127, common connection 99, common brush and ring of commutator 72, segment 96 and corresponding reading brush 95, jack *c*—5, connection 100, jack 101, relay magnet 133, resistance 134 and common wire 135, fuse *f* and lead 50 to the source. Energization of the relay magnet 133 causes a shifting of contacts 133AI, but energization of the magnet 49 and lighting of the pilot lamp 136 does not occur inasmuch as the contacts 137AI occupy the normal position shown in Fig. 4.

Master card sorting

During this first cycle the selection brush 105 makes contact with the contact roller 31 through the perforation in the sorting column of the master card M_1 which, by way of example, may be located in the "6" index point position. Immediately thereupon, the relay magnet R—10 and sorting magnet 11 become energized through a circuit leading from the source through leads 40, 138, common brush 66 of commutator 60, "6" segment corresponding to the "6" perforation in the card, brush 62, lead 139, common brush 140 of the contact roller 31, the roller itself, selection brush 105 which makes contact through the "6" perforation, jack 107, plug connection 106, jack 108, lead 141, contacts 142A (normally closed), lead 143, sorting magnet R—10, sorting magnet 11 and lead 50 to the source. Upon energization of the magnet R—10, the sorting relay magnet R6 also becomes energized, as previously explained, through the existence of a circuit leading from the source through the path just traced up to the lead 143 and from thence through the switch I_3, lead 144, shoe 145, stud "6" of the emitter 146, magnet R6, common lead 147 and leads 148, 50 to the source. Upon energization of the magnet R6, its associated pair of contacts become closed to establish a holding circuit from the source 17 through leads 40, 138, 149, commutator 150, brush 151, common wire 152 of the relay contacts R0 to R9, relay magnet R6, common connection 147, leads 148 and 50 to the source. Due to the common energization of relay magnets R6 and R—10 on one hand and of the sorting magnet 11 on the other, the master card M_1 is directed to the "6" pocket. Immediately following energization of the relay magnets R6 and R—10, the relay magnets R7, R8, R9 and 142 are successively energized as the collector's shoe 145 passes over the segments of the emitter 146. All of these magnets are maintained energized by their respective contacts and through similar circuits until the commencement of the following cycle, during which analysis of the "12" perforation and of the detail card D_1 occurs.

Differentiation between master card and detail card

Inasmuch as the master card M_1 is not provided with a "12" perforation, the detection relay magnet 113 will, in the instance given above, not become excited during the first cycle. During the second cycle, however, it will become excited by virtue of the existence of such a perforation which is characteristic of a detail card. In such an instance, the circuit leads from the source through leads 40, 138, brush 66, segment 61 corresponding on the commutator 60 to the "12" index point position, brush 62, lead 139, contact roller 31, detection brush 109 making contact with the roller through the "12" perforation, double jack 111, connection 110, jack 112, relay magnets 153 and 154, detection relay maget 113, resistance 155, commutator 156, lead 157, common connection 147, and leads 148 and 50 to the source. The holding circuit for the magnets 153, 154 and 113 passes through contacts 153A and leads 158, 138 and 40. Energization of the magnet 154 causes closing of the contacts 154A thus shunting the commutator 150 which exists in the holding circuit of the magnet R—6.

Detail card sorting

As a result of the energization of relay magnets R6, R7, R8, R9 and 142 in the first cycle and of the holding thereof throughout the next cycle, the card D_1 is directed to the "6" pocket whatever may be the perforations appearing in its sorting column. Thus this card is placed not in accordance with the sorting perforations appearing therein but in accordance with the sorting perforation appearing in its preceding master card. Switching of the card occurs immediately upon energization of the relay magnets R—10 and 11 during passage of the shoe 145 over the "6" segment of the emitter 146. It is to be noted that energization of the magnet 142, which continues during passing of the detail cards through the machine, precludes sorting by opening of the contacts 142A in the sorting circut. Thus, as succeeding detail cards D_2, D_3 and D_4 pass through the machine they are subjected to no changes whatsoever, regardless of the perforations that may appear in the sorting columns of these cards.

Second control

Energization of the magnet 113 causes closure of contacts 113A and energization of the magnet 137 through a circuit leading from the source through leads 40, 138, brush 66, segment 65 and brush 64 of the commutator 60, lead 159, contacts 113A (now closed), magnet 137, bar 135, fuse *f* and lead 50 to the source. A holding circuit for the magnet 137 is established upon closing of the contacts 137BI. Also, energization of this magnet causes a change-over in the contacts 137AI, but the control circuit shown in heavy lines in Fig. 4 is not established because the contacts 133AI occupy their normal positions.

Relay magnet 133 being deenergized because the commutator 72 emits a current impulse only once in every five cycles, the pilot light 136 in the heavy line circuit of Fig. 4 does not become energized. As a result, all operations occur normally and the detail cards D_1, D_2, etc., are all directed to the "6" pocket until directed otherwise by a new master card associated with a succeeding group. If the master card M_2 of the next group of cards presents itself for analysis four cycles after the first master card, which is to say, normally, analysis of this latter card occurs at such time as the commutators 68 and 72 establish their previously mentioned circuits and the machine continues to operate because the brush 109 does not encounter a "12" perforation. Thus the magnet 154 is not excited, its contacts 154A remain open, and the magnets R6, R7, R8, R9 and 142 are deenergized. The sorting circuit across the magnets R—10 and 11 may thus again await impulses as set forth above.

Absence of one or more detail cards

If the master card M_2 of the second group presents itself for analysis prematurely one, two, three or four cycles and before the fifth cycle (such condition representing absence of one or more detail cards), the control circuit will be established and will at the same time cause illumination of the pilot lamp 136, thus calling the operator's attention to the mistake and also stopping the machine, as will be described presently. The detection relay magnet 113 is not energized inasmuch as no "12" perforation appears in the master card. Also, the magnet 137 remains deenergized due to opening of the contacts 113A, these latter contacts being closed only in the event that the detection relay 113 is energized. As a result, the contacts 137AI remain in their normal position. Moreover, and this is essential, magnet 133 is not energized because the segment 96 of the commutator 72 is not disposed beneath the analyzing brush 95 at the time when the master card is in its analyzing position. Due to this fact, commutator 72 is designed to send its impulses only every five cycles. As the master card appears before the end of the fifth cycle, the magnet 133 cannot be excited when the master card which is devoid of a "12" perforation presents itself for analysis to the brush 109. Consequently, contacts 133AI remain in their normal position allowing relay magnet 49 and pilot lamp 136 to become energized through the solid line circuit of Fig. 4 which exists from the source 17, leads 40, 41, 42, switch I_1 (normal), lead 114, contacts 137AI, 133AI (both normal), cam controlled contacts 94, card lever contacts 159, contacts 55AI (normal), control relay magnet 49, pilot lamp 136, resistance *r*, fuse *f*, and lead 50 to the source. Energization of the relay magnet 49 is maintained by closing of the contacts 49A, whereupon the circuit extends from the source through leads 40, 41, 42, switch I_1, leads 114, 113, 116, contacts 117 of the auxiliary starting button SA, lead 161, contacts 49A (closed), magnet 49, pilot lamp 136, resistance *r*, fuse *f*, and lead 50 to the source. Energization of the magnet 49 causes on one hand opening of the contacts 49BI and on the other hand closing of the contacts 49BS. Opening of these former pairs of contacts produces elimination of the relay magnets 45, 47, 48 and 51, thus resulting, as previously seen, in deenergization of the motor circuit. Closing of the contacts 49BS causes energization of the magnet 130 which, due to closing of its contacts 130A, short-circuits the armature of the motor, as previously described, thus practically instantaneously stopping the machine within the first cycle after the error has been detected. At this point, the operator may remove the cards from the magazine 29' and remedy the error. Removal of the cards induces shifting of the card magazine contacts 122 so that they assume the position shown in Fig. 4, thus enabling the operator to depress the auxiliary starting button SA. Upon depression of this button, the magnet 49 becomes deenergized, while the magnets 119 and 55 become energized and the machine commences again at slow speed preparatory to synchronization with the commutators for the next cycle corresponding to the analysis of the first master card of a new group. The operation of the machine is then resumed as set forth above.

Absence of a master card

Another type of error that may also occur

resides in the fact that the number of detail cards present in any particular group may be too high. For example, the group of cards instead of including four details cards may include five or six such cards due to the fact that additional cards have been filed by mistake in the group due to the absence of a master card. The master card M_2, therefore, presents itself for analysis after the fifth cycle. The control circuit including the pilot light is designed to detect such an error inasmuch as on the fifth cycle it is not a master card which presents itself but rather it is a detail card having a "12" perforation. As a result, the magnet 133 is energized at the proper time by an impulse sent out by the commutator 72, but since a "12" perforation is positioned under the brush 109 the detection relay 113 becomes energized, thus closing the contacts 113A and energizing the relay magnet 137. Under these conditions, contacts 133AI and 137AI become reversed and the control circuit shown in solid lines in Fig. 4 is established, thus causing energization of the magnet 49 and illumination of the pilot lamp 136. The machine will stop in the manner previously described and the operator may then remove the surplus cards and again set the machine into operation by manipulation of the starting button SA.

It is to be distinctly understood that numerous modifications may be resorted to including either additions, eliminations, or both, without departing from the spirit of the invention; providing, of course, that the essential idea of controlling the frequency of occurrence of the group of cards by means of emitters having the same frequency is maintained. These senders, for example, instead of being in the form of commutators such as have been shown and described, may, if desired, be replaced by suitable endless strips of perforated film or of transparent or translucent film provided with suitable guiding marks, the frequency of which might be analyzed photoelectrically. Similarly, quick stopping of the machine in the case of an error could be carried out by various means other than the braking action herein described. For example, hydraulic or electromagnetic braking devices might conceivably be designed.

What is claimed is:

1. In a sorting machine for sorting record cards each having a control designation, said machine having a plurality of card receiving pockets, a card sensing station, card sensing means at said station for analyzing said control designations, means for successively feeding cards from a series of cards arranged in groups and in which the number of cards of each group is predetermined and equal and in which the cards of each group are preceded by a control card, means for emitting electrical impulses in accordance with the arrival-frequency of control cards at said sensing station, a main control circuit, a pair of relay-controlled contact groups disposed in said circuit, a normally deenergized relay magnet for each contact group, said contact groups normally maintaining said main control circuit closed, means operable upon energization of either magnet to the exclusion of the other for opening said circuit, and upon energization of both magnets simultaneously for closing the same, means operable under the control of said sensing means for energizing one of said magnets when a card other than a control card is normally present at said sensing station, and means operable under the control of said emit-

ting means for energizing the other magnet upon emission of each impulse.

2. In a sorting machine for sorting record cards each having a control designation, said machine having a plurality of card receiving pockets, a card sensing station, card sensing means at said station for analyzing said control designations, means for successively feeding cards from a series of cards arranged in groups and in which the number of cards of each group is predetermined and equal and in which the cards of each group are preceded by a control card, means for emitting electrical impulses in accordance with the arrival-frequency of control cards at said sensing station, a main control circuit, a pair of relay-controlled contact groups disposed in said circuit, a normally deenergized relay magnet for each contact group, said contact groups normally maintaining said main control circuit closed, means operable upon energization of either magnet to the exclusion of the other for opening said circuit, and upon energization of both magnets simultaneously for closing the same, means operable under the control of said sensing means for energizing one of said magnets when a card other than a control card is normally present at said sensing station, means operable under the control of said emitting means for energizing the other magnet upon emission of each impulse, and means operable under the control of said sensing means and said emitting means for energizing both of said magnets when a card other than a control card is present at said sensing station during emission of an impulse.

3. In a sorting machine for sorting record cards each having a control designation, said machine

having a plurality of cards receiving pockets, a card sensing station, card sensing means at said station for analyzing said control designations, means for successively feeding cards from a series of cards arranged in groups and in which the number of cards of each group is predetermined and equal and in which the cards of each group are preceded by a control card, means for emitting electrical impulses in accordance with the arrival-frequency of control cards at said sensing station, a main control circuit, a pair of relay-controlled contact groups disposed in said circuit, a normally deenergized relay magnet for each contact group, said contact groups normally maintaining said main control circuit closed, means operable upon energization of either magnet to the exclusion of the other for opening said circuit, and upon energization of both magnets simultaneously for closing the same, and means operable under the control of said sensing means and said emitting means for energizing both of said magnets when a card other than a control card is present at said sensing station during emission of an impulse.

IOINO GHERTMAN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,486,149	Lake	Mar. 11, 1924
2,000,236	Lake	May 7, 1935
2,000,237	Lake	May 7, 1935