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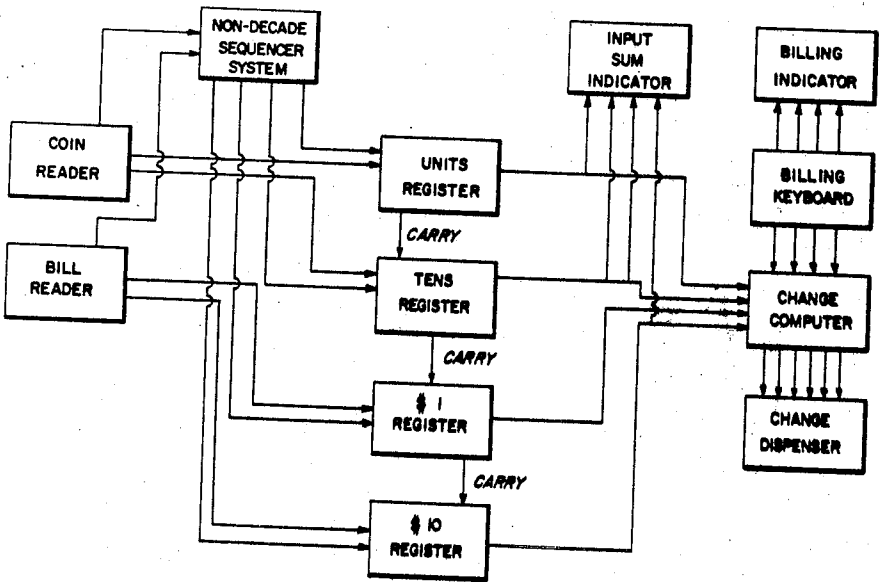
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Attorney—Shapiro and Shapiro

[54] **APPARATUS AND METHODS FOR REGISTERING CASH, REGISTERING A SALE, AND AUTOMATICALLY DISPENSING CHANGE**
43 Claims, 32 Drawing Figs.

[52] U.S. Cl..... **194/4, 221/88**
[51] Int. Cl..... **G07F 1/06**
[50] Field of Search..... **194/4, 10; 221/79, 80, 81, 88, 87, 69**

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ABSTRACT: Robbery-immune cash-handling system in which bills and coins are received, identified, and registered, the amount of a sale is registered and correct change is automatically computed and disbursed. Multicell magazines are provided for \$10, \$5, and \$1 bills, which are dispensed automatically as change. \$1 bills are also loaded automatically. Step switches are employed in a parallel addition technique for registering cash inputs and in a dynamic subtraction technique for computing and dispensing change. Cash reserves are accessible only to authorized personnel.



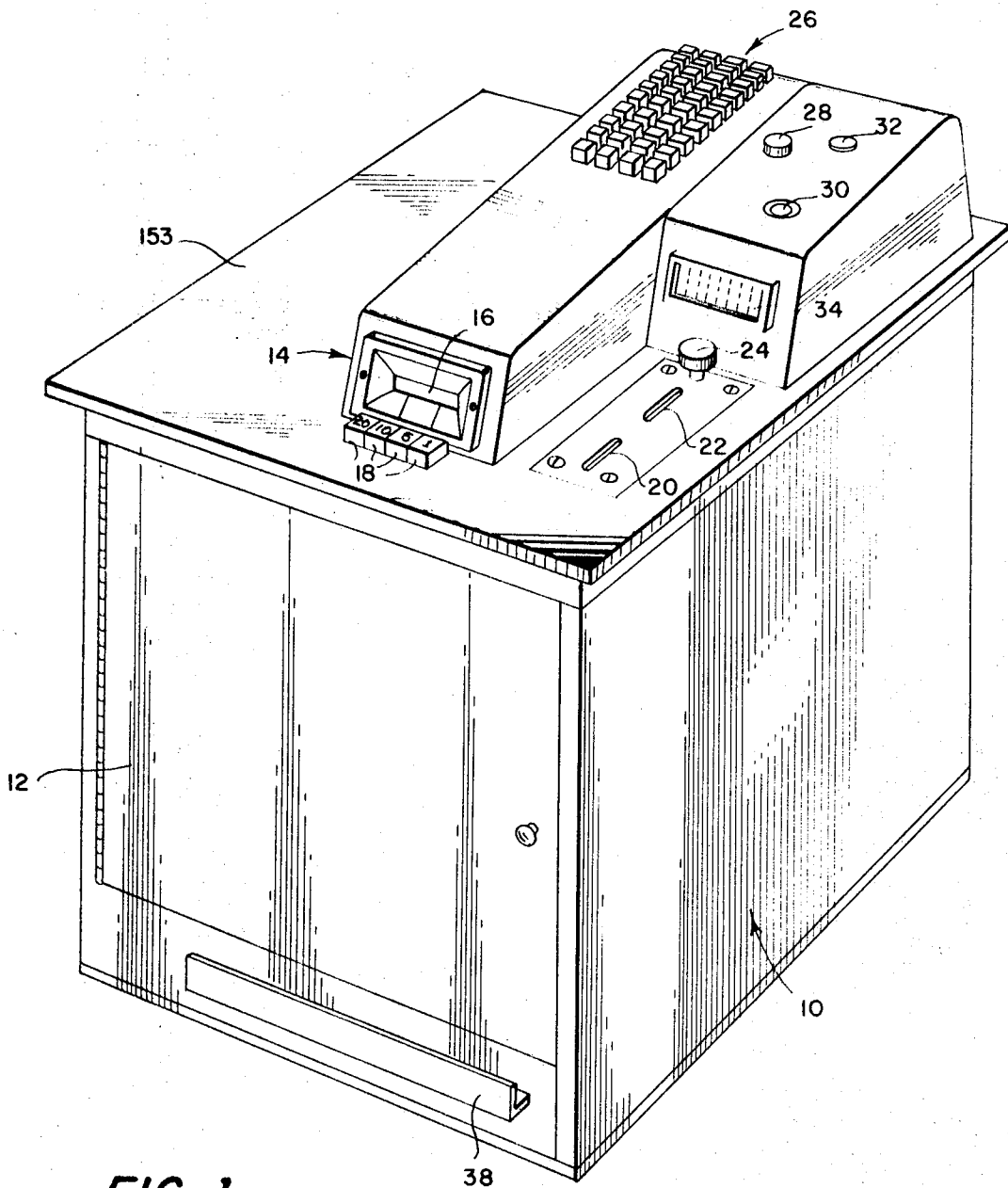


FIG. 1

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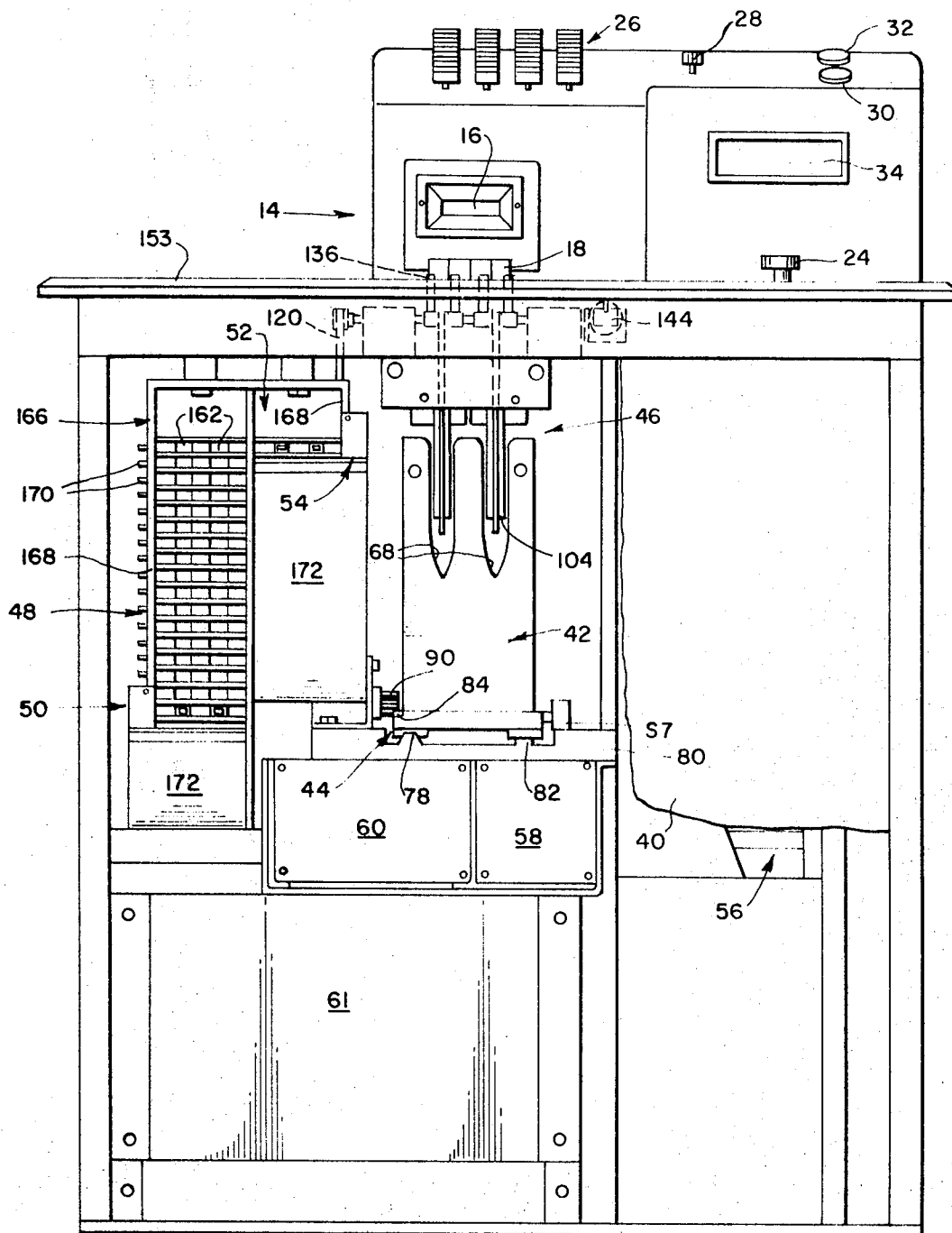


FIG. 2

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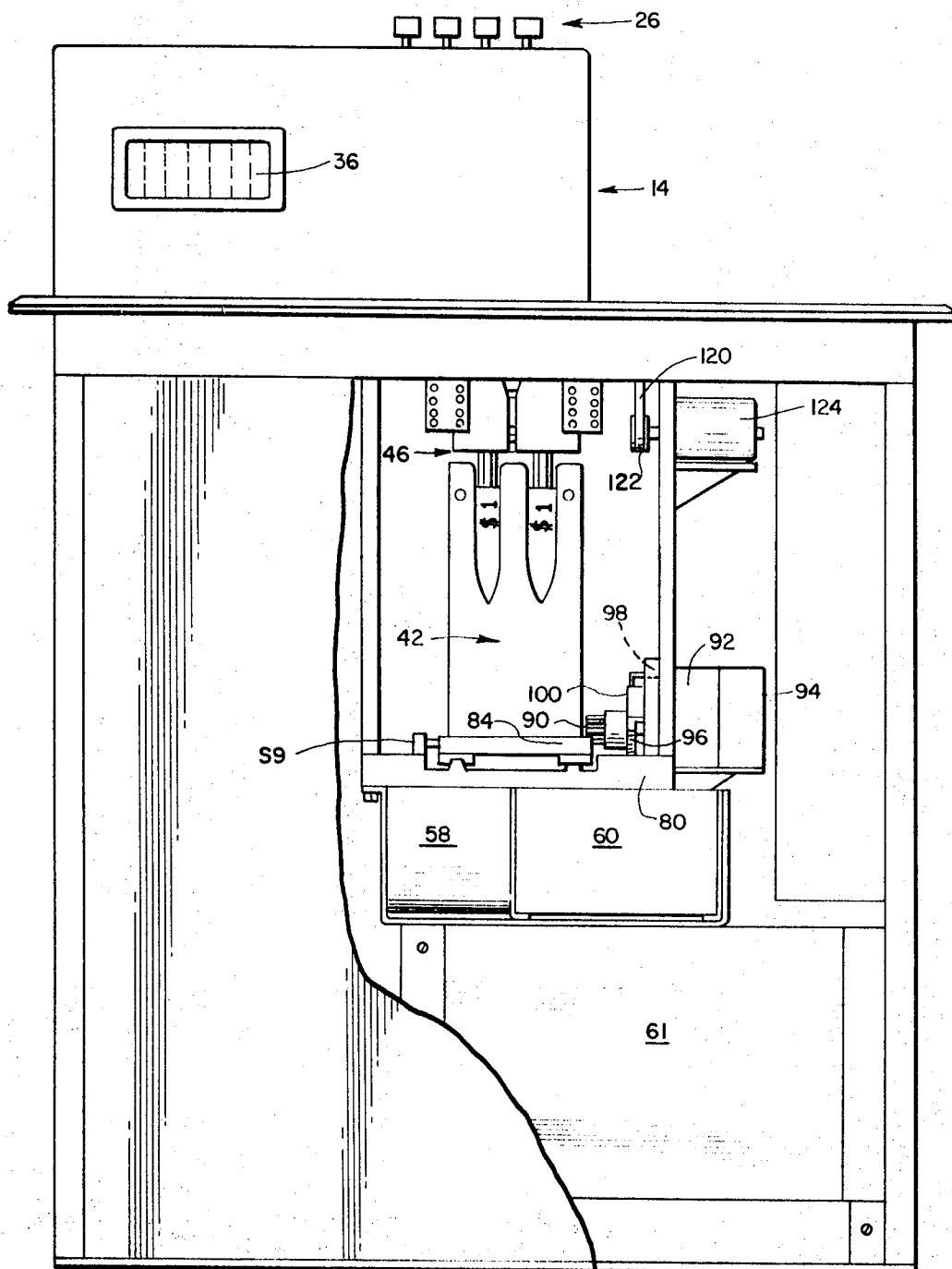


FIG. 3

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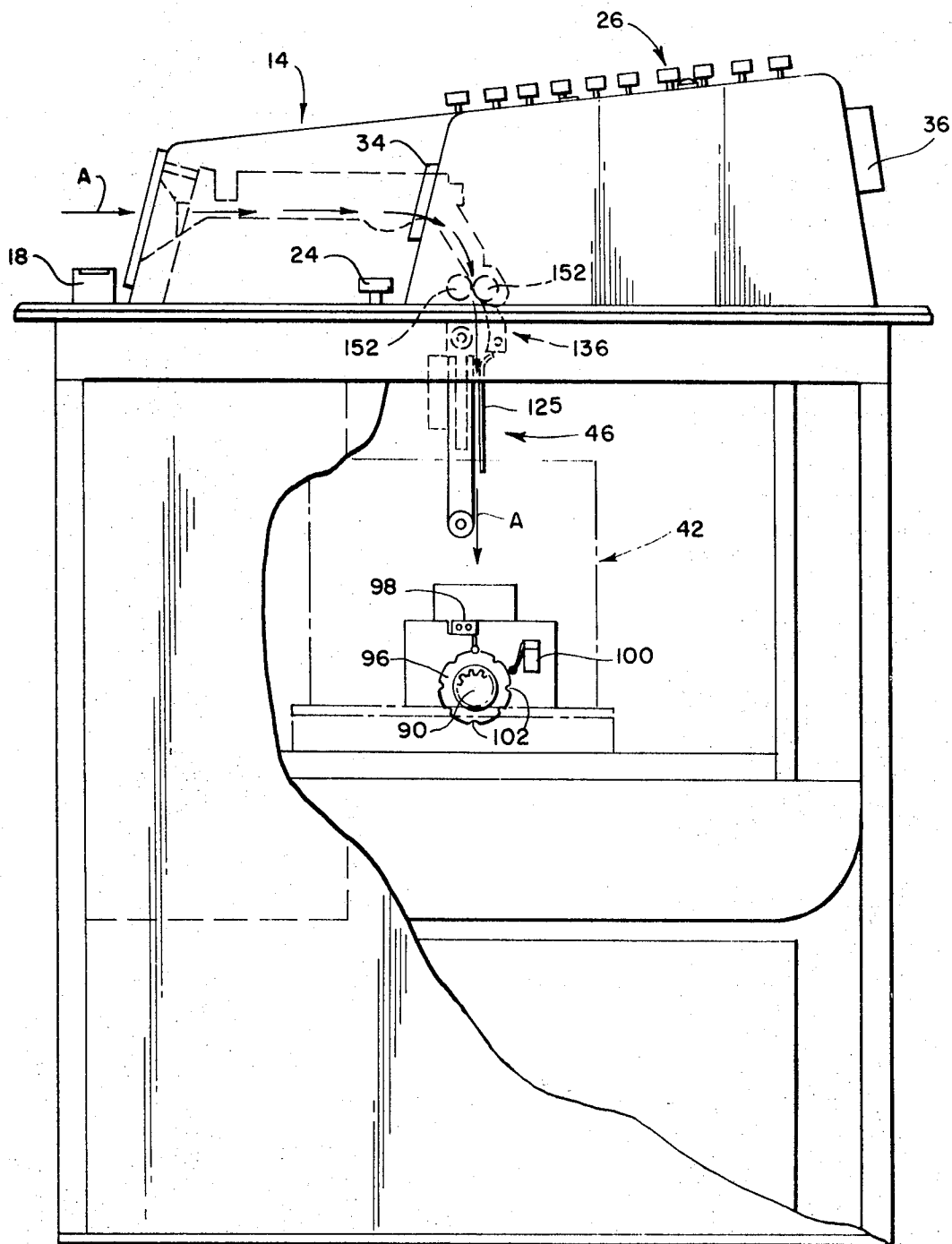


FIG. 4

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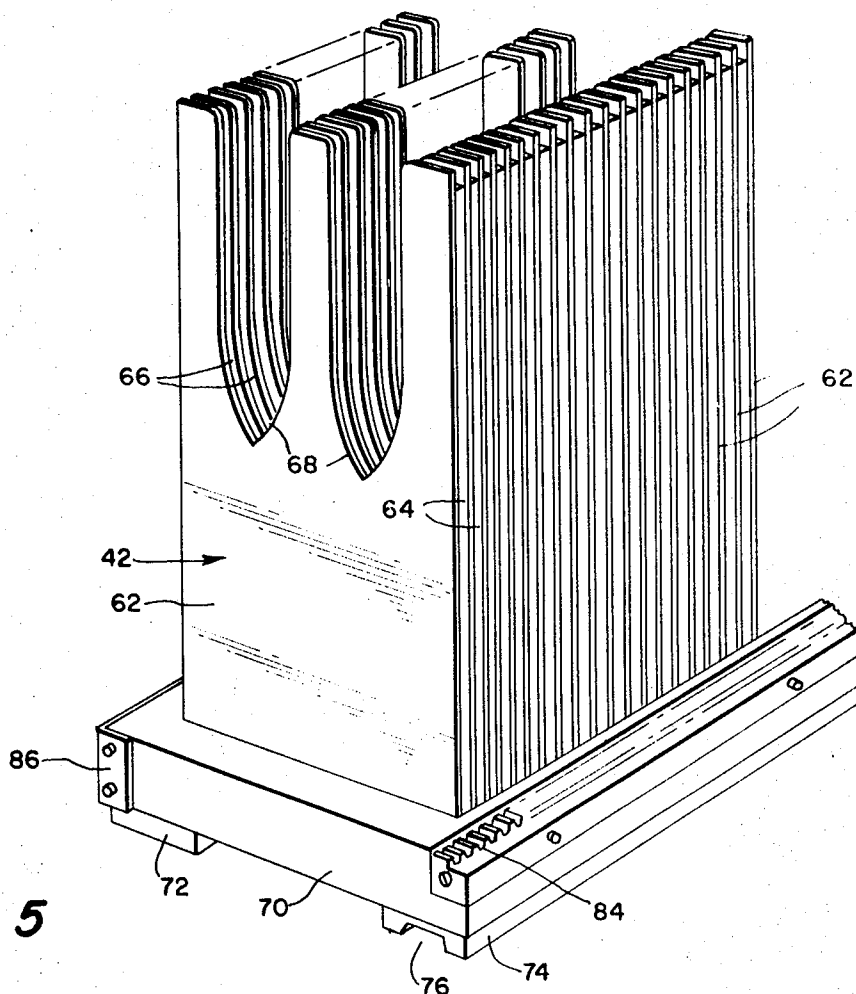


FIG. 5

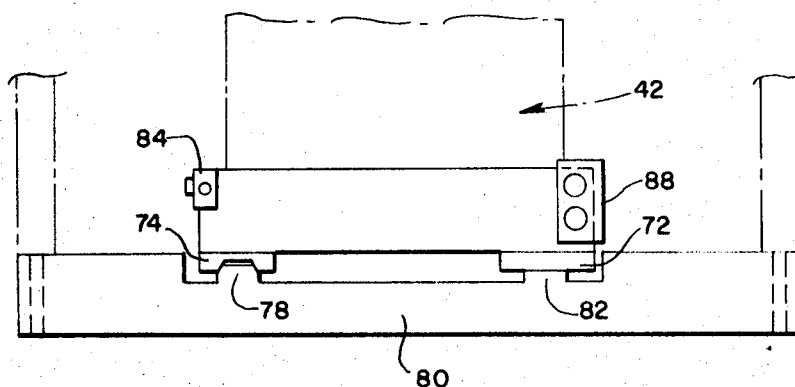


FIG. 6

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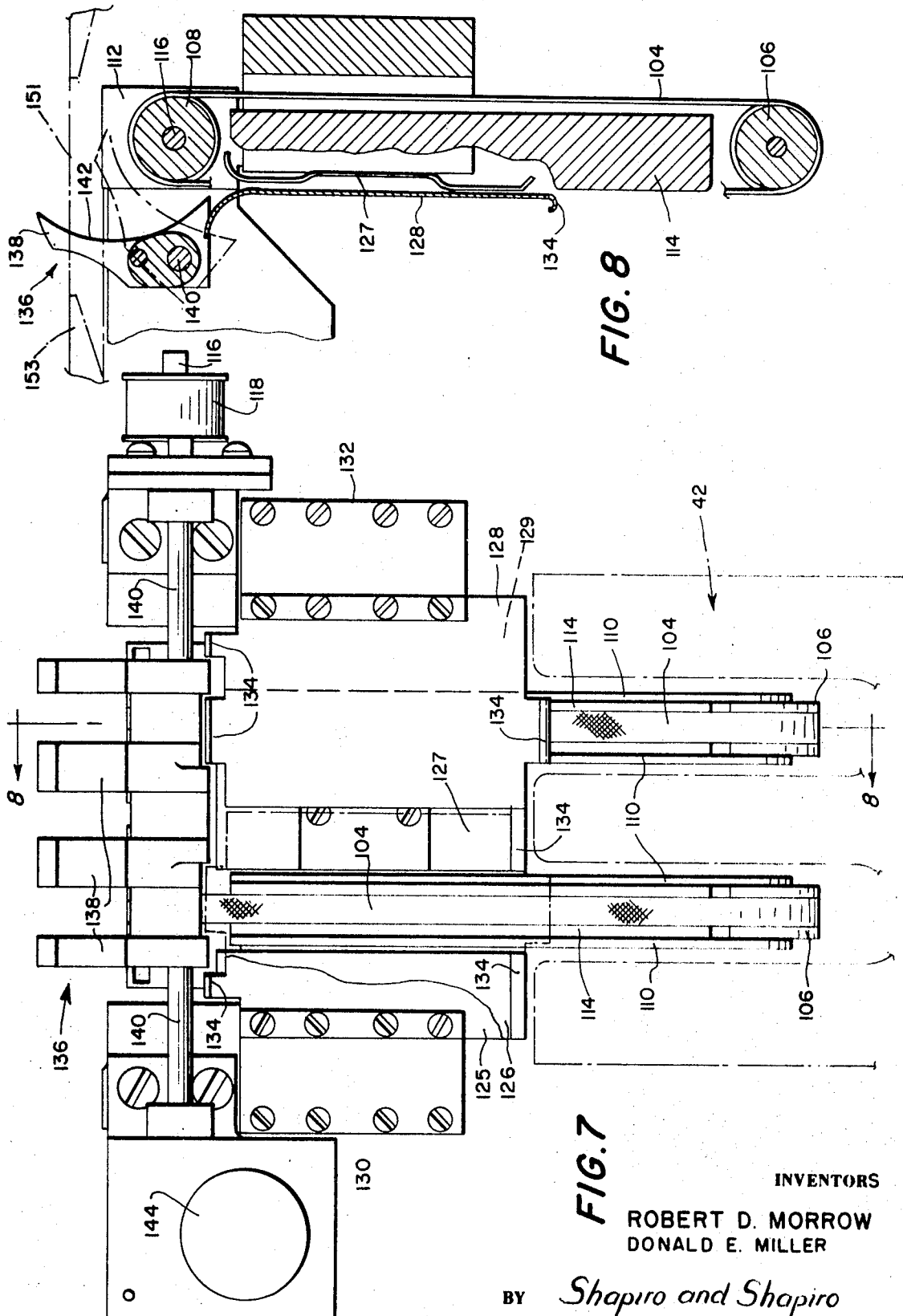


FIG. 7

FIG. 8

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FIG. 9

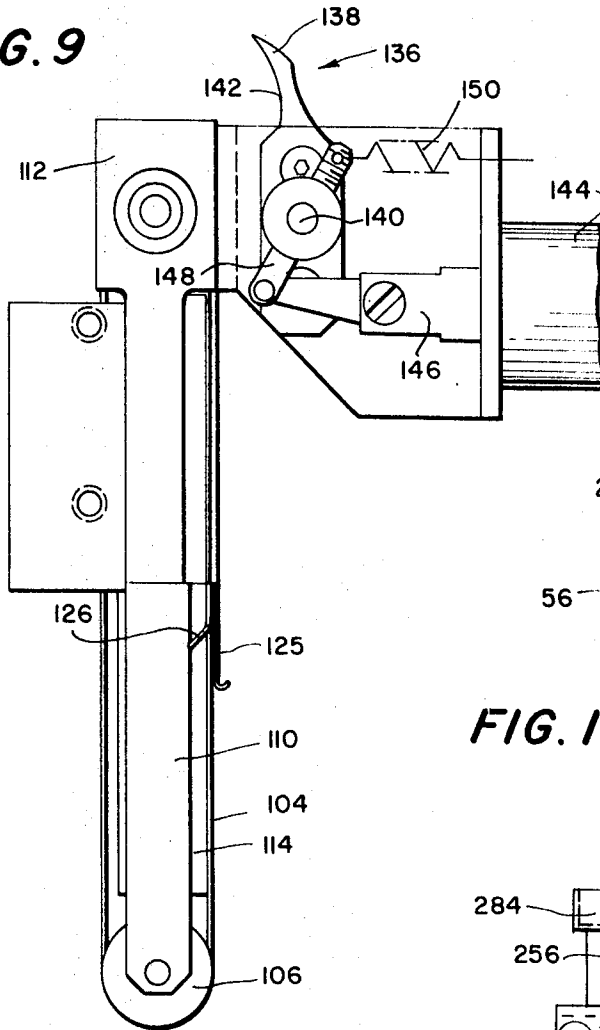
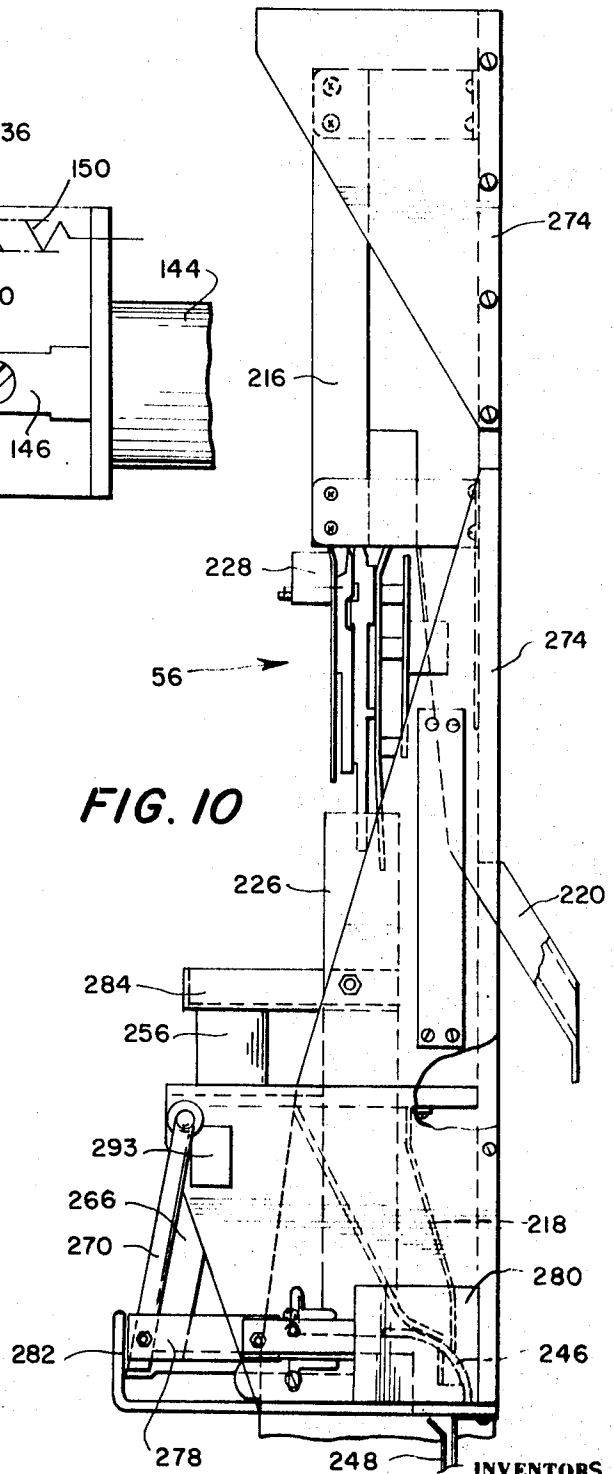


FIG. 10

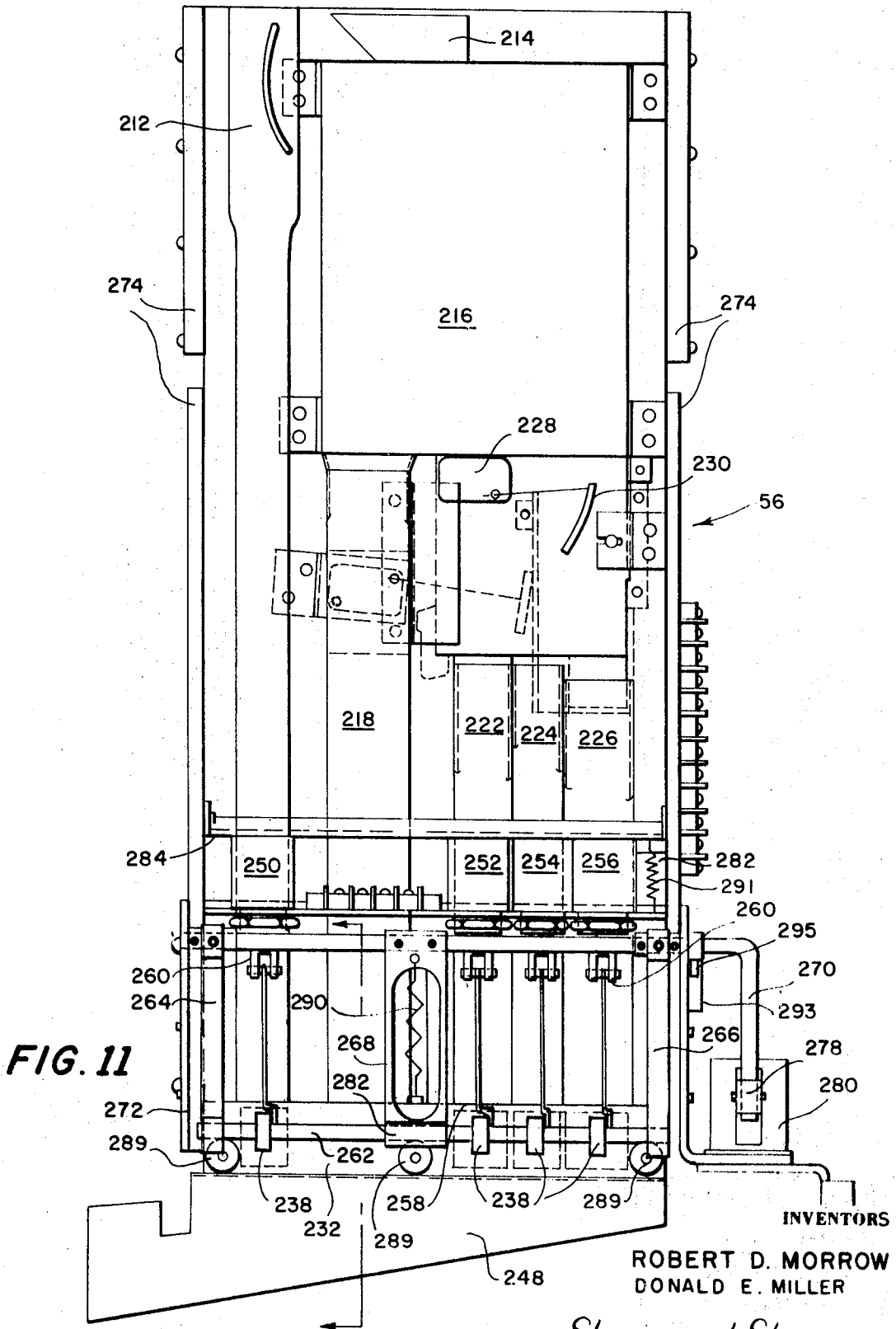


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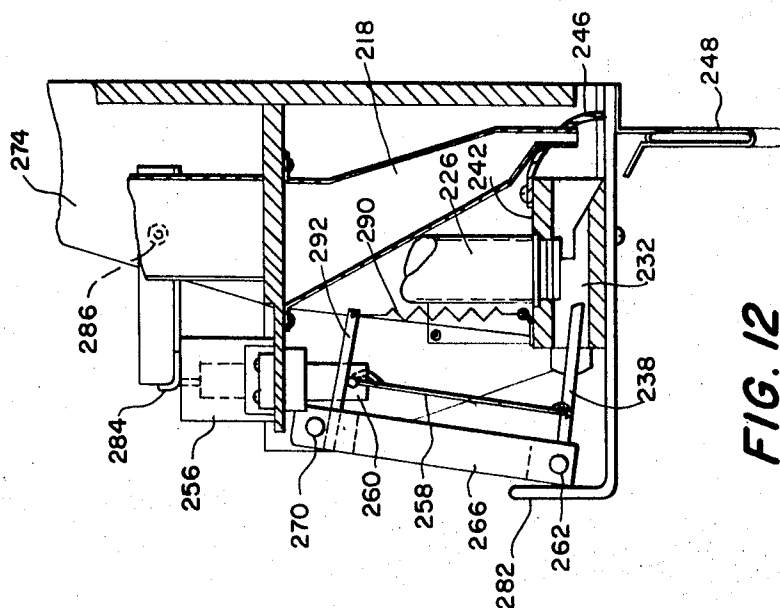
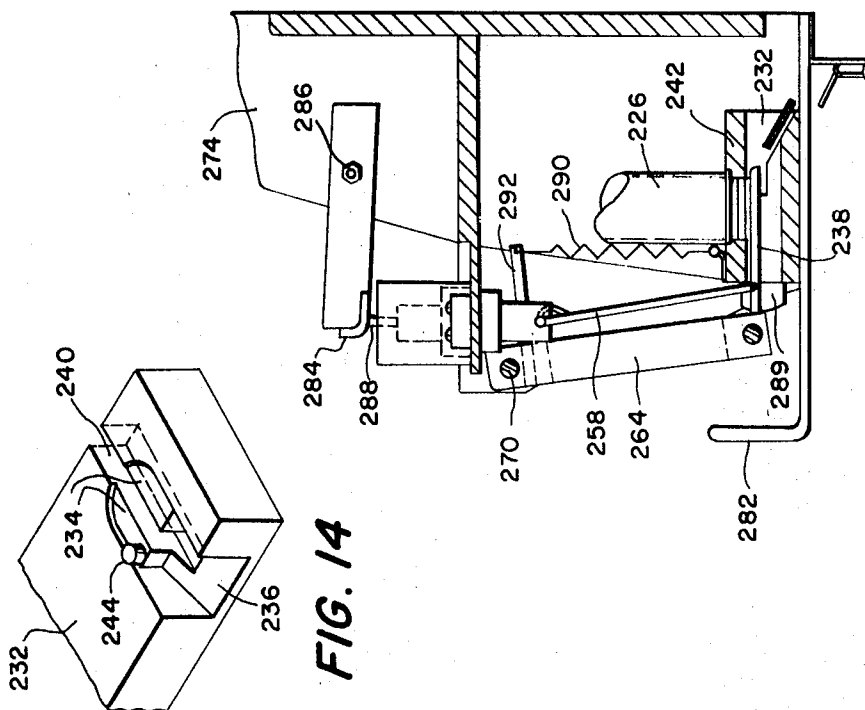


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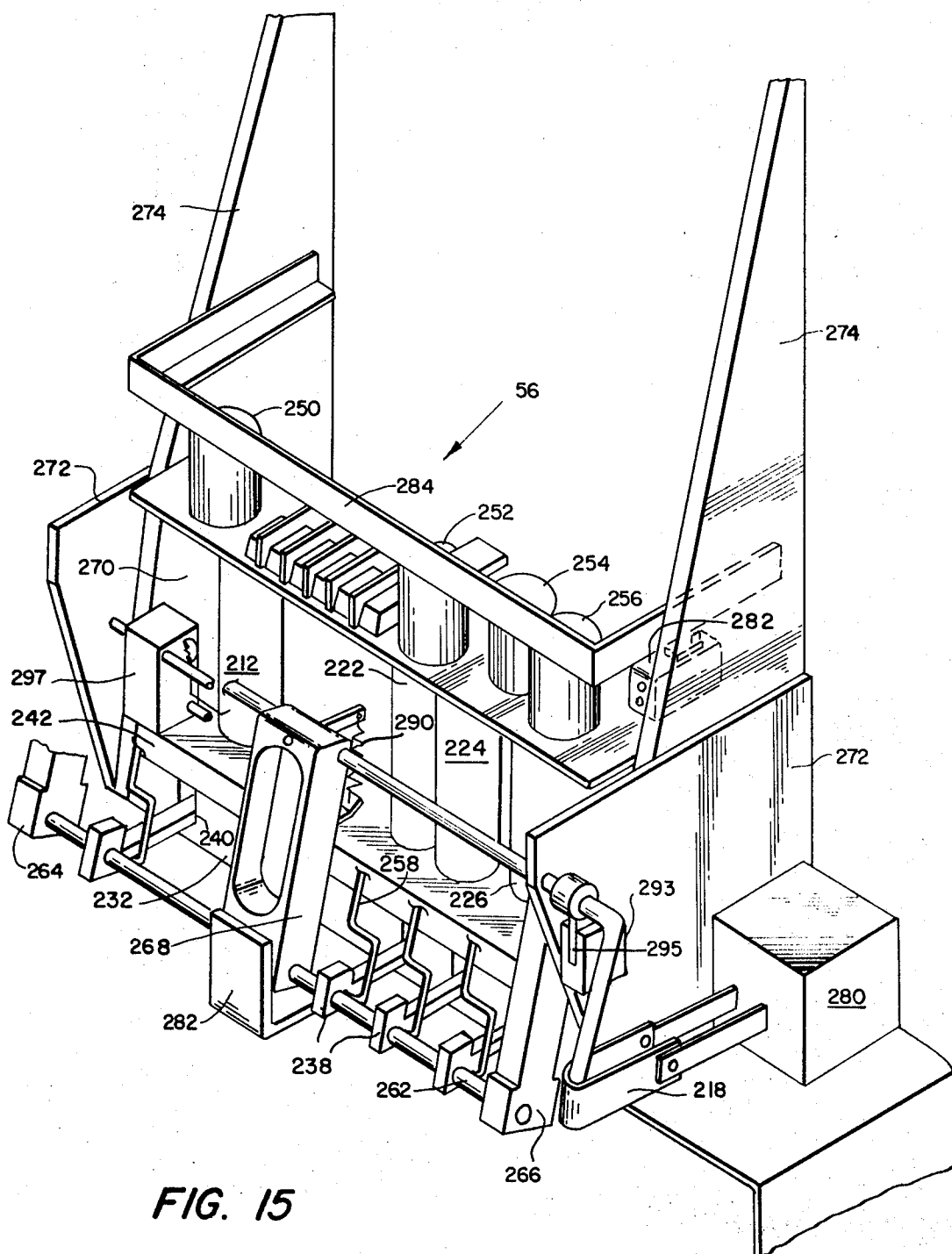


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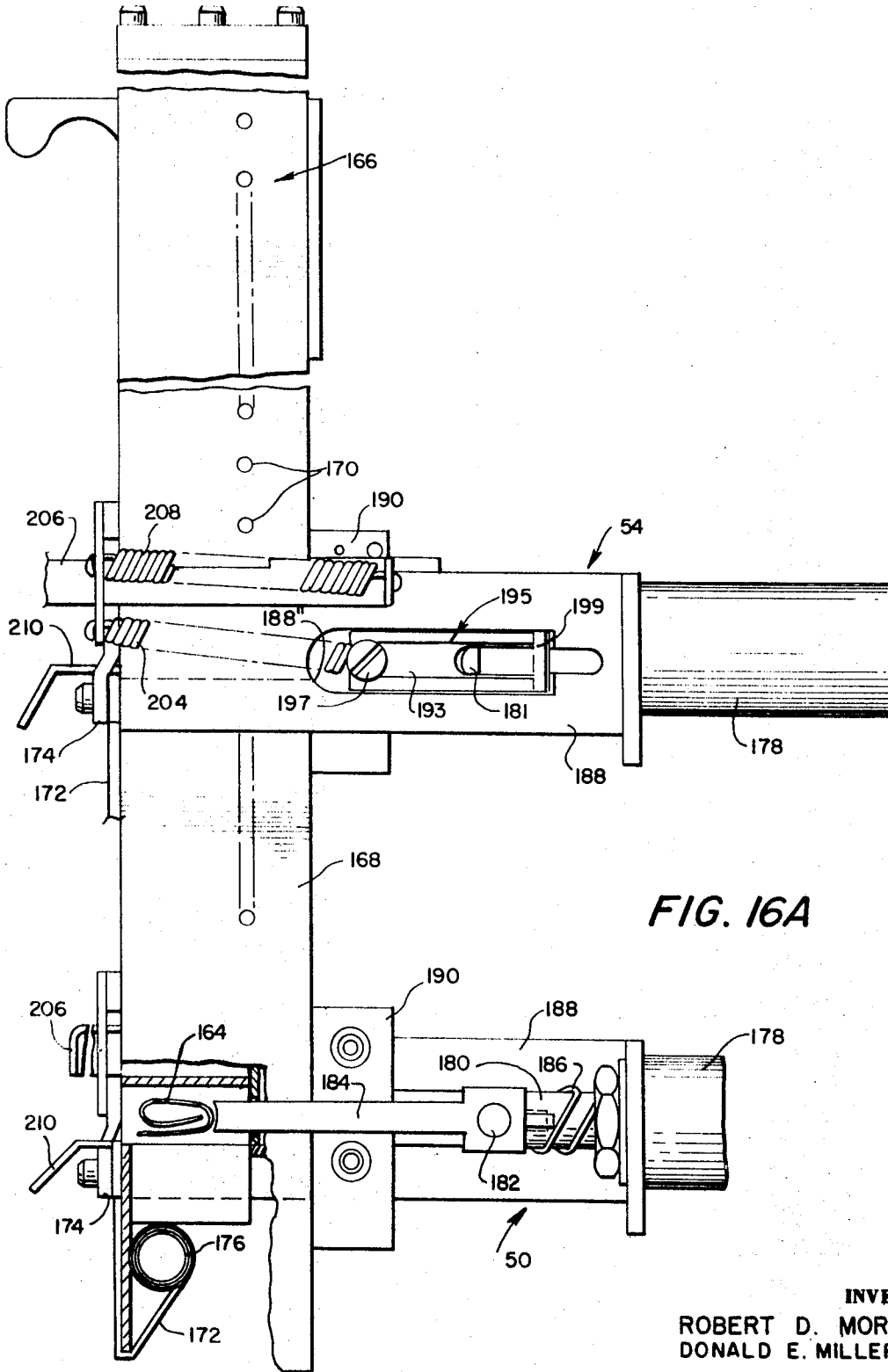


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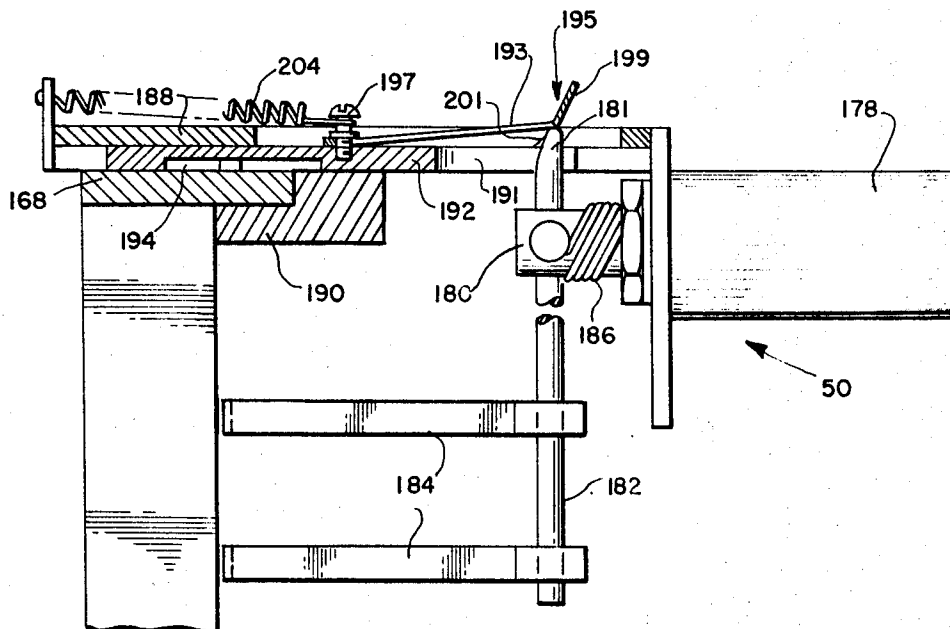
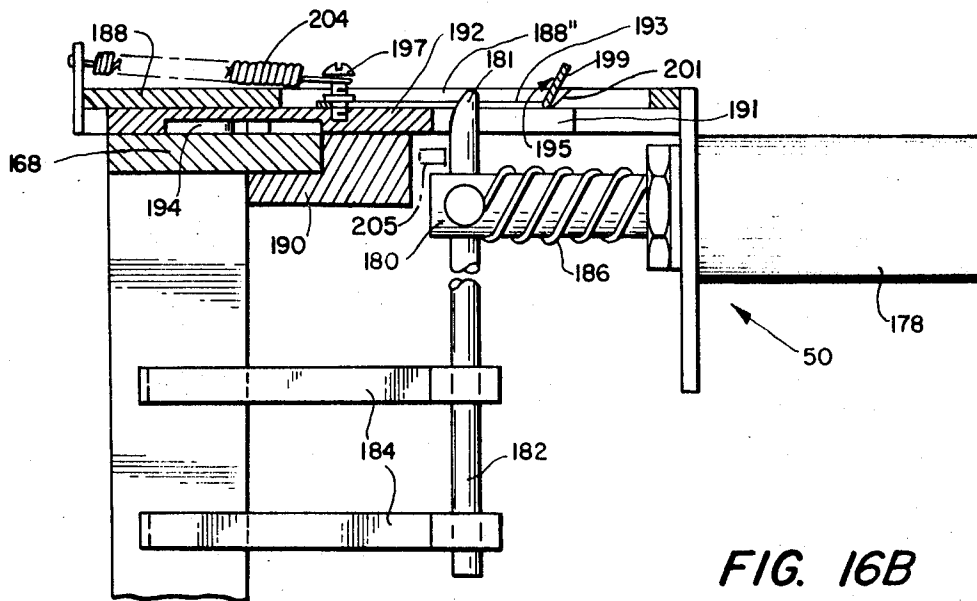


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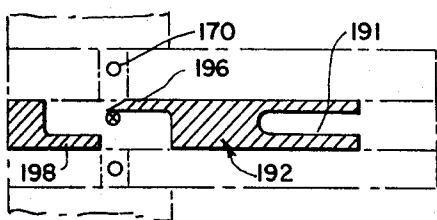


FIG. 16E

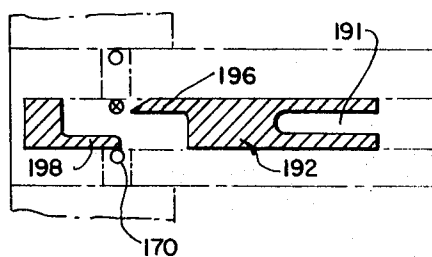


FIG. 16F

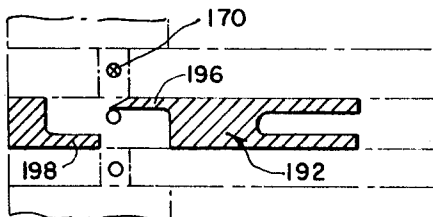


FIG. 16G

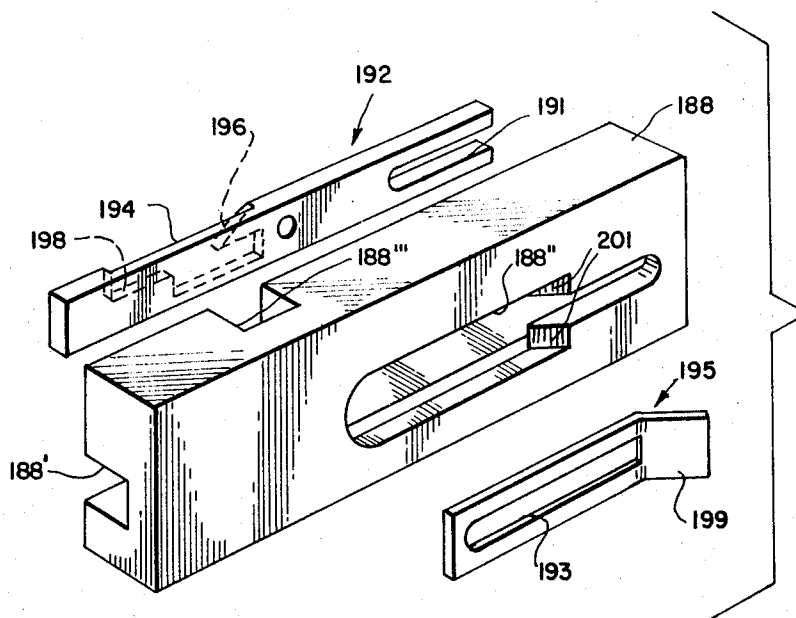


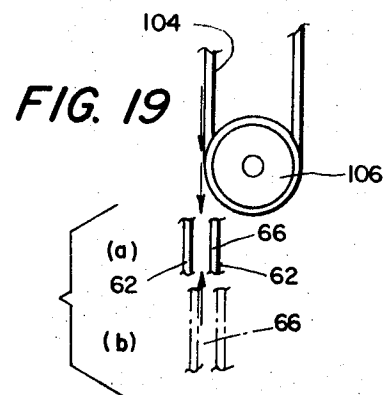
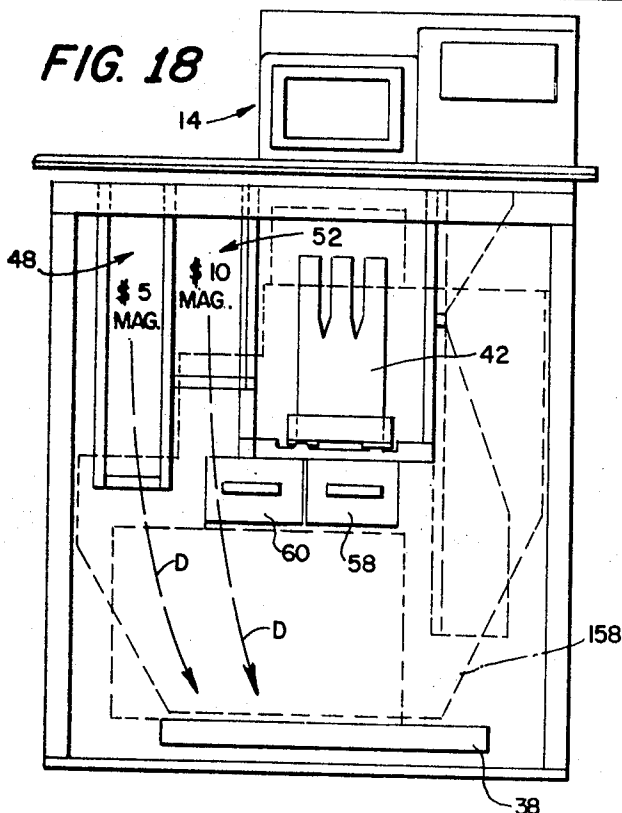
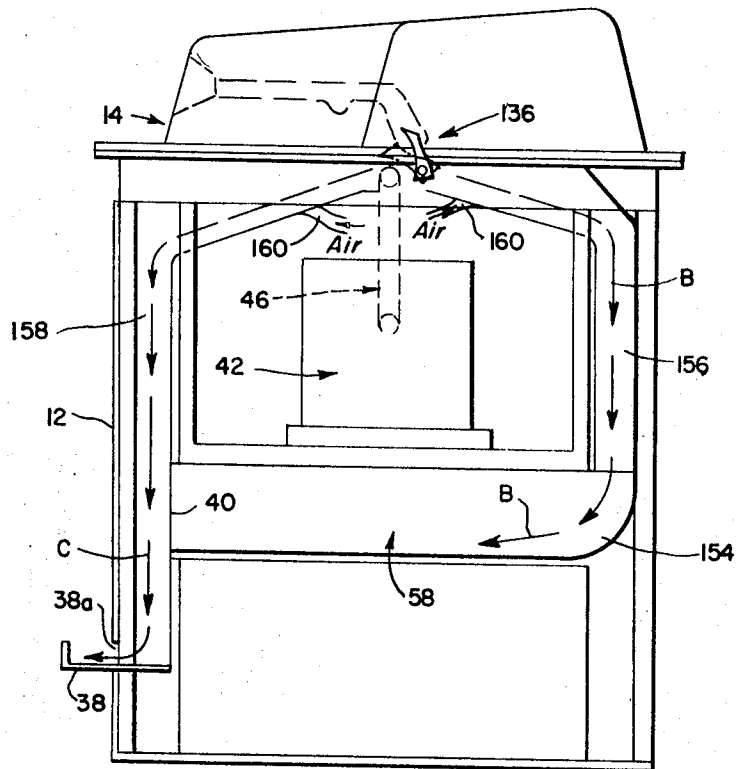
FIG. 16D

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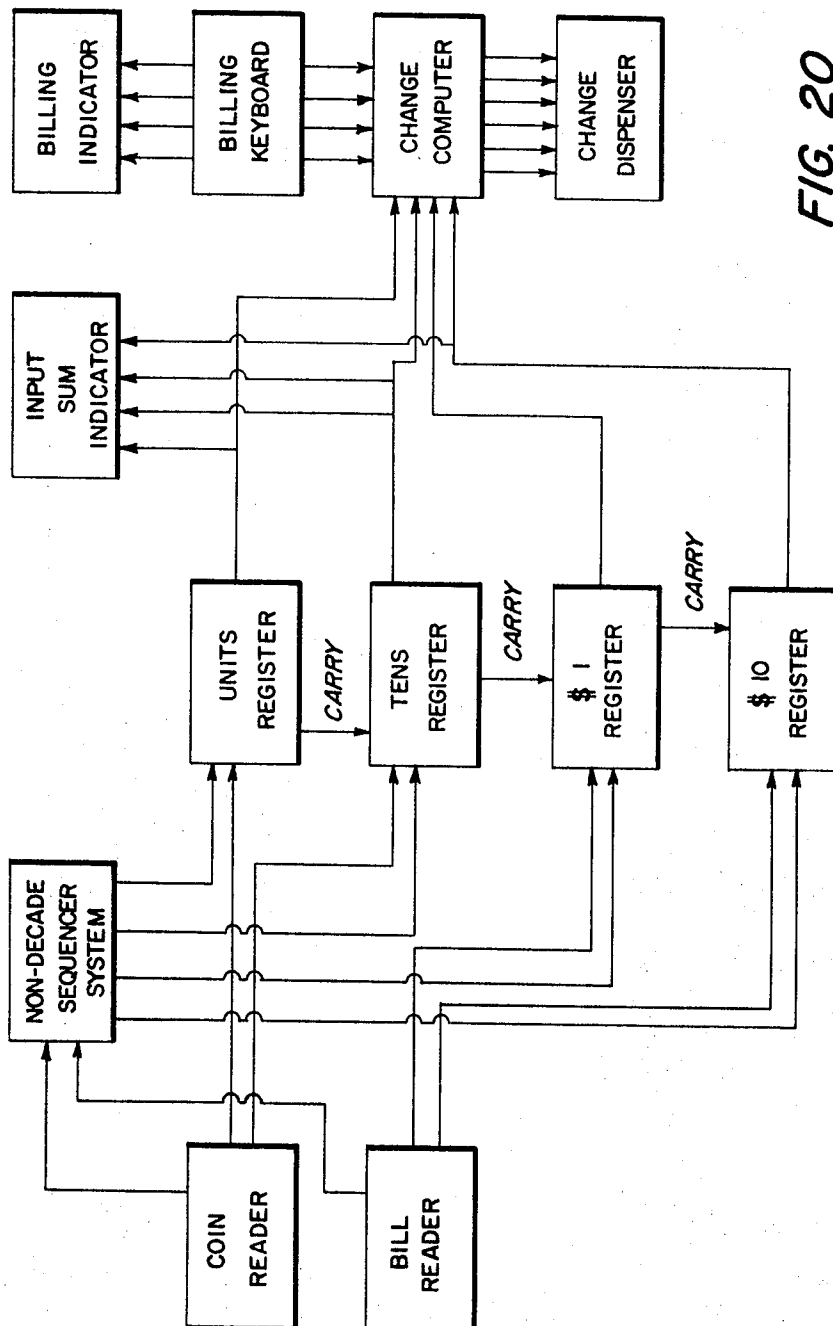


FIG. 20

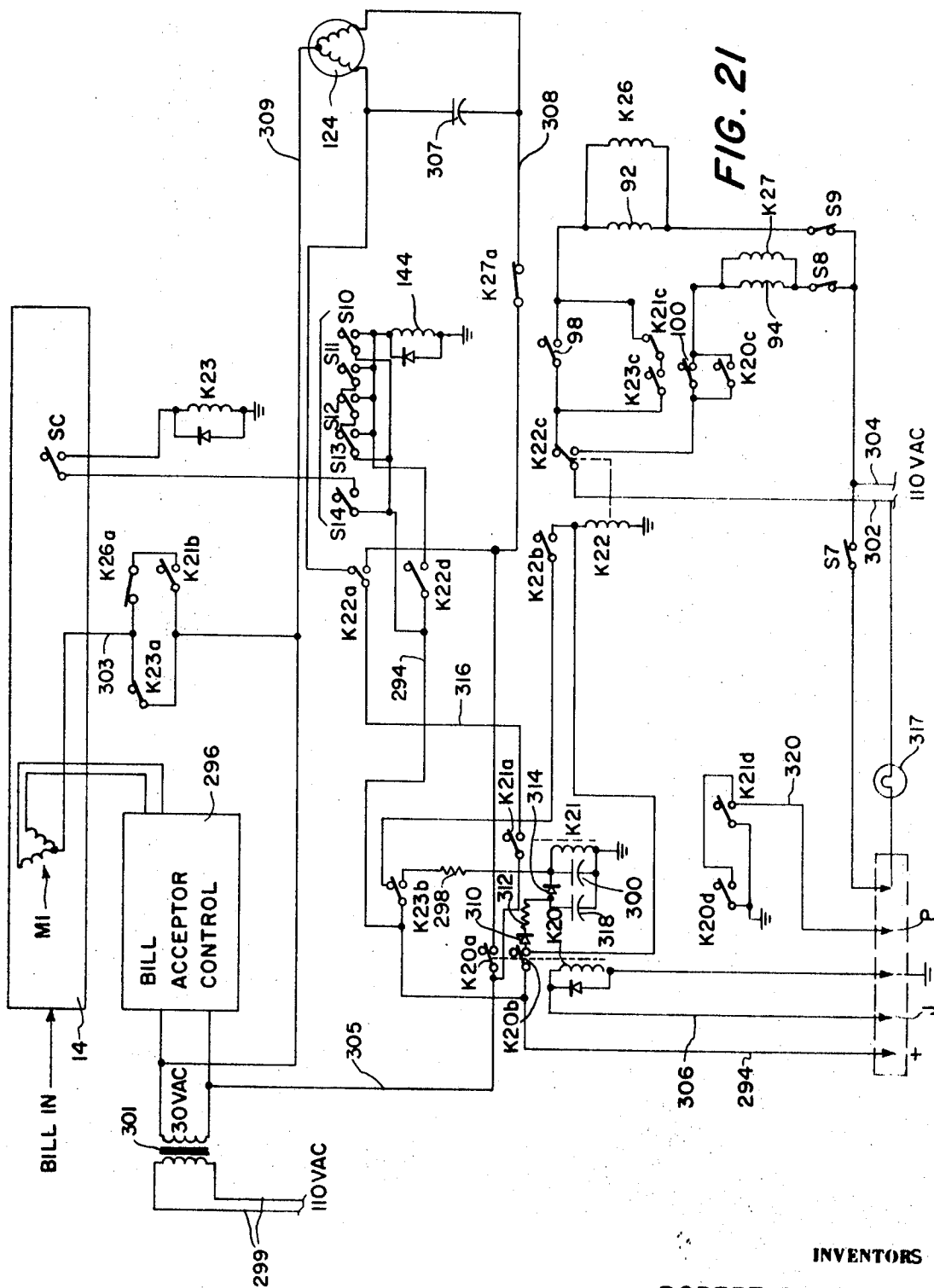
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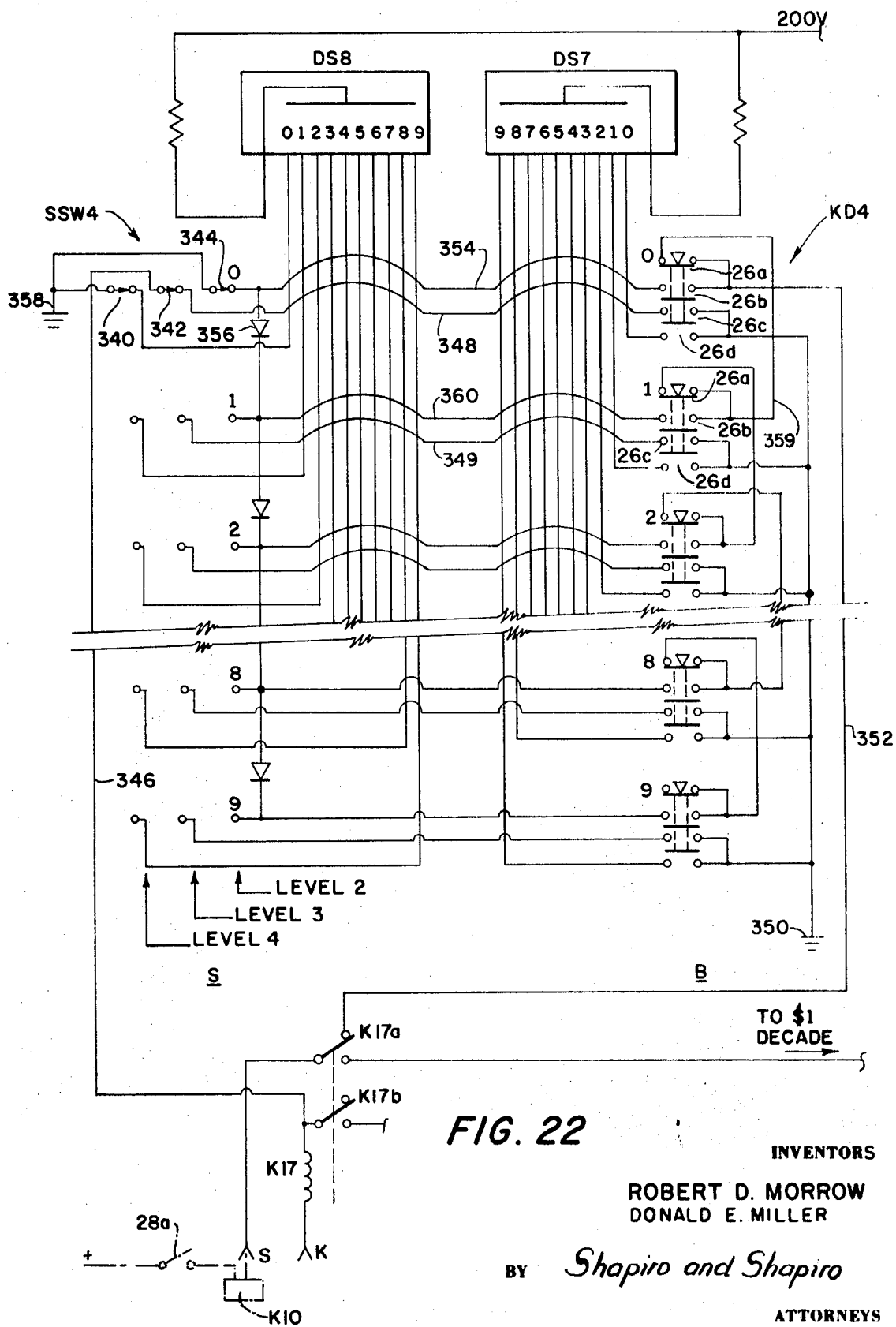


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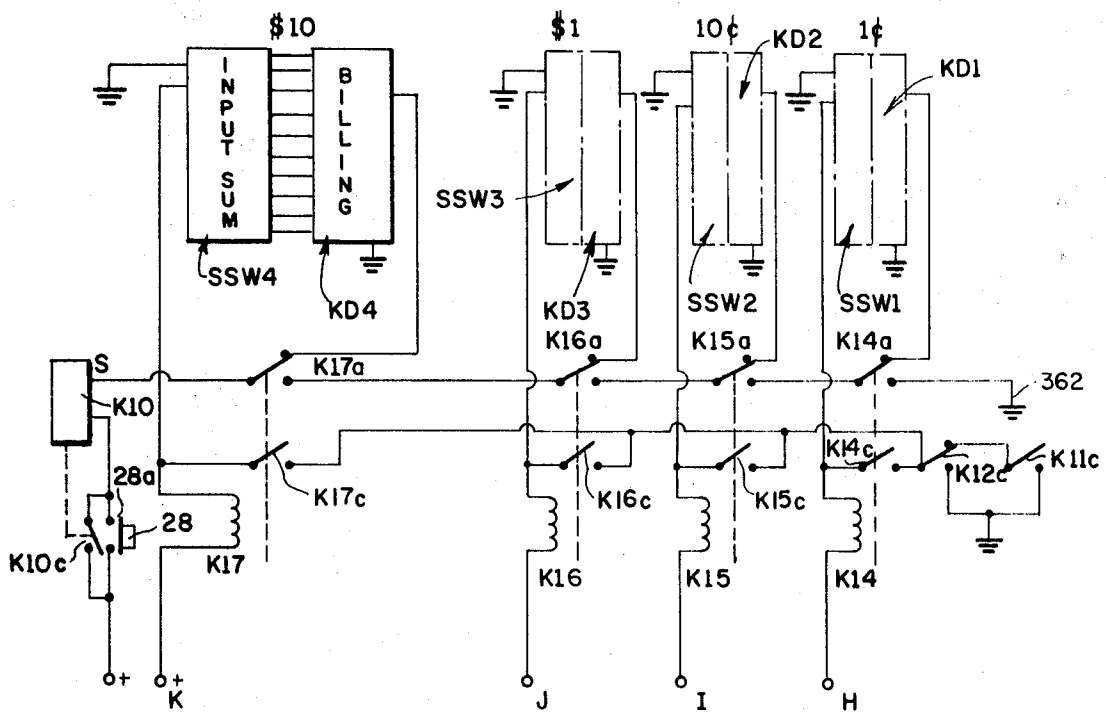


FIG. 23

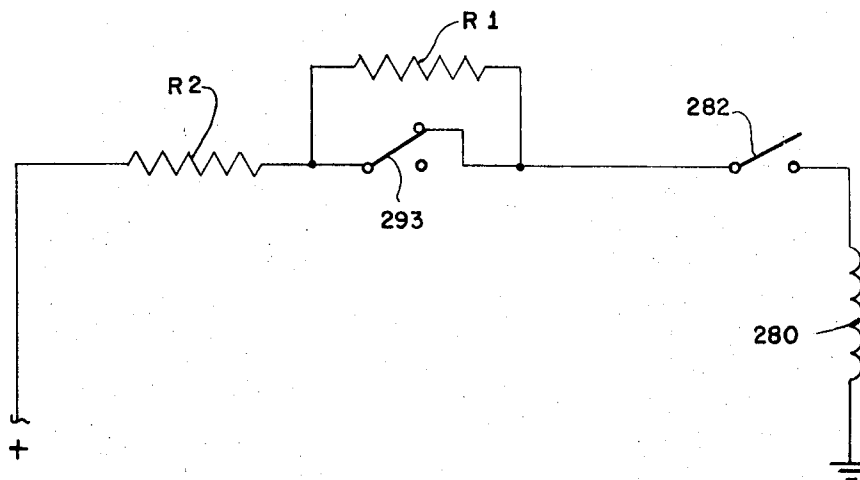


FIG. 24

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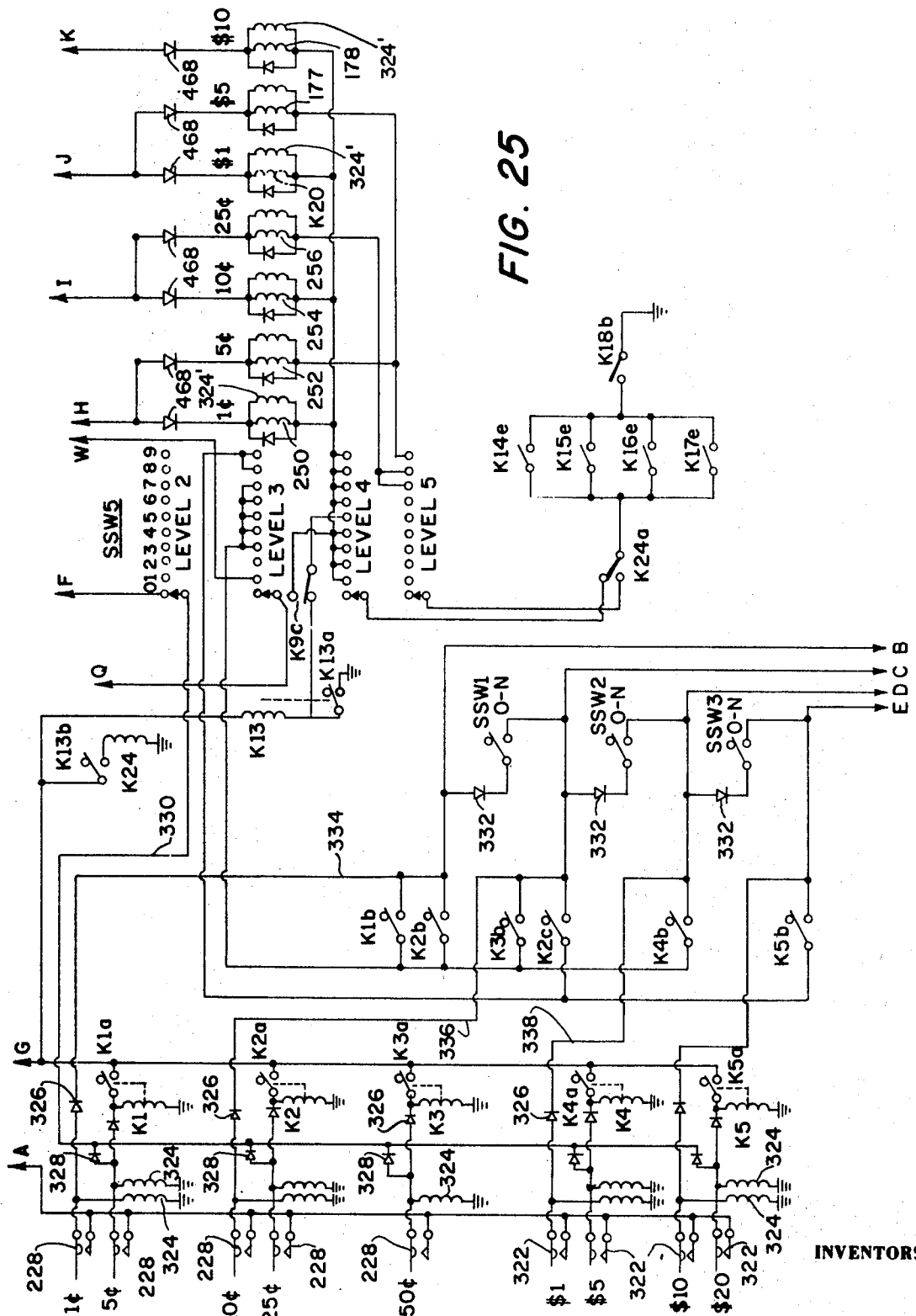


FIG. 25

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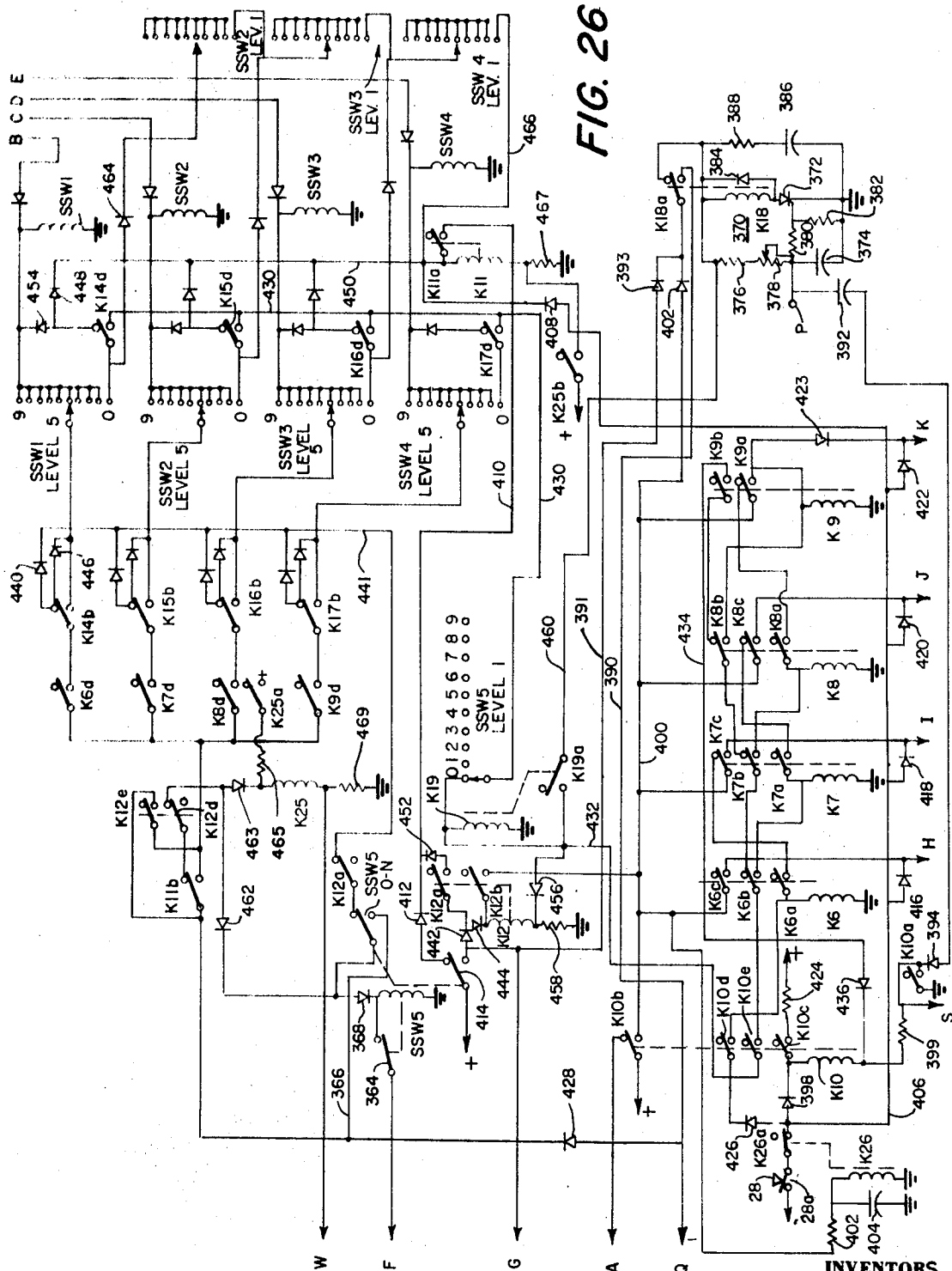


FIG. 26

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APPARATUS AND METHODS FOR REGISTERING CASH, REGISTERING A SALE, AND AUTOMATICALLY DISPENSING CHANGE

BACKGROUND OF THE INVENTION

This invention relates to automatic cash-handling apparatus and methods, and more particularly is concerned with automating the handling of cash covering the amount of a sale and the computing and dispensing of correct change in a manner which is substantially immune to quick theft or embezzlement.

The problem of cash losses due to armed robberies and embezzlement has become increasingly acute in recent years, so much so that insurance to cover such losses is now prohibitively expensive or impossible to obtain in many instances. At least as early as the turn of the century efforts were made to provide so-called automatic cashiers capable of receiving cash, dispensing correct change depending upon the amount of a sale and perhaps also dispensing a selected article of merchandise automatically. To a limited extent automatic vending machines perform the foregoing functions, receiving a quarter, for example, determining the genuineness of the coin, dispensing an article of merchandise, such as a soft drink or candy bar, and returning a dime or other appropriate change. When the apparatus is restricted to the handling of coins, several practical approaches have been found to be commercially successful. However, when an attempt is made to extend the apparatus to handle different denominations of bills, the problem becomes far more complex. Moreover, when large-denomination bills are received and stored, the motivation for theft is greatly increased, and it is essential that the apparatus be immune to cash loss from armed robbery or embezzlement. A practical system capable of reliably handling multidenominational coins and bills has not been achieved heretofore, despite the intense efforts of large research organizations to solve the problem. In general, the art has had to be satisfied with dollar-bill changers, dispensing coins which may be utilized in conventional coin-operated machines.

BRIEF DESCRIPTION OF THE INVENTION

The present invention provides novel apparatus and methods, embodied in a unique machine, for solving the foregoing age-old problem. The system of the invention is, in its basic concept, a simple one. A strong vault capable of storing cash of all types, including bills and coins of different denominations, is permanently anchored beneath the counter of a store or other business establishment. A keyboard and visual electronic display, similar to a cash register, is located above the counter together with one or more slots for receiving bills and coins. When a purchase is made, the attendant (or the customer) puts the money tendered into the machine, and the amount of the sale is entered upon the keyboard. Instantly, a determination is made as to the genuineness of the cash received, the cash is automatically registered, and the proper change is returned to the customer. No money can be disbursed without a larger amount being put into the machine. Neither the customer nor the attendant has access to the cash stored in the machine, which may be accessible to a limited number of authorized personnel, such as the employees of a bonded service company.

In a specific embodiment of the invention step switches constitute decimal registers for totalizing the cash input. A comparison is made between the state of step-switch registers and the setting of a keyboard representing the amount of a sale. If the input sum is greater than the amount of the sale, computation of the amount of change to be dispensed (and the actual dispensing of the change) is accomplished by a dynamic subtraction technique, decade by decade, during which the step switches are returned to their home positions. Both bills and coins are received and dispensed as change, bills being received by a bill acceptor and coins being received by a coin acceptor. Coins are segregated by the acceptor in accordance with their value. Dollar bills are automatically loaded in a special multicellular magazine from which the bills are automati-

cally dispensed as change. \$5, \$10, and \$20 bills are directed to a cash repository (together with \$1 bills received when the \$1 magazine is full). \$5 and \$10 bills are automatically dispensed as change from multicellular magazines which are loaded by authorized personnel.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described in conjunction with the accompanying drawings, which illustrate a preferred and exemplary embodiment, and wherein:

FIG. 1 is a perspective view of a machine in accordance with the invention;

FIG. 2 is a front elevation view of the machine with the front cover broken away;

FIG. 3 is a rear elevation of the machine with the rear cover broken away;

FIG. 4 is a side elevation view of the machine with the side cover broken away;

FIG. 5 is a fragmentary perspective view of the \$1 bill magazine and magazine transport;

FIG. 6 is a fragmentary end elevation view of a portion of the \$1 bill magazine transport;

FIG. 7 is an end elevation view, partially broken away, illustrating the \$1 bill conveyor and associated bill director;

FIG. 8 is a sectional view taken along line 8—8 of FIG. 7;

FIG. 9 is a side elevation view of the \$1 bill conveyor and associated bill director, as seen from the side opposite to that of FIG. 8;

FIG. 10 is an end elevation view of a coin acceptor and dispenser employed in the invention;

FIG. 11 is a side elevation view of the coin acceptor and dispenser;

FIG. 12 is a sectional view taken along line 12—12 of FIG. 11;

FIG. 13 is a similar sectional view illustrating the apparatus in a different condition;

FIG. 14 is a fragmentary perspective view of a detail of the coin dispenser;

FIG. 15 is a fragmentary perspective view of principal parts of the coin dispenser;

FIG. 16A is a fragmentary side elevation view, partly broken away, of \$5 and \$10 magazines and associated bill ejectors;

FIG. 16B and 16C are horizontal sectional views illustrating the operation of the bill ejectors;

FIG. 16D is an exploded perspective view of components of the bill ejectors;

FIGS. 16E, 16F, and 16G are diagrammatic views illustrating the operation of the bill ejectors;

FIG. 17 is a diagrammatic side elevation view illustrating the paths of bills through the machine;

FIG. 18 is a similar diagrammatic view as seen from the front of the machine;

FIG. 19 is a diagrammatic view illustrating the loading and unloading of the \$1 bill magazine;

FIG. 20 is a block diagram illustrating the cash-handling system of the invention;

FIG. 21 is a combined block and schematic diagram illustrating the apparatus and circuits for accepting and conveying bills and for operating the \$1 bill transport;

FIG. 22 is a contracted schematic diagram illustrating, for one decade, a step-switch register and associated keyboard register, together with indicators, for performing a comparison operation;

FIG. 23 is a combined block and schematic diagram illustrating the apparatus for performing the comparison operation for all decades;

FIG. 24 is a schematic diagram illustrating a portion of the energizing circuit for the coin dispenser;

FIG. 25 is a schematic diagram illustrating addition circuits for cash received and illustrating change-dispensing circuits;

FIG. 26 is a schematic diagram of subtraction and other circuits in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

General Apparatus of the Invention

The general apparatus or machine of the invention comprises, as shown in FIG. 1, a vault 10, which, for illustrative purposes, is shown as a rectangular cabinet to which access is obtained through a locked door 12. In practice, the vault will be heavily constructed of suitable theft-resistant materials and will be provided with the desired secure locks, which may include a time lock and a combination lock for example. The vault 10 may be incorporated into a counter (not shown) of a business establishment and firmly anchored.

The upper portion of the machine of the invention is provided with a bill acceptor 14 having an entry slot 16 into which bills may be inserted. A series of pushbuttons 18 is located adjacent to the entry slot, the appropriate pushbutton being pressed before insertion of a bill into the acceptor, so that the acceptor will be informed as to the denomination of the bill to be recognized. Two coin slots are also provided, slot 20 receiving pennies only, and slot 22 receiving all other denominations of coins up to and including fifty-cent pieces. A pushbutton 24 is provided for operating the conventional rejected coin return. A keyboard 26 is provided comprising four columns of 10 keys, the columns corresponding to four decades, namely, (from right to left) one-cent, ten-cent, one-dollar, and ten-dollar. Each decade has keys numbered from zero to nine, the keys of each decade being mechanically interlocked in a conventional manner, so that only one key of a decade can be depressed at a time. Also present at the top of the machine is a pushbutton 28 for commencing the change computation and dispensing operation, and a pair of indicator lights 30 and 32 for indicating that the machine is operative and that \$1 magazine is almost empty, respectively. An indicator 34, which may be comprised of gaseous discharge numeric indicator (Nixie) tubes, designates the sum of money inserted in the machine before a change-dispensing operation. A similar indicator 36 (FIG. 3) designates the amount of the sale or billing as represented by the setting of the keyboard 26. A tray 38 receives the change dispensed by the machine and is manually accessible.

Referring to FIG. 2, many of the major components of the machine can be seen when the front panel (including the door 12) and an inner skin 40 spaced inwardly therefrom are broken away. These components include \$1 magazine 42, the \$1 bill magazine transport 44, the \$1 bill conveyor 46, the \$5 bill magazine 48, the \$5 bill ejector 50, the \$10 bill magazine 52, and the \$10 bill ejector 54. Partially visible is the coin acceptor and dispenser 56. The dead-storage cash receptacle 58, cash-counter box 60, and step-switch logic box 61 are also indicated.

\$1 Bill Handling

An important subcombination of the machine is the apparatus for handling \$1 bills. Dollar bills are automatically inserted into and dispensed from the \$1 bill magazine 42, which is shown in greater detail in FIG. 5. The magazine comprises a series of parallel thin metal plates 62 which are spaced apart 0.125 inch by spacer bars 64 inserted between marginal side and bottom regions of the successive plates and joined to the plates to constitute a series of cells 66, each of which is intended to receive an unfolded \$1 bill with the bill oriented in a vertical plane parallel to the plates 62. Each plate 62 is provided with a pair of notches 68 which are open at their upper extremities and which may taper to a point at their lower extremities. The notches of the successive plates are aligned so that two grooves are in effect formed through the magazine along the length thereof. Each cell 66 may be 2.875 inches wide and 7.031 inches high. The notches 68 may be 3.375 inches long, 0.625 inch wide at the top and of uniform width to 5.5 inches from the top, and spaced 0.718 inch from the adjacent side edges of the plate 62. The upper extremities of the side spacers may taper to a point.

The magazine 42 is fixed to a baseplate 70, which is part of the magazine transport. Affixed to the bottom of baseplate 70 and extending longitudinally of the magazine is a pair of paral-

lel skids 72 and 74, the latter of which is provided with a trapezoidal-cross-sectional longitudinal notch 76, which, as shown in FIG. 6, complements a matching elongated rail 78 provided upon a table 80 of the machine frame which supports the \$1 magazine. A parallel unnotched rail 82 engages the skid 72. The arrangement is such that the \$1 magazine may reciprocate smoothly and rectilinearly along the table 80 in a direction parallel to the front-to-back axis of the machine. A gear rack 84 is fixed to one side of the baseplate 70 and constitutes a portion of the drive mechanism of the \$1 magazine transport. Corners of the baseplate 70 at one side thereof are provided with brackets 86 and 88 for actuating microswitches S7-S10 as will be described hereinafter.

Referring to FIGS. 2 and 3, the \$1 bill magazine 42 is driven by a rack and pinion mechanism including the rack 84 and a pinion 90. The pinion is fixed to the end of the common shaft of a pair of tandem-arranged electric motors 92 and 94, which may be of the type sold as Model 45 by Energy Conversion Systems Corporation, Grafton, Wisconsin. Motor 92 drives the \$1 bill magazine in one direction for loading of the bills into the magazine, while motor 94 drives the magazine in the reverse direction for dispensing of the bills. Motors of the type specified were chosen because of their ability to index precisely, so that the magazine may be accurately positioned by incremental movement of the respective motors, for proper insertion and withdrawal of \$1 bills. The motors are energized in a manner to be described hereinafter, and are deenergized by a cam and microswitch arrangement including the cam 96 and the microswitches 98 and 100 (see FIG. 4). The cam is fixed to the motor drive shaft along with pinion 90 and is provided with a series of circumferentially spaced notches 102. The microswitches 98 and 100 are supported upon the frame adjacent to the cam with their actuating feelers positioned so that the feeler of one switch enters a notch while the feeler of the other switch rests upon the rise between successive notches. As will be set forth later, each microswitch serves to deenergize an associated motor when the microswitch feeler enters a notch of the cam.

As shown in FIG. 2, the \$1 bill conveyor 46 comprises a pair of endless belts 104 which depend into and are aligned with the grooves constituted by the notches 68 of the \$1 bill magazine. The belts extend downwardly to the region where notches 68 start to taper. As shown in FIGS. 7-9, the endless belts 104 travel over spaced pulleys 106 and 108, pulleys 106 being rotatably supported as idlers between pairs of sideplates 110 which depend from a block 112. The sideplates are braced by spacers 114 which also depend from the block. Pulleys 108 are fixed (between coaxial spacer rollers) to a shaft 116 rotatably supported upon block 112. One end of shaft 116 is fixed to a sprocket 118 driven by a cogged belt 120 (see FIGS. 2 and 3) in turn driven by a sprocket 122 fixed to the shaft of an electric motor 124 supported on the machine frame. As shown in FIG. 2, the position of the belt conveyors 104 is selected so that when the \$1 bill magazine 42 is empty, it may move freely relative to the belts, the belts passing readily through the notches 68.

Provided in conjunction with the belts 104 is a set of spring plates 125-129, which are preferably of thin beryllium copper, plates 125, 126 and 128, 129 being fixed along an outer edge thereof to portions 130 and 132 of the block 112 and plate 127 being centrally depressed and fixed to another portion of the block. Upper and lower portions of each plate are rolled back as indicated at 134. Plates 125 and 128 tend to rub lightly upon the belts 104. The net effect is that if a thin sheet of paper, such as a \$1 bill, is positioned so as to span the distance between the belts adjacent to the spring plates, it will be supported by the plates and squeezed lightly between the belts and plates 125 and 128, so as to create traction upon the bill and ensure its feed movement.

As shown in FIGS. 7-9, associated with the \$1 bill conveyor is a bill director 136, which is a curved vane constituted by a group of spaced tines 138 fixed to a shaft 140. The shaft is supported for pivotal movement upon the block 112, so that the

director may be moved between an upward position shown in full lines in FIGS. 7-9 and a downward position shown in phantom lines in FIG. 8. In the upward position all bills fed from the bill acceptor pass downwardly into the \$1 bill conveyor. Hence, the director is in its upward position only when \$1 bills are being received. In the downward position all incoming bills are directed over the top surface of the director to a chute which will be described more fully hereinafter. Also, when the director is in its downward position, any \$1 bills fed upwardly by the \$1 bill conveyor engage the curved undersurface 142 of the director and are deflected into another chute to be described. The director is operated by a solenoid 144 mounted on the block 112, the plunger 146 of the solenoid being connected to a crank arm 148 fixed to shaft 140, so that when the solenoid is energized, the director is moved to its downward position. A return spring indicated at 150 in FIG. 9 and engaging an extension of the crank arm 148 serves to hold the director in its normal upward position.

FIG. 4 illustrates the relationship of the \$1 bill conveyor, the director, and the bill acceptor. The bill acceptor may be of a type BA-2 sold by Rowe International, Whippany, New Jersey (modified as will be described hereinafter). As shown in FIG. 4, a \$1 bill fed into the acceptor follows the path indicated by arrows A, passing between the rollers 152 of the bill acceptor and downwardly along the \$1 bill conveyor into a cell of the magazine 42. The tines 138 of the director 136 extend upwardly through a slot 151 (FIG. 8) in the top plate 153 of the machine. Additional guides, such as wire or leaf springs, may be placed adjacent the acceptor outlet to deflect the \$1 bills downward.

FIG. 19 indicates the relationship of the \$1 bill magazine to the \$1 bill conveyor for inserting bills into the machine *a* and for withdrawing bills from the magazine *b*. It will be noted that when a \$1 bill is inserted into the magazine, the cell to receive the bill is centrally aligned with the path of the bill followed through the \$1 bill conveyor, so that the bill drops down into the center of the cell, that is, midway between the plates 62 constituting the cell walls. On the other hand, when the \$1 bill is withdrawn from the cell, the cell is positioned so that the rear wall of the cell is substantially aligned with the path to be followed by the bill. The bill is therefore pressed against the rear wall by the portions of the conveyor belts 104 which depend into the cell, and sufficient traction is exerted upon the bill to assure that the bill is lifted until it enters between the belts and the cooperating spring plates. The magazine moves to the right in FIG. 4 when it is being indexed for loading with \$1 bills and moves to the left in FIG. 4 when it is being indexed for dispensing of \$1 bills. The cells are loaded in succession and emptied in succession, each cell being filled or emptied in turn. The precise positioning of the cells relative to the \$1 bill conveyor is controlled by the cam 96 and the microswitches 98 and 100, which, as described above, ensure that the drive motors for the \$1 bill magazine transport are deenergized for proper registration of the cells with \$1 bill conveyor.

FIG. 17 shows other paths of bills in the machine. Arrows B show the path followed by incoming bills into the dead storage drawer 58 (director 136 downward). The rear portion 154 of the drawer is curved to form a continuation of a chute 156 which extends downwardly from the bill director, so that incoming bills which pass over the upper surface of the bill director may be transported to the dead-storage drawer 58. All accepted \$5 bills, \$10 bills, and \$20 bills follow the path B into dead storage. When the \$1 bill magazine is full, as determined by the actuation of microswitch S10, the bill director is in its downward position, and all further \$1 bills entered into the machine are directed along path B.

When \$1 bills are dispensed from the machine, they follow the path indicated by arrows C, passing upwardly along the \$1 bill conveyor 46, engaging the curved undersurface of the bill director (which is downward), and then passing downwardly through a chute 158 located between the door 12 of the cabinet, and the inner skin 40 and extending downwardly from the region of the bill director. To facilitate the movement of

the bills through the chutes 156 and 158, air may be blown into the chutes from a blower (not shown) as indicated by the air inlets at 160. The air exhausts from the chutes through suitable openings at the front of the dead storage drawer 58 and through the cabinet opening 38a associated with the tray 38.

FIG. 18 shows the path D of \$5 and \$10 bills dispensed from the machine through chute 158.

\$5 and \$10 Bill Dispensing

The \$5 and \$10 bill magazines 48 and 52 are shown in FIG. 2. Each magazine comprises a vertical column of horizontally elongated cells open at the front and closed at the back except for a pair of slots 162. Each cell receives a rolled or folded \$5 or \$10 bill as indicated at 164 in FIG. 16A. The multicellular magazines may be removably supported in a frame 166, so that loaded magazines may be readily inserted into the machine. The bills are ejected from the magazines by the solenoid-operated ejectors 50 and 54 shown in FIG. 16A. The ejectors are adapted to ride along the side rails 168 of the frame 166, dropping by gravity to rest upon each of a plurality of horizontal pins 170 which project laterally from the rails 168 at the opposite sides of the frame 166. Associated with each ejector and magazine is a flexible shield 172, which has its free end attached to a plate 174 extending across the front of the magazine from the associated ejector and which has its opposite end connected to a spring-wound drum 176, the shield being unwound from the drum when the ejector is placed in its uppermost position and rewinding onto the drum under the action of the drum bias spring as the ejector moves downwardly along the magazine. The shield may be formed of a suitable flexible steel strip or mesh or of an appropriate strong plastic material. The purpose of the shield is to close off the front of the loaded magazine cells in order to avoid the possibility of unauthorized extraction of bills from the cells by an implement inserted through the opening 38a associated with tray 38.

As shown in FIGS. 16A and 16B, each ejector has a solenoid 178 with a plunger 180 carrying a rod 182 to which a pair of parallel ejector bars 184 are secured. The bars 184 are adapted to enter the cells through the corresponding slots 162 at the rear of the cells when the solenoid is deenergized and to push a bill 164 from a cell under the action of a plunger return spring 186. The solenoid is mounted upon a slide retainer 188 which cooperates with a retainer block 190 and plate 174 to hold the ejector upon the associated rail. The slide retainer has a horizontal slot 188' containing a slidable pawl assembly 192 (FIG. 16D), which is a bar of generally rectangular configuration having a groove 194 therein provided with a tapered pawl member 196 and a rectangular pawl member 198. Normally when the ejector is at rest, the tapered pawl member 196 overlies a pin 170, as indicated by the X'd pin shown in FIG. 16E. When the solenoid is energized by a pulse, the plunger 180 pulls into the solenoid, causing the end 181 of rod 182 to move from the position of FIG. 16B to the position of FIG. 16C. At first the end 181 slips along a slot 191 of the pawl and a slot 293 of a pawl latch 195 without moving the pawl. The latch is of springy material attached to the pawl by a screw 197 at one end of the latch and rides in a window 188'' of the retainer. When the end 181 reaches the bent portion 199 of the latch, the pawl is pulled to the position of FIG. 16F, releasing pawl element 196 from the X'd pin and permitting the ejector to drop (by virtue of vertical slot 188''' in retainer 188) until pawl element 198 rests on the next pin. End 181 continues pulling on the latch, causing the bent portion 199 to ride up an incline 201, as shown in FIG. 16C. The latch then rides off of end 181, releasing the pawl to return to its rest position under the action of return spring 204. The ejector drops further until pawl element 196 rests on the next pin as shown in FIG. 16G. The plunger 180 continues to retract for a while and then returns to the position of FIG. 16B under the bias of spring 186 when the solenoid is deenergized. In so doing, the end 181, which is tapered, rides under the bent portion 199 of the pawl latch, which flexes out of the way. When

the solenoid becomes deenergized, the bars 184 enter the newly associated cell of the magazine under the influence of the plunger return spring 186, ejecting a bill from this cell. It is apparent, then, that each time the solenoid is energized by a pulse, the ejector drops down to the level of the next cell and then ejects the bill from that cell.

In order that the ejectors may be moved manually (particularly to place them in their uppermost position when the magazine is empty) a push rod 206 is provided, which rides on the top of associated retainer plate 188. The push rod has a depending arm 205 (see FIG. 16B) which pushes the rod 182 and solenoid plunger rearwardly so that the ejector bars 184 are withdrawn. The ejector may then be moved upwardly, the pins 170 engaging the inclined upper surface of the tapered pawl member 196, camming the pawl member out of the way. Spring 208 is a return spring for the push rod 206. A lift bracket is provided at 210 to provide a convenient handle for lifting the ejector assembly, and also to provide a downwardly inclined surface which ensures that the ejected bills do not hang up on any portion of the retainer bracket. Ejected bills drop through the chute 158 previously described into the same tray 38 as the dispensed \$1 bills.

Coin Acceptor and Dispenser

The coin acceptor and dispenser is shown in FIGS. 10-15. Pennies enter the chute 212, while all other coins enter the chute 214. In the model shown no determination is made as to the genuineness of pennies. All other coins enter a coin rejector unit 216, such as Model 1-15-053 sold by National Rejector Company. The coin rejector unit determines whether coins are genuine, directs defective or fraudulent coins to a rejector chute 218 and segregates genuine coins into four chutes 220 (FIG. 10), 222, 224, and 226 (FIG. 11), which receive half-dollars, nickels, dimes, and quarters, respectively. Each of the coin denomination chutes is provided with a microswitch such as switch 228, having a feeler wire extending through a slot 230 into the chute, so that the switch is actuated once for each coin received in the chute. Further reference will be made to the switches hereinafter.

At the bottom of the coin chutes 212 and 222-226 is a block 232 having an appropriately dimensioned coin-receiving recess with a pair of shoulders 234 (see FIG. 14) under each such coin chute. The coin at the bottom of each of these coin chutes rests upon the associated shoulders 234. It may be pushed off of the shoulders and down an incline 236 by a pick 238, if the pick is raised and moved longitudinally, as shown in FIG. 13, so as to engage the edge of the lowermost coin and push the coin off the shoulders. The pick enters the block 232 through a slot 240 and moves along the lower surface of a cap plate 242 resting upon block 232 and provided with circular openings of appropriate dimensions to receive the lower end of the corresponding chutes. A resilient retainer 244 (FIG. 14), which may be a cylindrical Mylar or Teflon sleeve set vertically into a well of the block 232, prevents inadvertent release of a coin due to vibration of the machine, being resiliently compressed when a pick forces a coin from one of the recesses of block 232, each recess being provided with a retainer of the type described. The ejected coins strike a curved deflector 246 (FIG. 12) and then drop vertically into the tapered mouth at the top of an elongated chute 248 (see FIGS. 11 and 12), the chute being inclined downwardly so that the coins roll to the bottom of the chute and then drop into the tray 38 via the lower part of chute 158 (FIG. 17). Fifty-cent pieces are not dispensed, and upon being accepted roll down their own chute 220 (FIG. 10) and pass through a slot (not shown) in the adjoining wall of the dead storage cash-box 58.

As noted above, a coin is pushed from the bottom of a coin chute when the associated pick 238 is raised to an operative position and moved longitudinally. The raising of the picks is accomplished by a group of solenoids 250, 252, 254, and 256. Each solenoid has a depending link 258 pivotally attached to its plunger 260. Each pick is pivotally attached to the bottom of a link 258 intermediate the free end, which engages the

coins, and the opposite end, which is pivotally supported upon a rod 262. Rod 262 is part of a frame comprising a pair of side-pieces 264 and 266, an intermediate piece 268, and another rod 270 rigidly fixed to pieces 264, 266, and 268 and pivotally supported upon brackets 272 at opposite sides of the frame 274 of the coin dispenser. Rod 270 passes through a sleeve 276 and then is bent downwardly to engage the yoke 278 at the end of the plunger of a main solenoid 280. Solenoid 280 is energized to pull in its plunger when a microswitch 282 is tripped. The microswitch is actuated by the lifting of a U-shaped yoke 284, the side legs of which are pivoted upon the frame at 286 (FIGS. 12 and 13). Yoke 284 is lifted when any pick solenoid is energized, the plunger of each pick solenoid having an upward extension 288 which projects from the solenoid case as shown in FIG. 13 when the solenoid is energized. Thus, when any pick solenoid is energized by a pulse, the pick is lifted to an operative position and immediately thereafter the main solenoid 280 is energized to turn the entire frame supporting the picks from the position of FIG. 12 against a stop 282 to the position of FIG. 13 against bumpers 289. Whichever pick is lifted, therefore, ejects a coin. When the pulse which energizes the pick solenoid terminates, the pick solenoid drops its plunger under the influence of gravity and a plunger return spring (not shown), and the yoke 284 drops under the influence of a gravity and a return spring 291, deenergizing main solenoid 280 and permitting the pick frame to return to the position of FIG. 12 under the influence of a return spring 290 secured to the plate 242 and to an arm 292 fixed to the pick frame. The use of a single main solenoid to do the actual coin dispensing permits a powerful coin-ejecting action without the expense of a plurality of such solenoids and permits fast pulse-energized operation. Microswitch 293 is operated by arm 295 associated with sleeve 276. As shown in FIG. 24, when switch 293 opens, a resistor R1 is inserted in series with the energizing circuit of solenoid 280 (which includes resistor R2 and microswitch 282) to reduce the current to the solenoid during the final portion of the stroke (when switch 293 opens). This reduces the shock when the main solenoid 280 operates. Microswitch 297 is typical of a "low coin" switch which may be associated with each coin chute to sense when the supply of coins is almost depleted.

Bill-Handling Circuit

The circuit for controlling the movement of bills into the machine and the dispensing of \$1 bills is illustrated in FIG. 21. Switches S11, S12, S13, and S14 are operated by the pushbuttons 18 of FIG. 1, which are mechanically interlocked in a conventional manner so that depressing any pushbutton releases any that was depressed. When any of switches S11-S13 is closed upon its lower contact, a circuit is completed from the +24-volt DC line 294 through the coil of solenoid 144 to ground. Energizing solenoid 144 moves the bill director 136 to its lower position. Closing switch S10 also energizes solenoid 144. Switch S10 is the limit switch for the \$1 bill magazine and is closed when the magazine reaches the end of its loading travel. Before a bill is inserted into the bill acceptor 14, one of switches S11-S14 is closed upon its lower contact. If S14 is closed, the bill director 136 remains in its upper position, but a circuit from the 24-volt line 294 is extended through S14 to the blade of switch SC.

When a bill is inserted into the bill acceptor 14, the bill acceptor transport motor M1 is energized to advance the bill through the acceptor. The energization of motor M1 is initiated photoelectrically when the bill interrupts a light beam adjacent to the mouth of the acceptor, the motor being controlled by the bill acceptor control unit 296 which forms a part of the Rowe bill acceptor. The motor and the control unit are supplied from the 110-volt AC lines 299 through a stepdown transformer 301. Motor M1 is bidirectional, having a pair of windings connected to a phasing capacitor (not shown) by the control unit 296 to determine the direction of bill feed, the "common" terminal for the windings being connected to transformer 301 by line 303.

The bill acceptor identifies a genuine bill by sensing a grid pattern of the bill magnetically (although other types of acceptors well known in the art may be employed). When one of the switches S11-S14 is actuated, contacts not shown program the bill acceptor to identify the bill of the selected denomination. For example, if the bill acceptor produces a DC output dependent upon integration of a number of pulses produced by the grid lines of a genuine bill within a predetermine interval (for a given bill feed rate), closing of a bill denomination switch may change the time constants of the reading circuits of the bill acceptor and may switch different magnetic read heads into the circuit. The bill acceptor per se does not constitute the present invention, and, if desired, separate acceptors may be employed for the different bill denominations.

As is well known in the art, if an inserted bill is not found to be genuine, the bill acceptor control unit 296 will cause motor M1 to reverse its direction of operation and return the bill through the input slot of the acceptor before the bill can pass through the outlet of the acceptor. If, on the other hand, the bill is determined to be genuine, the motor will continue forward feed of the bill for a time (set by a time-delay unit in the bill acceptor control unit 296) sufficient to feed the bill through the outlet of the bill acceptor.

In the case of genuine \$5, \$10, and \$20 bills, the bills will pass continuously through the acceptor and into the dead storage as described above. In the case of a genuine \$1 bill, however, it is necessary to ensure that an empty cell of the \$1 magazine is positioned beneath the \$1 bill conveyor before the bill is permitted to pass through the acceptor and the conveyor. For this purpose the cam-operated switch SC is provided adjacent to the outlet of the bill acceptor. When the validated \$1 bill reaches a position adjacent to the outlet, it presses laterally upon a cam which actuates the feeler of switch SC and closes the switch, energizing the coil of relay K23 (S14 being closed). When relay K23 is energized, switch K23a opens (all relay switches being identified by the relay reference character plus a letter), deenergizing the motor M1 and initiating a pause in the advancement of the \$1 bill sufficient to permit an empty cell of the \$1 bill magazine to be registered with \$1 bill conveyor. Energization of relay K23 closes switch K23b upon its lower contact and extends an energization circuit from the 24-volt line 294 through a timing resistor 298 to the coil of relay K21, which is bridged by a timing capacitor 300. After a short delay determined by the time constant of the RC network 298, 300, relay K21 is energized, closing switch K21a upon its lower contact and extending an energization circuit from transformer 301, through line 305 and switch K22a to motor 124 for driving the \$1 bill conveyor belt in a direction to advance the bill toward the magazine. Motor 124 is another bidirectional motor having a phasing capacitor 307 and a "common" line 309. Switch K21b closes when K21 is energized, to prepare motor M1 to start again. Before K21 is energized, however, switch K23c is closed by relay K23, extending a circuit from line 302 of the 110-volt AC supply through K23c and K21c to \$1 bill magazine transport motor 92 and through limit switch S9 to line 304 of the AC supply. Relay K26 is also energized, opening switch K26a and preventing motor M1 from being energized. As the \$1 bill magazine commences to move, cam switch 98 closes, to continue the energization of motor 92 after relay K21 is energized (opening K21c). When the \$1 bill magazine has advanced to the desired position, with the next empty cell registered with the \$1 bill conveyor, cam switch 98 opens, deenergizing motor 92 and relay K26. Switch K26a closes, energizing motor M1 again to advance the \$1 bill out of the acceptor, opening switch SC. The resulting deenergization of relay K23 opens the previously closed circuit through switch K23b to relay K21, but relay K21 remains energized, because of the discharge of capacitor 300 through its coil, for a sufficient period of time to permit \$1 bill conveyor motor 124 to remain energized through switch K21a until the \$1 bill is advanced into the magazine. Then relay K21 drops out, deenergizing motor 124.

During dispensing of \$1 bills, line 306 is connected to +24 volts at terminal J, and an elongated pulse (ground voltage) is applied to the lower end of the coil of relay K20, energizing K20, which closes switches K20a and K20b. The closing of switch K20a extends an energization circuit from line 305 to motor 124 by means of line 308, causing motor 124 to operate in a direction to drive the \$1 bill conveyor in a bill-dispensing direction. The bill will not be moved from the magazine, however, until the magazine is moved to align the rear wall of a bill-containing cell with the conveyor belts as set forth previously. The closing of switch K20b extends a circuit through diode 310, a small value current-limiting resistor 312, and a further diode 314 to the coil of relay K21. The time constant of this energization circuit for K21 is very small, and the relay pulls in almost immediately, closing K21a. When this occurs, AC is extended through line 316 to switch K22a. At this time switch K22a is closed upon its lower contact, because the coil of relay K22 has already been energized by the closing of switch K20b. A circuit is thus extended from lines 305 and 316 through K22a to continue energization of motor 124 after K20a opens. Energization of relay K22 completes a holding circuit for the relay through K22b for energizing the relay after K20b opens. Energization of relay K22 (which occurs as soon as K20 is energized) closes switch K22c upon its lower contact, which extends a circuit from line 302 through switch K20c (which closed upon energization of relay K20) to motor 94 and through limit switch S8 to line 304 of the AC supply. Limit switch S8 opens when the \$1 bill magazine has moved to the limit of its payout travel. Magazine transport motor 94 is thus energized almost immediately upon energization of K20 to position the \$1 bill magazine for dispensing a \$1 bill. At the same time relay K27 is energized, opening switch K27a and deenergizing motor 124 until the \$1 bill magazine is properly positioned. Cam switch 100 closes (if it is not already closed) when motor 94 starts and maintains the magazine transport motor and relay K27 energized after switch K20c opens when relay K20 is deenergized. When switch 100 opens (K20 having deenergized) motor 94 stops and K27 is deenergized, closing K27a and permitting motor 124 to operate.

Energization of relay K22 also closes switch K22d, energizing the bill director solenoid 144, so that \$1 bills are properly directed during payout.

When relay K20 is deenergized, switch K20b opens, breaking the connection from line 294 to relay K21, but relay K21 remains energized, because of the discharge of capacitors 300 and 318 through the coil. This ensures that the \$1 bill conveyor motor 124 runs for a sufficient period of time to dispense the bill. Thereafter relay K21 drops out, opening the circuit through switch K21a and line 316 and 308 to the motor 124.

Switches K20d and K21d complete a groundpath to line 320 and point p in order to cause a delay in the operation of the machine during payout of the \$1 bill, as will be described more fully hereinafter. Switch S7 closes a circuit for lamp 317 to indicate that the \$1 bill magazine is almost depleted. Cash-Handling Logic, In General

The system by which money inserted into the machine is totaled and compared with the amount of a sale or billing and change is dispensed is illustrated diagrammatically in FIG. 20. The coin reader and the bill reader are part of the coin acceptor and bill acceptor referred to previously. Coins and bills which are exact decade denominations, such as pennies, dimes, \$1, \$10 bills, produce direct responses in the corresponding units register, tens register, \$1 register, and \$10 register. A parallel entry addition technique is employed, so that it is not necessary to step the units register 10 steps in order to register a dime, for example. Instead, the tens register is actuated directly. However, each register except the \$10 register has a carry connection to the succeeding register, and when a register is full and returns to its zero position, a carry signal is generated. For simplicity it will be assumed that coins and bill are inserted into the machine one by one on an individual basis, although suitable interlocks may be provided to permit the insertion of coins and bills simultaneously.

Nondecade cash, namely, nickels, quarters, fifty-cent pieces, \$5, and \$20 bills, do not produce an immediate response in a register, but, instead, actuate the nondecade sequencer system, which in turn actuates the necessary registers. If a nickel is placed in the machine, the nondecade sequencer will apply five penny pulses to the units register. If a quarter is placed in the machine, the sequencer system will apply two pulses to the tens register and five pulses to the units register. A fifty-cent piece will result in five pulses being applied to the tens register. A \$5 bill will cause five pulses to be applied to the \$1 register, while a \$20 bill will cause two pulses to be applied to the \$10 register.

The cash input registers are 10-position telephone-type step switches, such as the North Electric Type 44, having five decks or levels of contacts. These switches rotate in one direction only, and return to their home position by rotating through a complete cycle. Each step switch also has "off-normal" contacts, which may be closed or open at a particular position and which remain in the opposite condition for all other positions. The step switches are solenoid-operated, being advanced to the next position when the solenoid is deenergized following the application of an energizing pulse. As will appear more fully hereinafter, the step switches which constitute the cash input register are also employed in the change computation and in the dispensing of change. For simplicity of illustration, however, the registers are merely shown connected to a change computer, which in turn is connected to a change dispenser. The change computer also receives inputs from the billing keyboard described previously. The input sum registers and the billing keyboard respectively control an input sum indicator and a billing indicator referred to previously.

Addition Logic

FIG. 25 illustrates circuit for controlling the input sum registers (and also illustrates a portion of the change-dispensing system). The microswitches 228 referred to previously in association with the chutes of the coin acceptor are arranged to extend actuating voltage (DC from terminal A) to the coils of the associated step-switch registers connected to terminals E, D, C, and B. Similar microswitches 322 are shown provided for registering the input of \$1, \$5, \$10 and \$20 bills. These switches are actually constituted by switch contacts (not shown) of switch SC at the outlet of the bill acceptor (FIG. 21) in series with contacts of switch S11-S14, so that if one of the pushbuttons 18 is pressed and a bill of the proper denomination is judged to be genuine, the corresponding switch 322 will be closed momentarily as the bill passes the outlet of the bill acceptor. Coils 324 represent the solenoids of electromagnetic counters (which may be located in box 60 of FIG. 2) so as to count the number of coins or bills of particular denominations inserted into the machine. These counters may also be actuated negatively by the corresponding coin and bill dispensers, so that a running tally is maintained of the exact amount of cash which should be in the machine at any time.

It will be noted that each of the decade denominations, 1-cent, 10-cent, \$1, \$10, extends an energization circuit from terminal A through a diode 326 when the associated input switch 228 or 322 is closed. A pulse is thus available to actuate the associated step switch register. The non-decade denominations, 5-cent, 25-cent, 50-cent, \$5, and \$20, energize associated relay coils K1-K5 upon closure of the corresponding cash input switch, and these coils complete holding circuits for themselves, from a voltage available at terminal G, through the associated contacts K1a-K5a. Energization of any one of these relays also closes the corresponding switches K1b, K2b-K2c, K3b, K4b, and K5b. The closing of one of these switches extends a circuit to associated terminals E, D, C, and B from contacts of level 3 of a step switch SSW5, which is a step switch provided in addition to those of the cash-input registers previously described and which is employed in the nondecade sequencer system of FIG. 20 (as well as in the change computer and dispenser as will be seen hereinafter).

When any of the nondecade input switches 228 or 322 is closed, power from terminal A is extended through a diode 328 to line 330 which is connected to the slider of level 2 of SSW5. The home position of this switch is on its zero contact, as illustrated in FIG. 25, and power is thus extended to terminal F. This terminal is connected to the actuating coil of SSW5 (which will be described more fully in connection with FIG. 26 hereinafter), and the application of power to terminal F causes SSW5 to step off of its home position and, as will be described later, to proceed through a complete cycle of operation until it returns to its home position. As SSW5 steps along, the contacts at positions 1, 2, 3, etc. of each level close upon the slider in sequence. (The slider and stationary contacts are merely diagrammatic, there being separate pairs of actuated contacts at each position.) At each position of level 3 a pulse is applied from terminal Q. It will be noted that contacts 3-7 of level 3 are connected together and contacts 8 and 9 of level 3 are connected together. Thus, at each of contacts 3-7, a pulse is available for passage through any of the associated switches K1b, K2b, K3b, and K4b which may be closed and through these switches to the associated terminals E, D, C, B of the step-switch addition registers. Similarly, at each of contacts 8 and 9 a pulse is available for application through switches K2c and K5b to the associated terminals C and E.

Thus, if a nickel is inserted in the machine, relay K1 will be energized, closing switch K1b, and five pulses will be applied to terminal B as step switch SSW5 goes through its cycle. A quarter will cause the application of two pulses to terminal C and five pulses to terminal B. A fifty-cent piece will cause the application of five pulses to terminal C, while a \$5 bill will cause the application of five pulses to terminal D. If a \$20 bill is inserted, two pulses will be applied to terminal E.

As will be seen hereinafter, when step switch SSW5 completes its cycle, power is removed from terminal G, so that whichever of relays K1-K5 has been energized will be deenergized.

The step switches for the units, tens, \$1 and \$10 registers, are designated SSW1, SSW2, SSW3, and SSW4, respectively. The corresponding "off-normal" contacts for SSW1, SSW2, SSW3 are given the additional designation O-N in FIG. 25. These contacts are closed when the associated step switch is in position 9 (and open when the switches return to their O position). When a pulse is applied to step the associated switch to its O position, a pulse is also applied to the associated terminal E, D, or C through a diode 332 from the associated line 334, 336, and 338 connected, respectively, to the 1-cent, 10-cent, and \$1 input switches (228 or 332). Thus, if the units register is full, when the next penny is inserted, the units register will advance one step to zero, and a carry pulse will be applied to the tens register, causing it to advance one step. The same holds true when the tens register is full, a carry pulse being applied to the \$1 register upon the insertion of the next dime, and when the \$1 register is full, a carry pulse being applied to the \$10 register when another dollar is inserted. Nondecade cash also controls the application of carry pulses by means of the nondecade relays K1-K5 described above.

Authorization to Dispense Change

Before the machine will dispense change, it must be "authorized". This is accomplished by an instantaneous automatic preliminary determination as to whether the sum of cash inserted in the machine is greater than the amount billed, or, in other words, whether the bill B is less than the sum inserted S. As will be seen hereinafter, if B is equal to S, no change will be dispensed, but the machine will cycle and return to its rest condition. If B is less than S for the most significant decade, the \$10 decade, then B must be less than S for all of the decades considered as a whole. If B is greater than S for the most significant decade, then B must be greater than S for all of the decades considered as a whole. If B is equal to S for the most significant decade, an ambiguity exists, and a determination must be made at the next lower decade. If B is equal to S for this decade also, a determination must be made at the next lower decade, and so on.

The apparatus for making a comparison between B and S includes the step switch input registers SSW1-SSW4 and the billing keyboard switches KD1-KD4 associated with keyboard 26, which constitute billing registers. FIG. 22 illustrates fragmentarily a typical decade step switch SSW4 in association with a typical decade KD4 (both of which are for the \$10 decade). The illustrated interconnections of the step-switch contacts and the associated billing switches for positions 0, 1, 2, 8 and 9, are typical, it being understood that the interconnections for positions 3-7 are similar. To initiate the determination of whether B is less than or equal to S, the subtract pushbutton 28 (FIG. 1) is pressed. The actuation of pushbutton switch 28, closes switch 28a, and applies DC to one side of a subtract relay K10, the other side of which is connected to terminal S in FIG. 22. (These components will be referred to more fully with reference to FIG. 26.) Relay K17 is a coincidence or equality-signifying relay, which will be energized if B equals S for the decade shown in FIG. 22 and will transfer the determination to the next decade. As will be seen hereinafter, when switch 28a is actuated, DC is also applied to terminal K at one side of the coil of relay K17, and if the other side of relay K17 is then connected to ground, the relay will be energized and switch K17a will move from its upper contact to its lower contact, disconnecting relay K10 from the first decade and connecting it to the next lower decade. If, on the other hand, relay K17a will remain in the position shown. Relay K10 will therefore be energized only if it is connected to ground at the \$10 decade.

At the time that comparison of B and S occurs, the symbolically indicated sliders 340, 342, and 344 of step switch SSW4 have been stepped in unison from position-to-position of the step switch in accordance with the input sum. For example, if the sliders were moved to position 01, this would signify that \$10 (at least) had been entered into the machine. Similarly, a key of keyboard decade KD4 will have been depressed if the billing is \$10 or more. The actuation of any of the keys of keyboard 26 actuates the plurality of switches 26a-26d associated with that key. For example, pressing the key at position 01, opens switch 26a, closes switch 26b, closes switch 26c, and closes switch 26d. Assume, for example, that the step switch SSW4 is at its zero position and that the billing key at the zero position of KD4 is pressed. A connection will then exist from the top of the coil of relay K17, through conductor 346, slider 342 of level 3 of SSW4, conductor 348, the closed switch 26c at position zero of the billing decade KD4 to ground at 350. Relay K17 will thus be energized, signifying an equality condition at the \$10 decade, and switch K17a will operate to transfer the determination of whether B is less than S to the next lower decade.

If, in the above example, SSW4 had been at position 01, the connection from position 01 of the step switch through conductor 349 and through position 01 of the billing switch to ground at 350 would be incomplete, because switch 26c at position 01 of the keyboard would be open. Relay K17 would not "see" ground, and the determination of whether B is less than S would remain at the \$10 decade. With the step switch at position 01 and the billing key actuated at position zero, a connection from the subtract relay K10 at terminal S would be completed through switch K17a, conductor 352, the closed switch 26b at position zero of KD4, conductor 354, and through diode 356 and slider 344 (at position 01 of SSW4) to ground at 358, energizing relay K10 and signifying that B is less than S.

If SSW4 were at position zero and KD4 were actuated at position 01, on the other hand, the circuit from conductor 352 would extend through the closed switch 26a at position zero of KD4 and then by conductor 359 to switch 26b at position 01 and by conductor 360 to diode 356, but because of the polarity of diode 356, current could not flow to ground at 358, and relay K10 would not be energized, signifying that B is not less than S.

It will be observed that level 2 of SSW4 is employed in the determination of whether B is less than S and level 3 is em-

ployed in the determination of whether B is equal to S. Similarly, switches 26a of KD4 are employed in the determination of whether B is less than S, and switches 26c are employed in the determination of whether B is equal to S. It will be apparent from the interconnection of the various positions of SSW4 and KD4 that if B is less than S it does not matter at which position the sliders of SSW4 are located, because current will flow through the diodes 356 interconnecting the contacts of level 2 at the successive positions. Level 4 of SSW4 and switches 26d of KD4 are connected to indicators DS8 and DS7, respectively, which form a portion of the indicators 34 and 36 referred to previously.

FIG. 23 illustrates somewhat diagrammatically the apparatus employed in the determination of whether B is less than or equal to S for all the decades. SSW4 is shown interconnected with KD4 at the \$10 decade, but the associated step switches and billing keyboard switches for the other decades are merely indicated in phantom. It is to be understood that the same interconnections of step switches and billing switches exists for each of the decades. The coincidence relays for the lower decades are shown at K14, K15, and K16, respectively. It is apparent that if relay K17 is energized, its switch K17a will be closed upon its lower contact, connecting terminal S associated with relay K10 through switches K17a and K16a to the \$1 decade. If an equality or coincidence condition is present in this decade also, relay K16 will be energized, and the circuit from terminal S will be extended to switch K15a, the determination now being made in the 10-cent decade, and so on. If coincidence is present at all decades, representing the condition where B is equal to S, then all of the coincidence relays K14-K17 will be energized, and terminal S will be connected to ground at 362. Whenever terminal S is connected to ground, upon closure of switch 28a, subtract relay K10 will be energized, closing its switch K10a to complete a holding circuit for the relay. Relays K14-K17 are faster acting than K10 to ensure that the coincidence relays may be energized before relay K10.

The other switches of relays K14-K17 illustrated in FIG. 23 will be referred to later. It suffices to state at this point that the coincidence relays K14-K17 are utilized in the subtraction and change dispensing operations, and that these switches provide holding circuits for the respective coincidence relays when required.

Subtraction Logic

FIG. 26 illustrates the subtraction logic of the invention, which utilizes the same step switches SSW1-SSW5 referred to previously. The coils for driving switches SSW1-SSW5 are shown separately from the decks or levels of associated switch contacts. Terminals E, D, C, and B correspond to those shown in FIG. 25, which were referred to in the description of addition logic. Levels 2-5 of SSW5 are shown in FIG. 25, while level 1 is shown in FIG. 26.

It will be recalled that terminal F was mentioned in connection with the nondecade sequencer operation discussed with reference to FIG. 25. It will now be seen that this terminal in FIG. 26 is connected through the usual interrupter contacts 364 of step switch SSW5 to the coil of the step switch. The pulse produced (by switches 228 or 322) when a nondecade bill or coin is inserted into the machine is transmitted from terminal F through closed interrupter contacts 364 to the coil of SSW5, energizing the coil, opening contacts 364 and causing the step switch to advance from its zero position when the interrupter contacts open. When this occurs, the off-normal contacts O-N of SSW5 move from the position illustrated in FIG. 26 to the alternate position, extending a circuit from conductor 366 through the off-normal contacts and diode 368 to the coil of SSW5. As will be seen hereinafter, clock pulses applied to conductor 366 cause SSW5 to advance step by step until it returns to its home or zero position, at which time the off-normal contacts return to the position illustrated, the path to conductor 366 is broken, and step switch SSW5 comes to rest at home. It is thus apparent how SSW5 acts as a sequencer during addition in order to accommodate nondecade cash.

Subtract relay K10 is shown at the bottom of FIG. 26 in association with a group of transfer relays K6-K9. The subtraction operation is performed dynamically, decade by decade, commencing with the least significant decade, the units or penny decade. Relay K11, which appears in FIG. 26 adjacent to SSW4, is the "carry" relay employed during the subtraction process. When K11 is energized, a no-carry condition is signified. Relay K25 is a carry-memory relay. Relay K12 is a slave-memory relay employed in conjunction with SSW5. During subtraction SSW5 operates as a "slave" relay, as will be seen hereinafter. Relay K19 serves as a pulse stretcher relay.

The machine of the invention employs a system clock 370 shown at the lower right corner of FIG. 26. The clock may comprise an SCR 372 with an "off" timing circuit including a capacitor 374 and charging resistors 376 and 378, the latter of which is variable. One side of capacitor 374 is connected to the cathode of the SCR, which is grounded, and the other side of the capacitor is connected by a resistor 380 to the gate of the SCR. A resistor 382 is connected between the gate and cathode of the SCR. The anode of the SCR is connected to the coil of the clock relay K18 bridged by protective diode 384 (other such protective diodes being shown across other relay coils). A capacitor 386 is connected in series with a resistor 388 across relay K18 and the SCR in series to constitute an "on" timing circuit. The relay operates switch K18a. In the upper position of switch K18a positive DC is connected to the top of coil K18 and to the top of resistors 376 and 388, as will be described more fully hereinafter, while in the lower position, the energizing circuit for the clock is broken, and the DC available at switch K18a is connected by conductor 390 to terminal Q, clock pulses being constituted by the operation of switch K18a in response to the energization and subsequent deenergization of relay K18. During addition, when clock pulses are needed for operation of SSW5 as a nondecade sequencer, the clock is energized from line 391 through diode 393, DC being applied to line 391 through switch 414, which closes upon its lower contact when SSW5 takes its first step, as will be seen hereinafter.

When capacitor 374 charges to the trip point, the SCR becomes conductive, and the charge previously stored in capacitor 386 discharges through coil K18 and the SCR 372, energizing the relay and operating switch K18a to break the supply circuit for the clock. When capacitor 386 is discharged, relay K18 becomes deenergized, and switch K18a returns to its upper position, at which power is again applied to the clock, and the cycle repeats. Capacitor 374 discharges through the gate-to-cathode circuit of the SCR and through resistor 382. An additional capacitor 392 is bridged across capacitor 374 when relay K10 is energized and closes switch K10a to complete a charging circuit for capacitor 392 through diode 394 to ground. This increases the time between clock pulses during the subtraction operation of the machine, when relay K10 is energized. Point *p* of the clock is connected to the corresponding terminal of FIG. 21, and when relay K20 or K21 of that figure is energized, a path to ground is completed to point *p* through K20d or K21d, grounding the timing circuit of the clock, and preventing the operation of the clock. This causes the machine to "hold" during the insertion or dispensing of \$1 bills.

As pointed out above, the subtraction operation proceeds decade by decade, commencing with the decade of least significance. Subtraction involves the advancement of a decade switch from the position attained during the addition or cash insertion process to a position coincident with that of the corresponding billing keyboard decade and then a return to the home position of the step switch. As will be seen hereinafter, the progression of the decade step switch from the position of coincidence to the home position results, through cooperation with the slave switch SSW5, in the dispensing of the proper amount of change for that decade. When the subtraction process and change-dispensing process for the least significant decade is complete, a transfer pulse will be generated to cause

the transfer relay associated with the least significant decade to become deenergized and the transfer relay associated with the next decade to become energized. The process then continues in this decade, and, in turn, in the succeeding decades. When the process is complete in the most significant decade, a transfer pulse is produced which returns the apparatus to its rest condition.

The operation of the subtraction system of the invention can be most readily understood by reference to examples. Two simple examples will be considered first.

Let it be assumed that $B=S=0$. When subtract switch 28a is closed, DC is applied through switch 28a and switch K26a of an interlock relay K26, diode 398 to the coil of relay K10, which becomes energized (because terminal S is grounded per FIG. 23 at 362 when $B=S$) and which completes its holding circuit to ground through resistor 399 switch K10a. Relay K10 closes switch K10b upon its lower contact, extending operating DC through conductor 400, diode 402, and switch K18a to the clock 370. Interlock relay K26 becomes energized after a delay determined by the time constant of resistor 402 and capacitor 404. Energization of K26 opens switch K26a, rendering switch 28a incapable of affecting the operation of the machine, but K10c has already closed to complete a holding circuit to +DC for K10 through resistor 424.

The closing of switch 28a also applies operating DC to conductor 406 and through diode 408 to the top of the coil of relay K11, energizing K11 and transferring its contacts. Switch K11a is accordingly closed, completing a holding circuit for relay K11 through conductor 410, diode 412, and switch 414 (closed upon its upper contact). It may also be noted at this point that the initial application of DC to conductor 406 applies DC to terminals H, I, J, and K through diodes 416-422, for enabling the coincidence relays K14-K17 (FIG. 23) to operate during the determination of whether B is less than or equal to S. Diode 423 prevents energization of K9.

Energization of relay K10 also closes switch K10d to complete an energization circuit for transfer relay K6 through diode 426. A holding circuit for relay K6 is now completed through closed switch K6a, and switch K7c (closed upon its upper contact) to conductor 400, and through switch K10b to the DC supply.

The first clock pulse produced when K18a closes upon its lower contact passes from conductor 390 through diode 428, switch K11b (now closed upon its lower contact) and switch K6d (now closed upon its lower contact) to switch K14b of coincidence relay K14, which is energized because $B=S$. DC is applied to terminal H connected to coincidence relay 14 (FIG. 23) through the closed switch K6c. As shown in FIG. 23, energization of K14 also closes switch K14c, completing a holding circuit for K14 to ground through the closed switch K11c of the carry relay. The clock pulse thus progresses through K14b (now closed upon its lower contact) to the zero contact of SSW1, level 5, and through switch K14d (now closed upon its lower contact) and conductor 430 to the zero position of SSW5, level 1. The pulse then progresses through conductor 432, the closed switch K10e of relay K10, switch K6b (now closed upon its lower contact) to the top of the coil of transfer relay K7. Thus a transfer pulse is applied to K7, energizing this relay. When this happens, switch K7c transfers to its lower contact, breaking the holding circuit for K6 through K7c and K6a, and deenergizing K6. A holding circuit is now established for K7 through K7a, and switch K8c (closed upon its upper contact) to conductor 400.

The next clock pulse proceeds through switch K11b (still closed upon its lower contact), switch K7d (now closed), and switch K15b of latched coincidence relay K15 (closed upon its lower contact). The pulse passes through the zero contact of SSW2, level 5, and through switch K15d (closed upon its lower contact) to conductor 430, to the zero position of SSW5, level 1, and then along conductor 432, through closed switch K10e, through switch K6b (closed upon its upper contact), and switch K7b (now closed upon its lower contact) to the top of the coil of transfer relay K8. K8 becomes energized,

transferring switch K8c to its lower contact, and breaking the holding circuit for K7, which becomes deenergized. A holding circuit for K8 is now established through switch K8a, and switch K9a (closed upon its upper contact) to conductor 400. The sequence continues through SSW3, level 5, for the next clock pulse, K9 being energized by a transfer pulse through K8b (deenergizing K8) and latching through K9a. Then the same sequence continues through SSW4, level 5, for the next clock pulse, the resulting transfer pulse from SSW4 passing through switch K9b (closed when K9 is energized), conductor 434 and diode 436 to the bottom of coil K10. The potential at the top of the coil of K10 is thus balanced by approximately the same potential applied to the bottom, and the relay becomes deenergized, opening the holding circuit for K9 through K10b and returning the circuit to its rest condition.

In the next case it may be assumed that $B=S$ but is not equal to 0. For example, assume that $B=S=55.55$. This means that all of the decade step switches SSW1-SSW4 are located at position 5 and that all of the billing keyboard pushbuttons at position 5 are actuated. When the subtract switch 28a is closed, relay K10 is energized and latches electrically as before. Relay K6 is energized, in the manner described above, and relay K14 is energized by virtue of the application of DC to terminal H. The clock 370 is energized, and the carry relay K11 is also energized, as set forth above. A pulse is routed through diode 428 and through switch K11b (closed upon its lower contact), switch K6d and switch K14b (closed upon its lower contact) to contact 05 of SSW1, level 5. The clock pulse is applied to the coil of SSW1 (through bridged contacts 1-9 of level 5), causing the step switch to move upon termination of the clock pulse. Successive clock pulses are routed in the same manner, causing the step switch to step from position 5, past position 9 to the zero position. After SSW1 reaches its zero position, a transfer pulse (clock pulse) is routed through switch K14d (closed upon its lower contact because K14 is energized), conductor 430, and the zero contact of SSW5, level 1, to energize K7 and deenergize K6 in the manner described above. The same cycle now proceeds for SSW2, SSW3, and SSW4, each step switch returning to its zero position. The transfer pulse from SSW4 deenergizes K10 as described above.

Now let it be assumed that a subtraction operation is to be performed in the units (penny) decade when $S=9$ and $B=5$. In other words, the operation $9-5$ is to be performed. When the subtract switch 28a is closed, relays K10, K6, and K11 are energized as before, and the clock 370 is energized. The first clock pulse proceeds through switch K11b (closed upon its lower contact), switch K6d, switch K14b (closed upon its upper contact because coincidence relay is not energized), diode 440, conductor 441, switch K12a of relay K12, the off-normal switch O-N of SSW5, and diode 368 to the coil of SSW5, which is caused to take one step. When SSW5 takes its first step, the off-normal switch O-N closes upon its lower contact, and a ganged off-normal switch 414 closes upon its lower contact. The last-mentioned transfer breaks the holding circuit for relay K11, which becomes deenergized. The closing of switch 414 upon its lower contact applies DC to the coil of relay K12 through diodes 442 and 444, energizing relay K12.

The first clock pulse also passes through diode 446 to contact 09 of SSW1, level 5, and energizes the coil of SSW1, causing SSW1 to take one step to its zero position when the coil is deenergized. After this occurs, a pulse passes through switch K14d (closed upon its upper contact) and through diode 448 and conductor 450 to the coil of relay K11, energizing this relay and signifying the absence of a carry (borrow). The carry relay is held energized through its holding switch K11a, diode 452, switch K12a (which is now closed), and switch 414.

The pulse applied to the zero contact of SSW1 also passes through diode 454 to the coil of SSW1. Thus SSW1 does not stop upon reaching its zero contact but continues to step, SSW1 and SSW5 stepping in synchronism.

When SSW1 reaches its fifth position, coincidence between the step switch and the corresponding billing switch is achieved (since $B=5$), and coincidence relay K14 (FIG. 23) is energized in the same manner that it would have been if coincidence had existed initially. A ground circuit for electrically latching K14 is completed through K14c and K12c (which is now closed upon its lower contact in FIG. 23). As the step switches SSW1 and SSW5 take the next four steps (whereupon SSW1 will be at position 09) penny-dispensing pulses will be produced by SSW5 in a manner to be described hereinafter. When SSW1 reaches its contact 09, SSW5 will reach its zero contact (since SSW1 started at contact 09 and SSW5 started at its zero contact) and the off-normal switch 414 of SSW5 will return to the position illustrated in FIG. 26. K12 will remain energized, however, through its switch K12b, and K11 will remain energized, because switch 414 closes upon its upper contact before K11 can drop out.

The next clock pulse will not pass through switch K12a (which is still open) and will not pass through SSW5 O-N (which is now closed on its upper contact) and will not advance SSW5. It will, however, pass through switch K11b (closed upon its lower contact), switch K6d, and switch K14b (closed upon its lower contact) to contact 09 of SSW1, level 5, causing SSW1 to take another step to its zero position. Then a transfer pulse will pass through switch K14d (closed upon its lower contact), conductor 430, the zero contact of SSW5, level 1, and diode 456 to the junction of resistor 458 and the bottom of the coil of relay K12, causing K12 to be deenergized because of the application of balancing potential at the opposite ends of its coil. The transfer pulse also energizes relay K19, causing it to close its switch K19a, which connects diode 456 through conductor 460 to K18a, continuing the application of balancing potential to K12 when K18a returns to its upper contact and ensuring that K12 drops out. As indicated before, the transfer pulse will also cause K7 to be energized and K6 to be deenergized.

Let it now be assumed that a subtraction operation is to be performed in the units decade where $S=5$ and $B=9$ (it being assumed, of course, that as a whole B is less than S). The machine must perform the operation $5-9$ with the necessary carry (borrow). When the subtract switch 28a is closed, K10, K6, K11 and the clock 370 are energized as before. The first clock pulse goes through switch K11b (closed upon its lower contact), switch K6d, switch K14b (closed upon its upper contact), diode 440, conductor 441, switch K12a, the off-normal switch O-N of SSW5 and diode 368, to the coil of SSW5, causing this step switch to take one step. The first clock pulse also proceeds through diode 446 to contact 5 of SSW1, level 5, and causes SSW1 to take one step in synchronism with SSW5.

When SSW5 takes its first step, the holding circuit for K11 through switch 414 is broken, causing K11 to become deenergized. K12 is energized immediately thereafter when switch 414 closes upon its lower contact. SSW1 and SSW5 step together, and when SSW1 reaches its contact 09, coincidence with the billing switch is achieved ($B=9$), and coincidence relay K14 is energized. On the next step SSW1 reaches its zero contact. Then a pulse goes through switch K14d (now closed upon its lower contact), and conductor 430, to the slider of SSW5, level 1, which is not upon its zero contact and hence no transfer pulse is transmitted. Also, after SSW1 reaches its zero contact, no pulse is transmitted through diode 454, because switch K14d is closed upon its lower contact. Hence, the coil of SSW1 does not receive a pulse and SSW1 remains at its home position. However, SSW5 continues to step (having taken four steps when SSW1 reached its contact 09) and takes six more steps (after corresponding clock pulses) to reach its zero contact. As will be seen hereinafter, during these remaining six steps 6 cents will be dispensed, which is the correct amount of change in the units decade.

When SSW5 reaches its zero position, the next clock pulse through the zero contact of SSW1 and K14d (closed upon its lower contact) is transmitted through the zero contact of SSW5, level 1, causes K12 to become deenergized, energizes

K7, and deenergizes K6. The next clock pulse passes through K11b (closed upon its upper contact because K11 is not energized) and through K12d (closed upon its upper contact), and diodes 462 and 368 to the coil of SSW5, causing SSW5 to take one step without a clock pulse being applied to SSW2 (since K11b is not closed upon its lower contact). When SSW5 takes its first step, K12 is energized again, and the next clock pulse is applied through K12e (now closed) to switch K7d. This causes SSW2 to step in synchronism with SSW5. The carry (borrow) operation is thus reflected in the fact that SSW5 takes one step before SSW2 commences to step, and hence one less coin will be dispensed by SSW5 in the tens decade after coincidence is reached by SSW2, since SSW5 is one step closer to home than it would have been without the carry.

Let it now be assumed that S=0502 and B=0013. The operation to be performed is thus the subtraction of 13 cents from \$5.02, with a carry (borrow) being transferred from the units decade, to the tens decade and to the \$1 decade. When the subtract switch 28a is closed, K10, K11, K6 and the clock are energized as before. The first clock pulse goes through K11b (closed upon its lower contact), K6d, K14b (closed upon its upper contact) and through diodes 440 and 446 to SSW5 and SSW1, respectively. These step switches commence stepping in synchronism. When SSW5 takes its first step, the holding circuit for K11 through switch 414 is broken, and K11 is deenergized. When SSW1 takes its first step, to contact 03, coincidence is achieved (B=3), and during the next nine steps of SSW5 9 cents change will be dispensed, as will appear more fully hereinafter. SSW1 will stop upon reaching its zero contact, because K14d will already be closed upon its lower contact, and a pulse will not be applied through diode 448 to carry relay K11, so that the carry relay will not be energized, designating a carry (borrow) condition. After SSW5 reaches its zero position, a transfer pulse will be conveyed, as described previously, to cause K7 to be energized and K6 to be deenergized. The first clock pulse after transfer will advance SSW5 one step without advancing SSW2, because K11b will be closed upon its upper contact (K11 being deenergized). The same clock pulse will energize relay K25 through diode 463, and relay K25 will complete a holding circuit through resistor 465 and switch K25a to the source of positive DC. Energization of K25 also closes switch K25b, which connects the source of positive DC to the bottom of the coil of relay K11 across a resistor 467.

After SSW5 takes its first step, the next clock pulse is applied from terminal Q through contact 01, level 3, of SSW5 to terminal W, as shown in FIG. 25, and to the identically designated terminal of FIG. 0' and the bottom of the coil of relay K25 across a resistor 469. The same clock pulse is applied to the zero contact of SSW2, level 5, and through K15d (closed upon its upper contact because coincidence has not been achieved) to relay K11. This would tend to energize K11 and produce a "no carry" condition at the end of the subtraction process in the tens decade where a "carry" condition is desired. The application of DC to the bottom of the coil of K11 through K25b prevents the energization of K11, however, during the clock pulse applied to the zero contact of SSW2, level 5. Although this clock pulse is also applied to the bottom of the coil of K25, tending to make this relay drop out, the relay does not become deenergized until the very end of the clock pulse, at which time it is too late for K11 to become energized. After the end of the clock pulse SSW2 advances, (as well as SSW5), and when SSW2 reaches its contact 01, coincidence is achieved. During the next eight steps SSW5 will cause the dispensing of 80 cents in change as will appear more fully from the explanation of change-dispensing hereinafter. When SSW2 reaches its zero contact, K15d will be closed upon its lower contact (coincidence having been achieved), and K11 will not be energized. Thus, after transfer to the \$1 decade, SSW5 will again take one step before commencement of the stepping of SSW3, and \$4 in change will be dispensed during the subtraction operation in the \$1 decade.

Let it now be assumed that S=5 and B=0 for the lowest decade and that all other decades of B and S are equal to 0. In other words, the transaction is to be aborted by returning the money inserted. When the subtract switch 26a is closed, K10, K11, K6 and the clock are energized as before. Since coincidence has not been achieved, SSW1 and SSW5 start stepping together. When SSW5 takes its first step, it breaks the holding circuit for K11 (by transferring switch 414) and K11 is deenergized. When SSW1 reaches its zero contact, coincidence is achieved, and K14d is immediately closed upon its lower contact. Thus, the next clock pulse does not energize K11, and this would indicate that a carry should be passed to the next decade, which is incorrect for the case assumed. To prevent this condition the zero contacts of level 1 of SSW2, SSW3, and SSW4 are connected in series through the sliders of SSW3 and SSW4, level 1, to the top of the coil of relay K11, and the zero contact of SSW1, level 5, is connected through diode 464 to the slider of SSW2, level 1. After SSW1 reaches its zero contact, the next pulse is transmitted from the zero contact of SSW1, level 5, through diode 464, to the zero contact of SSW2, level 1, to the zero contact of SSW3, level 1, and the zero contact of SSW4, level 1, to the top of the coil of relay K11, energizing K11, and producing the proper "no carry" condition. This same pulse and the following four pulses advance SSW5 to its zero contact, causing the dispensing of 5 cents as will appear more fully hereinafter.

Change Dispensing Logic

It will be recalled from the description of the subtraction logic that the slave step switch SSW5 controls the dispensing of change as it returns to its zero position after coincidence between the associated decade switch SSW1-SSW4 and the billing switch is achieved. Coincidence is signified by operation of the respective coincidence relays K14-K17 (FIG. 23). As shown in FIG. 25, the coincidence relays include switches K14e-K17e, which are closed, respectively, when the coincidence relays are energized. Switch K18b is controlled by the clock 370 and closes in synchronism with each clock pulse. With switch 24a in the position illustrated in FIG. 25, a path extends from the bank of coincidence switches K14e-K17e to the slider of level 4 of SSW5. It will be noted that contacts 1-4 and 6-9 of level 4 are connected to the 1-cent ejector solenoid 250 (described in conjunction with the coin dispenser), the 10-cent ejector solenoid 254, relay coil K20 (associated with the \$1 bill dispensing logic) and solenoid 178 of the \$10 ejector. Thus, for each of the positions 1-4 and 6-9 of level 4 of SSW5, a dispensing pulse may be applied to the appropriate dispensing component, if the associated coincidence relay is energized, each time switch K18b is closed by the clock. The pulse is constituted by connecting the said contacts of level 4 to ground through K18b, terminals H, I, J, and K being provided with DC by the associated transfer relays K6-K9 of FIG. 26. Since only one transfer relay is energized at a time, only a selected value of coin or bill can be dispensed at a time. Coils 324' are part of the counters including coils 324 associated with the cash input, and register the amount of cash disbursed.

Level 5 of SSW5 has its contacts 07 and 08 connected together to the 25-cent ejector solenoid 256 and its contact 09 connected to the 5-cent ejector solenoid 252 and the \$5 ejector solenoid 177. It will be apparent that if switch K24a is closed upon its lower contact, the slider of level 5 is capable of producing a dispensing pulse when it engages each of contacts 7, 8 and 9. The normal position of switch K24a is illustrated in FIG. 25. The switch is moved to its alternate position by the coil of relay K24, which is energized by K13b when the coil of K13 is energized. Energization of K13 occurs when the slider of level 4 of SSW5 engages its contact 05, connecting ground to the bottom of coil K13 when clock switch K18b closes (assuming that one of the coincidence relays is energized). DC is applied to the top of K13 from terminal G.

When K13 is energized, it closes K13a, providing a holding circuit to ground, and it closes K13b, energizing K24. This transfers switch K24a, so as to place level 5 of SSW5 in the circuit, rather than level 4. K13 is termed the greater-than-five

detector, because if a coincidence relay is energized at the time that the slider of level 4 of SSW5 reaches its contact 05, more than five coins or bills of a particular denomination would be dispensed. Instead, the machine switches over to level 5 of SSW5, so that larger denomination coins or bills are dispensed. For example, if the subtraction operation is being performed in the units decade and coincidence is achieved before position 05 of SSW5 is reached, when position 05 is reached the greater-than-five detector will be energized, switching the dispensing circuit to level 5, and when position 09 of SSW5 is reached, a nickel will be dispensed (instead of five pennies). Similarly, if coincidence is achieved during subtraction in the 10-cent decade before position 05 of SSW5 is reached, a switchover to level 5 will be made, and when positions 7 and 8 are reached, two quarters will be dispensed instead of five dimes. Again, if the subtraction operation is taking place in the \$1 decade and coincidence is achieved before SSW5 reaches position 5, a switchover to level 5 takes place, and when position 9 is reached, a \$5 bill will be ejected (instead of five \$1 bills). It will be noted that the dispensing components for pennies and nickels are both enabled from terminal H, through diodes 468; the dispensing components for dimes and quarters are similarly ganged to terminal I; and those for \$1 and \$5 are similarly ganged to terminal J. This permits the dispensing operations just described to take place.

Contacts 1-4 and 7-9 of level 4 of SSW5 are connected to the upper contact of K9c, which transfers to that contact when K9 is energized (during subtraction in the \$10 decade). When this occurs, the circuit from contact 05 of level 4 to K13 is broken and instead contact 05 is bridged with contacts 1-4 and 7-9 of level 5, so that nine \$1 bills may be dispensed when required.

A better understanding of the operation of the change dispensing logic may be had by considering two previously referred to cases. Suppose, for example, that the operation 9-5 is being performed in the units decade ($S=9$ and $B=5$). It will be recalled from the description given in connection with the subtraction logic that in this case SSW1 will step from its contact 09 to its contact 05, at which time coincidence is achieved. SSW5, stepping in synchronism with SSW1 and starting at its zero contact, will then be upon its contact 06. The next four clock pulses will cause the advancement of SSW5 to its zero contact again. Considering SSW5 in FIG. 25, when the slider of level 4 reaches contact 06, coincidence is achieved and K14e is closed. The next clock pulse occurs when K18b closes, and contact 06 of level 4 will therefore be connected to ground, which will energize penny-ejector coil 250, since the top of the coil at terminal H is connected to +DC. This will cause one penny to be dispensed. At the termination of this clock pulse SSW5 will move to contact 07, when again K18b will close, and another penny will be dispensed. Pennies will also be dispensed when the slider of level 4 of SSW5 rests upon its contacts 08 and 09, and thereafter the slider will return to its zero contact. Thus, four pennies, the correct amount of change, will be dispensed.

If the subtraction operation 5-9 is being performed in the units decade (ignoring carry), as described in connection with the subtraction logic, coincidence will be achieved when SSW5 reaches its contact 04. The next clock pulse from K18b will eject a penny, with the slider of SSW5, level 4, resting upon its contact 04, and then SSW5 will move to its contact 05. At this point relays K13 and K24 will be energized, transferring switch 24a to its lower contact, and no further pulses will be transmitted from level 4 of SSW5. However, when the slider of level 5 reaches its contact 09, a pulse will be applied to the nickel ejector 252 (also connected to the energized terminal H), and a nickel will be ejected, making the correct change of 6 cents.

GENERAL OBSERVATIONS AS TO CHANGE COMPUTATION AND DISPENSING OPERATIONS

From the foregoing description of the subtraction and change-dispensing logic, certain general observations can be made.

1. If the sum of money inserted into the machine is insufficient for the transaction, when the "subtract" pushbutton 28 is pressed, the subtract relay K10 will not be energized, and the machine will not dispense change.

2. If $B=S=0$, when pushbutton 28 is pressed, the subtract relay will latch, and then the transfer relays will cycle and unlatch the subtract relay, but no step switches will move and no change will be dispensed.

3. During change dispensing operations, SSW5 always operates and controls the dispensing of change.

4. If for any decade B is less than S, the appropriate decade switch SSW1-SSW4 will pass its zero position without coincidence having been achieved, the carry relay K11 will be energized (except for SSW4), signifying no-carry, and SSW5 will stop at its zero position before the decade switch SSW1-SSW4 comes to rest at its zero position.

5. If for any decade B is greater than S (assuming that as a whole B is less than S), coincidence will be achieved by the appropriate decade switch SSW1-SSW4 before the decade switch reaches its zero position, and when that switch reaches its zero position it will stop, and the carry relay K11 will not be energized (signifying a carry), and SSW5 will continue stepping until it reaches its zero position.

6. If when subtraction commences in a particular decade coincidence does not then exist, SSW5 and the appropriate decade switch SSW1-SSW4 start stepping together, unless there has been a carry, in which event SSW5 commences stepping one clock pulse earlier.

7. If when subtraction starts in a particular decade coincidence has already been achieved, SSW5 is not stepped at all, unless there has been a carry, in which event SSW5 starts stepping one pulse earlier than the associated decade switch SSW1-SSW4.

8. If a carry is to be transmitted to a decade via an intermediate decade and the intermediate decade switch SSW2 or SSW3 rests upon its zero contact when the subtraction operation is commenced and if the billing entry for the intermediate decade is not equal to zero, then relay K25 comes into play to ensure the transmitting of the "carry" condition.

9. If a sum of money is inserted into one or more of the lower three step-switch decades and the higher decades of the sum are all at zero and if no billing is inserted into the machine, level 1 of each of SSW2-SSW4 comes into play to ensure that a carry is not transmitted.

10. Change-dispensing pulses are transmitted to the dispensers before the step switches respond to the corresponding clock pulses and move to the next contact, because the step switches are indirectly energized.

11. Transfer pulses are not effective to dispense change.

12. The first clock pulse after a transfer pulse always advances SSW5 one step before advancing the appropriate decade switch SSW2-SSW4 if the carry relay K11 is not energized, designating a carry condition.

13. During subtraction coincidence relays are energized immediately when a decade switch SSW1-SSW4 moves to a position of coincidence with the appropriate billing switch, because the coincidence relays are directly energized from the DC supply, rather than from the clock pulses, the stepping switches always moving to a new contact after termination of a clock pulse and resting on the new contact during the next clock pulse (which conditions the step switch to advance to the succeeding contact).

14. The change to be dispensed in any decade (ignoring carry) is the tens complement of the number of steps required to bring the decade sum switch SSW1-SSW4 to coincidence with the billing switch (assuming movement of the sum switch in a positive direction).

15. Change is dispensed during stepping of slave switch SSW5 to its zero position after coincidence of a sum switch SSW1-SSW4 with the associated billing switch, such stepping of the slave switch representing the tens complement of the number of steps taken by the slave switch until coincidence.

Typical values of resistors and capacitors employed in the circuits of FIGS. 21 and 26 are as follows:

Reference 0	Value
298	330 ohms
300	1000 microfarad
312	10 ohms
318	600 microfarad
374	25 microfarad
376	10K
378	25K
380	5K
382	1K
386	8 microfarad
388	10 ohms
392	25 microfarad
399	100 ohms
402	150 ohms
404	10 microfarad
458	100 ohms
465	220 ohms
467	220 ohms
469	100 ohms

While a preferred embodiment of the invention has been shown and described, it will be apparent to those skilled in the art that changes can be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims.

The invention claimed is:

1. Cash-handling apparatus comprising means for receiving and determining the genuineness of cash of different denominations, means for registering the amount of genuine cash received, means for registering the amount of a transaction, a vault for storing genuine cash received, means for comparing the amount of registered cash received and the amount of a registered transaction, and means for dispensing cash from said vault as change if the comparison shows that the amount of the transaction is less than the amount of the cash received, the last-mentioned means comprising means for advancing one of said registering means to a predetermined condition, and means producing change-dispensing signals during the advancement after the condition of said one registering means corresponds to that of the other.

2. Apparatus in accordance with claim 1, wherein said means for registering the amount of a transaction comprises a keyboard with a series of decades.

3. Apparatus in accordance with claim 2, wherein said keyboard has switches controlled by the keys thereof and constituting a series of decade registers.

4. Apparatus in accordance with claim 1, wherein said means for registering the amount of genuine cash comprises a series of decade stepping switches for the successive digits of a sum of cash.

5. Apparatus in accordance with claim 1, wherein said cash-receiving means has a bill acceptor and a coin acceptor.

6. Apparatus in accordance with Claim 5, wherein said bill acceptor has means associated therewith for directing bills of one denomination to a magazine and for directing other bills to a storage receptacle.

7. Apparatus in accordance with claim 6, wherein said bill acceptor has manually controlled switch means with switches corresponding to the different bill denominations to be received for controlling the position of said bill-directing means.

8. Apparatus in accordance with claim 6, said apparatus having means for dispensing bills from said magazine as change when required.

9. Apparatus in accordance with claim 8, further comprising means for placing said bill director in a predetermined position during dispensing of change in order to direct bills from said magazine to a change outlet.

10. Apparatus in accordance with claim 6, wherein said magazine has a series of cells and said apparatus has means for inserting a single bill in each of the cells and dispensing the same therefrom in sequence.

11. Apparatus in accordance with claim 6, further comprising an additional magazine for storing bills of a different denomination which are not received by said cash-receiving means, said apparatus having means for dispensing bills from said further magazine as change when required.

12. Apparatus in accordance with claim 11, said further magazine having a plurality of cells each receiving a single bill, and said means for dispensing said bills from said further magazine comprising a bill ejector movable step by step from cell to cell of said further magazine.

13. Apparatus in accordance with claim 6, wherein said magazine has means for indexing the same relative to means for inserting and withdrawing bills from the cells thereof.

14. Apparatus in accordance with claim 13, wherein said magazine has vertical cells and is arranged to index horizontally.

15. Apparatus in accordance with claim 6, wherein said bill-directing means is arranged to direct bills to different chutes.

16. Apparatus in accordance with claim 1, wherein said cash-registering means and said transaction-registering means each comprises a series of decade switches corresponding, respectively, to the digits of the cash received and the transaction, and said comparing means comprises means for comparing the condition of switches in the corresponding decades of the cash-registering means and the transaction-registering means and for determining whether, in each decade, the amount of cash registered is greater than or equal to the amount of the transaction registered, said comparing means having means responsive to an equality condition in each decade, except the least significant decade, for rendering that decade ineffective in the overall comparison.

17. Apparatus in accordance with claim 16, wherein said change-dispensing means comprises means for computing the change to be returned decade by decade, beginning with the least significant decade, and progressing in sequence to the most significant decade and wherein said means for dispensing change is actuated automatically in response to a determination that the amount of the transaction registered is less than the amount of the cash registered.

18. Apparatus for dispensing coins and the like, comprising a plurality of coin chutes for storing coins therein and having coin-dispensing outlets adjacent to the bottom thereof, a plurality of coin ejectors associated with the corresponding outlets and adapted to eject the bottom coin from the corresponding chutes when moved to an operative position and thereafter moved to a coin-ejecting position, a plurality of ejector solenoids adapted to move the corresponding ejectors to their operative positions, a main solenoid for moving said ejectors to their coin-ejecting positions, switch means for controlling the energization of said main solenoid, and common means for actuating said switch means in response to the energization of any one of said ejector solenoids, said ejectors being pivotally supported upon an element of a frame, said main solenoid being coupled to said frame for turning the same and moving the ejectors toward the corresponding outlets, said chutes being arranged vertically and said ejectors being oriented to move generally horizontally, said ejector solenoids having vertically movable cores with one end coupled to the corresponding ejectors for lifting the same when the ejector solenoids are energized, the other ends of said cores having means for lifting the common switch-actuating means.

19. Apparatus in accordance with claim 18, said main solenoid having switch means for inserting an impedance in its energization circuit to reduce the energization of said main

solenoid after said main solenoid has completed a predetermined portion of its operative stroke.

20. Apparatus for storing and dispensing articles such as rolled or folded bills, which comprises a fixed vertical magazine having a series of cells forming a vertical column and adapted to receive said articles, said cells being open at one side thereof, article ejector means having an element adapted to enter said cells through the opposite side thereof and to push said articles through said one side of said cells, said ejector means having means for indexing the same downwardly along said magazine from cell to cell, said indexing means comprising means for holding said ejector means adjacent to each cell and for releasing said ejector means momentarily to drop by gravity to the next lower cell.

21. Apparatus in accordance with claim 20 wherein said means for indexing said ejector means along said magazine comprises a pawl and ratchet mechanism.

22. Apparatus in accordance with claim 21, wherein the ratchet of said mechanism is fixed to said magazine and the pawl is supported upon the ejector means.

23. Apparatus in accordance with claim 22, wherein the pawl is solenoid-actuated.

24. Apparatus in accordance with claim 23, wherein said ejector means has means for actuating said pawl to permit said ejector means to drop to the next cell and thereafter for actuating said pusher element to dispense the article of that cell.

25. Apparatus in accordance with claim 24, the last-mentioned means comprising means movable in a pusher-element-retracting direction for moving said pawl to a predetermined position and thereafter releasing said pawl and continuing to move in said direction, said pawl having spring means for moving it in the opposite direction.

26. Apparatus in accordance with claim 25, said means for moving said pawl comprising a solenoid-actuated spring-return plunger.

27. Apparatus in accordance with claim 26, wherein said means for moving said pawl comprises a spring-biased latch element attached to said pawl, normally biased into engagement with said drive means therefor, and cammed out of engagement with said drive means when the latch element reaches a predetermined position in the travel of said pawl.

28. Apparatus for handling bills and the like comprising a bill acceptor for determining the genuineness of the bills, said acceptor having means for advancing a bill to a predetermined location after determination that the bill is genuine, a multicellular bill magazine for receiving unfolded bills, one per cell, conveyor means for conveying bills from said acceptor to said magazine, means for indexing said magazine, cell by cell, sequentially to place empty cells in alignment with said conveyor means for receiving bills therein, means responsive to a bill upon reaching said predetermined location for actuating said indexing means to index said magazine and for actuating said conveyor means to advance the bill from said location to the cell aligned with said conveyor means.

29. Cash-handling apparatus comprising first digital register means for registering therein the amount of cash received, second digital register means for registering therein the amount of a transaction, a change computer, a change dispenser connected to the output of said computer, means for comparing the positions of the digits entered in said first register means and said second register means, and means for actuating said change computer only when the digit in said first register means is at a position representing a higher value than the digit in said second register means.

30. Apparatus in accordance with claim 29, wherein each of said register means comprises switch means having a plurality of individually operative switches at different positions, and wherein said comparing means comprises means for comparing the positions of the operative switches.

31. Bill-handling apparatus comprising bill acceptor means having motor means for advancing a bill therethrough, a bill magazine movable to receive bills from said acceptor means, and means for causing said motor means to pause in its opera-

tion until said bill magazine has moved to a position to receive a bill from said acceptor means and thereafter to become operative again to continue the advancement of said bill.

32. Apparatus in accordance with claim 31, further comprising bill conveyor means for advancing bills from the outlet of said bill acceptor means to said magazine, and means for actuating said bill conveyor means to advance a bill from said bill acceptor means to said magazine after said magazine has moved to a bill-receiving position.

33. Apparatus in accordance with claim 32, said magazine having motor means for moving the same to a bill-receiving position and having limit switch means for terminating the operation of said magazine motor means when said magazine has reached said position.

34. Apparatus in accordance with claim 33, wherein said magazine is movable in the opposite direction for the dispensing of bills therefrom and has motor means for moving the magazine in said opposite direction to a position at which a bill may be dispensed, the last-mentioned motor means having limit switch means for terminating the operation thereof when said magazine is in said dispensing position.

35. Apparatus in accordance with claim 34, said conveyor means having means for operating it in a direction to withdraw a bill from said magazine.

36. Apparatus for controlling the dispensing of change, comprising a first register for registering a sum of money received and a second register for registering the amount of a transaction, one of said registers being a stepping register and having means for advancing it to a condition in accordance with the input thereto, means for advancing said one register from said condition to a condition of correspondence with the other register, and means for producing control signals for the dispensing of change in accordance with the complement of the number of steps taken by said one register to reach said condition of correspondence with the other register.

37. Cash-handling apparatus comprising a plurality of stepping decade registers for the successive digits of a sum, a plurality of billing registers for the successive digits of a billing, there being a sum register associated with each billing register, means for setting said sum registers in accordance with the amount of a sum, means for setting said billing registers in accordance with the amount of a billing, means for advancing the sum register of the least significant digit to a home condition from its set condition, means for determining when the condition of the last-mentioned sum register corresponds to the condition of the associated billing register, means for producing a change control output representing the complement of the number of steps taken by said advanced sum register to reach said condition of correspondence, and means for causing similar advancing, determining, and producing operations in successive sum decade registers when the preceding decade registers have reached their home condition.

38. Apparatus in accordance with claim 37, said means for producing a change control output comprising slave-stepping register means operative synchronously with the sum registers.

39. Apparatus in accordance with claim 38, wherein said slave means has means for advancing it synchronously with one of said sum registers for the production of change control signals, and further comprising carry relay means for advancing said slave means one step before it is advanced in synchronism with said one sum register in response to the production of a carry command from the preceding sum register.

40. Apparatus in accordance with claim 37, there being a plurality of transfer relay means for enabling the advancement of said sum registers to their home conditions in sequence.

41. Apparatus in accordance with claim 37, said means for advancing said sum registers comprising a clock.

42. Apparatus for receiving an amount representing a sum of cash and an amount representing a billing and for dispensing change representing the difference therebetween, comprising a series of decade stepping registers having means

for setting the same in accordance with the successive digits of the sum of cash, a series of decade registers having means for setting the same in accordance with the successive digits of the billing, transfer relay means for enabling said sum registers to advance to their home condition individually in succession, means for advancing each of said sum registers to its home condition, coincidence relay means for determining when the condition of each sum register corresponds to the condition of an associated billing register, slave-stepping register means, means for causing said slave-stepping register means to advance from its home condition in synchronism with the stepping of the sum registers when the amounts set in the sum registers and the associated billing registers call for the dispensing of change, means for halting the advancement of said sum registers at their home condition after said registers

have reached a condition of correspondence with the associated billing registers, means for causing said slave register means to return to its home condition after the sum register stepping in synchronism therewith has reached its said condition of correspondence, and means responsive to said coincidence relay means and said slave register means during its return to its home condition for producing change-dispensing commands.

43. Apparatus in accordance with claim 42, further comprising carry relay means for advancing said slave register means one step from its home condition before synchronizing the stepping of said slave relay means with a sum register if a carry is called for from the preceding decade.

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