Dec. 8, 1942. J. W. BRYCE 2,304,442

RELAY COMMUTATOR

Filed Nov. 16, 1938 6 Sheets-Sheet 1

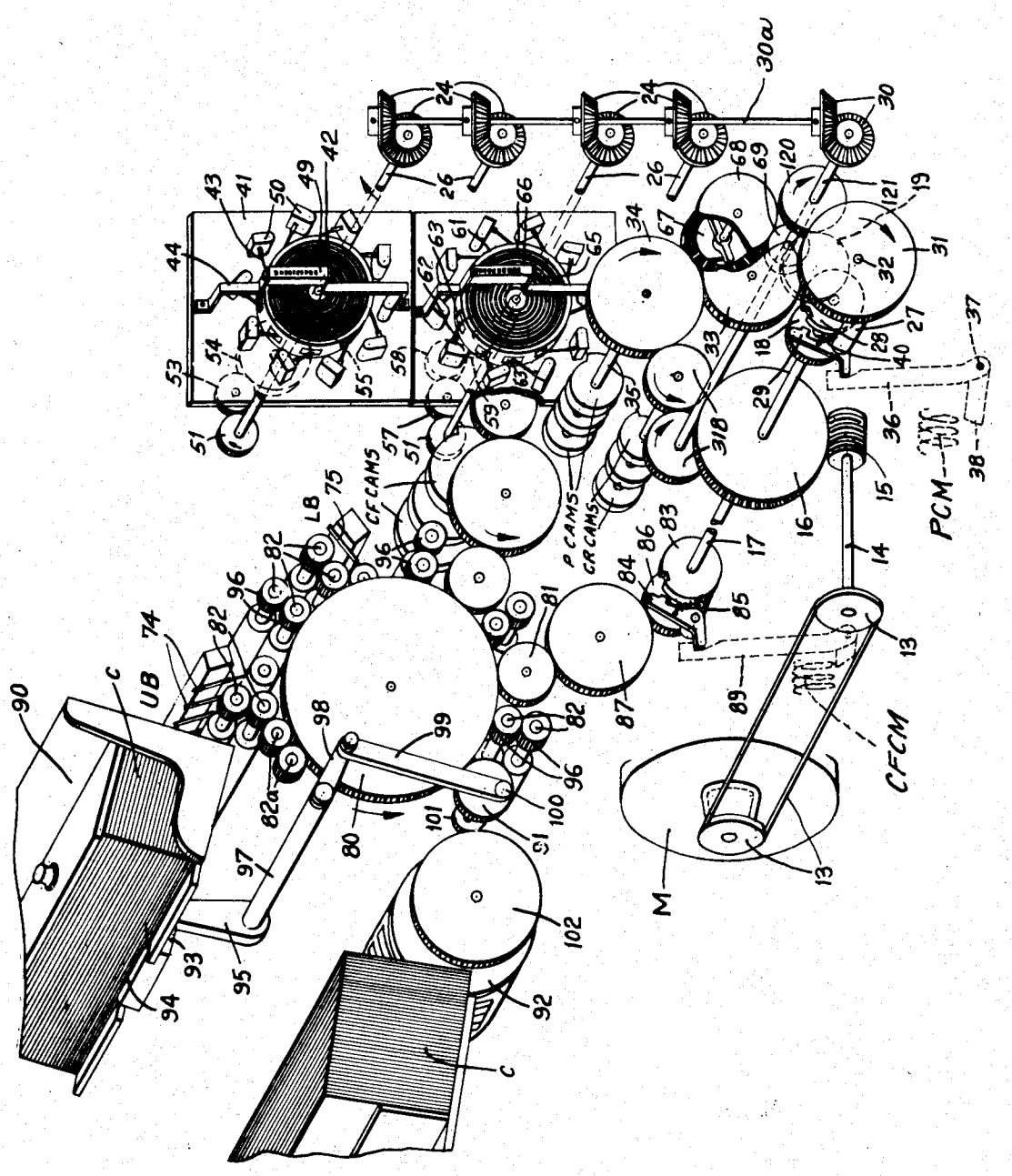


FIG. 1.

INVENTOR
JAMES W. BRYCE

BY J. W. Lonnitzer

ATTORNEY

Dec. 8, 1942. J. W. BRYCE 2,304,442

RELAY COMMUTATOR

Filed Nov. 16, 1938 6 Sheets-Sheet 2

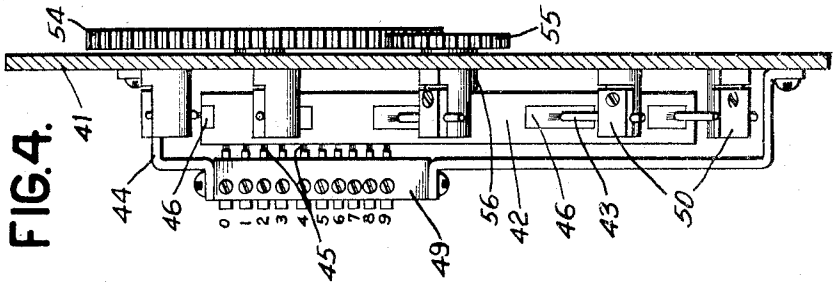
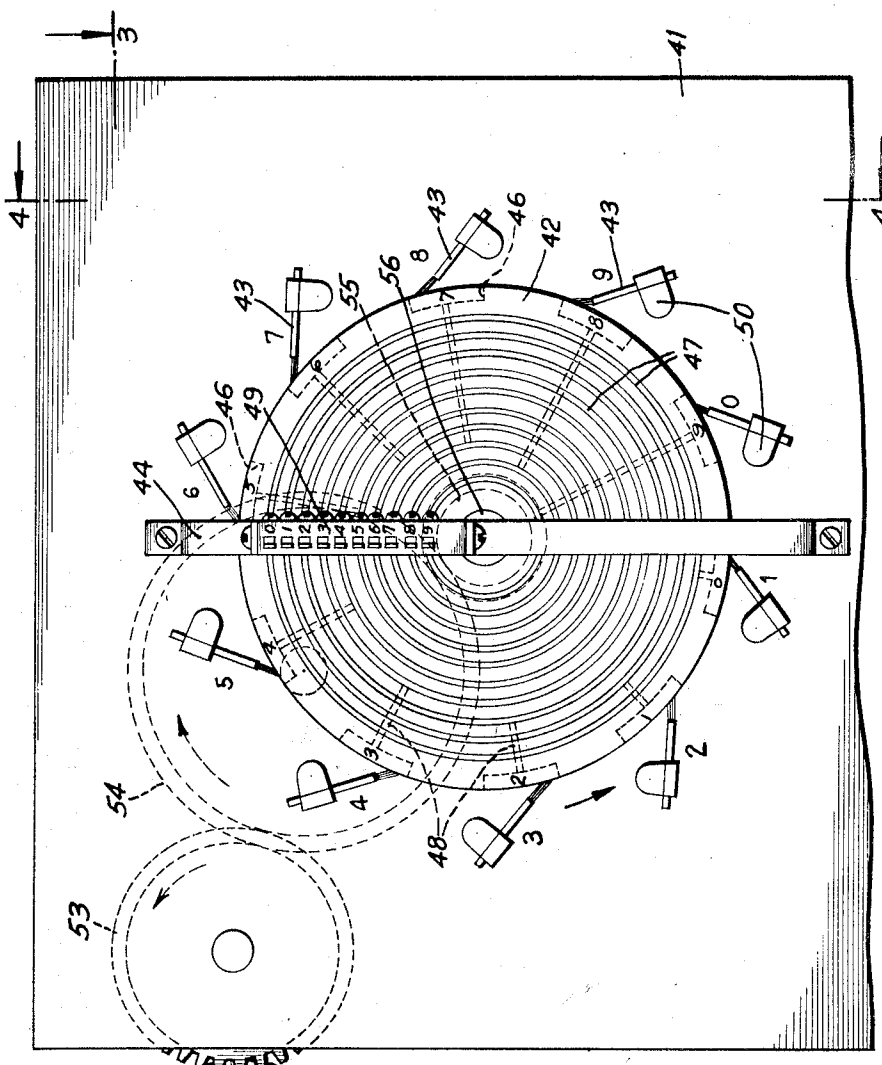


FIG. 4.



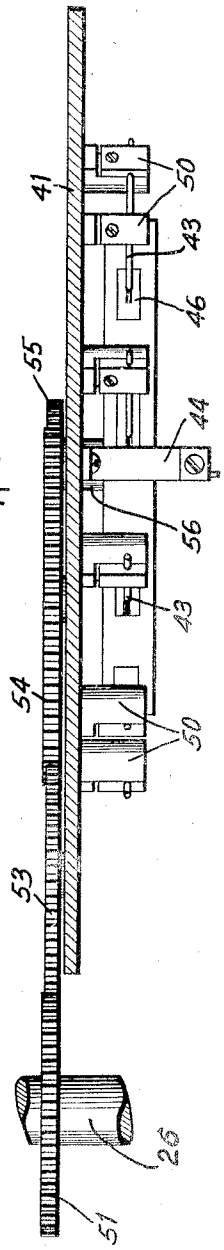


FIG. 3.

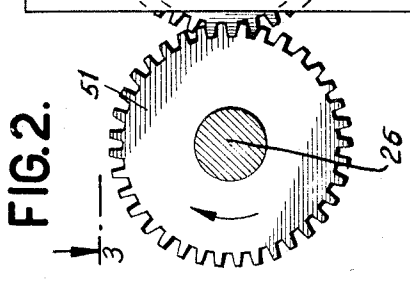


FIG. 2.

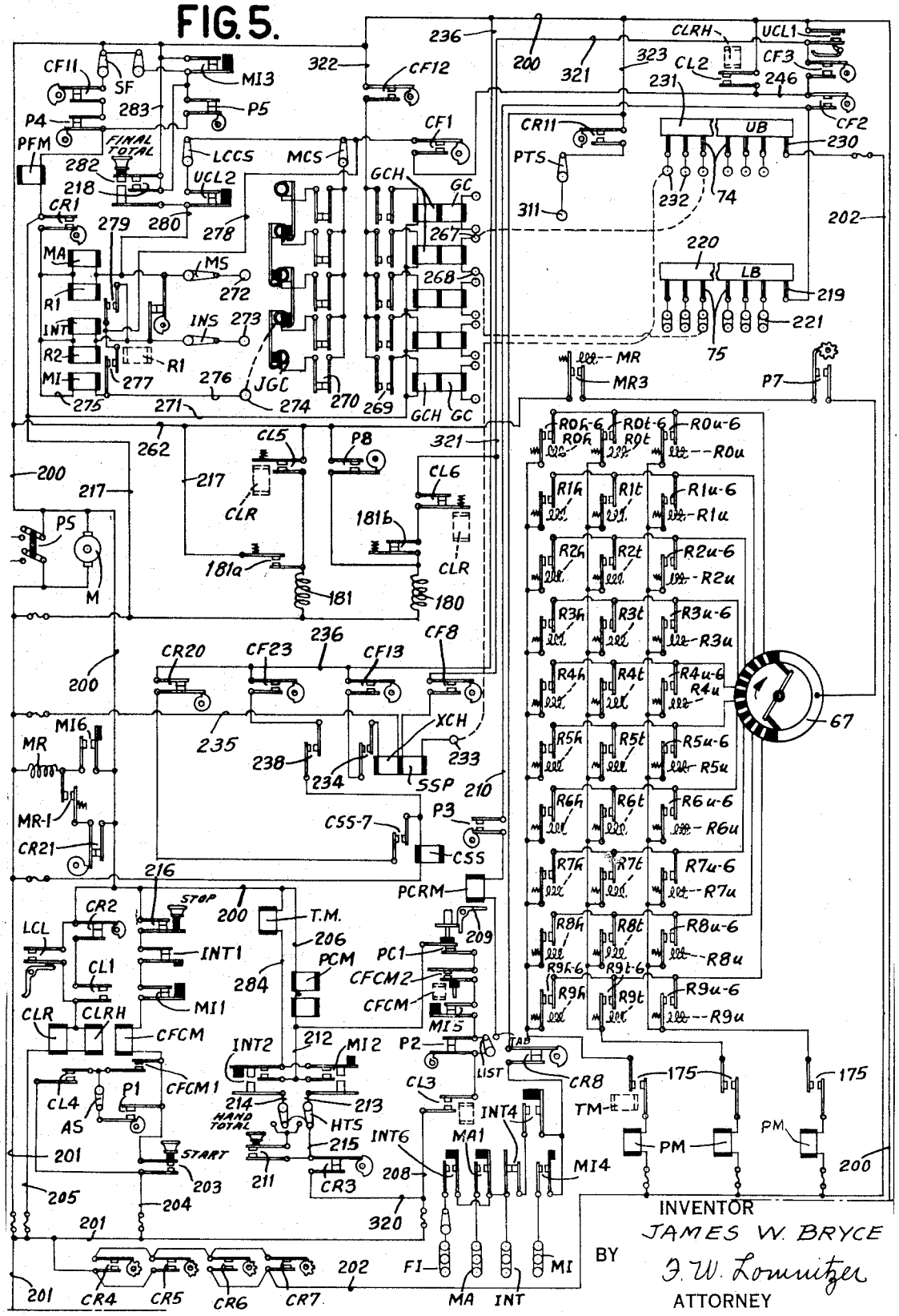
INVENTOR
JAMES W. BRYCE
BY J. W. Lonnitzer
ATTORNEY

Dec. 8, 1942. J. W. BRYCE 2,304,442

RELAY COMMUTATOR

Filed Nov. 16, 1938 6 Sheets-Sheet 3

FIG. 5.



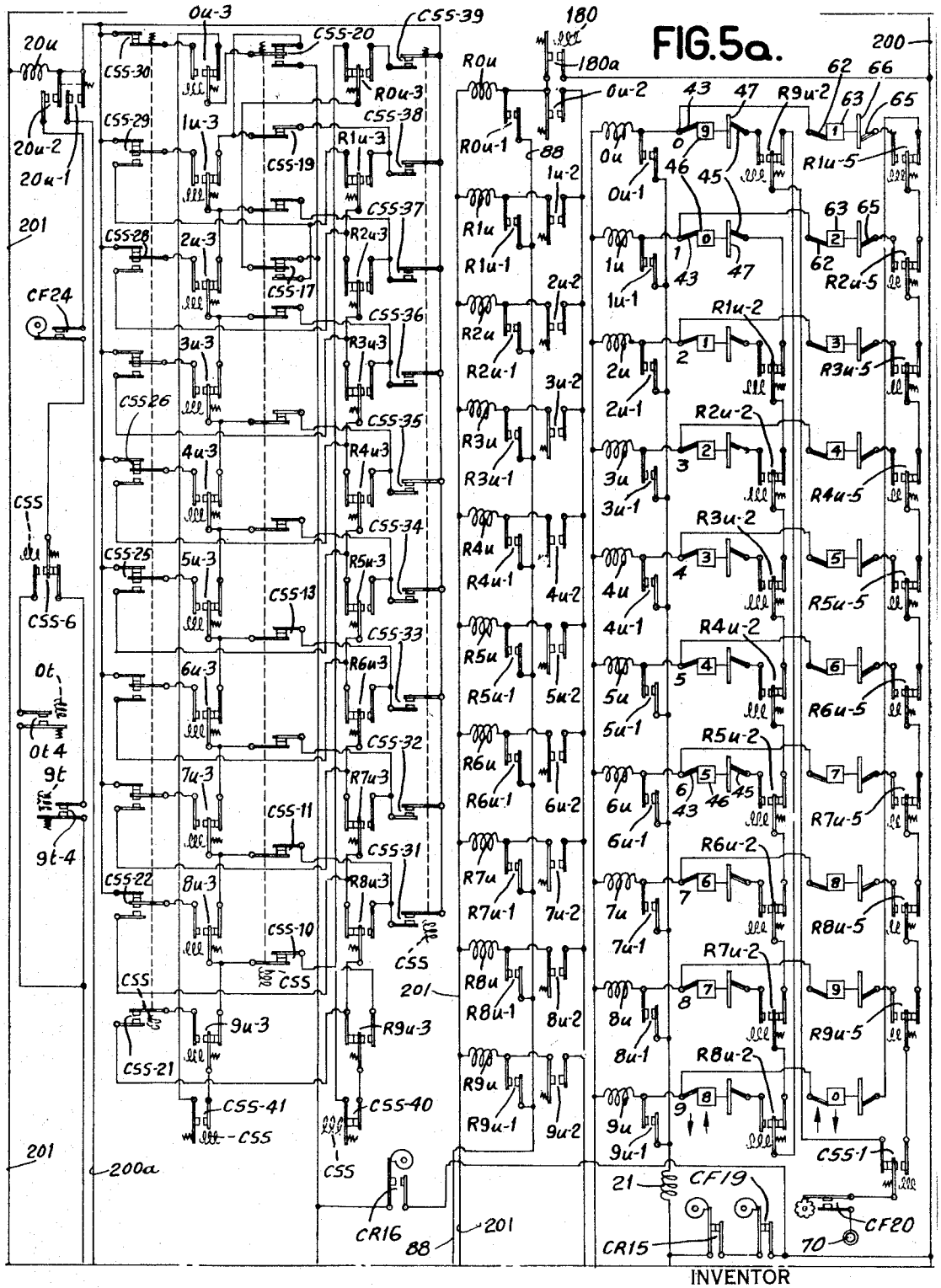
INVENTOR
JAMES W. BRYCE
BY
J. W. Lonnitzer
ATTORNEY

Dec. 8, 1942. J. W. BRYCE 2,304,442

RELAY COMMUTATOR

Filed Nov. 16, 1938 6 Sheets-Sheet 4

FIG.5a.



INVENTOR
JAMES W. BRYCE
BY
J. W. Lonnitzer
ATTORNEY

Dec. 8, 1942. J. W. BRYCE 2,304,442

RELAY COMMUTATOR

Filed Nov. 16, 1938 6 Sheets-Sheet 5

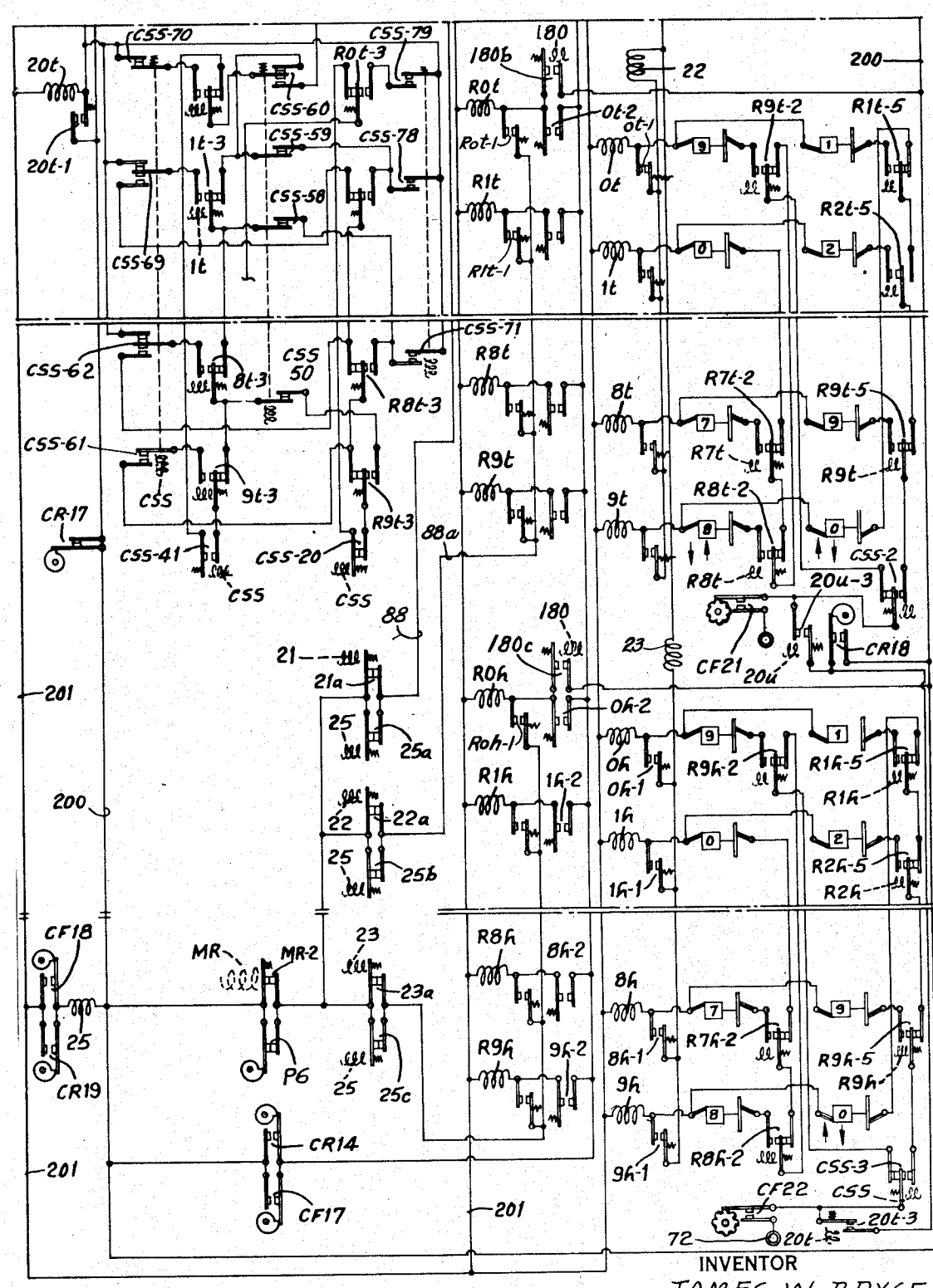


FIG. 5b.

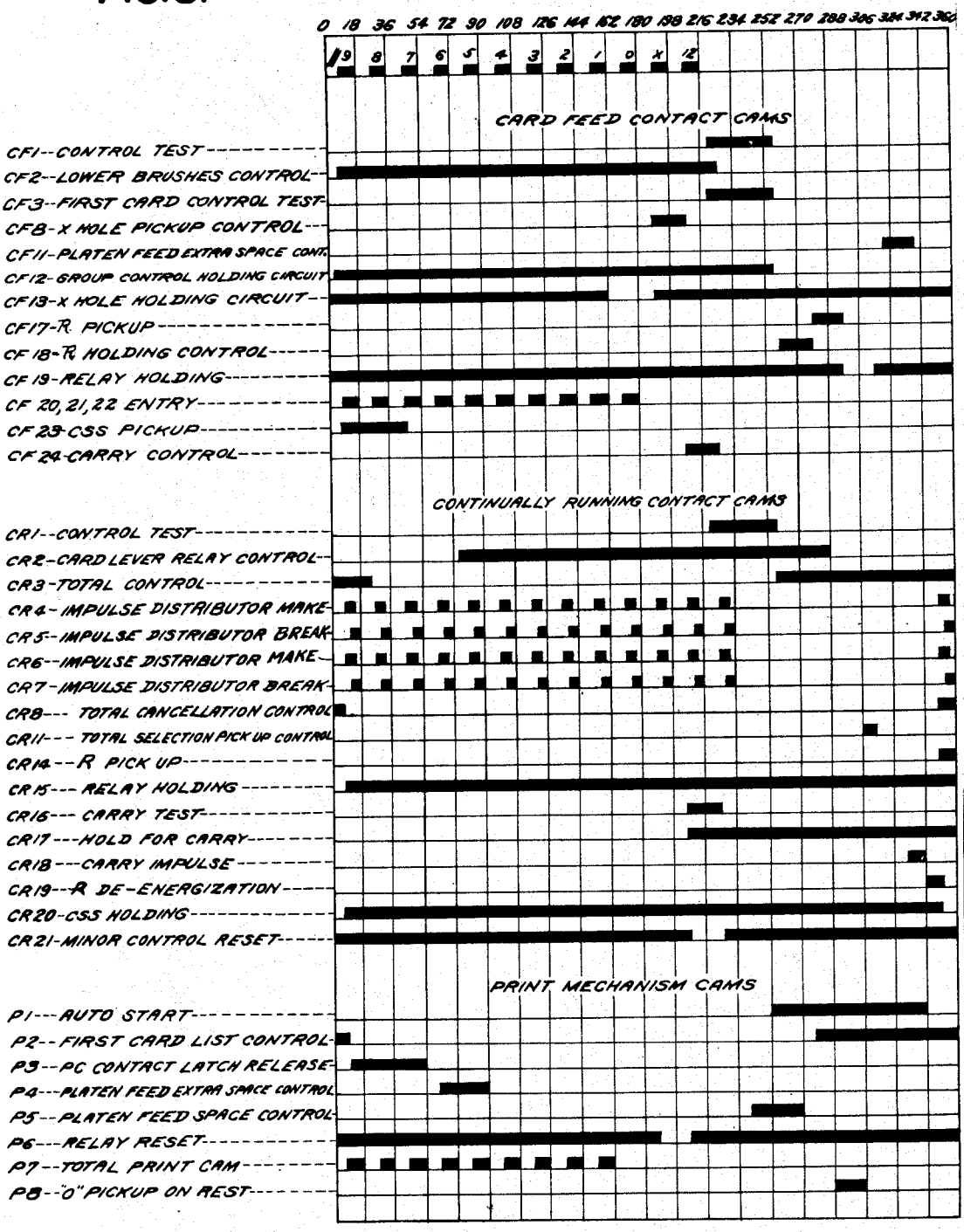
INVENTOR
JAMES W. BRYCE
BY
J. W. Lonnitzer
ATTORNEY

Dec. 8, 1942. J. W. BRYCE 2,304,442

RELAY COMMUTATOR

Filed Nov. 16, 1938 6 Sheets-Sheet 6

FIG.6.



INVENTOR
JAMES W. BRYCE
BY J. W. Lomnitzer
ATTORNEY

UNITED STATES PATENT OFFICE

2,304,442

RELAY COMMUTATOR

James W. Bryce, Glen Ridge, N. J., assignor to International Business Machines Corporation, New York, N. Y., a corporation of New York

Application November 16, 1938, Serial No. 240,743

6 Claims. (Cl. 235—61.8)

This invention relates to accumulating devices and, more particularly, to accumulators of the relay type which are entirely electrical in their operation.

It is an object of the present invention to provide an improved accumulator of the strictly electrical type which is adapted for receiving and accumulating both additive and subtractive entries at a high rate of speed.

Another object of the invention resides in the provision of an accumulator comprising a plurality of series of relays, commutating means for controlling the selective operation of the same, and circuits interconnecting the commutators with the relays uniquely arranged with a view toward minimizing the switching circuits necessary to change the operation of the accumulator from addition to subtraction upon receiving a subtractive entry.

Still another object is the provision of novel electrical carry means which is commonly operable for adding and subtracting operations.

A further object is to provide a multi-denominational accumulator having a series of value accumulating relays and a series of value retaining relays in each order, and a novel tens carry means intermediate the orders controlled by the relative magnitudes of the value retained from a previous entry and value accumulated after a new entry.

Further objects of the instant invention reside in any novel feature of construction or operation or novel combination of parts present in the embodiment of the invention described and shown in the accompanying drawings.

In the drawings:

Fig. 1 is an isometric skeleton view of an accounting machine to which the present invention may be applied.

Fig. 2 is a front elevation view and adding commutator.

Fig. 3 is a top elevation of the adding commutator shown in Fig. 2.

Fig. 4 is a right side elevation of the adding commutator shown in Fig. 2.

Figs. 5, 5*a*, 5*b* when arranged vertically in the order named form a circuit diagram of the machine.

Figure 6 shows a timing diagram of the machine.

For the sake of convenience, the accumulator which forms the subject matter of the present invention will be described as applied to an electrical accounting machine of the type disclosed in the U. S. Patent No. 2,079,418 issued May 4, 1937, to Albert W. Mills. Machines of the latter class are controlled from record cards on which numbers may be represented by perforations differentially located to represent the various digits. Each column of a card ordinarily represents a denominational order and, to accommodate a decimal system of numbers, each column is therefore provided with ten item positions progressively spaced from the edge of the card to represent the ten digits. The main drive unit of the machine and the card feeding mechanism will be first explained, followed by a detailed description of the accumulator structure and operation. Because of the abbreviated nature of the disclosure of the feeding mechanism in the above mentioned patent, a more complete view of a feeding mechanism which may be used in the present machine has been taken from the U. S. Patent No. 2,042,324 issued May 26, 1936, to John Royden Peirce.

Main drive

Referring to Fig. 1 it is noted that a motor M has a belt and pulley connection 13 with a worm shaft 14. The worm 15 mounted thereon, drives worm wheel 16 fixed upon shaft 17 so that the shaft continues running as long as the motor receives current.

A gear 18 mounted upon constantly running shaft 17 through gears 19 and 120 drives shaft 121 which in turn through bevel gears 30 causes vertical shaft 30*a* to rotate. A group of parallel shafts 26 are operatively connected with the upright shaft 30*a* through bevel gears 24.

Thus, through this train of gearing, shafts 26 are seen to be in constant rotation so that gears 51 mounted upon these shafts will in turn keep in constant rotation the actuating elements of the accumulator units with which they are related and which will be hereinafter more fully explained.

The shaft 17 carries, adjacent to gear 18, a notched disk 28 adapted to be engaged by a dog 29 pivotally mounted upon an arm 27 integral with a gear 31. The latter gear is carried by a stub shaft 32 in axial alinement with shaft 17 and, through idler gear 33, drives a gear 34 mounted on cam shaft 35. An armature latch 36 pivoted at 37 upon an arm 38, normally holds dog 29 out of engagement with the driving disk 28 in the position shown in the drawings. A magnet PCM upon energization, draws armature latch 36 to the left releasing dog 29 so that its spring 40 may bring it into engagement with driving disk 28.

Upon deenergization of magnet PCM, armature 36 will be moved by its spring into the path of a projecting toe of dog 29 to throw the dog out of engagement with the disk 28. Arm 27 will be arrested at this time to prevent further movement of gear 31 in a clockwise direction. Any suitable rebound latch (not shown) may be used.

The shaft 17 is also shown as carrying a second clutch driving disk 83 cooperating with a dog 84 mounted on an arm 85 to which is fixedly connected a gear 86 to drive the card mechanism through idler gear 87 as will be described presently. The engagement of these clutch elements is controlled by magnet CFCM and armature latch 89 in the manner described in connection with magnet PCM and its armature latch 36.

Card feeding mechanism

Energization of magnet CFCM causes connection to be made between constantly running shaft 17 and a ring gear 80 through a pinion 81 and idler gear 87. The record cards C are fed singly from the supply magazine 90 by the usual card picker mechanism comprising in the present embodiment a slidably mounted reciprocal plate 93 carrying a picker knife 94 for cooperation with the record cards. The plate 93 has a pin and slot connection with an arm 95 secured to a shaft 97 which carries at its end an arm 98 connected by a link 99 to a stud 100 mounted eccentrically on a pinion 91 meshing with the ring gear 80. Each reciprocation of plate 93 and picker knife 94 causes a card to be fed from the magazine to the analyzing mechanism, wherein the card is presented to two sets of analyzing brushes 74 and 75 which sense the perforations thereon.

The feeding of the record cards is effected by concentrically arranged pairs of rollers 96 having driving connection to the ring gear 80 through the pinion gears 82. The cards pass from the last pair of rollers 96 to any suitable stacker mechanism 92, that shown being of the rotary type to the end of the shaft of which is attached a gear 102 meshing with a pinion 101 secured to the pinion 100.

The usual card levers (not shown) may be positioned at the card stations to control the various functions of the machine as will be described in connection with the circuit diagram. As the leading edge of a record card reaches the upper analyzing brushes 74, the card lever at the upper station UB is operated to close contacts UCL1 and to open contacts UCL2 (Fig. 5). As the card reaches lower brushes 75, a similar card lever at the lower station LB is operated to close contacts LCL. As long as successive cards are presented at the analyzing brushes the card levers are maintained in an operative position.

Accumulator

In the present type of machine the passage of the card under the sensing brushes is synchronized with the balance of the mechanism to produce the proper differential action in the accumulating device.

The accumulator structure includes the provision of rotating commutators such as the one illustrated in Figs. 2, 3 and 4. A plate 41 forms a mounting for commutator disk 42 and brush holders 50 containing brushes 43. Brackets 44 are affixed to the plate 41 and carry an insulating block 49 in which brushes 45 are adjustably mounted. The disk 42 is moulded of insulating material and has ten segment spots 46 of conducting material spaced equally around the periphery. Imbedded in the face of the disk 42 is a series of concentric conducting rings 47. The rings are wired internally to segment spots 46 by means of connectors 48 shown in dotted outline in Fig. 2. Brushes 45 bear upon the rings 47 and establish a connection to brushes 43 through the segment spots 46.

The commutator disk 42 is connected to the drive gear 51 (Fig. 1) through a gear train comprising gears 53, 54, and 55 which are mounted on the back of the plate 41, gear 55 and commutator 42 being affixed to a common shaft 56. Hence rotation of the drive gear 51 in a clockwise direction causes commutator 42 to rotate in a counterclockwise direction.

In Fig. 2, the relation between the disk 42 and the brushes 43 is the relation assumed at 150° or 330° time in the machine cycle (Fig. 6). The machine cycle comprises 360° which is divided into twenty so-called index points of 18° each. The rotation of the disk 42 is in synchronism with the passage of the card past the brushes, that is, the 0 segment 46 contacts the 9 brush 43 between 0° and 18°, at which time the card brush is scheduled to enter a 9 hole, if any, in the card. Between 18° and 36° the 0 segment 46 contacts the 8 brush 43, etc. As will be explained later, when a hole in the card actually occurs, a circuit will be completed through the 0 segment 46 and the brush with which it is contacting at the time the card brush enters the hole. This assumes that no previous entry had been made in the accumulator. If, for example, the accumulator had a value of "4" standing therein, then the 4 segment 46 instead of the 0 segment 46 would be the active segment through which a circuit is completed at the time the card brush enters the hole in the card. If it were, say, a "5" hole in the card, a circuit would be completed through the 9 brush 43; and if it were, say, a "4" hole, a circuit would be completed through the 8 brush 43, etc.

Immediately below the commutator 42 is located a commutator 61 of similar construction which is used for subtraction. The latter commutator is driven from the main drive through a train of gears 57, 58, 59, and 60, an extra gear being provided in the train so that commutator 61 is driven in a clockwise direction instead of counterclockwise as in the case of the adding commutator 42. Brushes 62 cooperate with segments 63, and brushes 65 cooperate with concentric rings 66 which are similar to the previously described rings 47.

Cooperating with the above described commutators are a plurality of series of relays. Two groups of ten relays each form a denominational order. One of the two groups consists of value accumulating relays and the other group comprises value retaining relays. In Fig. 5*a* the two groups of relays for the units order are shown and are designated R0*u* to R9*u* and 0*u* to 9*u*, respectively.

A readout emitter 67 is connected for rotation to the continuously running shaft 121 through gears 68 and 69. Although this emitter is in constant rotation it is only rendered effective to complete certain circuits of the machine upon total taking cycles as will be described hereinafter in connection with the circuit diagram.

General circuits

As previously mentioned, the machine is provided with analyzing brushes, one for each column of the record card. The card is fed by these brushes so that the "9" digit position leads, followed by the "8" position, then the "7," etc., in a manner well known in the art. Hence circuits are completed at differential time depending upon the magnitude of digit values analyzed on the record card.

To set the machine in operation, the switch PS (Fig. 5) is closed to provide a current supply to lines **200** and **201**. Motor M is thus energized to set in motion the continuously rotating drive members of the machine. Depression of the start key closes contacts **203** to establish a circuit from line **200**, stop key contacts **216**, contacts INT1 and MI1, card feed clutch magnet CFCM, contacts **203** now closed, wire **204**, to line **201**. The energization of the card feed clutch magnet CFCM causes operation of the card feeding mechanism to feed cards through the machine. This magnet also controls CFCM1 and CFCM2, closing them when energized. The card lever contacts UCL1 and LCL are held closed by the feeding of the cards past the upper and lower brushes as previously described.

With upper card lever contacts UCL1 closed and before relay contacts CL6 open during the feed of the first card, a circuit is completed from line **200**, contacts UCL1 now closed, wire **321**, relay contacts CL6, relay contacts **181***b*, relay coil **180**, to line **201**. Closure of contacts **180***a*, **180***b*, and **180***c* (Figs. 5*a*, 5*b*) provides a circuit from line **200** to relays R0*u*, R0*t* and R0*h*, respectively, to line **201**. Energization of these relays provides a zero manifestation in each order of the accumulator when starting.

Holding circuits for relays R0*u*, R0*t*, and R0*h* are established as follows: for R0*u*, from line **201**, relay coil R0*u*, contacts R0*u*—1 now closed, via wire **88** to contacts **21***a* and **25***a* in parallel, contacts MR—2 and P6 in parallel back to line **200**; for R0*t*, from line **201**, relay coil R0*t*, contacts R0*t*—1, via wire **88***a* to contacts **22***a* and **25***b* in parallel, contacts MR—2 and P6 to line **200**; and for R0*h*, from line **201**, relay coil R0*h*, contacts R0*h*—1, contacts **23***a* and **25***c* in parallel, contacts MR2 and P6 to line **200**. As the first card operates the lower card lever to close contacts LCL, a circuit is completed to energize relay coil CLR from line **200**, contacts LCL now closed, magnet CLR, wire **205**, to line **201**. Contacts CL5 close upon energization of relay coil CLR and provide a circuit as follows: from line **200**, wire **262**, relay coil **181**, to line **201**. Contacts **181***a* provide a holding circuit for coil **181** which is maintained energized as long as the switch PS remains closed. Contacts **181***b* open at this time to prevent further energization of relay coil **180** by the circuit described above.

Cards now continue to feed through the machine until the stop key is depressed, or until the machine runs out of cards, or, if group controlling as will be explained presently, until the end of a control group is reached. The effect of any of these three occurrences is to break the circuit to the card feed clutch magnet CFCM. This circuit is from line **200**, stop key contacts **216**, contacts INT1, contacts MI1, magnet CFCM, contacts CFCM1 now closed, contacts CL4 now closed, wire **204**, to line **201**.

The machine is provided with group control devices for sensing and comparing the group number indications on successive cards under the upper and lower brushes. For this purpose each one of a group of magnets GC is connected in series with an upper and lower brush. A plug wire may connect jack **267** to jack **232** and another plug wire may be placed between jack **268** and jack **221**. Then, if the indications in a certain column on successive cards agree in index position, the related magnet GC is energized to prevent the taking of an automatic total. The magnets GC are associated with contacts **269** in series with group control holding circuit magnets GCH, so that when magnet GC is energized, a contact **269** is closed and is held closed by the energized magnet GCH which at the same time opens a group control contact **270**. The circuit through magnets GCH is from line **201**, wire **217**, wire **271**, magnets GCH, contacts **268**, contacts CF12, and wire **322** to line **200**.

The opened contacts **270** prevent the energization of the major, intermediate and minor group control magnets MA, INT, and MI, which may be connected in series to one or more of contacts **270** in parallel by plug wires from jacks **272**, **273**, and **274** to jacks JGC. For purposes of illustration and simplicity, only the minor control is shown utilized in the circuit diagram. Obviously, in a similar manner the intermediate and major controls could be likewise utilized.

When one or more of the contacts **270** remain closed indicating a change in record card groups, the connected group control magnet is energized. The circuit is from line **201**, wire **217**, contacts CR1, wire **275**, magnet MI, wire **276**, jack **274**, plug wire to the second jack JGC, one or more contacts **270**, control switch MCS, contacts CF1 closed after comparing cards, wire **246** and contacts CL2, to line **200**. The energized magnet MI acts to operate all the MI contacts throughout the machine, opening some and closing others to stop the regular adding operations of the machine so that an automatic total may be taken from the accumulator in a manner to be described hereinafter.

Accumulator circuits

Referring now to Figs. 5*a* and 5*b*, three denominational orders of the accumulator are shown as representative. An explanation of these three orders; namely, the units, tens, and hundreds orders, will serve to describe the operation of the accumulator regardless of how many denominational orders are employed.

Consider first the units order as shown in Fig. 5*a*. When adding into the accumulator the socket **70** (lower right hand corner of Fig. 5*a*) is plugged to socket **221** going to the lower brushes. Assume, for example, that "6" is being added into the accumulator. At the "6" index point in the card feed cycle, the brush **43** associated with the relay **6***u* will be contacting the segment **46** associated with the zero brush **45**. Hence a circuit is completed from line **200** (Fig. 5), contacts CL2 and CF2, common brush **219**, contact roll **220**, brush **75** making electrical contact with roll **220** at a differential time controlled by the location of the digit indication, jack **221**, plug wire to jack **70**, contacts CF20 now closed, CSS—1 contacts in the normal position, through the R9*u*—2, R8*u*—2, etc., contacts in the position shown, zero brush **45**, corresponding concentric segment **47**, zero segment **46**, brush **43** associated with the **6***u* relay, relay **6***u* and back to line **201**. Contacts CSS—1 are

controlled by a subtraction control magnet CSS which during adding operations, such as are now being effected, remains deenergized. At such time as subtractive entries are being made in the accumulator, relay magnet CSS is energized from control designations in the card as will be explained hereinafter. Contacts 6*u*—1 close to provide a holding circuit through relay contacts 6*u*—1, relay coil 21, cam contacts CR15, cam contacts CF19, to line 200. Shortly thereafter cam contacts CF18 (Fig. 5*b*) close to energize relay 25 by a circuit from line 201, CF18, relay 25, to line 200. Relay contacts 25*a* open and, with contacts 21*a* open, the holding circuit for relay coil R0*u* is opened and the relay deenergized. Then cam contacts CF17 close to complete a circuit from line 200, through contacts CF17, contacts 6*u*—2 now closed, relay coil R6*u*, to line 201. Relay points R6*u*—1 close and provide a stick circuit through contacts 25*a* and P6 to line 200. Finally cam contacts CF19 open to deenergize relay coil 6*u*.

During the next adding cycle as the succeeding card passes the brushes 75 assume that an "8" is to be added to the "6" already in the accumulator. A circuit is then completed as previously traced to the jack 70, through cam contact CF20, relay contacts CSS—1, as shown, through contacts R9*u*—2, R8*u*—2, R7*u*—2 in the position shown, contacts R6*u*—2 now shifted, brush 45, ring 47, segment 46, through brush 43 of relay coil 4*u* which contacts the "6" segment 46 at this time, relay coil 4*u*, to line 201. Relay 4*u* is maintained energized in the manner previously described through its contacts 4*u*—1, relay coil 21, and cam contacts CR15, CF19, to line 200.

Cam contacts CF18 close to energize relay 25 by a circuit from line 201, through CF18, relay 25, to line 200. Relay contacts 25*a* open and with contacts 21*a* open the holding circuit for relay R6*u* is opened and relay R6*u* deenergized. Then cam contacts CF17 close to energize relay coil R4*u* through the now closed 4*u*—2 contacts in a similar manner to that previously described for R6*u*.

Since "8" has been added to "6" in the units order to obtain "4" therein it is also necessary to carry 1 to the next higher or tens order. Accordingly just after adding is completed a test circuit in the units order is made to determine if a carry is required. Contacts CR16 close and a circuit is completed from line 200, through contacts CR16, CSS—17, R0*u*—3, CSS—40, R9*u*—3, etc., in the position shown, to and through the R6*u*—3 contacts in the shifted position through the CSS—13 and 5*u*—3 contacts in the position shown, through the 4*u*—3 contacts in the shifted position through contacts CSS—26 in the position shown, relay coil 20*u*, to line 201. Relay coil 20*u* closes its contacts 20*u*—1 to provide a holding circuit through wire 200*a* and cam contacts CR17 to line 200. It will be appreciated that this circuit is tested immediately following adding operations at which time relay coils R0*u* to R9*u* manifest the amount from the previous cycle and the accumulator relay coils as 1*u*, 2*u*, etc., manifest the old amount plus the amount just received from the card. The energizing circuit to the 20 relay is completed only if the new amount standing therein is less than the previous amount. Such a condition indicates a carry is required to the next higher order.

Accordingly, at the end of the cycle cam contacts CR18 close and a circuit is completed from line 200, cam contacts CR18, contacts 20*u*—3 now closed, contacts CSS—2, in the position shown, R9*t*—2, R8*t*—2, etc., contacts all in the position shown, zero brush 45, ring 47, zero segment 46, "1" brush 43, contacting zero segment 46 at this time, relay 1*t*, to line 201. Relay 1*t* is maintained energized by a circuit from line 201, relay coil 1*t*, through contacts 1*t*—1, relay coil 22, cam contacts CR15, CF19, to line 200. CR19 then closes to energize relay 25. The 25*b* points open and, with the 22*a* points open, the holding circuit to the R*t* relay coils is momentarily opened. This removes any setup contained in the R*t* coils before putting in the new setup caused by the carry. The circuit for the new setup is completed when contacts CR14 close in the following manner: from line 200, contacts CR14, contacts 1*t*—2, relay coil R1*t*, to line 201. The R1*t* coil is held energized through R1*t*—1 contacts, 25*b* contacts, contacts P6, to line 200. Contacts CR15 then open to deenergize relay coils 1*t* and 22 by opening the holding circuit through the 1*t*—1 relay contacts.

In the event that "9" was standing in the tens order, a carry of "1" into the tens order from the units order would also carry through to the hundreds order in a similar manner. This occurs upon closure of contacts 9*t*—4, which complete a circuit at the carry test time as follows: Simultaneously with the energization of 20*u* relay, contacts 20*u*—2 close and establish a circuit from line 200, contacts CR16, etc. as described previously for the energization of relay coil 20*u*, to but not through the latter coil, contacts 20*u*—2 now closed, through cam contacts CF24 now closed, contacts CSS—6 in the position shown, contacts 9*t*—4 now closed, relay coil 20*t*, to line 201. If the "9" value in the tens order is held over from a previous cycle, the 9*t* relay has to be reenergized before the carry impulse, since the accumulator relays are deenergized after their values are transmitted to the retaining relays. For this purpose the zero index points in all columns of the field not containing a significant digit are punched, to reenergize the accumulator relay corresponding to the energized retaining relay of the same order, by an impulse transmitted at the zero position of the commutator. Relay points 20*t*—1 and cam contacts CR17 maintain the 20*t* relay coil energized through the carry time in the cycle. The 20*t*—3 points provide carry into the hundreds order in the same manner the 20*u*—3 points carry to the tens order.

Accumulator theory subtracting

In subtracting operations the input circuit to the relays is provided through a subtracting commutator which rotates in a reverse direction to the adding commutator. The input circuit from the brushes is shifted under control of an "X" indication in the card which is to effect subtraction. This "X" indication is located in the "11" position of the card immediately above the zero index position.

Assume for purposes of illustration that a card with an "X" indication bears a negative amount of "136," and that there is already an amount of 234 standing in the accumulator. As the card bearing "136" passes the upper brushes (Fig. 5) a circuit is completed as follows: from the line 201, contacts CR4 to CR7, wire 202, common brush 236, contact roll 231, the upper brush 74 cooperating with the particular card column containing the "X" perforation, jack 232, a plug wire to jack 233, subtraction selection pickup magnet SSP, contacts CF8 now closed, wire 321, contacts

UCL1, to line 200. When magnet SSP is energized it closes contacts 234, and a holding circuit is established through magnet XCH from line 201, wire 235, magnet XCH, contacts 234 now closed, contacts CF13 now closed, wire 236, to line 200. Magnet XCH closes contacts 238 and, at the beginning of the next cycle when cam contact CF23 closes, a circuit is completed from line 200, wire 236, cam contacts CF23 now closed, contacts 238 now closed, relay coil CSS, wire 239, to line 201. Relay contacts CSS—1 in conjunction with contacts CR20 provide a holding circuit through wire 236 to line 200.

Considering now the units column of the accumulator (Fig. 5a), the R4*u*—5 relay contacts are already closed and therefore at the "6" position a circuit is completed through the card from line 200, contacts CL2 and CF2 now closed, common brush 219, contact roller 220, lower brush 75, plug 221 to jack 70, cam contacts CF20, contacts CSS—1 now shifted, through the R9*u*—5, R8*u*—5, etc., relay contacts in the position shown, to and through contacts R4*u*—5 now shifted, through the "4" segment 63, brush 62 of the 8*u* relay now contacting the "4" segment, through the 8*u* relay coil, to line 201. Relay coil 8*u* is held through its 8*u*—1 contacts in the usual manner. Transfer of the setup to the R*u* relays is effected in the manner previously described for addition. In a similar manner to that just described for the units column, the subtraction of "3" from "3" in the tens column will leave a zero therein, and the subtraction of "1" from "2" in the hundreds column will leave "1" therein.

The fact that "6" has been subtracted from "4" in the units column to give eight makes it necessary to subtract an extra "1" during the carry time from the tens order. This is because a higher number has been subtracted from a relatively lower number and such a condition requires borrowing one from the next higher order. In this problem such further subtraction of "1" in the tens order from zero standing therein after the normal subtraction time also necessitates a still further subtracting operation in the hundreds order due to the zero in the tens order being less than the "1" which is being subtracted.

To effect the above borrowing operation immediately following the normal entry position of the cycle the cam contacts CR16 close. A circuit is then provided from line 200, contacts CR16, contacts CSS—20 now shifted, contacts 0*u*—3, in the position shown, contacts CSS—41 now closed, contacts 9*u*—3 in the position shown, contacts 8*u*—3 and CSS—22 now shifted, contacts R7*u*—3, R6*u*—3 and R5*u*—3 in the position shown, R4*u*—3 now shifted, contacts CSS—35 now closed, relay coil 20*u*, to line 201. Relay coil 20*u* was energized because of the fact that the new value of "8" in the units column was greater than the old value of "4." Such a condition indicates a negative carry of "1" when subtracting. In the tens order the new value of zero is less than the old value of "3" and no carry test circuit will be completed to energize relay coil 20*t*. The latter coil, however, is energized by another circuit through the 0*t*—4 relay contacts. At the time coil 20*u* is energized, the contacts 20*u*—1 and 20*u*—2 close and a circuit is established from line 200, CR—17 contacts, line 200*a*, contacts 20*u*—1, contacts 20*u*—2, CF24 contacts, normally open side of transfer contacts CSS6, contacts 0*t*—4, relay coil 20*t*, to line 201. Contacts 20*t*—1 are now closed and the relay coil 20*t* is held energized via the circuit from line 201, contacts 20*t*—1, CR—17 contacts, to line 200.

During the carry portion of the cycle, contacts CR18 close and a circuit is completed from line 200, contacts CR18, contacts 20*u*—3 now closed, contacts CSS—2 now shifted, relay contacts R9*t*—5, etc., through the subtracting commutator to energize the 9*t* relay coil. Likewise, in the hundreds order the closed 20*t*—3 points effect a subtraction of "1" from "1" standing therein to leave zero. Hence the final result of 098 is manifested upon the R relays at the completion of the carry.

To summarize the above description of the accumulator operation, it has been shown that two commutators are provided for each order of an accumulator. These are wired in a similar manner but rotate in opposite directions. The commutators cooperate with two groups of ten relays each, i. e. 0*u* to 9*u* and R0*u* to R9*u* which receive and store data from the record card. Entry routing circuits to the commutators, and hence to the accumulator, are shifted under control of the stored data as manifested by relays R0*u* to R9*u* newly entered data is accumulated with the stored data. The entry circuits upon being shifted, in effect change the differential time of entry. For example, if an accumulator column contains zero, an entry of "4" is directed to the 4*u* relay. If the accumulator contained "5," however, the entry of "4" would be directed to energize the "9" relay. When subtracting, if the accumulator contained "5" and "4" were subtracted, the oppositely rotating commutator would effect energization of the "1" relay. Carry is effected electrically by a test circuit. This circuit is controlled by the data previously in the accumulator and the data contained therein. Should the amount standing in an accumulator order as manifested by the 0*u*—9*u* relays after an entry is effected be less than the amount in the accumulator order before such entry is effected as manifested by the R0*u*—R9*u* relays, a test circuit controlled by contacts of these relays indicates a carry requirement.

Total taking

When a total is to be taken, the contacts MI2 close to energize the total magnet TM. The circuit is from line 200, magnet TM, wire 284, contacts MI2 now closed, wire 213, switch HTS, wire 215, contacts CR3, wire 320, to line 201. The energized magnet TM operates to shift its contacts 175. The printing clutch magnet PCM is energized by a circuit from line 200, wire 206, magnet PCM, wire 212, contacts MI2 now closed, wire 213, switch HTS, wire 215, cam contacts CR3, wire 320, to line 201. The energization of magnet PCM causes the print operating devices to be clutched to the main drive. These operations are more fully described in the aforementioned patent to Mills and are well known in the tabulating art so that further description of the printing mechanism and controls is considered unnecessary. Closure of contacts MI6 energizes magnet MR by a circuit from line 200, MI6 contacts now closed, MR relay, to line 201. Magnet MR is then held energized through contacts MR—1 and cam contacts CR21.

Printing in the present embodiment of the invention is controlled by special contacts of the R relays. Referring again to Figure 5, the R6 contacts are wired to an emitter 67, the other side of the contacts are wired to the print magnets PM, through contacts 175. Depending upon

which R relay contact is closed, circuits are completed at a differential time to print magnets PM in the well known manner to print the accumulated results. Assume the units and tens orders of the accumulator contain "4" and "6" respectively, then at the "6" index point in the total print cycle a circuit is completed from line 200, wire 262, contacts MR—3, now closed, cam contacts P7, emitter 67, contacting the "6" spot, contacts R6t—6, contacts 175 now closed, tens order print magnet PM, to line 262. In a similar manner, at the "4" time a circuit is completed through the R4u—6 contacts to energize the units print magnet PM to print a "4."

Near the end of the print cycle, cam contacts P6 open (Fig. 5b) and, with MR—2 contacts also open, the holding circuits for the R relays are opened and they are deenergized. Shortly thereafter contacts P8 (Fig. 5) close to energize relay coil 180 by a circuit from line 200, wire 262, P—8, relay coil 180, and back to line 201. Contacts 180a, b and c, (Figs. 5a and 5b) upon closing energize the R0u, R0t, and R0h relays to again set up zero in the accumulator. If the auto start switch AS is closed, the closing of cam contacts P1 at the end of the total cycle serves to energize the card feed clutch magnet CFCM to resume card feeding. If this switch is open the start key 203 must be again depressed.

Since the basic novel features of the invention have been shown and described as one modification, it will be understood that various omissions and substitutions and changes in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A record controlled accounting machine including a source of differentially timed entry representing impulses having a multi-denominational order accumulating device controlled thereby for receiving digit value entries in the various orders and including in each denominational order a plurality of value retaining relays one for each digit value, cyclically operating commutating means provided with differentially related segments associated with the value retaining relays, a plurality of value accumulating relays one for each digit value, a plurality of entry circuit connections available for selective completion under the joint control of the value retaining relays and the commutating means to select one of the value accumulating relays for energization according to the detected digit value representation through the selected entry circuit connections for the purpose of manifesting the accumulated digit value, means controlled by an energized accumulating relay and effective following the accumulating portion of the cycle of the commutator means for energizing a corresponding value retaining relay, means for deenergizing the value accumulating relay subsequent to the energization of said value retaining relay, means controlled by the latter relay upon energization for completing a different one of the entry circuit connections through an associated segment of the commutator prior to the next cycle in accordance with the magnitude of the digit value shifted from the accumulating relays, and means to deenergize the value retaining relay under the control of the value accumulating relays during the accumulating portion of the next cycle of the commutator.

2. In combination with a source of differentially timed entry representing impulses a multi-denominational order accumulating device controlled thereby for receiving digit value entries in the various orders and including in each denominational order a plurality of value retaining relays one for each digit value, a cyclically operating commutator having differentially related segments associated with the value retaining relays, a plurality of value accumulating relays one for each digit value including contacts, a plurality of entry circuits selectively completable through the associated segments of the commutator under control of the value retaining relays for selecting one of the value accumulating relays for energization in accordance with the detected digit value representation through the selected entry circuit to manifest the accumulated digit value, means controlled by an energized accumulating relay and effective following the accumulating portion of the cycle of the commutator for energizing a corresponding value retaining relay, means for deenergizing the value accumulating relay subsequent to the energization of said value retaining relay, contacts operated by the latter relay upon energization thereof for conditioning a different one of the entry circuits through the associated segment of the commutator prior to the next cycle in accordance with the magnitude of the digit value shifted from the accumulating relays, and means to deenergize the value retaining relay under the control of the value accumulating relays during the accumulating portion of the next cycle of the commutator.

3. In a record controlled accounting machine having analyzing means for analyzing digit value representations on a record card and for detecting the presence of a special control designation thereon and a multi-denominational order accumulating device for receiving differentially timed entries corresponding to the digit value representations in the various orders comprising, in each denominational order, a plurality of value accumulating relays and a plurality of value retaining relays, said relays being used to represent digit values, commutating means including a pair of cyclically operating commutators, means controlled by the analyzing means in accordance with the presence or absence of a special control designation on the card to determine which one of said pair of commutators is to be operatively connected with the value accumulating relays, means controlled by the connected commutator and the value retaining relays upon analysis of a value representation in a related portion of the card for selecting one of the value accumulating relays for energization in accordance with the time during the cycle at which the analysis of the value representation occurred so as to manifest the algebraic sum of the analyzed digit value with the value represented by the retaining relays previous to that time, means to shift the manifested sum to one of the value retaining relays to energize the latter in a corresponding manner near the end of the cycle so as to provide a new controlling relation between the commutating means and the value accumulating relays, means for deenergizing the energized value accumulating relay subsequent to the energization of said value retaining relay, and means controlled by the value accumulating relays for deenergizing the energized value retaining relay during the accumulating portion of the next cycle.

4. In a machine of the class described, a multi-denominational order accumulator for receiving

digit representing entries in the various orders comprising, in each denominational order, a first and second series of digit value representing relays, entry control means including a cyclically operating commutator capable of effecting a digit representing entry by selecting one of the relays of the first series for energization under the control of the second relay series and the commutator to represent the units digit of the sum of the digits entered during the cycles of the commutator, means controlled by the first series of relays at a time near the end of the cycle in which a digit was entered for correspondingly energizing one of the relays of the second series so as to represent the digit, means for deenergizing the energized relay of the first series after the latter relay becomes energized, maintaining means for the relays of the second series to cause the energized one of the latter relays to retain the digit representation until after another digit entry has been made in the first series during a subsequent cycle to cause the relays in the first series to represent the units digit of the sum of the former and latter digit entries, means effective in the latter cycle after the last mentioned digit entry for determining whether the digit represented by the first series is less than that represented by the second series, a carry controlling device, and means under control of the determining means for operating said carry device when the units digit of the sum as represented by the first series is less than the digit value represented by the second series.

5. The machine as set forth in claim 4, in which the determining means comprises a test circuit under the control of the relays of each series which is completable only in the event that the units digit of the sum represented by the first series is less than the digit value represented by the second series and in which the carry controlling device comprises a carry control magnet adapted to be energized upon completion of the test circuit.

6. An accounting machine having a multi-denominational order accumulating device for receiving differentially timed digit entry impulses in the various orders comprising, in each order, a plurality of value retaining relays one for each digit value, a cyclically operating commutator having differentially related segments, individual circuit connections for said segments made under selective control of the value retaining relays to connect with one of the segments for the passage of a digit entry impulse through the commutator, a plurality of value accumulating relays one for each digit value, a plurality of routing circuits having progressively changing connections with the commutator during a cycle of operation of the latter for selecting one of the accumulating relays for energization by a digit entry impulse according to the commutator segment through which the entry is made and the differential time of said entry in order to represent the accumulated value, means effective following the accumulating portion of the commutator cycle in accordance with the condition of the accumulating relays for correspondingly energizing one of the retaining relays to retain the accumulated digit value representation, thereby conditioning the individual circuit connections to the commutator prior to the next cycle in accordance with said accumulated digit value to select which segment is to transmit the next digit entry impulse during the following cycle, means for deenergizing the value accumulating relay subsequent to the energization of said value retaining relay, and means to deenergize said value retaining relay under control of said value accumulating relay subsequent to said next digit entry impulse.

JAMES W. BRYCE.