Nov. 7, 1944. A. H. DICKINSON 2,361,996

RECORD CONTROLLED COMPUTING MACHINE

Filed May 1, 1943 15 Sheets-Sheet 1

FIG.1.

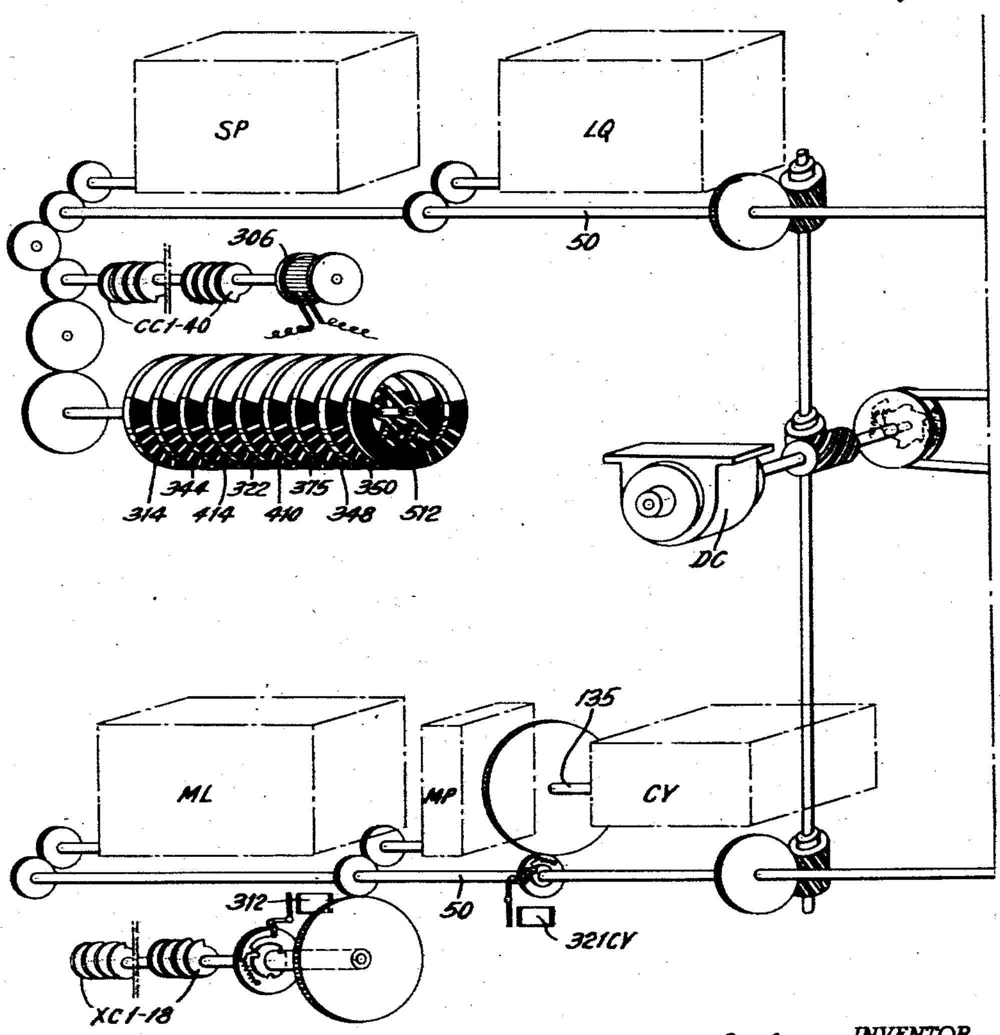

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FIG. 1a.

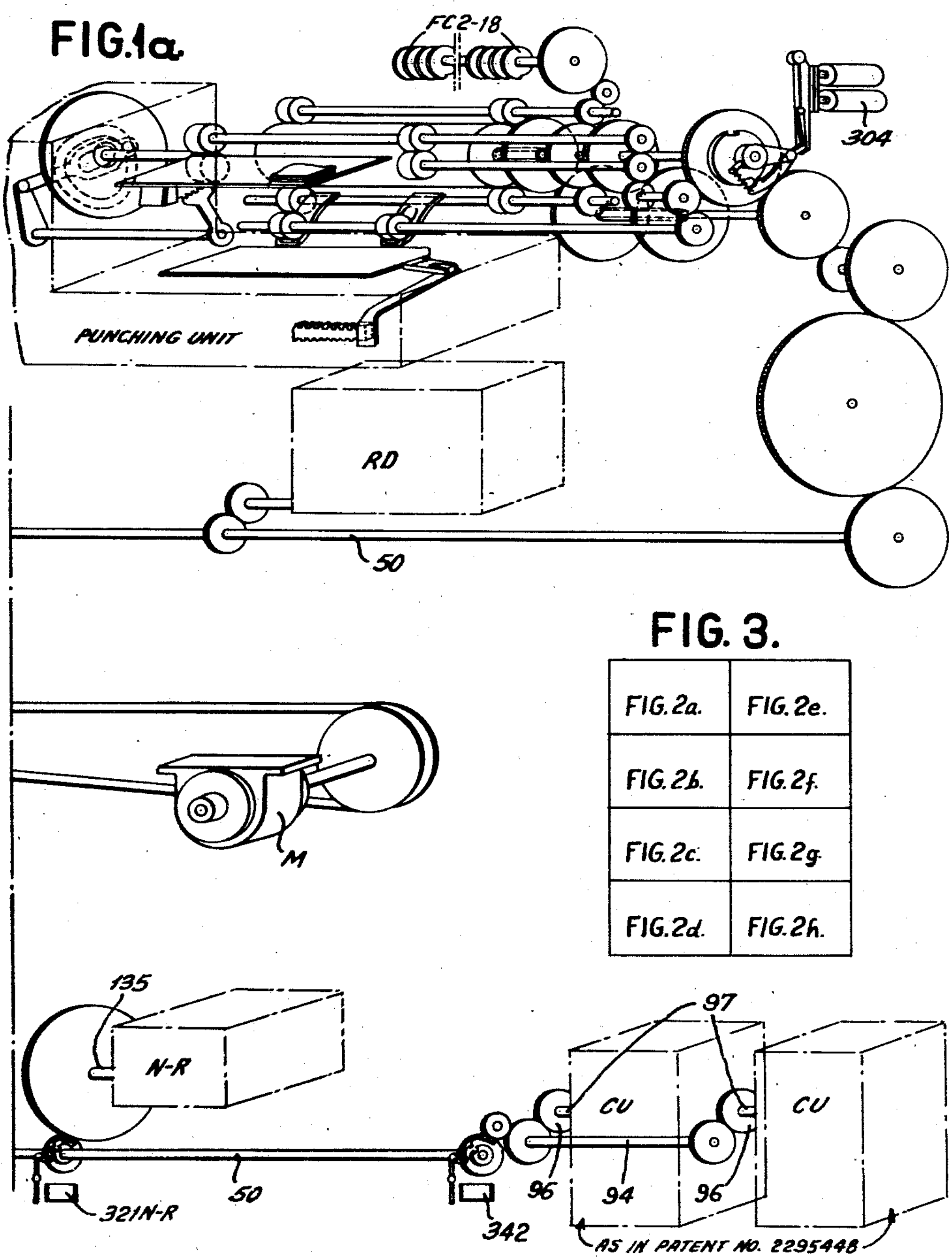

FIG. 3.

FIG. 2a.	FIG. 2e.
FIG. 2b.	FIG. 2f.
FIG. 2c.	FIG. 2g.
FIG. 2d.	FIG. 2h.

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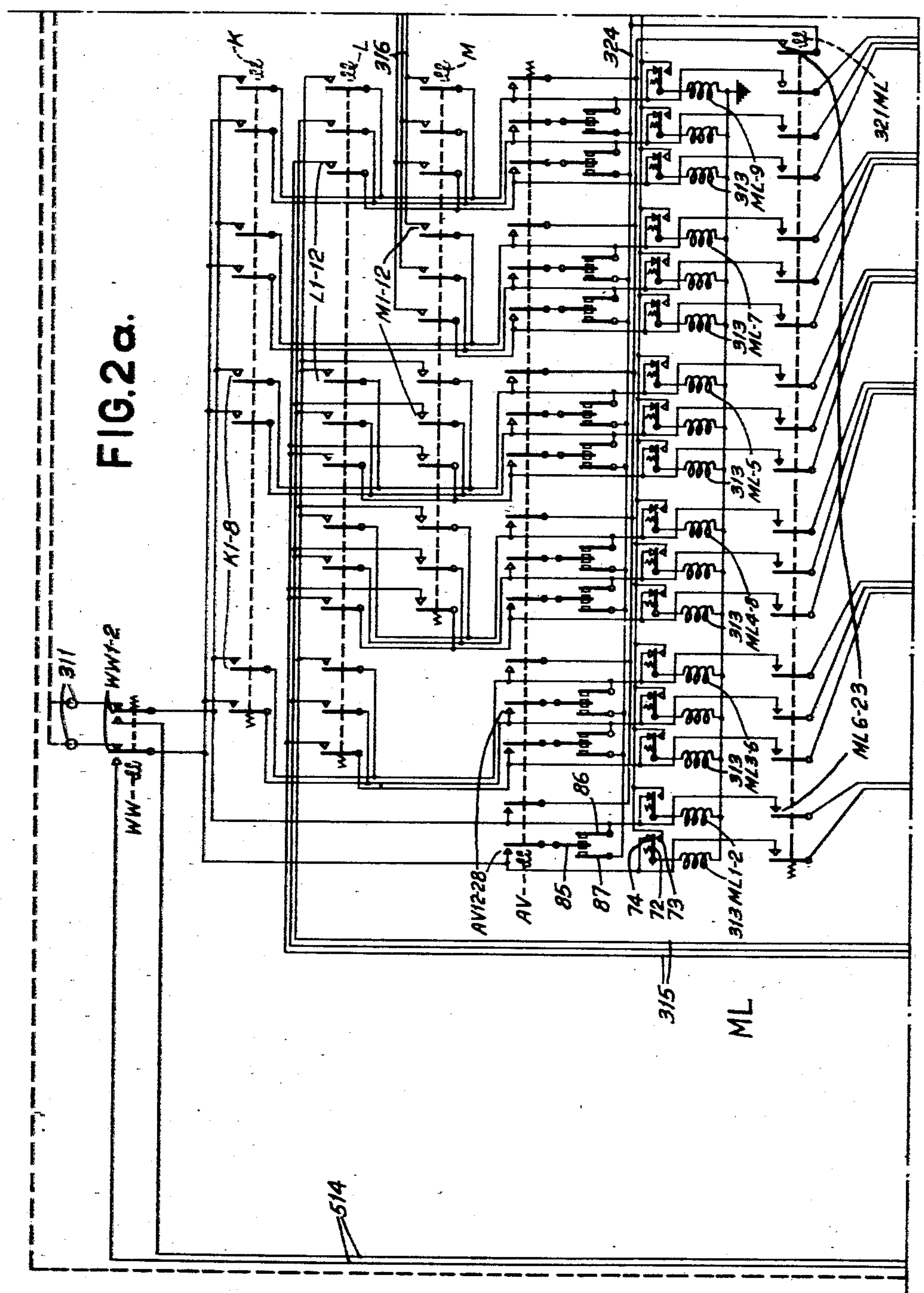

FIG. 2a.

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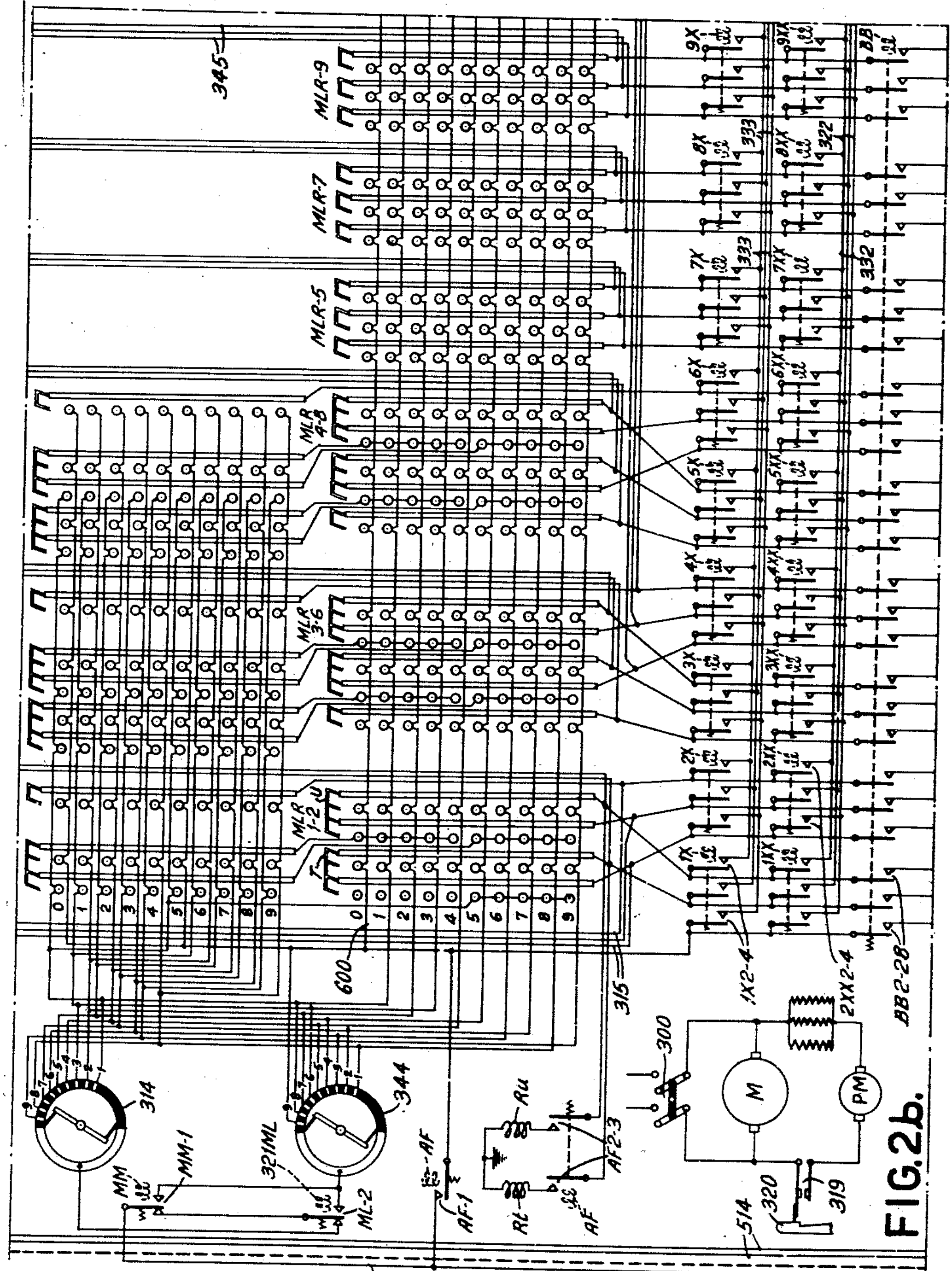

FIG.2b.

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RECORD CONTROLLED COMPUTING MACHINE

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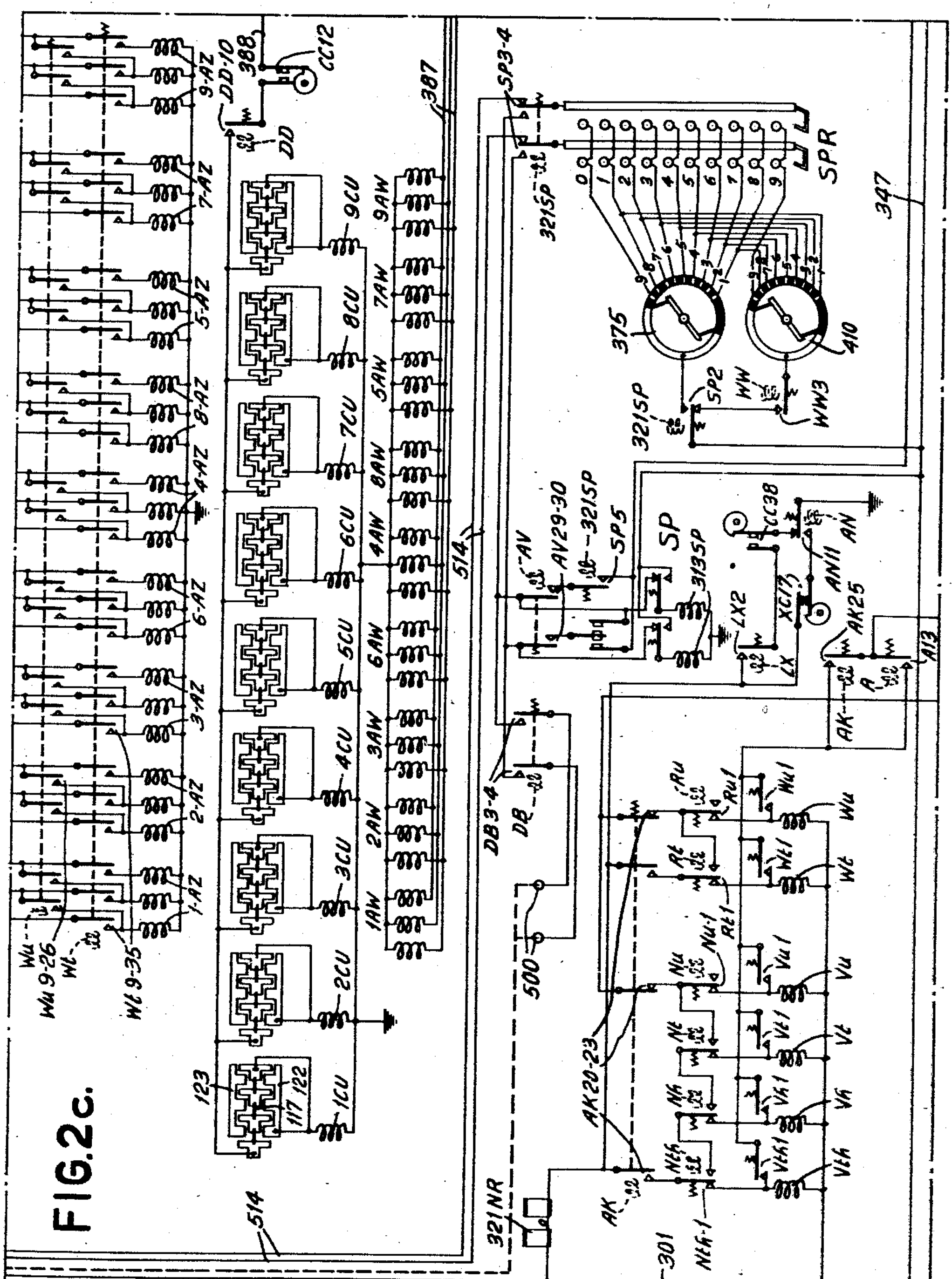

FIG. 2c.

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RECORD CONTROLLED COMPUTING MACHINE

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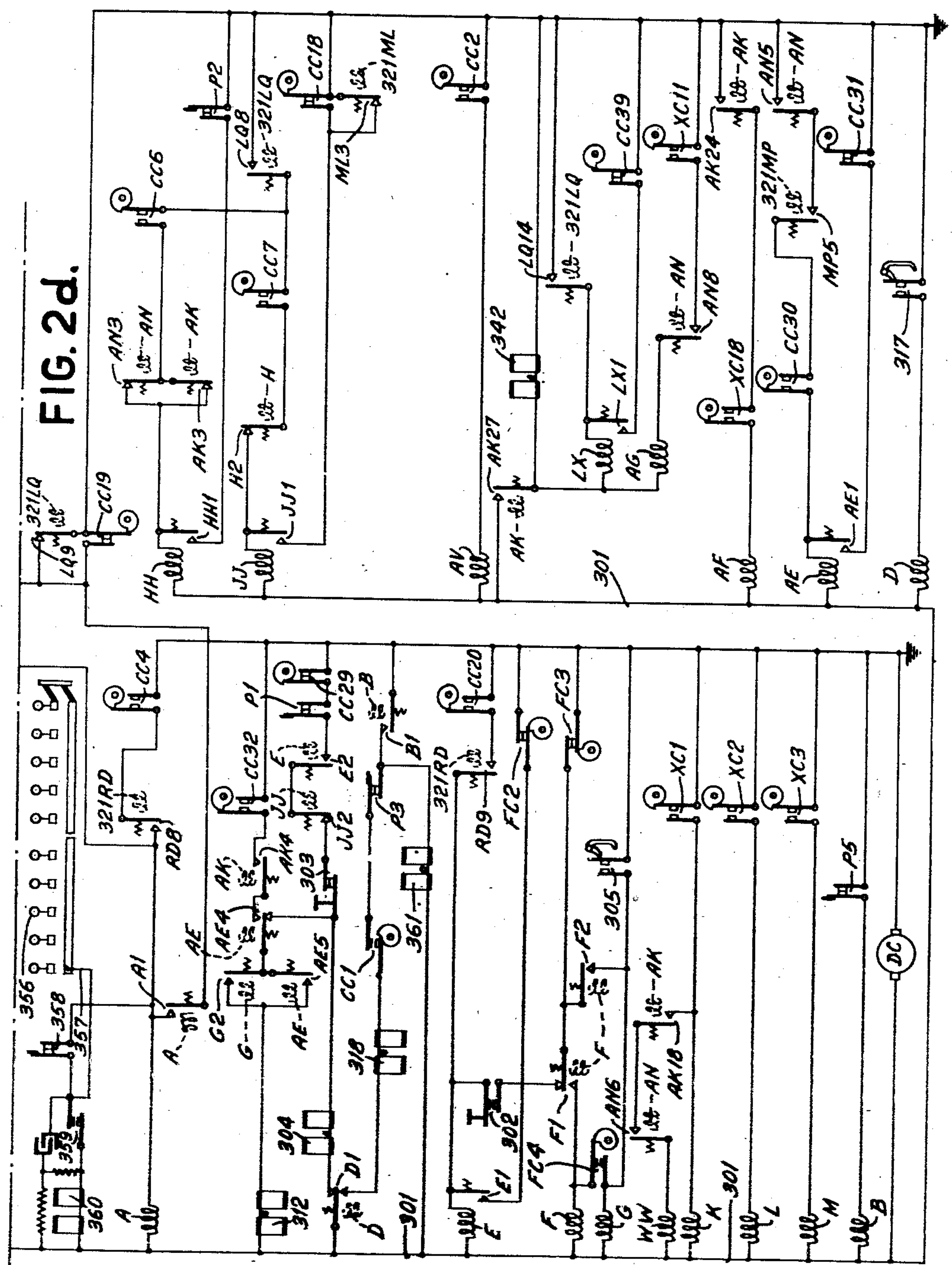

FIG. 2d.

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RECORD CONTROLLED COMPUTING MACHINE

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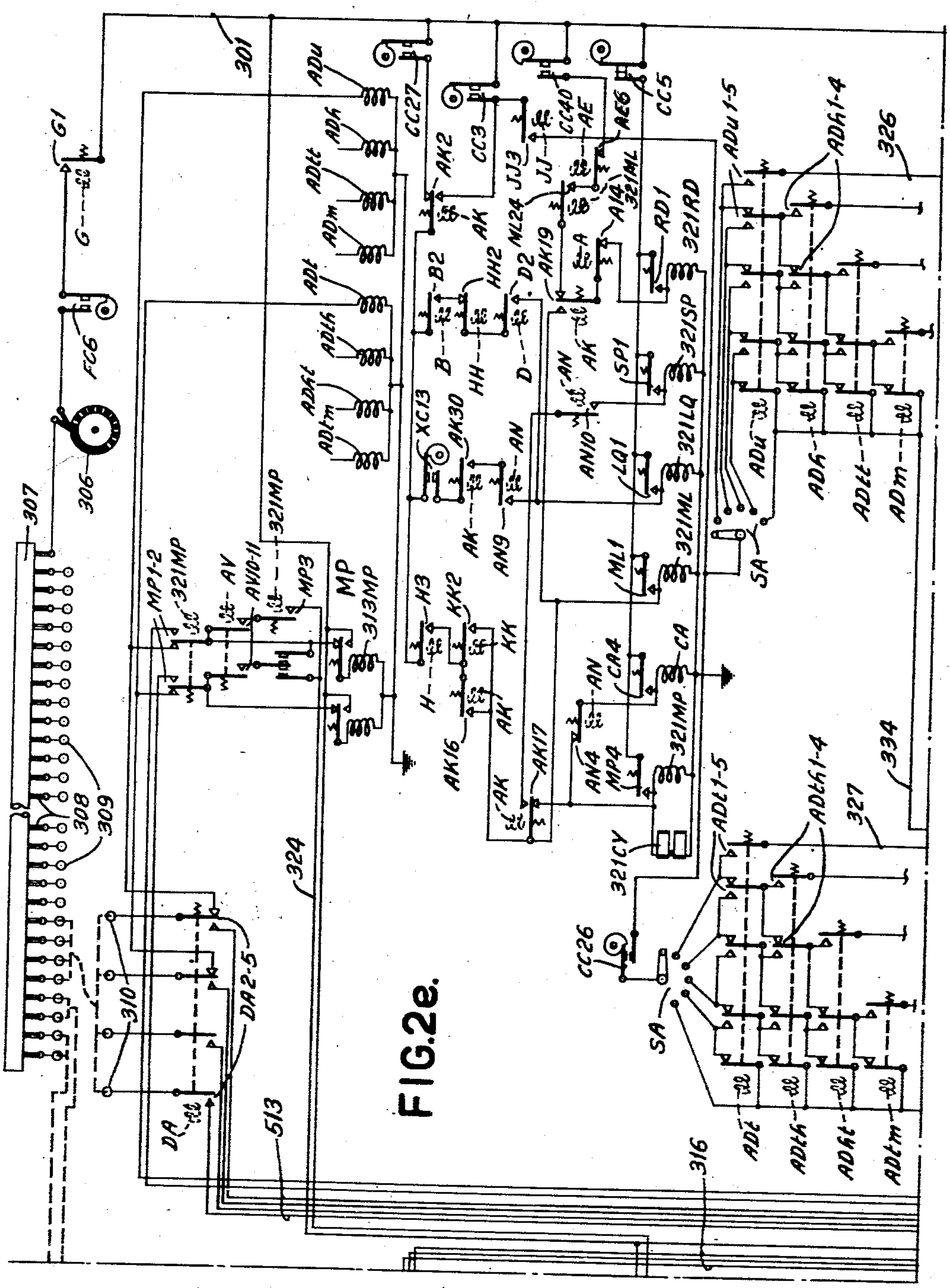

FIG.2e.

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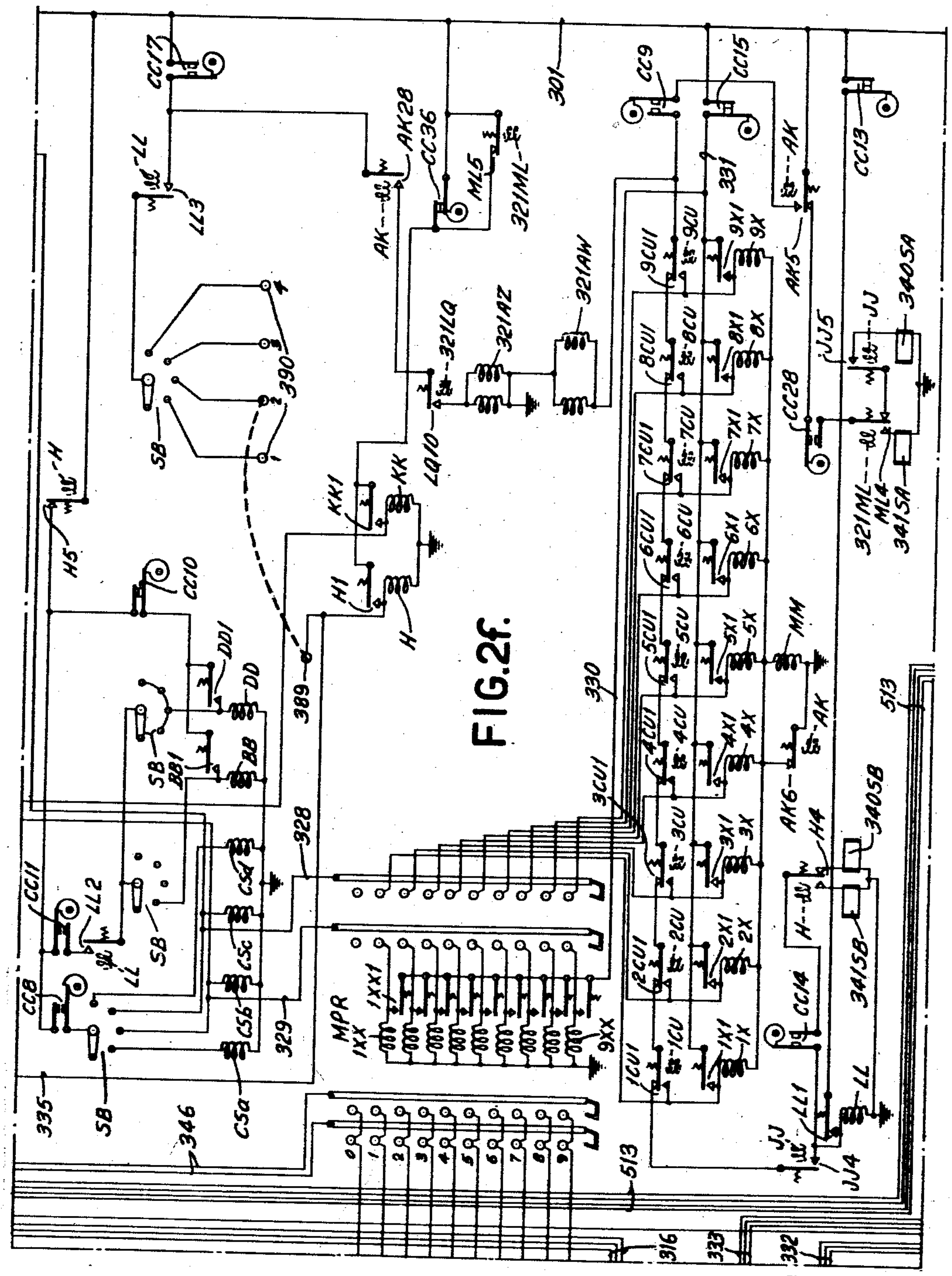

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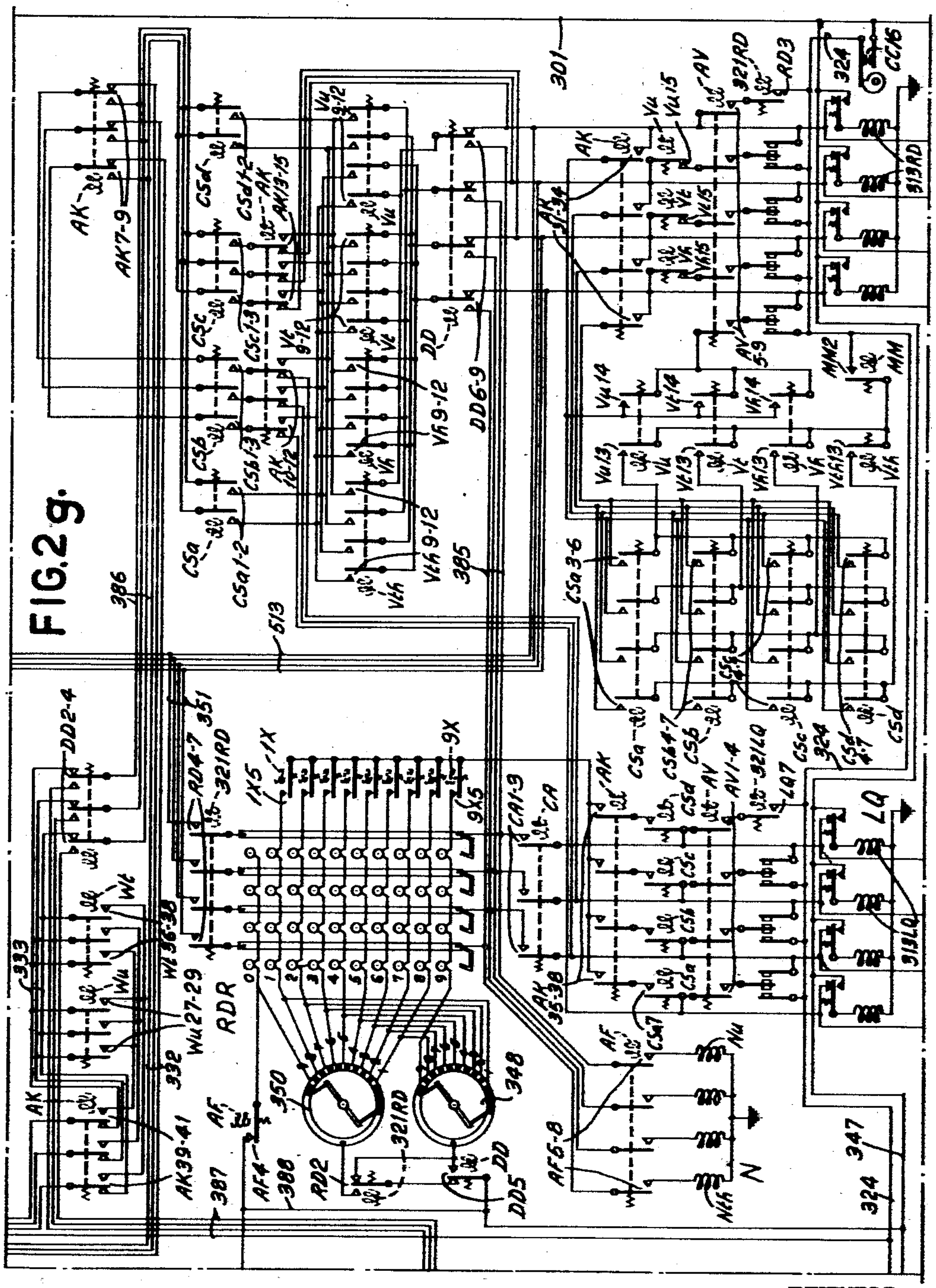

FIG. 2g.

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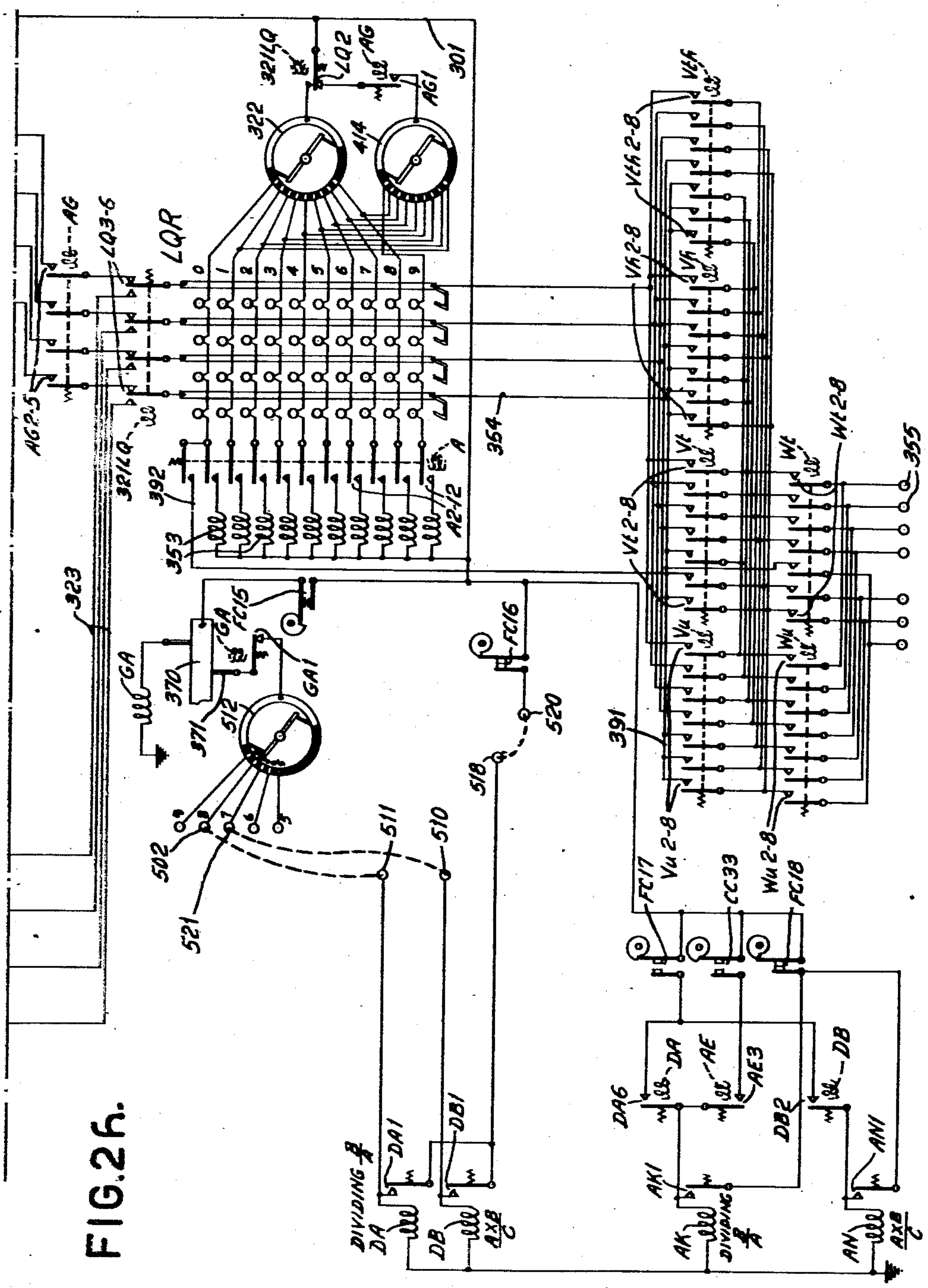

FIG. 2h.

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FIG. 4.

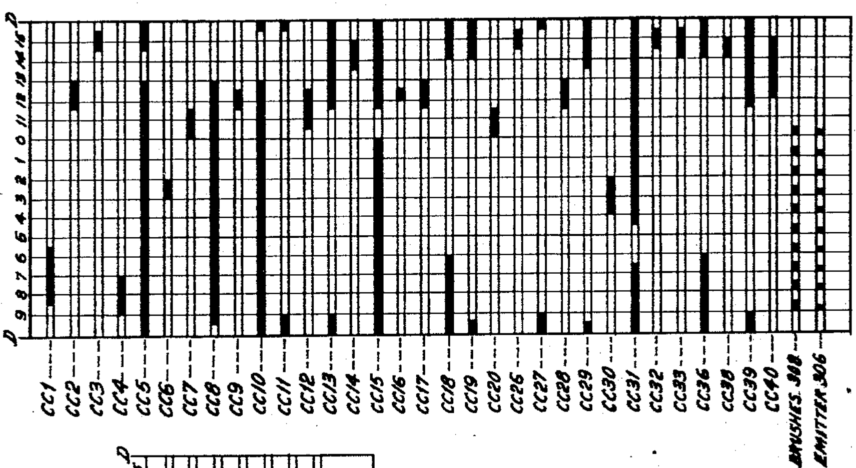


FIG. 6.

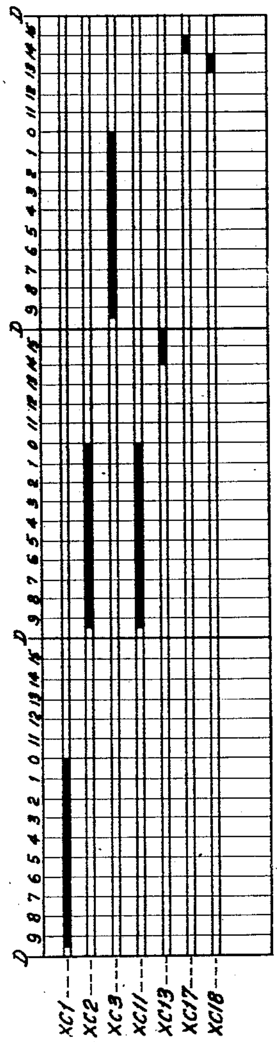
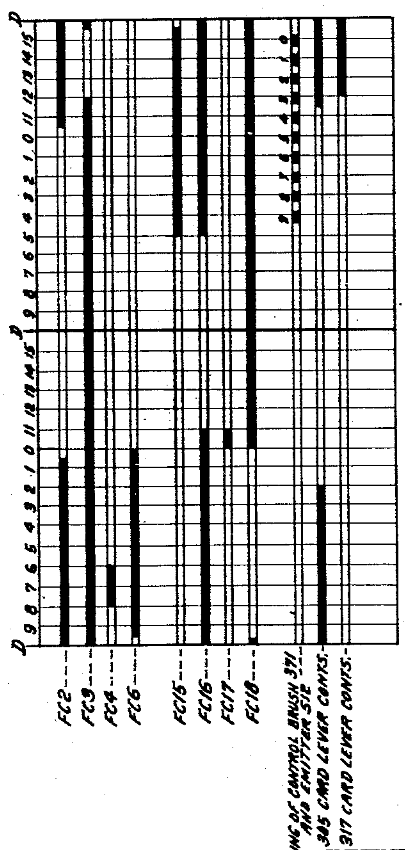


FIG. 5.



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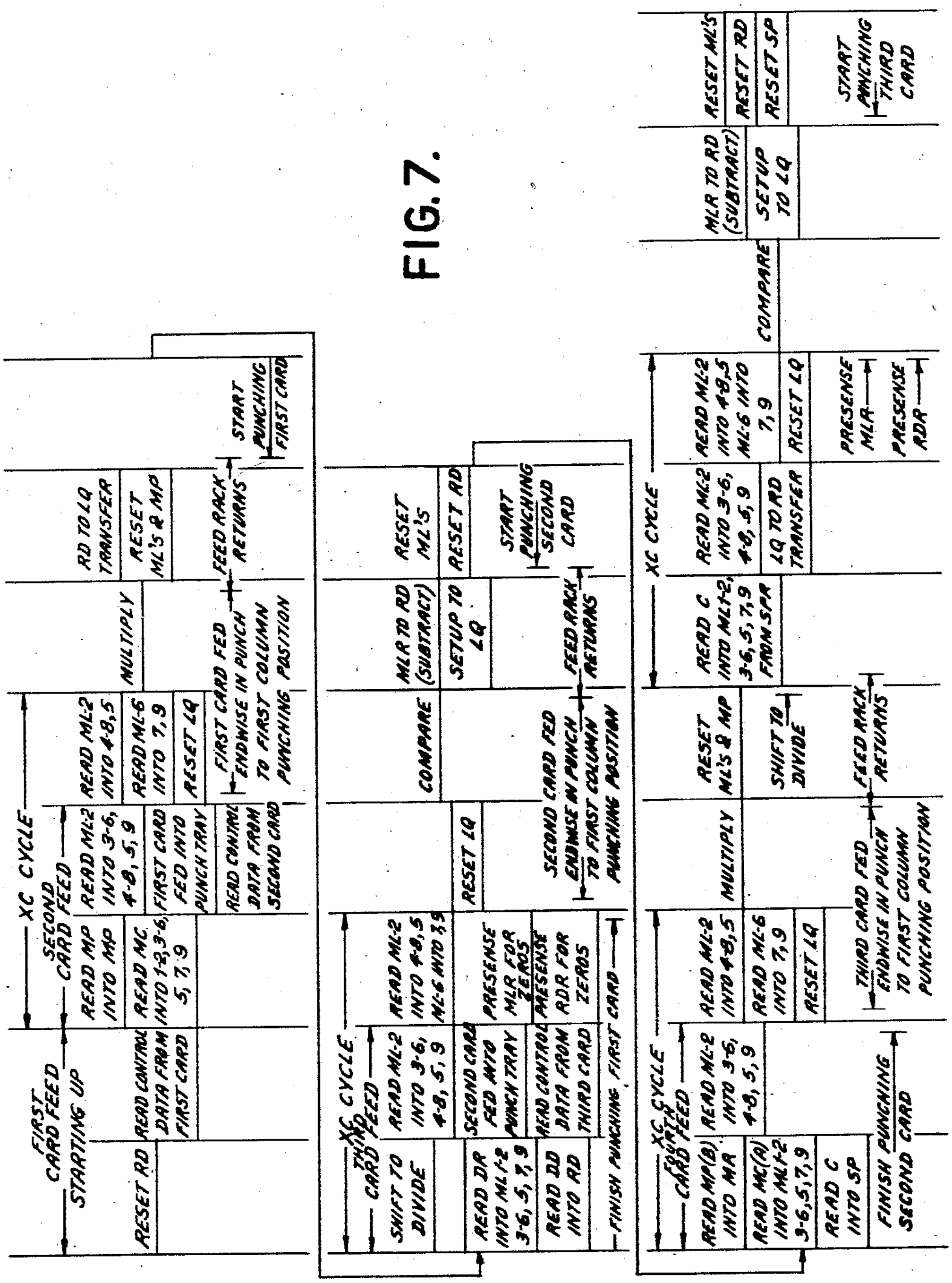

FIG. 7.

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FIG. 9.

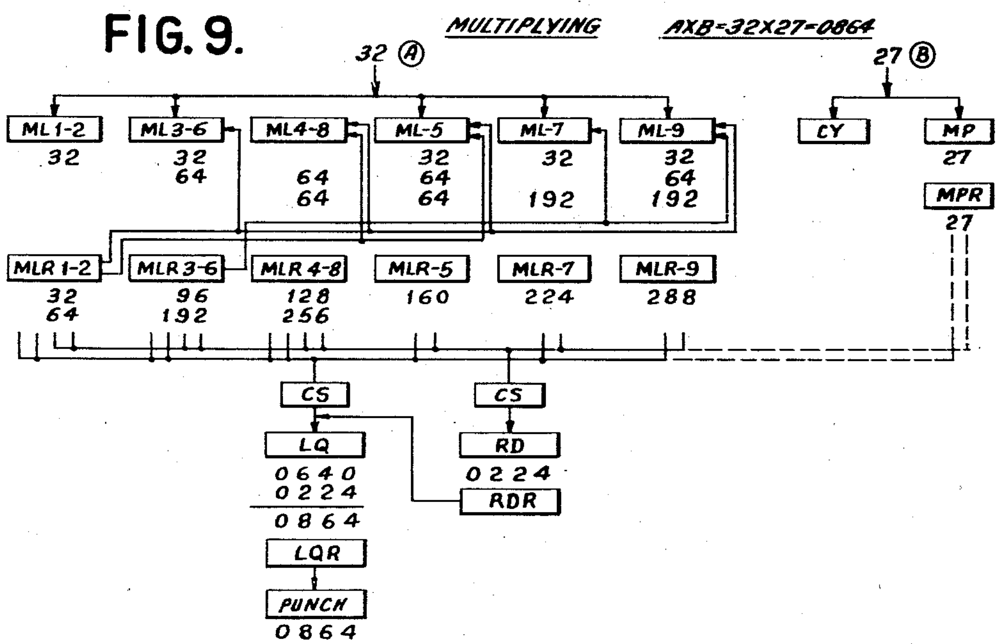
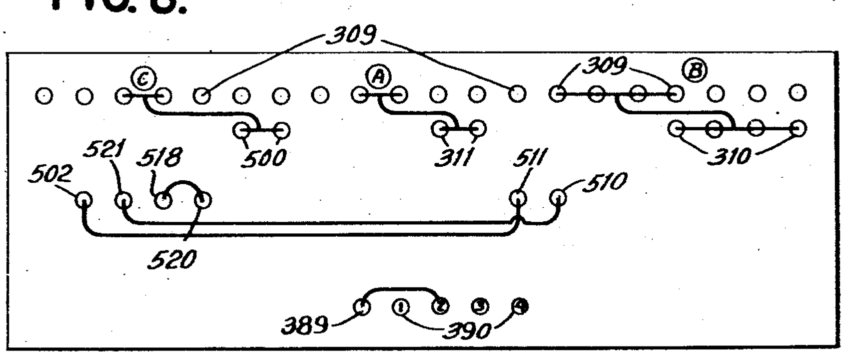


FIG. 8.



PLUG CONNECTIONS FOR EFFECTING NORMAL MULTIPLICATION WITH DIVISION & $\frac{A \times B}{C}$ COMPUTATIONS SELECTED BY CARD CONTROLLING THE CALCULATION.

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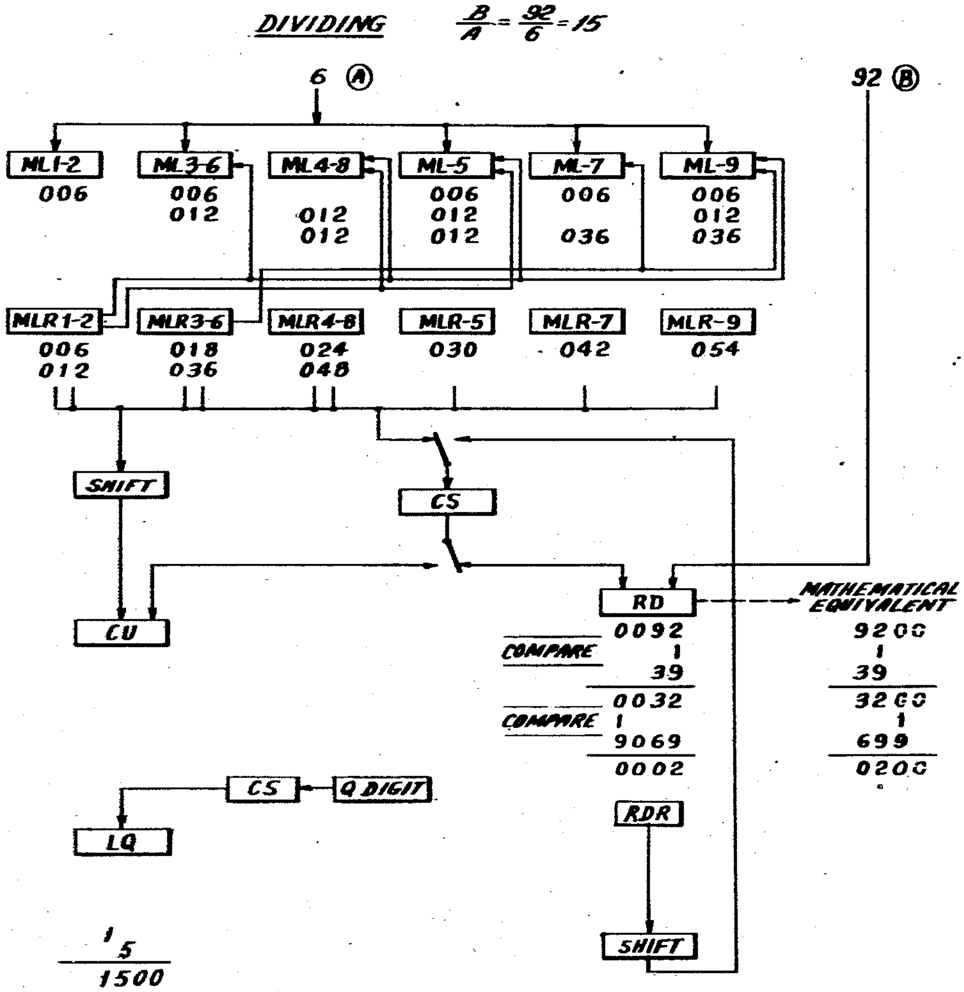
FIG. 10.



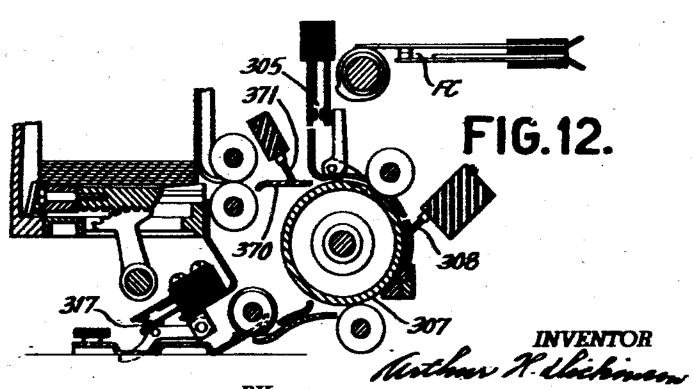


FIG. 12.

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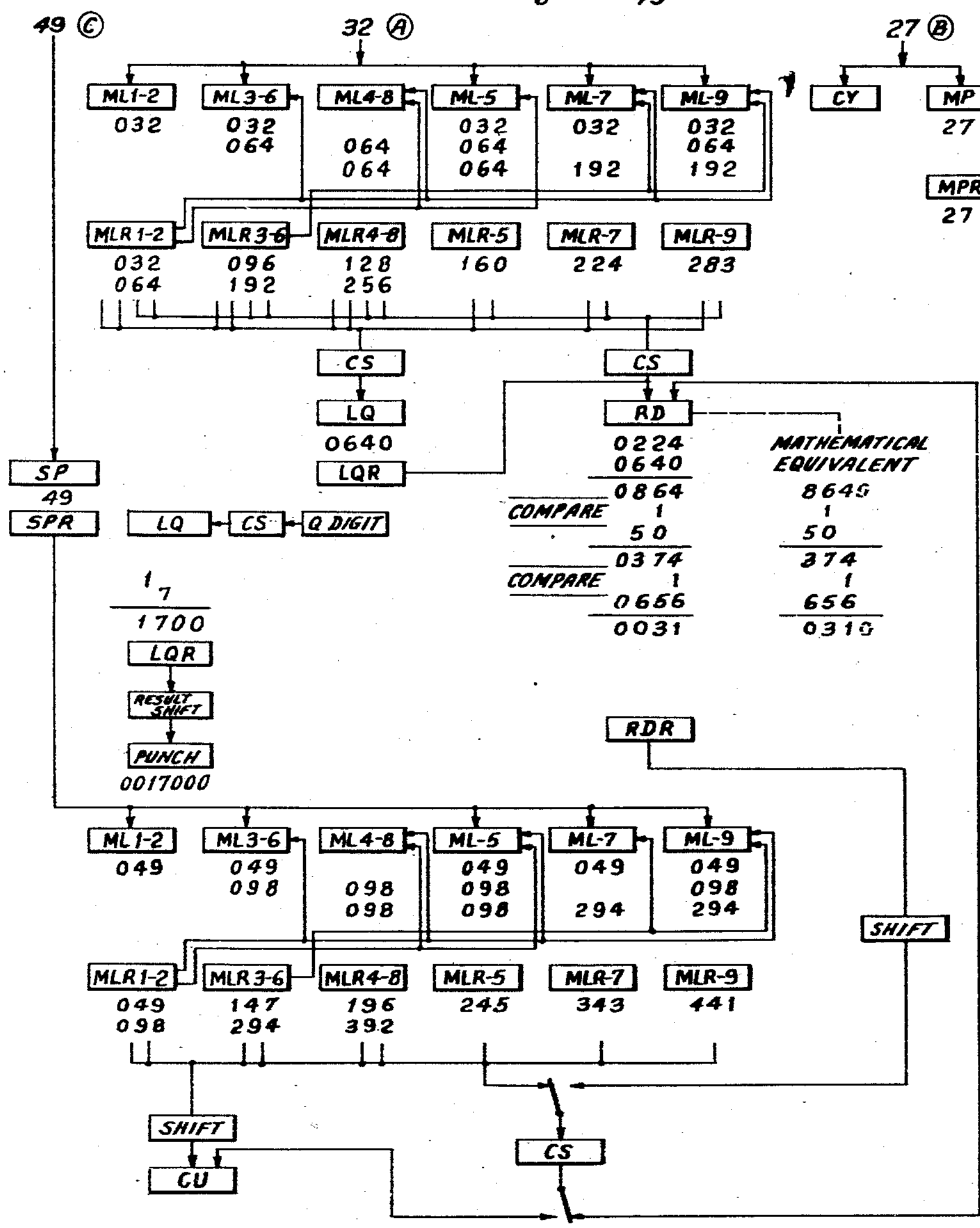
FIG. 11.

COMPUTATION OF $\frac{A \times B}{C} = \frac{32 \times 27}{49} = 17$



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Patented Nov. 7, 1944 2,361,996

UNITED STATES PATENT OFFICE

2,361,996

RECORD CONTROLLED COMPUTING MACHINE

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Application May 1, 1943, Serial No. 485,316

7 Claims. (Cl. 235—61.7)

This invention relates to computing machines and more particularly to the type controlled by perforated cards and provided with calculating or computing mechanisms for carrying out different computations under control of the cards or records.

The present improvements are directed particularly to improvements in such machines for selectively calling the different computing mechanisms into operation according to the different requirements.

The main object of the present invention is to provide a computing selecting mechanism under record control so that the record or card controlling the computation will determine the type of computation to be performed.

A still further object of the present invention is to provide a calculating machine which is capable of performing the different computations;

$$A\times B,\ \frac{B}{A}\text{ or }\frac{A\times B}{C}$$

and of selecting the different computing mechanism under control of the card representing the amounts involved in the computation.

A still further object of the invention is the provision of a presenting station which analyzes the card to determine the type of computation to be performed prior to the analysis of the designations representing the amounts involved in the computation, and in this respect a further improvment consists in the provision of feeding two cards concurrently, the leading card to the analying station for analysis of the amounts involved in the computation and the following card to the presensing station to determine the type of computation to be performed under control of the card coordinated with the presensing station.

Considerable saving in machine time accrues from this arrangement because it enables a setup of the selecting mechanism for the different computing mechanisms to be made for a following card during the cycle that the amounts on the leading card are derived and this setup is to be maintained during the cycles of operation that are taking place for the previously selected computing mechanism and under control of the leading card, and immediately upon the completion thereof the machine will be conditioned to effect the computation next selected and under control of the following card. With such routine of events, no cyclic time is lost and different or the same computations successively follow except that the interim between successive computations consists of a card feeding cycle causing the concurrent feeding of two cards, one to control the previously selected computation, and the other to establish a setup of the selection of the next computation.

A still further object of the invention is to provide means to cause the automatic entry of the "C" amount represented on the card when the computing selecting mechanism conditions the machine for the computation

$$\frac{A\times B}{C}$$

This enables each card to receive a "C" amount, if so desired, and utilize it only in the computation in which this third amount is involved and disregard such amount in effecting the computation of multiplication or division.

A further improvement relates to simplification of prior devices relating to the denominational shift for the entry of the dividend and divisor in effecting division. It is understood that in division computations the subtraction of the divisor from the dividend requires the proper ordinal relationship and previously such amounts were presensed by analyzing means for the presence of zeros at the left and in accordance with their denominational magnitude the divisor and dividend entry was shifted so that the highest denominationally ordered digits occupied the extreme left orders of the divisor and dividend receiving devices.

In the present arrangement the divisor and dividend entries are made in the respective receiving devices without regard to their denominational size, and obviously their coordinated readouts stand in this same digital representation.

The improved arrangement provides for the sensing of the divisor and dividend readouts to determine the denominational magnitude of the digital representations thereof and in accordance with the denominational sizes shift or route the entries from the readouts by altering the wiring connections from the orders of the readouts. The ultimate result is precisely the same as in prior record controlled dividing computing mechanisms but is attained in a much simpler manner, facilitating wiring of the machine and enabling the removal of parts heretofore considered essential.

The improved arrangement can be used to store the dividend and divisor amounts in storage units, and then by sensing such units for determination of the denominational magnitude, the divisor and dividend amounts can be read out of such storage units and routed to other receiving devices in proper denominational order for determining how many multiples of the divisor are contained in the dividend amount for securing and determining a quotient digit.

The present arrangement can also be advantageously utilized in the specific form of dividing mechanism herein shown. The value of the divisor is set up in all digital multiples thereof on one side of a comparing unit, and the value of the comparison portion of the dividend is set up in a plurality of comparing units. The denominational shifting means intermediate the divisor comparing units and the readout for the received divisor amount and the denominational shifting means intermediate the dividend comparing units and the readout for the received dividend amount correlate the orders of the comparing units for comparing of all digital multiples of the divisor with the comparison portion of the dividend in proper denominational relationship.

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

In the drawings:

Figs. 1 and 1*a* taken together with Fig. 1*a* to the right of Fig. 1 show a somewhat diagrammatic view of the various units of the machine and the drive therefor.

Figs. 2*a* to 2*h* inclusive, taken together show the complete circuit diagram of the machine when arranged according to the diagram of Fig. 3.

Fig. 3 is a diagram (on the sheet showing Fig. 1*a*) indicating the manner of assembly of Figs. 2*a*–2*h* comprising the wiring diagram.

Fig. 4 is a timing diagram showing the timing of the various CC cams.

Fig. 5 is a timing diagram of the FC cams.

Fig. 6 is a timing diagram of the XC cams.

Fig. 7 is a sequence diagram indicating the cyclic operations of the machine when multiplying, dividing and

$$\frac{A\times B}{C}$$

computations are successively effected, multiplication being normally performed and the other two computing mechanisms being selected by the card controlling the computation.

Fig. 8 is a diagram of the plugboard connections made to effect the A, B and C entries and also the plugboard connections made to effect the selection of the different computing means under record control.

Fig. 9 is a flow diagram showing the manner of entering factors of a multiplying computation and how the machine performs such multiplication.

Fig. 10 is a flow diagram showing the manner of entering factors of a dividing computation and how the machine performs a dividing computation.

Fig. 11 is a flow diagram showing the manner of entering factors of a

$$\frac{A\times B}{C}$$

computation and how the machine performs the computation according to this equation.

Fig. 12 is a sectional view of the card feeding and analyzing structure.

Machine drive

Referring first to Figs. 1 and 1*a*, in general the machine comprises five accumulating units which are respectively designated SP, LQ, RD, ML, and MP. It may be explained that the unit ML contains accumulators and readouts from which all of the nine digital multiples of the divisor or multiplicand can be derived depending upon whether the machine is used for division, multiplication, or

$$\frac{A\times B}{C}$$

computation. The MP receiving device receives the multiplier upon entry in the multiplying or

$$\frac{A\times B}{C}$$

calculation. Such unit is not utilized in a dividing computation of

$$\frac{B}{A}$$

The accumulating units LQ and RD receive components of the products upon multiplication with the final product formed in LQ, and upon division or

$$\frac{A\times B}{C}$$

computation LQ receives the quotient amount. In division RD receives the dividend amount, and in

$$\frac{A\times B}{C}$$

computation RD receives the product of $A\times B$. The SP unit is utilized in receiving the "C" factor of a

$$\frac{A\times B}{C}$$

computation. The various accumulating units are driven by the gearing delineated from the driving motor M. The machine is also provided with a direct current generator DC. The card handling and feeding section of the machine is of customary form like that shown in Daly Patent No. 2,045,437 and is driven in the usual manner. The FC cam contacts FC2—18 (Fig. 1*a*) are also driven in the customary manner in synchronism with the drive of the card handling section of the machine. The units designated CY, N—R, are electromechanical relay setup units of the general construction shown in Figs. 16 and 17 of Patent No. 2,295,448, issued to J. W. Bryce et al. Each of these units is adapted for reset from the constantly running drive shaft by the customary one revolution clutch arrangement. The reset magnets for the units are respectively designated 321CY, 321N—R. The comparing units are shown diagrammatically at CU—CU. These comparing units are of the form shown in Figs. 12 to 15 inclusive of the patent to Bryce et al. No. 2,295,448, and such units are adapted to be driven from the drive shaft by the use of the well-known one-revolution clutch, the clutch magnet being designated 342. Also driven from the main drive shaft are the usual CC cams designated CC1—40 and the impulse distributor 306. In addition there are also provided eight impulse emitters which are designated 314, 344, 414, 322, 410, 375, 348, 350 and 512.

Accumulators and entry receiving devices

As stated, the SP, LQ, RD, ML and MP units are accumulators of electromechanical type. These accumulators are identical in construction except for the number of readout sections, some accumulators having four readout sections and others having less. The accumulator which is here employed may be of various types known in the art, more particularly the type of accumulator having electrical transfer and electrical reset. Suitable accumulators of this type are shown and described in United States Patent No. 1,834,767 and suitable readout structure may be that shown in United States Patent No. 2,062,117 employing the electric reset of Patent No 1,834,767, modified as per British Patent No. 422,135.

The present invention involves transfer total arrangements according to British Patent No. 422,135.

While the aforesaid accumulators are a suitable type for use with the present invention, a preferred accumulator is of the form illustrated and described in Lake and Pfaff Patent No. 2,232,006, dated February 18, 1941.

Insertible plugboard

The insertible plugboard construction is of a type known in the art and the insertible plug unit is generally indicated at 141 in Fig. 18 of Patent No. 2,295,448. Devices of this type are generally known as "automatic plugboards" and a suitable form of such plugboard is shown and fully described in the patent to C. D. Lake, No. 2,111,118, dated March 15, 1938. Such automatic plugboard arrangement comprises a series of relatively fixed machine sockets to which the fixed machine wiring is connected. Adapted for cooperation with such sockets are plug prongs carried by a replaceable plugboard assembly or unit. Such plug prongs on the replaceable board are in turn connected to plug sockets upon the replaceable board. These plugboard sockets may be in turn plugged up by the operator selectively at will or the entire board may be pre-plugged with a desired set of connections.

The manner in which the replaceable plugboard unit 141 is wired and plugged for the form of control described herein is shown in Fig. 8.

It may be explained that the plug socket reference numerals used on the circuit diagram of Fig. 2a–2h are the same as those used on the diagrammatic plugboard view of Fig. 8.

Cam timing diagrams

The cam timing diagrams, Figs. 4, 5 and 6 are self-explanatory. It should be noted that the cams controlling the CC cam contacts of Fig. 4 make one revolution for each machine cycle. The cams controlling the FC cam contacts of Fig. 5 when called into operation make one revolution for each card feed cycle which comprises two machine cycles. The cams controlling the XC cam contacts of Fig. 6 when called into operation make one revolution for three machine cycles.

Such XC cam contacts are driven from the drive shaft through a one-revolution clutch which is controlled by magnet 312 (Fig. 1). The drive side of the one-revolution clutch receives its drive from the main drive shaft 50 through the gearing shown which drives the XC cams one revolution for each three revolutions of the main drive shaft.

Operation utilizing plugboard shown in Fig. 8

This figure shows plug connections to be made when the machine is to be set for normal multiplying computations, the

$$\frac{A\times B}{C} \text{ or } \frac{B}{A}$$

computations being effected when the cards controlling the computation are significantly perforated in the control column. For simplification it will be assumed that the first card is not significantly perforated in the control column which calls for multiplying, the second card calls for dividing, and the third calls for the

$$\frac{A\times B}{C}$$

computation.

Multiplying

The operation of the machine will first be explained with reference to multiplying. In explaining multiplying the manner in which multiples of an entered amount are built up and stored in the machine will be set forth but these multiple building up operations are equally applicable to the building up of the divisor in dividing computations and in the

$$\frac{A\times B}{C}$$

computation.

Before describing multiplying operations it may be stated that the circuit diagram of the instant application has been shown with a certain columnar capacity. For simplicity of illustration the capacity as shown by the circuit diagram is two columns by two columns, but it will be appreciated that in actual practice the machine may have a greater columnar capacity. Greater columnar capacity is derived primarily by a duplication of orders of accumulators, readouts, and increased number of entry circuits.

It will be assumed that a set of record cards is in place in the supply magazine of the machine. The operator then closes switch 300, supplying current to driving motor M (Fig. 2b). With the main driving motor M in operation the DC generator marked "DC" (Fig. 2c) is set in operation supplying current to ground and to DC line 301. The operator now depresses start key 302 (Fig. 2d) and a circuit is completed from ground through the FC3 contacts through relay contacts F1, through the start key contacts back through relay coil E to line 301. Relay coil E upon being energized is maintained energized by a stick circuit through relay contacts E1 and cam contacts FC2. The energization of relay coil E closes relay contacts E2 and a circuit is completed from ground, through cam contacts CC29, through the punch controlled contacts P1 (Fig. 2d) and the E2 contacts now closed, through the JJ2 contacts, through the stop key contacts 303 now closed, through the card feed clutch magnet 304, back through the D1 contacts in the position shown to line 301. A card is now fed by the card feeding and handling section of the machine (Fig. 12) and during the card feed cycle. When the first card is brought to a position about to be analyzed by brushes 308 the first card will have been analyzed by the presensing brushes 371 to determine the computation to be performed in a manner to be subsequently explained. It is explained here that the absence of a perforation in the control column will enable the machine to remain on its normal status for effecting a multiplying operation of $A\times B$. In starting up the machine on a run of cards, the start key must be maintained depressed for two card feed cycles or it may be depressed and released and redepressed. During the initial card feed cycle certain idle operations occur which may be merely alluded to. The RD accumulator is reset to zero and circuits of the machine are conditioned just as if a product amount were to be punched. Punching does not occur at this time, however, because there is no product to record and the card has not reached the punch.

Late in the second machine cycle of the card feed cycle, the card lever contacts 305 close bringing about an energization of relay coil G (Fig. 2d). Energization of relay coil G brings about closure of relay contacts G1 (Fig. 2e) which affords current supply to the FC6 contacts. These contacts upon closure permit current to be supplied to the impulse distributor 306 from which current impulses flow to the card feed and contact roll 307. The usual regular analyzing brushes 308 are provided which are connected to plug sockets generally designated 309.

Upon redepression or maintained depression of the start key and with relay coil G energized in the manner previously explained, relay contacts G2 (Fig. 2d) will become closed and a circuit will be established not only to the card feed clutch magnet 304 in the manner previously traced, but a branch circuit will be established through the AE4 contacts now in the position shown, through the now closed G2 contacts, to a supplemental clutch magnet 312. This supplemental clutch magnet 312 (Fig. 1) releases for rotation the group of XC cams which rotate one revolution for the three subsequent machine cycles. During the second card feed cycle the card passes between the brushes 308 and contact roll 307 and the MC and MP, or A and B amounts on the card are analyzed and entered in the respective accumulators. (See Fig. 7). During the entry portion of this XC cycle, cam contacts XC1 close to energize relay coil K (Fig. 2d). With relay coil K energized, the K1—8 contacts (Fig. 2a) become closed. The multiplicand amount is entered under control of the related analyzing brushes 308, plug connections between plug sockets 309 and the 311 plug sockets (Figs. 2a and 8) through the WW1—2 contacts, down through the now closed K1—8 contacts. The amount of the multiplicand is entered into the following multiple receiving devices ML1—2, ML3—6, ML5, ML7 and ML9. On the circuit diagram the prefix reference numeral 313 refers to the accumulator magnets of these multiple receiving devices. At this point it may be explained that the multiple receiving devices are commonly used for both multiplying operations and for dividing operations. On multiplication, these multiple receiving devices are used to build up and store nine different multiples of the multiplicand and on division the same multiple receiving devices are used to store nine different multiples of the divisor. The multiple receiving devices have been previously described; these are in the form of electrically controlled accumulators with electrical readouts. The ML1—2, ML3—6 and ML4—8 receiving devices are provided with doubling readouts in addition to the usual straight readouts. The other multiple receiving devices are provided with straight readouts only. On the entry portion of the feed cycle, as explained, the amount of the multiplicand or "A" amount, is entered into five of the multiple receiving devices concurrently.

Before describing how the multiples of the multiplicand are built up, it may be stated that the multiplier or B amount is entered in the following manner. The multiplier enters under control of the related analyzing brushes 308, through plug connections between plug sockets 309 and plug sockets 310 (Figs. 8 and 2e) through the DA4—5 contacts now in the position shown through the MP1—2 contacts now in the position shown, to the 313MP accumulator magnets and to ground. The amount of the multiplier is thus entered into the multiplier receiving device.

Coincidentally with this set up of the multiplier in the multiplier receiving device there is a setup of the cycle controller and this setup is made according to the presence of significant digits in the multiplier amount. Assuming 27 to be the amount of the multiplier, at the "7" index point in the cycle, the grounded ADu relay (Fig. 2e) coil is energized and at the "2" index point the grounded ADt relay coil is energized. "u" and "t" refer to the units and tens columnar orders.

During the entry cycle, controls are set up to cut off the start key control circuit and to also maintain the operation of the machine under record card control. Referring now to Fig. 2d, early in the entry cycle cam contacts FC4 close, energizing relay F. F being energized, it is maintained energized by a stick circuit which is completed through contacts F1 and cam contacts FC3. The shift of the F1 contacts cuts off the circuit to the start key contacts 302. Energization of F closes contacts F2 to maintain a stick circuit for relay coils F and G either through FC3 or the card lever contacts 305.

Building up of multiples

It has been previously explained that on the entry cycle, the multiplicand amount was entered into ML1—2, ML3—6, ML5, ML7 and ML9. On the machine cycle following the entry cycle, there occurs the first step in the building up of further multiples. (See Fig. 7.) As stated, the ML1—2 device is provided with a doubling readout. This is designated MLR1—2 on Fig. 2b. In this machine cycle cam contacts XC2 (Fig. 2d) close, energizing relay coil L. With relay coil L energized, relay contacts L1—12 (Fig. 2a) close and current supply is afforded for the adding emitter 314 as follows: From line 301 (Fig. 2b), through contacts MM1, and ML2 in the position shown, thence to emitter 314. From emitter 314 the impulses flow over to the transverse buses of the doubling section of MLR1—2, down through the piloting section of this readout and out via a group of lines generally designated 315. From these lines the impulses flow down through the L1—12 contacts (Fig. 2a) which are now closed and ultimately reach the ML3—6, ML4—7, ML5 and ML9 accumulators or multiple receiving devices. This operation will have completed the building up of the 3 multiple in ML3—6.

On the following machine cycle, the cam contacts XC3 (Fig. 2d) close, energizing relay coil M and causing closure of contacts M1—12 (Fig. 2a). With the emitter 314 in operation the times 2 multiple of the multiplicand is read out from MLR1—2 and flows via lines 315 and through the M1—6 contacts to the ML4—8 and the ML5 accumulators. This will have completed the setting of the 4 and 5 multiples on these receiving devices. During the same cycle in which these entries are being made, the 6 multiple of the multiplicand is read out from the doubling readout section of MLR3—6 and such 6 multiple flows via lines 316 (Figs. 2b, 2f, 2e and 2a), through the M7—12 contacts and finally reaches the ML7 and ML9 receiving devices. This operation will have completed the setting up of the 9 multiple on ML9 and the setting up of the 7 multiple on ML7. The multiple building up operations are now complete.

During the second card feed cycle, the record card from which the factors were read is advanced to the punch tray in the usual manner. Upon reaching this tray, the contacts 317 close (Fig. 2d) to energize relay coil D. The energization of relay coil D shifts relay contacts D1 to a reverse position from that shown cutting off current supply from the card feed clutch magnet 304 and providing current supply for the punch rack trip magnet 318 upon closure of cam contacts CC1 with contacts P3 and relay contacts B1 closed. The relay contacts B1 become closed upon energization of relay coil B upon closure of the customary last column punch contacts P5. With punch rack trip magnet 318 energized, contacts 319 become closed and remain latched closed in the customary manner by latch 320 (Fig. 2b). Current supply is then provided for the punch driving motor PM and endwise card feed occurs in the usual way to feed the card to the first computation result punching position.

LQ reset

With relay coils B and D energized in the manner previously explained relay contacts B2 and D2 (Fig. 2e) become closed. Upon closure of cam contacts CC27, current will flow from the 301 line through these contacts through the relay contacts AK2 now in the position shown, down through the now closed B2 contacts, the HH2 contacts now closed, the D2 contacts now closed to and through the 321LQ reset relay coil to ground. Reset will then be effected of the LQ accumulator.

The present machine employs electric reset and provision is accordingly made to maintain the 321LQ relay coil energized during the reset cycle. This is provided for by stick contacts LQ1, such contacts being in a stick circuit including cam contacts CC5. Upon energization of the LQ relay contacts LQ2, LQ3—6 (Fig. 2h) and LQ7 (Fig. 2g) shift to reverse position from that shown. With LQ2 (Fig. 2h) in reverse position current supply is afforded to an emitter 322 which is wired in a nines complementary manner to the LQR readout. Complemental impulses representative of the nines complement of the amount standing in LQ flow through the now shifted LQ3—6 contacts, through the set of lines generally designated 323 to the 313LQ accumulator magnets and back to ground (see also Fig. 2g). By thus introducing the nines complement of the amount standing in LQ the accumulator elements are restored to a 9 position. To bring the accumulator to zero from the all 9 position, an elusive 1 is entered in the units order at the carry time in the cycle. This entry is provided through the contacts LQ7 which are closed in the manner previously explained. This impulse is supplied in the following manner: From line 301, through cam contacts CC16, (Fig. 2g) via line 324, through the LQ7 contacts, through the normal carry relay contacts AV4 controlled by relay coil AV (Fig. 2d) down to the units order of the 313LQ magnets. The units order is thus advanced one step and the electric transfer devices of the accumulator cause advance of all the other higher orders one step.

It may be explained that as long as the machine is operating, cam contacts CC2 close once each machine cycle at the carry time in the operation of the accumulators. Such closure of cam contacts CC2 energizes relay coil AV (Fig. 2d). The energization of coil AV closes contacts AV1—4, and AV5—9 (Fig. 2g), AV10—11 (Fig. 2e), AV12—28 (Fig. 2a) and AV29—30 (Fig. 2c), which are respectively associated with the LQ, RD, MP, ML and SP accumulators. Since coil AV becomes energized once each machine cycle the aforementioned relay contacts thus close at the carry time. The closure of these contacts permits the electric carry devices to be effective for performing carry operations whenever they are required in their related accumulators.

During LQ reset, provision is made to prevent repetition of such reset. This repeat reset preventing means is provided for as follows: During LQ reset, the LQ8 contacts are closed (Fig. 2d). Accordingly, when cam contacts CC6 close, a circuit is provided from ground through the LQ8 contacts, through CC6, either through relay contacts AK3 or through the AN3 contacts to relay coil HH. Relay coil HH becoming energized, establishes its stick circuit through contacts HH1 and the punch controlled contacts P2 now closed. On Fig. 2e, the relay contacts HH2 open and thus interrupt the reset initiating circuit to 321LQ.

Computing operations of the machine, that is to say, the adding of selected multiples of the multiplicand into the product receiving device, are initiated by LQ reset. From the LQ8 contacts, (Fig. 2d) a branch circuit extends to contacts CC7 and upon closure of these cam contacts, relay coil JJ is energized, relay contacts H2 being now closed. JJ once being energized is maintained energized by a stick circuit through contacts JJ1, through the reset contacts ML3 and back to ground. Coil JJ is the computing initiating control.

With the present machine for multiplying, multiplication is effected by entering into the dual product receiving devices multiples of the mulplicand from the multiple readout devices. The selection of multiples is made under the control of the MPR readout according to the amount of the multiplier standing in the MP receiving device. Inasmuch as the multiple receiving devices and readouts associated therewith provide all nine digital multiples of the multiplicand, it is possible to enter two multiples pertaining to two different orders of the multiplier concurrently into the separate sections of the result receiving devices. While multiple selection is afforded by the MPR readout for such concurrent entry there are supplemental entry controls afforded by the cycle controller. The cycle controller ascertains in which columns of the multiplier there are significant digits and in which columns there are zeros. Selective controls are set up in the cycle controller according to such zeros and significant digits and these controls determine which orders of MPR are to be effective for controlling multiple selection. The cycle controller also controls column shift action for routing of multiple entries to the result receiving devices in proper columnar relationship therein.

Before the cycle controller is further explained its principles of operation may be briefly set forth. If significant multiplier digits are present in all odd and even columns of the multiplier the machine will concurrently enter multiples pertaining to adjacent odd and even columns and thereafter advance to another pair of odd and even columns and make another concurrent multiple entry for these two columns. If zeros are present in any odd multiplier column, multiple entry cycles will be omitted for any such odd orders. Likewise where zeros appear in even orders of the multiplier amount entry cycles will be omitted for such even orders. In referring to odd and even orders of the multiplier, counting of orders is commenced from the right, that is, the units is one, an odd order, and the tens is two, an even order. The cycle control for odd orders is wholly independent of the cycle control for even orders.

In the operation of the machine, both the odd order cycle controller and the even order cycle controller must both have completed their independent control of entries before further machine operations can take place.

In substance, the machine has two independent cycle controllers, one for even orders and the other for odd orders and, in effect, multiple entries. The machine may complete one set of multiple entries under the control of one cycle controller ahead of the multiple entries which are effected under the control of the other cycle controller. However, whenever possible, concurrent entries are made into both sections of the product receiving device. The only time when such concurrent entries are not made is when zeros are present in either all odd multiplier orders or in all even multiplier orders or when one cycle controller has completed its controls in advance of the other.

The entry routing controls are so arranged that multiples pertaining to odd orders of the multiplier always go to RD and multiples pertaining to even orders of the multiplier always go into LQ.

Summarizing, the machine has in effect two cycle controllers. One cycle controller derives its control from odd numbered columns of the multiplier. The other cycle controller derives its control from even numbered columns of the multiplier. Each cycle controller tries to complete its operations in the minimum number of successive machine cycles and both cycle controllers can operate concurrently. One cycle controller will direct entries into one accumulator and the other cycle controller will direct entries into the other accumulator. In the complete wiring diagram only a dual order multiplier is utilized, but in practice, this multiplier, of course, might contain many more orders. The cycle controller is, however, here shown with provision for more than two orders in order that its principles of operation may be disclosed and understood.

Upon energization of relay coil JJ in the manner previously explained relay contacts JJ5 (Fig. 2*f*) close and upon closure of cam contacts CC28, a circuit is completed from line 301, through the AK5 contacts in the position shown, through CC28, through the ML4 relay contacts in the position shown, through the JJ5 contacts now closed, through 340SA and back to ground. Magnet 340SA is the magnet of a stepping switch SA. Such stepping switch may be of the general type shown in United States patent to Bohlman No. 1,569,450. Upon energization of 340SA the stepping switch arms of the cycle controller are advanced from normal off contact position to the first contact position (Fig. 2*e*). In Fig. 2*e* the first contact position is that which is in circuit with contact ADt5 and ADu5. The energization of relay coil JJ will have closed relay contacts JJ3 and upon the closure of cam contacts CC3 and CC26 current will flow from line 301, through CC3, through JJ3, through the ADu5 contacts now in closed position as brought about by the energization of the ADu magnet in the manner previously explained, down via line 326, through the column shift relay magnet CSc and back to ground. A circuit is also completed through contacts ADt5, via line 327 to the column shift relay magnet CS*b* and back to ground.

The energization of CSc will close its related column shift contacts CSc1—3 shown in Fig. 2*g* and direct the entry of the multiple related to the units order of the multiplier into the proper columns of the RD result accumulator. The energization of CS*b* will close its related column shift contacts CS*b*1—3 on Fig. 2*g* and direct the entry of the multiple pertaining to the tens order of the multiplier into LQ. Concurrently with the energization of the above mentioned shift magnets CS*c* and CS*b*, current supply is afforded through lines 328 and 329 to the units and tens common segments of MPR (Fig. 2*f*). With the problem under consideration (see Fig. 9) the multiplier amount is 27 so the brush in the units order of MPR will stand on 7 and the brush in the tens order will stand on 2. With such brushes in these positions, the 7 brush in the units order will allow current to flow to the 7X multiple selecting relay. The circuit back to ground is through the AK6 relay contacts now closed. The brush standing on the 2 spot of the tens order will permit energization of the 2XX multiple selecting relay. The respective multiple selecting relays X and XX have stick contacts such as 7X1 and 2XX1 which when closed establish stick circuits which not only maintain their related multiple selecting relays energized but also maintain the selected column shift relays energized. The stick circuit from the XX relays is via line 330, which extends back to line 301, through cam contacts CC15. The circuit to the stick contacts of the X relays is via line 331, which extends to line 301, through cam contacts CC15.

With the above mentioned multiple selecting relays energized the related contacts such as 2XX2—4 and 7X2—4 (Fig. 2*b*) will become closed and a readout of the 2 multiple will be permitted from the doubling section of MLR1—2 with the entry of such 2 multiple into LQ. The path of impulse flow from the contacts 2XX2—4 is via a group of lines generally designated 332, (see Figs. 2*b*, 2*f*, 2*g*). Lines 332 extend to contacts AK7—9 in the position shown and the impulses will flow through these contacts through the now closed CS*b*1—3 column shift contacts, through the AK10—12 contacts in the position shown, to the 313LQ accumulator magnets. The 7 multiple will be read out from MLR7 and the impulses will flow through the 7X2—4 contacts over a group of lines 333 (Figs. 2*b*, 2*f* and 2*g*), through contacts AK39—41 and contacts DD2—4 which are in the position shown, down through the CS*c*1—3 column shift contacts, through the group of contacts AK13—15 in the position shown, to the 313RD accumulator magnets.

It will be understood that with the foregoing computation if the multiplicand amount is 32, the 7 multiple of that amount would be 224. The 2 multiple would be 64. Accordingly, there would be a concurrent entry of 64 and 224 respectively, into LQ and RD. (See Fig. 9.) 64 would be entered into LQ in a tens relationship. The multiplying computation so far as entry of selected multiples is concerned is now complete, but it will be understood that with a larger size machine further multiple and selecting cycles would follow. Assuming, however, that the computation is complete on the entry of two multiples for a two significant digit multiplier, the machine will now terminate multiple selecting and entering operations and controls will be conditioned for the next step of the computation. This next step involves the transfer of the amount in RD over into LQ. During this same transfer cycle there will be other operations effected as follows: The multiple receiving devices and the MP receiving device will all be reset to zero. There will also be a reset of the cycle controller set up unit. During this same cycle in which these resets take place, the stepping switch SA will be restored to its normal or non-advanced position.

Near the end of the multiple entering cycle cam contacts **CC28** (Fig. 2*f*) reclose and again energize **340SA**. The stepping switch arms (Fig. 2*e*) will be advanced to the second contact position. Contacts AD*t*—**4** and AD*u***4** will be in shifted position and all remaining cycle controller contacts such as AD*h***1**—**4**, AD*th***1**—**4**, etc., will be in non-shifted position. Upon closure of **CC3** and **CC26** current will flow through the **JJ3** contacts now closed, through the switch arms of the stepping switch, through the AD*u***4** (Fig. 2*e*) contacts, through the lower pyramidical contacts, out via line **334**, down through relay coil KK (Fig. 2*f*) and back to ground. Another circuit will be established through the contacts AD*t***4** (Fig. 2*e*), through the lower pyramidical contacts, through line **335**, down through relay coil H (Fig. 2*f*). In the event that relay coils H and KK are concurrently energized, the subsequent controls are brought into action, but if one or the other of these coils H or KK is not energized and the other one is energized, the controls now to be described will not be effective.

Upon energization of coils H and KK, these coils are maintained energized by stick contacts **H1** and **KK1**, respectively, the stick circuit extending through the **ML5** contacts and back to line **301**. The energization of relay coils H and KK will cause closure of relay contacts **H3** and **KK2** (Fig. 2*e*) and upon closure of cam contacts **CC27** current will flow from the line **301**, through the **AK2** contacts now in the position shown, through the **H3** contacts, through the **KK2** contacts, through the **AK17** contacts now in the position shown, through the **321MP** reset relay and also to the **321CY** reset magnet. A branch circuit is also completed to energize the CA transfer relay coil. The coils **321CY**, **321MP** and CA are maintained energized by a stick circuit through contacts **MP4** and **CA4** which extend to line **301**, through cam contacts **CC5**.

In order to reset the multiple receiving devices, the **321ML** reset relay is energized. This magnet is energized in the following manner: At the time contacts **KK2** and **H3** close, a branch circuit is established through the **321ML** reset relay. Upon energization of this relay the **ML1** contacts close to provide a stick circuit for coil **321ML**. The return circuit to line extends to cam contacts **CC5**.

The foregoing description has explained the manner in which **321CY** is energized. The CY unit (Fig. 1) is then reset in the customary manner. The description has also explained the manner of energization of relay coils **321MP** and **321ML**. Upon energization of relay coil **321MP**, the relay contacts **MP1**—**2** and **MP3** (Fig. 2*e*) shift to reverse position from that shown. Upon energization of **321ML**, the **ML6**—**23** contacts (Fig. 2*a*) and the **ML2** contacts (Fig. 2*b*) shift to reverse position from that shown. The shift of contacts **ML2** (Fig. 2*b*) places a nines complementary emitter **344** in circuit and nines complementary impulses are emitted from this emitter through the straight readout sections of the **MLR1**—**2**, the **MLR3**—**6**, **MLR4**—**8**, **MLR5**, **MLR7**, **MLR9** and through one section of MPR (Fig. 2*f*). Considering the **MLR9** readout, the nines complementary impulses of the amount standing in the related receiving device flow through it and via a group of lines generally designated **345** (Figs. 2*b* and 2*a*), through the **ML20**—**22** contacts to the **313ML9** accumulator magnets and back to ground. By such nines complementary impulses the **ML9** receiving device is brought to an all 9 position. The closure of contacts **ML23** allows a circuit to be established to the carry impulse line **324**, the circuit being completed through the now closed carry relay contacts **AV28** to the units order **313ML9** accumulator magnet. This provides for an entry of one in the units order of this accumulator and thereafter the regulator electric transfer contacts provide for carries into higher orders. This resets the **ML9** receiving device to zero. The other multiple receiving devices are reset in a generally similar manner and individual reset circuits need not be traced therefor.

Referring now to Fig. 2*f* the nines complementary impulses flow through one section of MPR and up via lines **346** (see also Fig. 2*e*). From these lines the impulses flow through the now shifted **MP1**—**2** contacts, through the **313MP** accumulator magnets, to ground. This brings the MP receiving device to the all 9 position. A circuit is established from the carry impulse circuit **324**, through the **MP3** contacts now closed, through the carry relay contacts **AV11** now closed, back to the units order **313MP** accumulator magnet. The usual transfer circuit also energizes the higher order accumulator magnet. This brings the MP accumulator to an all zero condition.

As previously explained, at the end of the computation the amount standing in the RD accumulator is transferred into the LQ accumulator to set up the final result in LQ. Transfer of such amount is brought about in the following manner: Referring first to Fig. 2*g* a circuit completed from line **301**, via wire **347**, through contacts **DD5** and **RD2**, all in the position shown, to add emitter **348**. From the add emitter impulses are emitted to RDR and the impulses flow out through the **CA1**—**3** contacts now in shifted position to the **313LQ** accumulator magnets. In this manner the amount which previously stood in RD is transferred over and entered into LQ.

After the foregoing operations have been completed, provision should be made to terminate the computing initiating control, viz. to deenergize relay coil JJ (Fig. 2*d*). Provision should also be made to restore the cycle controller stepping relay to its off-contact position and reset of the RD accumulator should be effected and punching operations should be initiated. Furthermore a new card feed cycle should be initiated. Deenergization of the JJ relay is brought about in the following manner. Energization of the **321ML** relay coil (Fig. 2*e*) will have opened contacts **ML3** (Fig. 2*d*). With such contacts open and at a later time in the cycle, upon opening of contacts **CC18** the stick circuit to relay coil JJ will be broken, whereupon this relay will be deenergized. This will disable the computing initiating control circuits and allow the contacts controlled by relay JJ to return to the position shown in the circuit diagram.

Relay contacts ML24 (Fig. 2d) become closed upon energiaztion of relay coil 321ML and upon closure of cam contacts CC20 a circuit is established through contacts AE2 in the position shown to energize relay coil E. Relay coil E upon being energized closes contacts E2 which permit energization of the card feed clutch magnet 304. The clutch magnet 312 for the XC cam contacts is also energized under control of the closed E2 contacts. A new card feed cycle now ensues.

To restore the cycle controller stepping relay to normal position relay contacts ML4 (Fig. 2f) are provided. Such contacts shift to a reverse position upon energization of relay coil 321ML and upon closure of cam contacts CC28, a circuit is established through the AK5 contacts and the now shifted ML4 contacts to energize the release magnet 341SA of the stepping relay. The stepping relay then assumes its off-contact position.

RD Reset

In order to reset the RD accumulator the following control circuits are provided. Referring to Fig. 2e, upon closure of cam contacts CC40 during the ML reset cycle, a circuit is established from line 301, through cam contacts CC40, through the now closed AE6 contacts, the ML24 contacts now closed, through the AK19 contacts now in the position shown, through the now closed A14 contacts, to the 321RD reset relay coil. Energization of 321 RD closes stick contacts RD1, the stick circuit being completed back to line through cam contacts CC5. Energization of 321 RD as above explained causes the shift of contacts RD2 (Fig. 2g) and a shift of contacts RD4—7. With such contacts shifted a circuit is established from line 301 (Fig. 2c) via wire 347 (see also Fig. 2g) to and through the DD5 contacts in the position shown, through the now shifted RD2 contacts to emitter 350. Emitter 350 is a nines complementary emitter and with current supplied to it, nines complementary impulses are emitted through RDR and through the now shifted RD1—4 contacts to a set of lines generally designated 351. The impulses flow via these lines and lines 513 to the 313RD accumulator magnets and advance the accumulator elements to an all 9 position. Thereafter a carry impulse is introduced into the units order of the accumulator through the closed RD3 and AV9 contacts which establish a circuit from the carry impulse line 324 to the 313RD accumulator magnet in the units order. The customary electric transfer contacts in the accumulator afford carry into the higher orders of the accumulator so that all accumulator elements are brought back to a zero status.

Punching operations are initiated in the early part of the RD reset cycle in the following manner. Referring to Figs. 2c and 2d, when cam contacts CC4 close a circuit will be completed through the CC4 cam contacts, RD8 contacts, down through the closed AK23 contacts and Ru1 contacts in the position shown, to pick up Wu. A branch circuit also extends through the closed AK21 contacts and Nu1 contacts in the position shown to pick up Vu. Closure of contacts RD8 contacts and cam contacts CC4 also establishes a circuit to relay coil A, energizing it. Upon energization of relay coil A a stick circuit is established for A relay by relay contacts A1, the circuit being completed back to ground through contacts LQ9 which are now in the position shown. With relay contacts A13 closed a stick circuit back to ground is afforded through stick contacts Wu1 and Vu1 for relays Wu and Vu (Fig. 2c).

The punch interposer magnet circuits will now be traced. Referring to Fig. 2h, line 301 is connected to one side of the set of interposer magnets 353 and the circuit is completed through one of these magnets, through one of the A2—12 contacts now in shifted position, to and through LQR and for the first product punching position to an outgoing readout line 354, through one of the Vu2—8 contacts and one of the Wu2—8 contacts to one of the plug sockets 355, through a plug connection to one of the plug sockets 356 (Fig. 2d). In the punch the usual readout strip and brush commutator device establishes a circuit to the line 357. The circuit from wire 357 back to ground is completed through the usual punch escapement contacts 358, through the A1 contacts now closed and through the circuit previously traced. The energization of selected ones of the coils 353 will cause closure of the punch interposer controlled contacts 359 and upon closure of 359 there will be an energization of the punch magnet 360. Punching now takes place for the first result punching position. The usual escapement occurs in the punch and for succeeding orders of LQR the punch circuits are established not via wire 354 (Fig. 2h), but through successive ones of the contacts Vu2—8 and Wu2—8 which are now closed.

It may be explained that concurrently with completion of punching the result on the record card there is a new card feed cycle and that during this card cycle a new set of multiples are being entered and built up on the multiple entry receiving devices.

Card feed of a new card is brought about in the cycle which immediately follows the RD reset cycle and such card feeding operation is initiated during the RD reset cycle in the following manner. Upon energization of 321RD relay coil (Fig. 2e) contacts RD9 (Fig. 2d) close and upon closure of cam contacts CC20 a circuit is completed through RD9 now closed to and through relay coil E. Coil E is maintained energized by a stick circuit previously described through E1 and FC2. Energization of relay coil E closes relay contacts E2 to condition the circuit for subsequent energization of card feed clutch magnet 304 and the XC clutch magnet 312. Energization of these two magnets occurs upon closure of cam contacts CC29 (Fig. 2h) which complete a circuit in the manner previously explained.

In the customary way the punch controlled contacts P5 (Fig. 2d) become closed on the card reaching the beyond the last column position and closure of such contacts brings about energization of relay coil B. Energization of relay coil B closes relay contacts B1 and the circuit is completed to the usual eject magnet 361 in the punch. Upon eject of the card under the control of the eject magnet 361, the contacts P3 become closed in the usual way and punch rack trip magnet 318 becomes energized when cam contacts CC1 close.

Record selection of dividing mechanism

Reverting to operations performed in the second card feed cycle in which the entry was made from the first card, at this time the second or following card is being analyzed at the control station in the second machine cycle of the card feed cycle. It will be assumed that the second card is perforated at the "8" index point position of a control column which calls for a dividing computation and referring to Fig. 2h a circuit will be completed in the second machine cycle of the card feed cycle from line 301, through the FC15 cam contacts, conductor plate 370, analyzing brush 371 in a column to sense the "8" index point position of the control column, GA1 relay contacts, to the emitter 512 which when it makes at the time the "8" index point is analyzed by brush 371, causes an impulse to flow from plug hub 502 via the plug connection from plug socket 502 to plug hub 511 (see Fig. 8) and to grounded relay coil DA. Relay coil DA energizes to close its stick contacts DA1, the stick circuit extending back through DA1 contacts, plug connection between plug sockets 518—520 to the cam controlled contacts FC16 which continues the energization of relay coil DA to the end of this card feed cycle. Since cam contacts FC16 are closed at the "D" position, relay coil DA will remain energized all through the subsequent multiplying operations and will not be deenergized until cam contacts FC16 open during the first machine cycle of the third card feed cycle.

When cam contacts FC17 (Fig. 2h) close during the first machine cycle of the third card feed cycle, a circuit will be completed from line 301, through cam contacts FC17, DA6 contacts now closed, relay coil AK, to ground. Relay coil AK will close its stick contacts AK1, the stick circuit extending through cam contacts FC18 which continues the energization of AK relay through the second machine cycle to the "D" position. By the maintained energization of the AK relay the machine is now conditioned for dividing operations effected in subsequent computing cycles.

In the first machine cycle of the third card feed cycle the "B" amount is entered from the second card. The "B" amount, or dividend amount, will be entered via the shifted DA2—5 contacts (Fig. 2e) and wires designated 513 (Figs. 2e, 2f, 2g) to the 313RD accumulator magnets (Fig. 2g). The "A" amount, or divisor, is entered into ML1—2, 3—6, 5, 7 and 9 as before, through the K1—8 contacts. Buildup of the multiples of the divisor amount then ensues in the normal manner.

With the card in the beyond the last column position in the punching machine, relay coil B (Fig. 2d) will be energized and with the new card in the receiving tray of the punch, relay coil D (Fig. 2d) will be energized because card lever contacts 317 will have beome closed. With relay coils D and B thus energized, relay contacts D2 and B2 (Fig. 2e) will become closed and with such contacts closed the 321LQ reset coil will be energized by a circuit from line 301, contacts CC3 (Fig. 2e) the now transferred AK2 contacts, contacts B2 now closed, normally closed HH2 contacts, D2 contacts now closed, to the 321LQ reset magnet. Reset of the LQ accumulator will then be brought about in the manner previously explained and such reset will initiate the dividing computing operation by causing as described the energization of the computing initiating coil JJ (Fig. 2d). During LQ reset contacts LQ9 (Fig. 2d) open, thereby breaking the stick circuit for relay coil A, and coils Wu and Vu.

Dividing operations

On dividing operations (see Fig. 10), the various ML devices are utilized to afford all nine digital multiples of the divisor. The dividend amount is introduced into the RD accumulator. The successive quotient digits as they are obtained are set up in LQ. The MP receiving device is not utilized on dividing. Likewise the SP receiving device is not utilized on dividing. Generally, the method of division which is used involves the concurrent comparing of all of the available digital multiples of the divisor with a comparison portion of the dividend on the dividend receiving device. By such comparison there is a determination of which is the largest multiple of the divisor which is less than or equal to the comparison portion of the dividend. Having made such determination there is a selection of the corresponding quotient digit and such quotient digit is entered into the quotient receiving device LQ. Also the selected largest going multiple of the divisor is subtracted from the comparison portion of the dividend. Further operations then follow for another dividend comparison operation and so on until the computation is complete.

It may be further explained that if none of the divisor multiples is contained in the comparison portion of the dividend which is being compared, there is a new comparison effected immediately with a newly selected comparison portion of the dividend and that there are no idle cycles taken up either with unnecessary subtractions or for the introduction of a zero or zeros in the quotient receiving device.

Elimination of shift of DD and DR entry in respective entry receiving devices

Referring to Fig. 10, it will be noted that the divisor—6—is not shifted to the left on entry into the ML receiving devices and that the dividend—92—is not shifted to the left on entry into the RD receiving device. Provision is made, however, to shift the wiring connections from the readouts of the ML and RD receiving devices in accordance with the number of zeros to the left, or in other words according to the denominational size of the amounts entered in these receiving devices.

Referring now to Fig. 7, it will be noted that in the first machine cycle following the third card feed cycle in which dividend and divisor entries were made from the card into the ML and RD receiving devices, the MLR and RDR readouts are presented for zeros to the left and accordingly controls are set up to route the entries from such readouts to the comparing units.

Referring to Fig. 1a, setup relay units N—R are provided, which in general construction, are similar to the electromechanical relay units fully disclosed in Patent No. 2,295,448 and shown in Fig. 17 therein. In the N—R unit, the tripping magnets are designated N (Fig. 2g) and R (Fig. 2b) with u, t, etc., suffixes indicating denominational order. It will be understood that magnets N and R are generally similar in function to the AD magnets of Fig. 17 in Patent No. 2,295,448.

It will be assumed that the machine is performing the division calculation of Fig 10. Accordingly, in the first machine cycle following the third card feed cycle or the last machine cycle of the XC cycle, the MLR1, 2 and RDR readouts are tested for the presence of zeros at the left. Referring to Fig. 2d when cam contacts XC18 close, a circuit will be completed through the now closed AK24 contacts to energize relay coil AF. The closure of relay contacts AF1 and AF2 (Fig. 2b) will complete a circuit from line 301, through contacts AF1, to wire 600 connecting all zero spots, right hand brush T of the tens order of the MLR1—2 readout, through the common segment, relay contacts AF2, the Rt relay tripping magnet to ground. It will be observed, that if the brush U of the units order of the MLR1—2 readout was also standing on zero, and a significant digit was in the hundreds order, by closure of contacts AF3, the Ru magnet would also be energized. In such the same manner, and by an obvious circuit shown in Fig. 2g the closure of relay contacts AF4 and AF5—8 will complete circuits for the example assumed through the hundreds and thousands orders of RDR to energize tripping magnets Nh and Nth because such orders represent zeros.

It has been explained that, at the completion of punching and with a new card in the receiving tray of the punch, an LQ reset is brought about. As the machine is now conditioned for dividing, relay coil LX (Fig. 2d) will be energized immediately after energization of 321LQ. Relay coil 321LQ closes contacts LQ14 to close a circuit, from line 301, AK27 contacts now closed, relay coil LX, LQ14 contacts to ground. A stick circuit is provided for relay coil LX through the LX1 stick contacts and cam contacts CC39. Late in the same machine cycle the LQ reset occurs, a circuit will be completed from ground, through the An11 contacts now in the position shown (Fig. 2c) cam contacts CC38, LX2 contacts, now closed, AK22 contacts, transferred Rt1 contacts, Ru1 contacts, relay coil Wu to line 301. A branch circuit also extends through the now closed AK20 contacts, transferred Nth1 contacts, transferred Nh1 contacts, Nt1 contacts in the position shown, relay coil Vt, to line 301. Relay coils Vt and Wu have stick circuits provided through their associated stick contacts Vt1 and Wu1, the now closed AK25 contacts and the LQ9 contacts to ground. The same impulse used to energize the V and W coils is also used by an obvious branch circuit to energize the 321N—R coil which causes the N and R relay unit to be subsequently reset in the customary manner.

Summarizing for the example assumed, relay coils Vt and Wu are energized for a purpose made clearer later on.

Upon LQ reset the LQ10 contacts (Fig. 2f) are closed. Inasmuch as the machine is set for dividing and contacts AK28 are closed, current will be supplied through cam contacts CC17, through AK28, through LQ10 to the divisor reset coils 321AZ in the comparing units, which are similar in function to 321AZ reset coils of Fig. 14 of Patent No. 2,295,448. This will release all of the divisor side sectors and allow them to be restored so as to be in position to receive a setting of the divisor multiples thereon.

Comparison of dividend with divisor multiples

The machine is now ready to compare the comparison portion of the dividend with all of the divisor multiples. In general this is effected by reading out a comparison portion of the dividend from the RDR device, setting such portion of the dividend up on one side of all sections of the comparing units and at the same time reading out from the multiple readouts the various divisor multiples, each of which multiples becomes set up on one section on the other side of the comparing units. This operation will now be traced on the circuit diagram.

It will be recalled that during multiplying operations the comparing units CU were not in operation. In dividing computations, however, such units are placed in operation. This is effected by maintaining energized the clutch magnet 342, (Figs. 1a and 2d). The circuit for energizing clutch magnet 342 is completed from line 301 through the closed AK27 contacts, through 342 and to ground. The maintained energization of 342 releases a one revolution clutch to place the drive shafts 94 and 97 of the CU units (Fig. 1a) in timed operation with shaft 50.

A comparing cycle is initiated by the energization of relay coil LL (Fig. 2f) which becomes energized in the following manner. As previously explained, the computing initiating relay JJ was energized upon LQ reset. Energization of such relay closes contacts JJ4 (Fig. 2f). A circuit is completed from line 301 (Fig. 2f) through the now shifted AK5 contacts, through the CC9 contacts, and through all of the 9Cu1, 8Cu1 etc., transfer contacts now in the position shown and finally through the 1Cu1 contacts, through the JJ4 contacts now closed, through the LL relay coil and back to ground. LL once energized is provided with a stick circuit extending back to line 301 through stick contacts LL1 and cam contacts CC13. After the foregoing stick circuit is established cam contacts CC14 close and establish a circuit through the non-shifted H4 contacts to energize magnet 340SB of the SB stepping switch. With magnet 340SB energized the switch arms SB of this relay (Fig. 2f, top) are stepped to the first contact position.

Shortly after the switch arms of the stepping relay have advanced to this position, a circuit is completed from line 301, through the H5 contacts now closed, through cam, contacts CC8, through the switch arm of the stepping relay, through the CSa column shift relay coil and back to ground. Another circuit is established through the CC11 contacts, through the LL2 contacts now closed, through the stepping relay switch arm, through the BB relay coil and back to ground. A branch circuit is also established to energize relay coil DD. With coils BB and DD energized, they are maintained energized by their respective stick contacts BB1 and DD1, the stick circuit extending back to line through cam contacts CC10.

It may be explained that column shift relay CSa and relay coil DD cooperate to control the readout of the dividend comparison portion from RDR and contacts BB are utilized to control the readout of the various divisor multiples from the MLR readout devices.

The manner in which a comparison portion of the dividend is set up on the comparing units will now be described. It will be understood that the comparison portion of the dividend includes a selected number of columns. The number of columns selected is determined by the CSa relay Referring to Fig. 2c a circuit is completed from line 301, via wire 347 (see also Fig. 2g) to and through the now shifted DD5 contacts, to an add emitter 348. With such emitter in circuit, impulses are emitted through RDR, via a set of lines 385, through the now shifted DD6—9 contacts, through the now closed Vt9—12 contacts, through the now closed CSa1—2 contacts, through the shifted DD2—4 contacts, via lines 387 (see also Fig. 2c) and to the dividend side comparing magnets generally designated 1AW, 2AW, etc. which are the same as the similarly designated magnets of Patent No. 2,295,448.

It will be understood that the comparison portion of the dividened is set up in multiple in the comparing units, that is to say, there are nine identical setups, of the comparison portion of the dividend in order that there can be comparing between each setup and nine different divisor multiples. In the typical problem under consideration, the comparison portion of the dividend which was so set up is the amount of 92 (see Fig. 10). The setup of the multiples of the divisor on the other side of the comparing unit sections will now be described.

It has been previously explained how relay coil BB (Fig. 2*f*) becomes energized. With such relay coil energized all of the contacts BB2—28 (Fig. 2*b*) become closed. Add emitter 314 will be placed in circuit in the following manner: From line 301 to the non-shifted MM1 contacts and ML2 contacts to the add emitter 314. Such add emitter will emit impulses to and through all of the MLR readout devices and the multiple amounts available on such readouts will be individually transmitted through the now closed BB2—28 contacts, and W*u*9—26 contacts to the various divisor multiple comparing magnets 1AZ, 2AZ, 3AZ, etc. Note that W*u*9—26 contacts cause the shift of entry one place to the left. It will be understood that the divisor multiple side of the comparing units will receive settings of the different divisor multiples in the manner more fully explained in Patent No. 2,295,448. The comparing units operate in the manner explained in this patent to make suitable settings of the brushes upon comparing commutators.

Having entered both the dividend comparison portion in a multiple manner into the comparing units and having entered the various multiples of the divisor in the other side of such comparing units the brush devices of the comparing units receive their settings, in the manner previously explained, to indicate a greater than, an equal to or a less than condition. As shown in Fig. 2*c*, the comparing unit commutators are in sections, one section being provided for each multiple.

Referring to Fig. 2*c* top, it will be noted that the comparing unit commutators are shown diagrammatically and as sectionalized, one for each multiple and elements 117, 122, 123 are the same as in Patent No. 2,295,448. For each section there is an associated relay coil such as 9CU for a 9 multiple, an 8CU for an 8 multiple and so on. The brush action of the comparing devices is adapted to prevent energization of all magnets relating to multiples which are higher than the comparison portion of the dividend and to permit energization of magnets related to multiples equal to or less than the comparison portion of the dividend.

With the problem of Fig. 10, the only magnet which will be energized is relay magnet 1CU. The circuit energizing th's magnet is from line 301, (Fig. 2*g*), via wires 347 and 388 (see also Fig. 2*c*), through cam contacts CC12, relay contacts DD10 now closed, through the commutator associated with 1CU, through 1CU and back to ground. At this point it may be explained that if the 4 multiple was the selected multiple, the 4CU coil, the 3CU coil, the 2CU coil and the 1CU coil would be energized and all higher number magnets above 4CU would not be energized.

It may be explained that on a comparing cycle which takes a single machine cycle the setup of the comparison portion of the dividend and of all the divisor multiples is made during the first portion of the comparing cycle. Immediately after the set up is made and in the same machine cycle testing is effected. All testing is done concurrently for all multiples.

Referring now to Fig. 2*f* the energization of relay coil 1CU will have shifted relay contacts 1CU1 to reverse position from that shown and upon closure of CC9 current flows through contacts 1CU1, to and through the 1X multiple selecting relay and through the MM relay to ground. The multiple selecting relay 1X is maintained energized through stick contacts 1X1, the stick circuit extending back to line through CC15. It may be mentioned that this 1X relay coil is energized in one cycle just after the commutator test is made and that such relay is maintained energized through a portion of the next cycle to select the 1 multiple which is to be read out from the MLR1 device and which muliple is to be subtracted from the dividend comparison portion of the divisor. The 1X multiple selecting relay also selects a related quotient digit for entry into the quotient receiving device LQ. Relay coil MM is maintained energized as long as the 1X coil is maintained energized, being in circuit therewith.

Previously when subtractive entries were made for resetting purposes the elusive 1 which was introduced into the accumulator to bring the all 9 setting of the accumulator wheels to a zero setting was introduced after the complementary entry. In subtracting the divisor multiple, however, the elusive 1 entry is made during a comparing cycle. In this connection it is to be noted that such elusive 1 is only introduced into the RD accumulator in the event that a multiple is to be subtractively introduced into such accumulator in the following cycle. If no such multiple is to be introduced the entry of such elusive 1 in the comparing cycle is suppressed.

At the carry time in the comparing cycle, the carry impulse flows from line 324 (Fig. 2*g*) through now closed MM2 contacts, through the V*t*13 contacts now closed, through the CS*a*5 contacts now in shifted position, through the now closed AK34 contacts to and through the 313RD accumulator magnet in the units order. It may be explained that the order in which such entry is made is selected under control of coil CS*a*, in this instance, by the CS*a*5 contacts and the V*t*13 contacts. Such carry impulse for subsequent steps of the computation will be introduced into other orders.

It has been explained that if there was no going multiple for any given comparison portion of the dividend that no elusive 1 entry would be made. Such entry is suppressed because of the fact that, in the event that no going multiple is found on test none of the X magnets will be energized because none of the 0—CU, 1CU to 9CU relays will be energized. With no X coil energized there will be no energization of coil MM and accordingly with MM deenergized the MM2 contacts will remain open and no elusive 1 entry can be effected. On a comparing cycle with a relay coil such as 1CU energized, the energizing circuit to coil LL (Fig. 2*f*) will be interrupted, since a shift of contacts 1CU1 cuts off the circuit.

Unless LL is energized it is impossible to energize the stepping switch magnet SB. All of the SB switch arms remain on their first contact position and inasmuch as contacts LL2 are open, even though cam contacts CC11 close, there will be no energization of either BB or DD. However, relay coil CSa will be energized again under the control of CC8 on the next machine cycle following the above described comparing cycle. Accordingly, the CSa1—2 contacts (Fig. 2g) will be again closed on the following machine cycle after the comparing cycle. In such cycle, the relay MM is maintained energized as explained before. Accordingly, relay contacts MM1 (Fig. 2b) will shift to reverse position from that shown and a circuit will be established from line through the MM1 contacts in shifted position to the subtract emitter 344.

Such emitter will emit nines complemental impulses through the MLR1 readout only. Impulses flow out of this readout, through the 1X2—4 contacts which are maintained closed by the energization of 1X during this cycle. Nines complementary impulses representative of the nines complement of 60, i. e. 39, flow over the lines 333 (Figs. 2b, 2f and 2g), through the now shifted AK39—41 contacts through the Wu27—29 contacts through the contacts DD2—4, in the position shown, over the lines 386, through the now closed CSa1—2 contacts, through the Vt—9—12 contacts, non-shifted DD6—8 contacts and into the proper columnar orders of the RD accumulator energizing the proper of the 313RD magnets. This operation will deduct the amount of 60 from the amount of 92, the comparison portion of the dividend in this accumulator (see Fig. 10). It will be recalled that the elusive 1 entry into this accumulator has been previously made and that the regular transfer mechanism of the accumulator will provide for transfer to higher orders when required.

Entry of quotient digit

With the multiple selecting relay coil 1X energized a supplemental contact 1X5 (Fig. 2g) will be closed. The DD5 and the RD2 contacts are now in the position shown and accordingly add emitter 348 is in circuit. A "1" impulse is emitted through the 1 bus of RDR, through the now closed 1X5 contact, through the AK35 and CSa7 contacts now closed, to the left hand accumulator magnet of LQ. This will enter the quotient digit of 1 in such accumulator.

On the quotient entering and subtracting cycle, inasmuch as the DD relay coil was not energized, contacts DD10 (Fig. 2c) are in open position. Accordingly, even if CC12 contacts close there will be no energization of any of the CU relays. Accordingly, with none of such coils energized the O—CU1, the 1CU1, etc. contacts of Fig. 2f remain in the position shown and upon closure of CC9 current supply is afforded through the JJ4 contacts to energize relay coil LL. Relay coil LL when energized will close its stick contacts as before described and there will be another energization of stepping relay coil 340SB under the control of contacts CC14. Accordingly, switch arms of SB will step to the second contact position. After comparison is made with one dividend comparison portion at the time the multiple selecting relays are energized under control of contacts CC9 a supplemental circuit is established through coils 321AW to ground. These coils are the reset coils of the comparing unit pertaining to the comparison portion of the dividend (see Fig. 14 of Patent No. 2,295,448). With such coils energized the dividend comparison side of the comparing units becomes restored so that a new dividend comparison portion can be introduced therein. It will be understood that the divisor multiple side of the comparing unit retains the divisor multiples during all deducting and quotient entering operations.

Referring to Fig. 10, the RD accumulator in effect now has standing in it the remainder amount of 3200. There is now to be another comparison operation and with such comparison operation there is a different comparison portion of the dividend which is selected for comparison. In Fig. 10 it will be noted that the first comparison which has been previously described pertains to the two extreme lefthand orders of the dividend and the second comparison pertains to the next three orders. There must, accordingly, be a column shift to take a different comparison portion of the dividend from the RD receiving device.

It has been previously explained how the SB stepping switch was brought to the second contact position. It was also explained that the relay coil LL was energized. With relay coil LL energized relay contacts LL2 (Fig. 2f) are closed and accordingly upon closure of cam contacts CC11 a circuit is completed through a switch arm of the stepping switch to energize relay coil DD. It will be noted that there is no energization of relay coil BB because the second contact of the stepping switch and those thereafter are not wired in circuit to relay coil BB. Accordingly, at this time there is no energization of relay coil BB. With relay coil DD energized, it is maintained energized in the customary manner and following its energization cam contacts CC8 close and a circuit is established to energize column shift coil CSb. It will be noted that relay coil CSa is not now energized since the switch arm of the stepping switch is in the second contact position and out of circuit with CSa. With the coil CSb and relay coil DD energized, their associated contacts shift to a reverse position from that shown in the circuit diagram.

Referring to Fig. 2g with coil CSb energized, contacts CSb1—3 close and there is a new readout relation established with RDR. The readout relation is now such that the three left hand columns of the dividend amount are selected for readout and entry into the dividend side of the comparing units. The entry circuit will now be traced. From line 347 (Figs. 2c and 2g), through the DD5 contacts now shifted, to the add emitter 348, from the add emitter impulses are emitted through RDR, to lines 385, thence through the DD6—9, Vt9—12 and AK10—12 contacts now shifted, through the closed CSb1—3 contacts, through the shifted AK7—9 contacts, lines 386, thence through the now shifted DD2—4 contacts, to lines 387, thence to Fig. 2c and to the various 1AW, 2AW, etc. comparing unit magnets. This operation will have set up the new comparison portion of the dividend, viz. 320 in the various comparing units.

It will be recalled that the divisor multiples still remain set up in the divisor side of the comparison units. There is then a further comparison effected and the comparison commutators and circuits of the comparing unit bring about an energization of all of the CU coils from 1CU up to and including 5CU but leaves coils 6CU, 7CU, 8CU and 9CU deenergized. With the 5CU comparison relay coil energized, the related relay coil 5X (Fig. 2f) becomes energized under the control of CC9, over the circuit previously described, but which in this instance, is completed through the now shifted 5CU1 contacts to the multiple selecting relay 5X. When relay coil

5X is energized, relay coil MM likewise becomes energized in the manner previously explained. Both 5X and MM are held energized through the 5X1 stick contacts.

In the comparing cycle and at the carry time in such cycle, provision is made for introducing an elusive 1 into the RD accumulator in extreme left hand order. Such elusive 1 entry is made generally in the manner previously explained except that at this time the CS*b*4—7 (Fig. 2*g*) contacts are in shifted position due to the energization of CS*b*. With relay coil MM energized, the MM2 contacts are closed and a circuit is completed from line 324 at the carry time, through MM2, through the now closed V*t*13 contacts, through the now shifted CS*b*6 contacts through the AK31 contacts down to and through the thousandths order 313RD accumulator magnet. This will enter the elusive 1 in such order. It will be noted that the V*t*14 contacts are closed to provide a carry from the thousandths to the units order of the RD accumulator. This circuit is from line 324, relay contacts AV5, contacts V*t*14, relay contacts AK34, to the units order 313RD to add the elusive unit in such order. On the following cycle the 5 divisor multiple is entered subtractively into the RD accumulator and the 5 quotient digit is entered into the proper columnar order of LQ.

Referring to Fig. 2*b* energization of the 5X multiple selecting relay coil, brought about as previously explained, will close the 5X2—4 contacts. The energization of relay coil MM will shift MM1 contacts to reverse position and place the nines complementary emitter 344 in circuit with line 301. Nines complementary impulses flow from the 344 emitter, through the MLR5 readout, out through the 5X2—4 contacts to the lines 333 through the transferred AK39—41 contacts, now closed, W*u*27—29 contacts (see also Figs. 2*f* and 2*g*), through the non-shifted DD2—4 contacts (DD having now become deenergized), through the shifted AK7—9 contacts, through the closed CH*b*1—3 contacts, CS*b* having been reenergized in such cycle since the stepping relay SB remains on the two contact position, through the AK10—12 contacts now shifted, through the DD6—9 contacts in the position shown, to the accumulator magnets of the RD accumulator. This will enter the nines complement of the 5 multiple of the divisor into such accumulator. Concurrently with the foregoing deducting operation the 5 quotient digit is entered into LQ. The energization of relay coil 5X will have closed contacts 5X5 (Fig. 2*g*). Add emitter 348 will now be in a circuit which extends through the DD5, and the RD2 contacts in the position shown. A current impulse will be emitted from the 5 spot of the add emitter 348 to and through the RDR readout and through the closed 5X5 contacts, through the AK36 contacts, the CS*b*8 contacts, down to the hundreds order of accumulator magnet of the LQ accumulator. This will enter the 5 quotient digit in such order of this accumulator.

Referring to Fig. 10, in the computation illustrated, the quotient is carried to two places. It will be assumed in this description that it is desired to divide only to this number of places, and computing is now terminated in a manner now to be described.

Place limiting device

Referring to Fig. 2*f* and Fig. 8 the insertible plugboard will have provided a plug connection from socket 389 to the second socket 390 from the left. The second socket from the left is plugged up because the computation is to be carried to two quotient places. If the computation was to be carried to further quotient places the third or fourth socket 390 from the left would be plugged up. During the second multiple deducting cycle just described, relay coil DD will be deenergized and accordingly the DD10 contacts (Fig. 2*c*) remain in open position. There will accordingly be no energization of any of the CU relay coils. With none of such relay coils energized the 1CU1 to 9CU1 contacts (Fig. 2*f*) will remain in the position shown so that upon closure of cam contacts CC9, relay coil LL will become energized. With such relay coil LL energized the relay contacts LL3 will be closed and upon closure of CC17 the circuit will be completed through LL3, through the switch arm of the stepping switch now still in the second contact position, through the plug connection from socket 390 to socket 389 to energize relay coil H. H being energized, closes its stick contacts H1 and the stick circuit is completed back to line 301 through ML5 contacts now in normal position. The energization of relay coil H will have shifted relay contacts H4 (Fig. 2*f*) to a reverse position from that shown at a time prior to the closure of cam contacts CC14. Accordingly, with such CC14 contacts closed, a circuit is completed through the stick contacts of LL1 of LL, through the CC14 contacts, to the release magnet 341SB of the stepping switch. With this operation, due to the shift of contacts H4, the stepping switch magnet 340SB will be out of circuit. Energization of the 341SB release magnet will release the stepping switch and allow it to return to normal home position, i. e. the position shown in the circuit diagram. It may be mentioned that no circuits are inadvertently established by the switch arms on SB on restoration because on restoration the H5 relay contacts are in open position. The foregoing restoration of the stepping switch and opening of contacts H5 terminates further energization of the CS magnets, the BB or the DD magnets.

The machine has now reached the stage in its operation in which it is ready to record the quotient upon the record. The various ML multiple receiving accumulators can now be reset and the RD device can also be reset. Reset of the ML devices is brought about in the following manner: Energization of relay coil H (Fig. 2*f*) in the manner previously explained will have caused closure of relay contacts H3 (Fig. 2*e*). Upon closure of CC3, a circuit is established from line 301, through the AK2 contacts now in shifted position, through contacts H3 and AK16 now closed, through 321ML, to ground. A branch circuit is also completed through the AK19 contacts now shifted, through relay contacts A14, through the 321RD reset relay coil and back to ground. Energization of 321ML and the 321RD reset coils will bring about electric reset of the corresponding accumulators. The detailed impulse circuits for resetting will not be traced as these have been previously traced. The energization of the 321ML relay coil also serves to deenergize the computing initiating relay coil JJ as follows: Opening of relay contacts ML3 (Fig. 2*d*) breaks the stick circuit for coil JJ but the time of deenergization of coil JJ is timed by the CC18 cam contacts following the opening of relay contacts ML3.

The energization of relay coil 321RD brought about as previously explained causes the closure of contacts RD8 (Fig. 2d). Upon closure of cam contacts CC4, the circuit is established through the now closed RD8 contacts, through the A relay coil to line 301, and a stick circuit is provided back to ground through the A1 and LQ9 contacts.

Referring to Fig. 2h, it will be noted that there is a column shifting arrangement similar to Patent No. 2,295,448 intermediate plug sockets 355, which are sockets which are connected to the punch readout strip sockets 356 (Fig. 2d), and LQR (Fig. 2h). Such column shifting arrangement is provided by the multi-contacts controlled by the various V relays and the W relays. The W relays are selectively energized according to the number of zeros to the left in the divisor and the V relay coils are selectively energized according to the number of zeros to the left in the dividend. With relay coils Vt and Wu energized, there will be a closure of the related contacts Vt2—8 and Wu2—8 and the closure of these contacts in combination will establish a readout relation between LQR and the sockets 335 so that there will be a punching not in the extreme left hand field of the record card, but in a field shifted two columns to the right from the extreme left hand field.

It will be assumed that all of the seven sockets labeled 355 (Fig. 2h bottom) are connected to sockets 356 (Fig. 2d). If the circuits from the two left hand sockets of the 355 group and the extreme right hand 355 sockets are traced it will be found that their circuit extends back to a line 391, which line connects to a line 392 and that this circuit is completed back to line 301, through the now closed A2 and A3 contacts to and through the zero interposer magnet 353. This will provide for punching zeros on the record card in columns of the quotient field not controlled by LQR.

Now referring to the third socket from the left of the 355 group, it will be noted that this circuit is completed through the Wu4 contacts, through the Vt5 contacts, to a line which extends up to the thousands order of LQR. Inasmuch as the brush in this order is standing upon 1, the one punch selecting interposer magnet 353 will be energized during the punching operation. If the line from the fourth socket from the left of the 355 sockets be traced, it will be noted that this circuit is completed through the Wu5 contacts, through the Vt6 contacts, to the hundreds order of LQR. In this order, the brush is standing on the 5 spot so that the line will be completed through A8 contact to and through the five interposer magnet 353.

Referring now to the two sockets 355, which are in the second and third columns from the right of the group, it will be noted that circuits are completed through Wu6—7 and Vt7—8 to the tens and units orders of LQR. The brushes in these orders stand at zero, therefore there will be a circuit completed from both orders back to the zero interposer punch selecting magnet 353.

The foregoing description has explained the circuits for selectively reading out amounts to the punch on final recording. Punching occurs successively column by column in the usual way, the control circuits being those traced in detail for result recording on multiplying, but it may be mentioned that the return circuit from any plug socket 356 is via the punch readout brush to the common strip of the readout, thence via wire 357 (Fig. 2d), through the usual escapement contacts 358 of the punch, through the stick contacts A1 and thence back to ground. The energization of any interposer magnets 353 (Fig. 2h) closes the interposer controlled punch magnet contacts 359 (Fig. 2d) and energizes the punch magnet 360 in the usual manner. Punching then proceeds in the usual way column by column and eventually the card reaches the beyond last column position and closes P5 energizing coil B. Energization of B closes contacts B1 and energizes the eject magnet 361 of the punch. Card eject then occurs and contacts P3 become closed to condition control circuits for a succeeding computation.

Card feed of a new card is brought about in the cycle which immediately follows the ML and RD reset cycle and such card feeding operation is initiated during the ML and RD reset cycle in the following manner. Upon energization of 321RD (Fig. 2e) contacts RD9 (Fig. 2d) close and upon closure of cam contacts CC20 a circuit is completed through RD9 now closed to and through relay coil E. Coil E is maintained energized by a stick circuit previously described through E1 and FC2. Energization of relay coil E closes relay contacts E2 to condition the circuit for subsequent energization of card feed clutch magnet 304 and the XC clutch magnet 312. Energization of these two magnets occurs upon closure of cam contacts CC29 (Fig. 2h) which complete a circuit in the manner previously explained.

Record selection of $\frac{A\times B}{C}$ computing mechanism

It will be assumed that the third card is punched at "7" in the control column which calls for an

$$\frac{A\times B}{C}$$

calculation outlined in Fig. 11. In the third card feed cycle, (Fig. 7) the third card will also be analyzed at the presensing station and during the second machine cycle of the third card feed cycle a circuit will be completed from line 301 (Fig. 2h), through cam contacts FC15, conductor plate 370, analyzing brush 371 in the control column to sense the "7" index point, GA1 relay contacts now closed, emitter 512, plug socket 521, plug connection to plug socket 510, relay coil DB to ground, thus energizing relay DB. Relay coil DB closes its stick contacts DB1, the stick circuit extending back to ground through the DB1 contacts and cam contacts FC16. Cam contacts FC16 maintain DB energized to the end of the third card feed cycle and since cam contacts FC16 are closed at the "D" position relay DB will remain energized throughout dividing operations for the second card and also for a greater part of the first machine cycle of the fourth card feed cycle.

During the fourth card feed cycle and before cam contacts FC16 open cam contacts FC17 close to send an impulse to relay coil AN through the DB2 contacts now closed. Relay coil AN closes its stick contacts AN1, the stick circuit extending back to line through cam contacts FC18. Cam contacts FC18 maintain relay AN energized to the remainder of the fourth card feed cycle, and since contacts FC17 are closed at the "D" position, relay coil AN will be kept energized during the successive computing cycles to condition circuits of the machine for effecting an

$$\frac{A\times B}{C}$$

computation.

During the fourth card feed cycle, the "C" or divisor amount will be analyzed by the brushes 308 for the "C" field and entered by plug connections between the related plug sockets 309 to sockets 500 (Figs. 2c and 8) and by wires 514 (Figs. 2a, 2b and 2c) the entry is directed through the closed DB3—4 contacts (Fig. 2c) to the 313SP accumulator magnets and stored in the SP accumulator. (See also Fig. 11.) The multiplicand or "A" amount will be entered into the ML accumulators and the "B" or multiplier amount will be entered into the MP receiving device in the same way as described for the multiplying computation, and as outlined in Fig. 11.

Multiples of the "A" or multiplicand amount are built up in the same way as described for multiplying computations, as outlined in Fig. 7.

With relay contacts B2 and D2 closed (Fig. 2e), by circuits previously described for the multiplying computation an impulse is directed to 321LQ when cam contacts CC27 close, thus resetting LQ in the last machine cycle of the fourth card feed cycle.

Computing cycles for multiplication are initiated by the LQ reset, it being recalled that the circuit to energize JJ (Fig. 2d) is closed by LQ8 contacts. Also closure of JJ5 contacts (2f) initiate the transmission of an impulse to 340SA stepping switch magnet and thus the SA switch arms are stepped to their first contact position.

Since the same factors are involved in the

$$\frac{A\times B}{C}$$

computation as in the previously described multiplying computation relay coils ADu and ADt are energized, and also as described for the multiplying computation column shift coils CSb and CSc are energized.

Of course, with the same multiplier amount—27—MPR will represent 27 by the brush positions, thus selecting the 2 and 7 multiplicand multiples for entry in the LQ and RD accumulators, with a subsequent transfer to RD from LQ so that the latter represents the final product, which is utilized as a dividend for the subsequent dividing computation. These operations need not be redescribed at this time as they were previously described in detail for the same multiplying computation.

In the description of the multiplying computation the circuits to pick up H and KK were described and such relays are also energized in this computation to close contacts H3 and KK2 (Fig. 2e) to energize 321CY, 321MP and 321ML, effecting the reset of such units. However, differing from the previous description since contacts AN4 are now open (Fig. 2e) relay coil CA will not be energized. An impulse is also directed to 341SA resulting from the closure of ML4 contacts (Fig. 2f) and the SA switch arms restore to normal, as for the multiplying computation.

It should be noted that upon the completion of multiplication there is an automatic shift from multiplying to division, and while previously this was performed under record card control automatically closed circuits institute this change in computation.

In the cycle that MP is reset with MP5 contacts now closed, (Fig. 2d) a circuit is completed from line 301, through AE relay coil, cam contacts CC30, MP5 relay contacts, relay contacts AN5 now closed, to ground. A stick circuit for AE relay is provided by stick relay contacts AE1 and cam contacts CC31. Before the end of the cycle in which AE was picked up and held energized, cam contacts CC33 (Fig. 2h) close, thus completing a circuit from line 301, cam contacts CC33, relay contacts AE3 now closed, relay coil AK to ground. This is the relay coil that changes the circuits to a dividing status. Relay coil AK closes its contacts AK1, and a stick circuit is provided by FC18 contacts which are now at rest and closed, to thus maintain relay coil AK energized until the next card feed cycle ensues.

A different circuit from that described is effective to energize the magnet 304 to cause the rotation of the XC cams. This circuit is from line 301, clutch magnet 304, G2 contacts closed by the circuit previously described, AE4 contacts now transferred, AK4 contacts now transferred, cam contacts CC32 to ground. Contacts AE5 are shunted across G2 contacts to take care of the last card condition and in the place of the circuit being closed by G2 contacts it is closed by AE5 contacts. With AE4 contacts transferred the impulse cannot be sent to magnet 304 as before by this impulsing circuit.

The energization of the magnet 312 clutches the shaft which rotates the XC cams to the driving shaft so that an XC cycle follows as shown in Fig. 7 after conditioning the machine to a dividing status. During the first machine cycle of the ensuing XC cycle a circuit is closed to effect the energization of relay coil WW (Fig. 2d) when XC1 cam contacts close by the following circuit: From the line 301 through relay coil WW, relay contacts AN6 now closed, AK18 relay contacts now closed, cam contacts XC1 to ground. Relay coil WW is energized during the entry part of the first machine cycle of the XC cycle so that the C amount is entered in the ML1—2, 3—6, 5, 7, 9 accumulators. This entry circuit is described as follows: From line 301, wire 347 (Fig. 2c), through SP2 contacts now in the position shown, through relay contacts WW3 now closed, to the emitter 410, thus connecting emitter 410 to the line 301. Additive impulses will now flow by the emitter 410 under control of the SPR readout and in accordance with the C amount standing on the SPR readout timed digital impulses will be transmitted through relay contacts SP3—4 now in the position shown and thence by wires 514 (Figs. 2c, 2b, 2a) the impulses will be directed to contacts WW1—2 which now are transferred and from such contacts the impulses will pass through K1—8 contacts now closed and be directed to the ML1—2, 3—6, 5, 7 and 9 accumulators, thereby entering the C amount in such accumulators. With the C amount entered in such accumulators, a buildup of the multiples of the C amount is effected during the second and third machine cycles of the XC cycle precisely in the same manner as described for dividing operation. Hence, from the outline of the computation in Fig. 11, it will be observed that multiples of the C amount or —49 are represented, in the ML receiving devices. The C amount is, of course, the divisor so that in the subsequent dividing operation all of the digital multiples of the divisor can be compared with the comparison portion of the dividend exactly as has been outlined in the description of the dividing computation.

Transfer of the amount in LQ to RD prior to the dividing operation is brought about in the following manner: Referring to Fig. 2d when cam contacts XC11 close during the entry part of the second machine cycle of the XC cycle, a circuit will be closed from line 301 through relay contacts AK27, relay coil AG, relay contacts AN8 now closed, cam contacts XC11 to ground. Referring to Fig. 2h the closure of AG1 relay contacts will connect the line 301 through LQ2 relay contacts, AG1 contacts now closed to the emitter 414. Impulses will be now directed by this emitter and under control of the LQR readout, impulses representative of the digital amount on LQR will be transmitted through LQ3—6 contacts now in the position shown through AG2—5 contacts now closed, through the 313RD accumulator magnets to ground.

During the third machine cycle of the XC cycle prior to dividing operations the LQ accumulator is reset in order that it may receive the subsequently derived quotient digits. Referring to Fig. 2e when cam contacts CC3 close, a circuit will be closed from line 301 through cam contacts CC3, relay contacts AK2 now transferred, thence through cam contacts XC13 which are closed at the time cam contacts CC3 are closed, thence through relay contacts AK30 now closed, relay contacts AN9 now closed to the 321LQ reset coil, thereby causing the resetting of the LQ accumulator during the third machine cycle of the XC cycle as outlined in Fig. 7.

During this machine cycle there is a presensing of the amount standing in MLR and RDR to determine the presence of zeros and this is carried out by the circuits previously described in detail. With the dividend amount 0864 now represented in RDR, the zero testing circuit will sense the presence of a zero in the ten thousands order and accordingly relay coil N*th* (Fig. 2g) will be energized. The transfer of the related contacts N*th*1 (Fig. 2c) will accordingly cause relay coil V*h* to be energized and its contacts V*h*9—12 (Fig. 2g) will be closed to route the entries from RDR to the dividend side comparing magnets 1AW, 2AW, etc.

With regard to the divisor which is 049 (Fig. 11) it will be observed that there are no zeros in either the units or tens orders and accordingly none of the relays R*u* or R*t* (Fig. 2b) will be energized upon sensing MLR1—2 for zeros by the circuit previously described. Accordingly, with contacts R*u*1 and R*t*1 (Fig. 2c) in the position shown, relay coil W*t* will be energized and the latter will shift its contacts W*t*9—35 (Fig. 2c) to route the entries from all the MLR readout devices to the divisor multiple comparing magnets 1AZ, 2AZ, 3AZ. The above operations are effected just prior to dividing and for the reasons previously described in detail in connection with the dividing computation. The machine is now ready to divide the product of the previous multiplying computation by the C amount and dividing is carried out exactly in the manner previously described. During the first machine cycle after the XC cycle is terminated there is a comparison of the comparison portion of the dividend with the multiples of the divisor and in the next machine cycle the selected largest going multiple of the divisor is subtracted from the comparison portion of the dividend. In accordance with the selected largest going multiple, the corresponding quotient digit is entered in LQ. In the example outlined in Fig. 11, the first quotient digit is "1" and two subsequent machine cycles then ensue with repetitions of the dividing operations just described to secure the next quotient digit "7" which is also entered in the LQ accumulator. Obviously, with the machine set to secure two quotient digits by reason of the plug connections between 389 and 390 shown in Fig. 8, dividing operations will terminate when two quotient digits have been derived and thereafter quotient recording operations are brought about in precisely the same manner as has been described.

The final operations for this computation consist in resetting the ML receiving devices and the RD and SP accumulators. It will be recalled that for resetting the ML receiving devices a circuit is closed from line 301 to cam contacts CC3, AK2 contacts now transferred, through contacts H3 which are now closed because dividing operations have been terminated, through relay contacts AK16 to 321ML to ground. By a branch circuit an impulse is also directed through relay contacts AK19 now transferred, relay contacts A14 to 321RD reset coil. It will also be observed that this impulse through AK17 now transferred is directed through AN10 contacts now closed, to 321SP reset coil. Accordingly, by these reset circuits the ML receiving devices and RD and SP accumulators are reset to zero.

As shown in Fig. 2h, the grounded GA relay has a serial connection through a brush to the contact roll 370, the circuit thence passing through the FC15 contacts to line 301. This brush is separated from the contact roll by an intact portion of the card, preferably the marginal edge, and as long as cards are being fed the separation of the brush from the contact roll 370 will retain the GA relay deenergized. Whenever the last card passes the presensing station, electrical contact between the contact roll 370 and the brush is made to cause the GA relay to be energized during the time that the FC15 contacts are closed. When the GA relay is energized it opens the GA1 contacts, so that it is evident upon the passage of the last card the circuit to the impulse emitter 512 is broken at the GA1 contacts, thus preventing improper impulses from being directed by the impulse emitter 512 in the absence of cards passing the presensing station. In other words, the GA relay is provided to prevent improper operations upon the last card condition of the machine.

As outlined in Fig. 7 this indicates the sequence of events when multiplying, dividing and a

$$\frac{A \times B}{C}$$

computation are effected in succession, determined by the passage of three tabulating cards designated accordingly to select such computing mechanisms. It is obvious, of course, that further computing operations may then follow and such computing operations need not be in the same sequence as outlined in Fig. 7 and the type of computation may vary from card to card with repetitions of the same form of computation being accomplished, or changing from card to card.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a single modification, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in it 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.

In the claims the term "master computation control means" refers to AK and AN relays of Fig. 2*h* which have the function of conditioning the machine for different types of computations while the "setup" means refers herein to the DA and DB relays which are set up under card control and possess the function of selecting the related computation control relays AK and AN.

What is claimed is:

1. In a record controlled machine with record feeding means for feeding in a card feed cycle, separate records in succession through the machine to select and control computations each of which computations requires a succession of computing cycles following a card feed cycle, each separate record bearing designations for representing amounts for controlling computations and also bearing computation selection designations for selecting the type of computation to be performed under control of the same record, record sensing means for sensing in one card feed cycle said amount designations on one record for controlling computations to be effected in the subsequent computing cycles and other means for sensing in the same card feed cycle the computation selection designations on a following record, a plurality of master computation control means, each when selected for operation for causing the related type of computation to be performed, a corresponding number of setup means controlled by said other sensing means and set up within a card feed cycle in accordance with the designation sensed, and each when set up for selecting the related master computation control means, means controlled by the setup means which is set up for maintaining it set up during the successive computing cycles the computation is being effected under control of a record previously sensed by the amount sensing means and of the type determined by the computation selection designation it bears, and means controlled by the setup means which is set up for selecting at the termination of said computing cycles the related master computation control means for causing the associated type of computation to be effected under control of said following record.

2. In a record controlled machine with record feeding means for feeding in a card feed cycle separate records in succession through the machine to determine the type of computation to be performed in a succession of computing cycles following each card feed cycle and to also control the computation, each separate record bearing designations for representing amounts for controlling computations and also bearing designations for determining the type of computation to be performed under control of the same record, record sensing means for sensing in one card feed cycle said amount designations on one record for controlling the computation to be effected in subsequent computing cycles and other means for sensing in the same card feed cycle said computation determining designations on a following record, master computation control means when rendered effective for changing the condition of the machine in which one type of computation would be effected to another condition to cause a different type of computation to be performed, setup means controlled by said other sensing means and set up within a card feed cycle when a particular designation is sensed, means controlled by the setup means when set up for maintaining it set up during the successive computing cycles the computation is being performed under control of the record previously sensed by said amount sensing means, and means controlled by the setup means when set up for rendering at the termination of said computing cycle, said master computation control means effective for changing the condition of the machine to cause a different computation to be performed under control of said following record.

3. In a record controlled machine with record feeding means for feeding separate records in succession through the machine to control computations and to also determine whether a multiplying or dividing computation is to be performed under control of the same record, each separate record bearing designations for representing amounts for controlling computations and also bearing designations for determining the type of computation to be performed, record sensing means for sensing said amount designations on one record for controlling computations and other means for sensing said computation determining designations on a following record, master computation control means when rendered effective for changing the condition of the machine in which a multiplying computation would be effected to another condition to cause a dividing computation to be performed, setup means controlled by said other sensing means and set up when a particular designation is sensed, means controlled by the setup means when set up for maintaining it set up during the time the multiplying computation is being performed under control of a record previously sensed by said amount sensing means, and means controlled by the setup means when set up for rendering said master computation control means effective for causing a dividing computation to be performed under control of said following record.

4. In a record controlled machine with record feeding means for feeding separate records in succession, one pair passing through the machine for each card feed cycle to select and control computations, which latter are effected in a plurality of computing cycles, each separate record bearing designations for representing amounts for controlling computations and also bearing computation selection designations for selecting the type of computation to be performed under control of the same record, record sensing means for sensing said amount designations on one record in one card feed cycle and other means for sensing in the same card feed cycle the computation selection designations on a following record, a plurality of master computation control means, each when selected for operation for causing the related type of computation, a corresponding number of setup means controlled by said other sensing means and set up in accordance with the designation sensed, and each when set up for selecting the related master computation control means, means controlled by the setup means which is set up for maintaining it set up within the card feed cycle said setup means is set up; during successive computing cycles, and within the following card feed cycle, and means controlled by the setup means which is set up including means operable within the card feed cycle following the last computing cycle for selecting the related master computation control means for causing the associated type of

computation to be performed under control of said following record.

5. In a record controlled machine with record feeding means for feeding separate records in a card feed cycle in succession and to condition the machine to effect a computation under control of the same record in a plurality of computing cycles following each card feed cycle, each of said records having computation determining designations and amount designations, record sensing means for sensing in one card feed cycle said amount designations of one record to control the computation to be effected in subsequent computing cycles, and other means for sensing in the same card feed cycle the computation determining designations of the following record, computation control means for conditioning the machine to effect a computation under control of the record, setup means controlled by said other sensing means and set up within a card feed cycle when said computation determining designation is sensed, means controlled by the setup means when set up for maintaining it set up during the plurality of computing cycles the computation is being effected under control of the record previously sensed by said amount sensing means, and means controlled by the setup means when set up for rendering at the termination of said plurality of computing cycles said computation control means effective for conditioning the machine to effect a computation under control of said following record.

6. In a record controlled machine with record feeding means for feeding separate records in a card feed cycle in succession and to condition the machine to effect a computation under control of the same record in a plurality of computing cycles following each card feed cycle, each of said records having computation determining designations and amount designations, record sensing means for sening in one card feed cycle said amount designations of one record to control the computation to be effected in subsequent computing cycles and other means for sensing in the same card feed cycle the computation determining designations of the following record, computation control means for conditioning the machine to effect a computation under control of the record, setup means controlled by said other sensing means and set up within a card feed cycle when said computation designation is sensed, means controlled by the setup means when set up for maintaining it set up during the plurality of computing cycles the computation is being effected under control of the record previously sensed by the amount sensing means, and also within the card feed cycle following the plurality of computing cycles, and means controlled by the setup means when set up and including means operable within said subsequent card feed cycle for rendering said computation control means effective for conditioning the machine to effect a computation under control of said following record

7. In a record controlled machine with record feeding means for feeding separate records in succession through the machine to control computations and to also determine whether a multiplying or dividing computation is to be performed under control of the same record, each separate record bearing designations for representing amounts for controlling computations and also bearing designations for determining the type of computation to be performed, record sensing means for sensing said amount designations on one record for controlling computations and other means for sensing said computation determining designations on a following record, master computation control means when rendered effective for changing the condition of the machine in which one type of computation would be effected to another condition to cause a computation of the other type to be performed, setup means controlled by said other sensing means and set up when a particular designation is sensed, means controlled by the setup means when set up for maintaining it set up during the time the computation of one type is being performed under control of a record previously sensed by said amount sensing means, and means controlled by the setup means when set up for rendering said master computation control means effective for causing a computation of said other type to be performed under control of said following record.

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