April 2, 1940. J. M. CUNNINGHAM ET AL 2,195,850

MULTIPLYING MACHINE

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FIG.2.

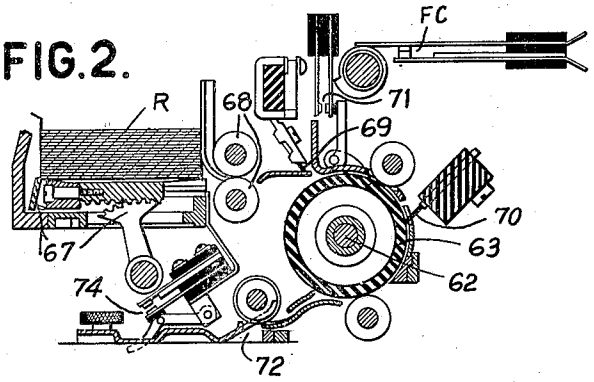
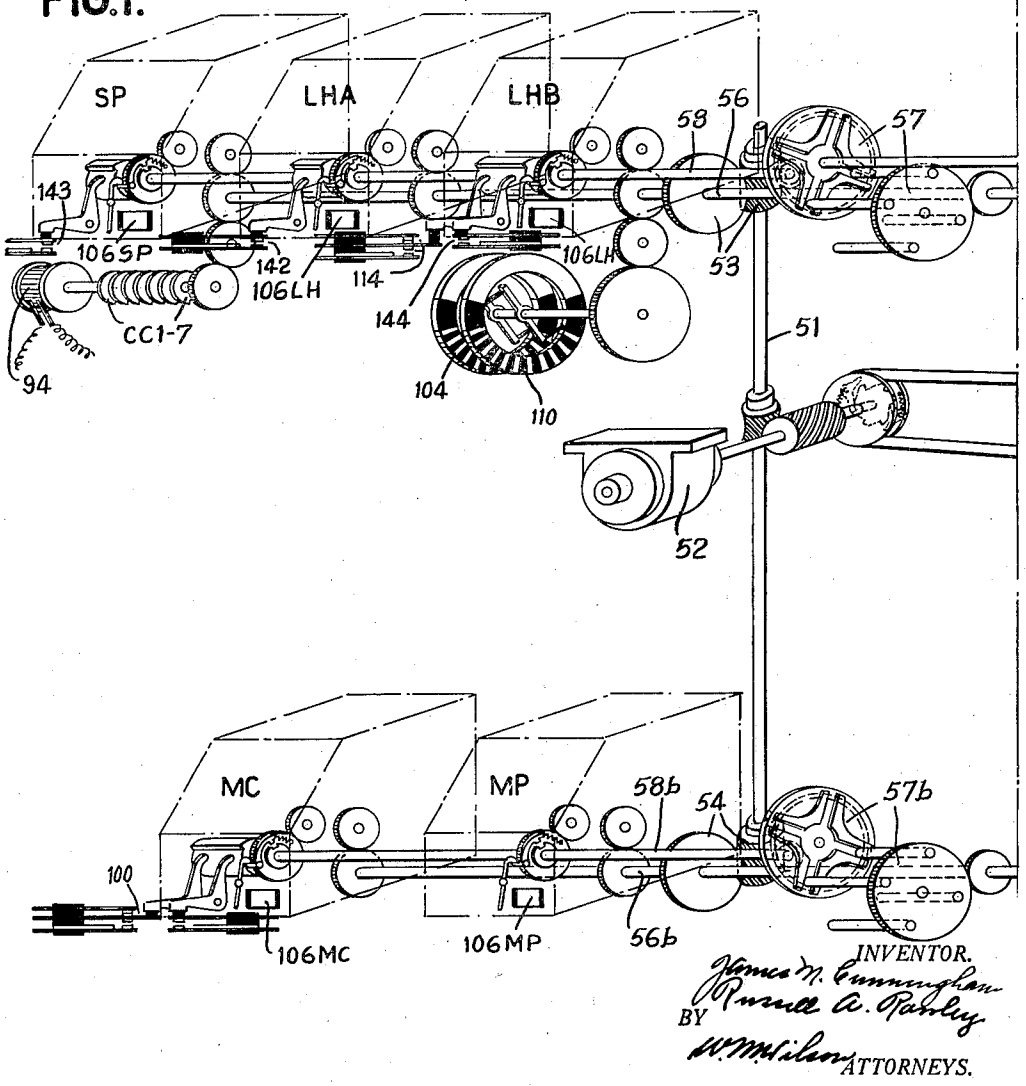


FIG.1.



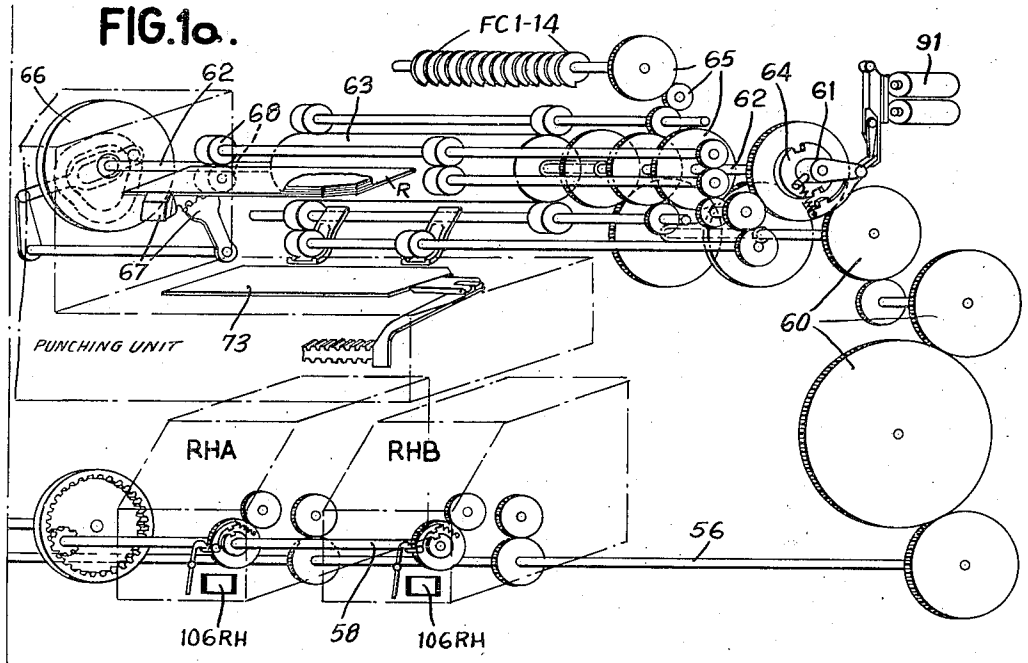
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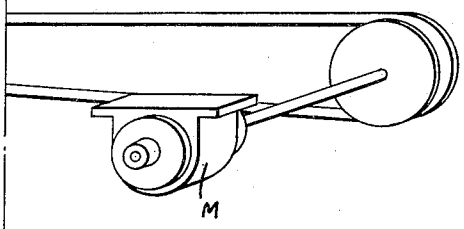
April 2, 1940. J. M. CUNNINGHAM ET AL 2,195,850

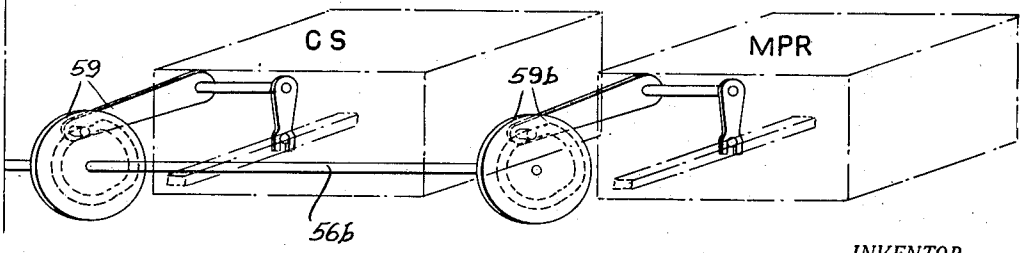
MULTIPLYING MACHINE

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FIG.1a.







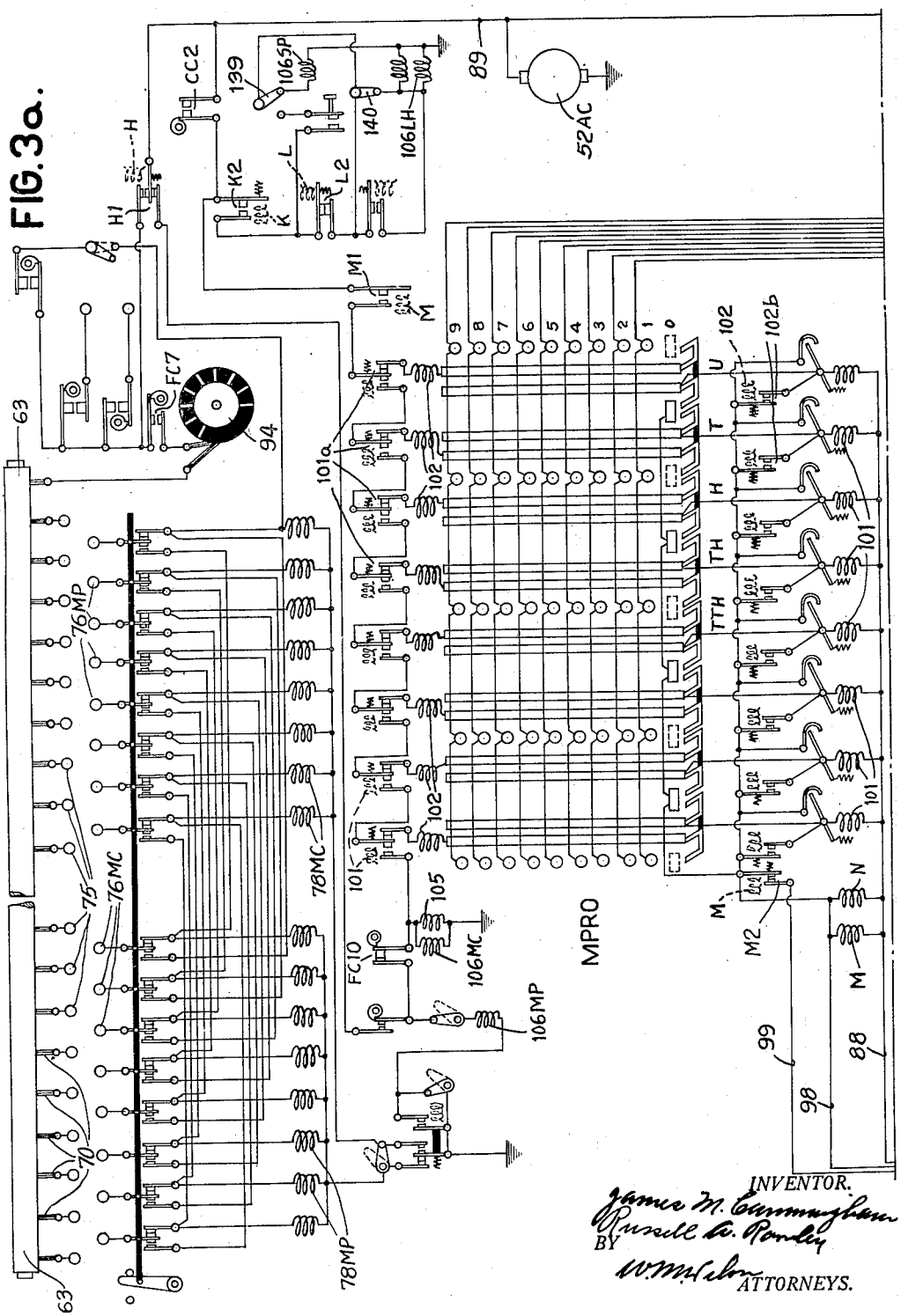
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MULTIPLYING MACHINE

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FIG. 3a.



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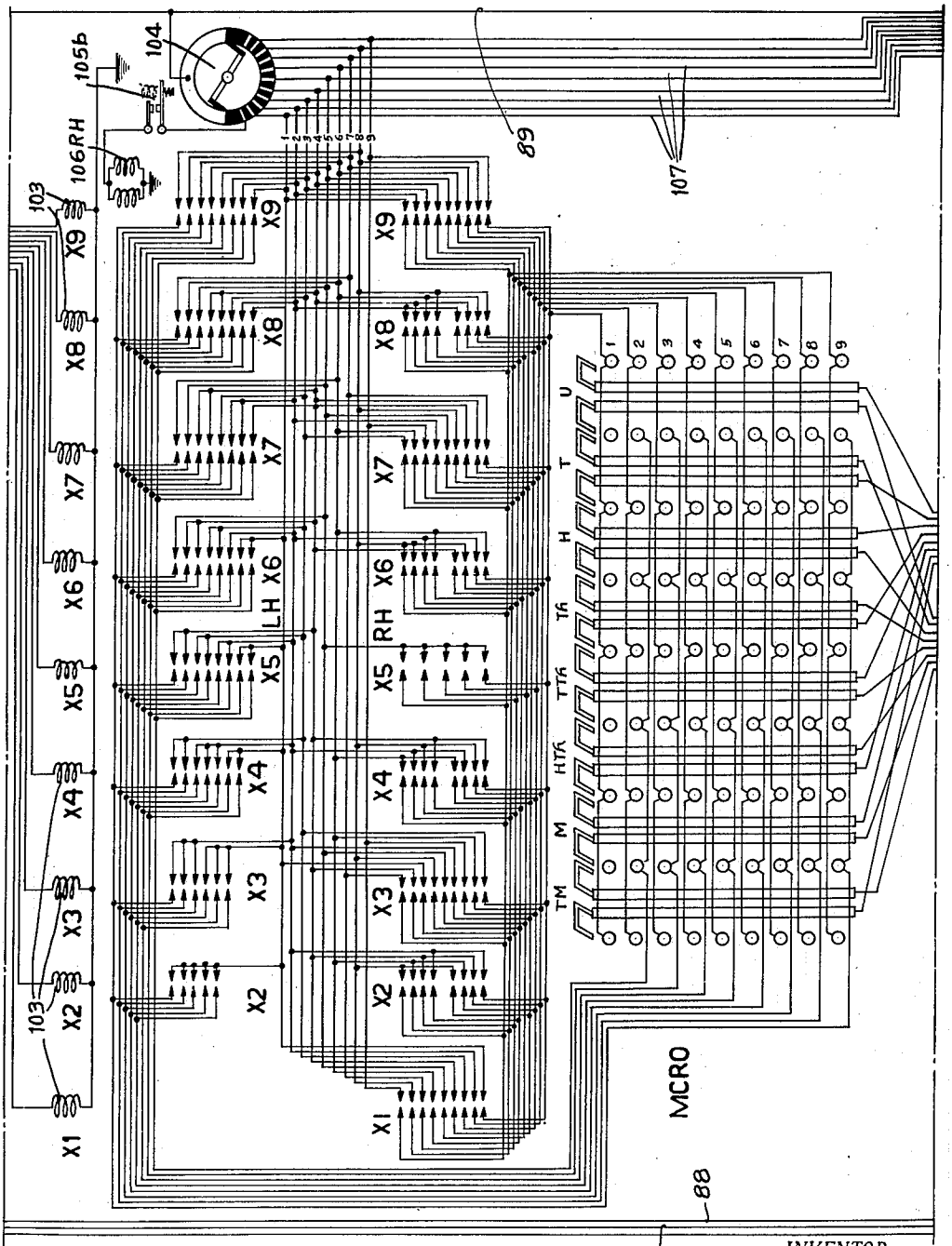


FIG. 3b.

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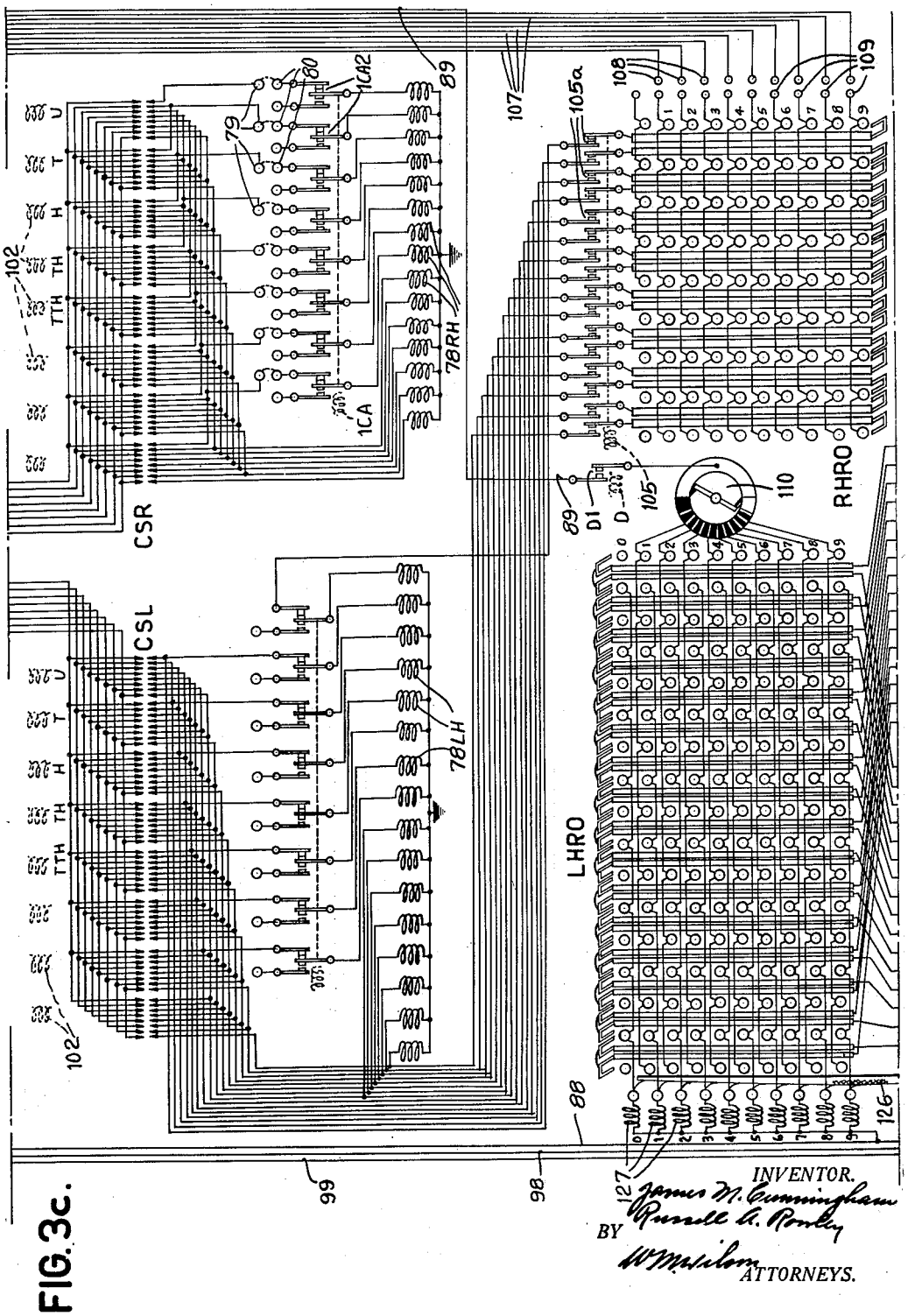


FIG. 3c.

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MULTIPLYING MACHINE

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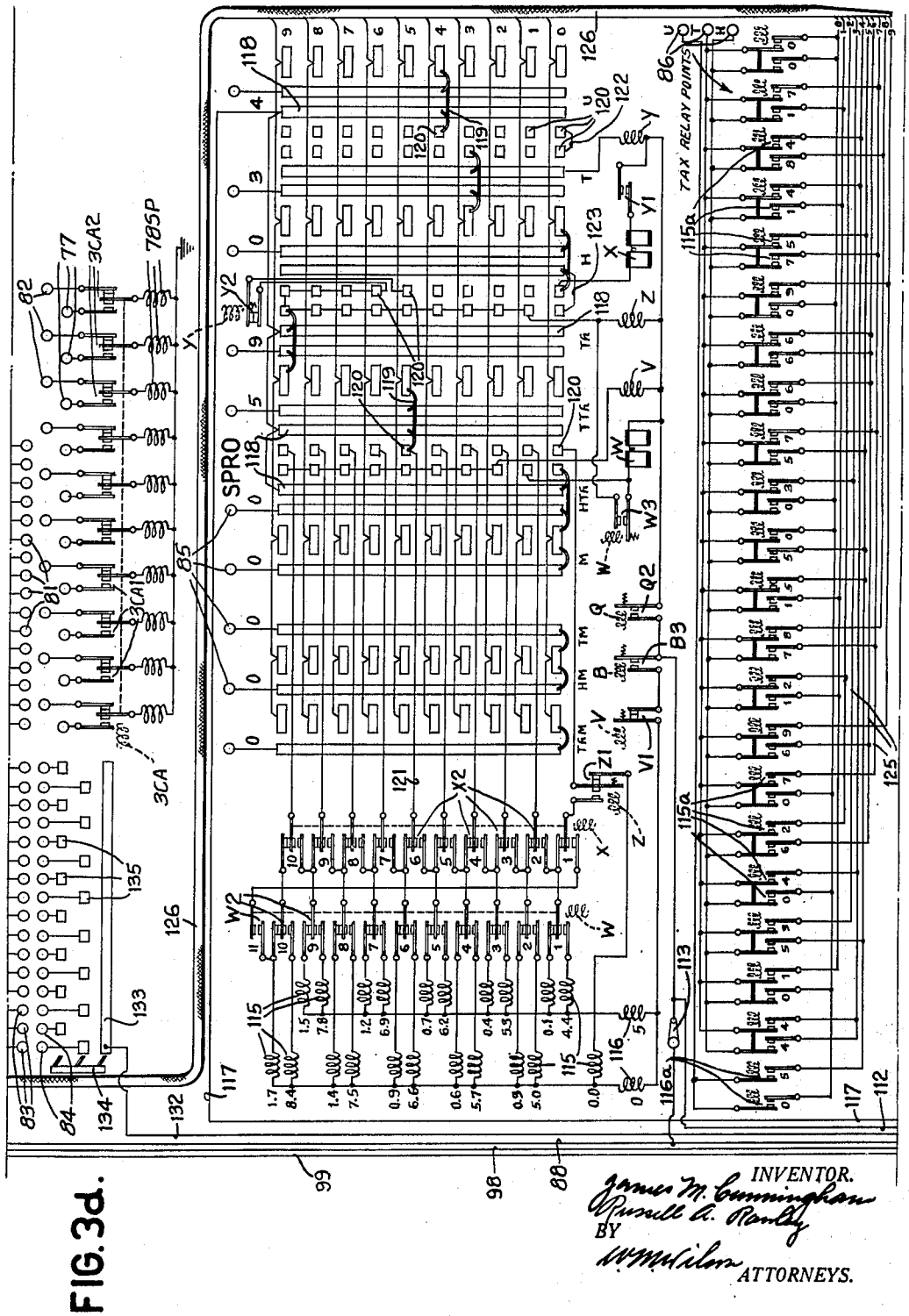


FIG. 3d.

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MULTIPLYING MACHINE

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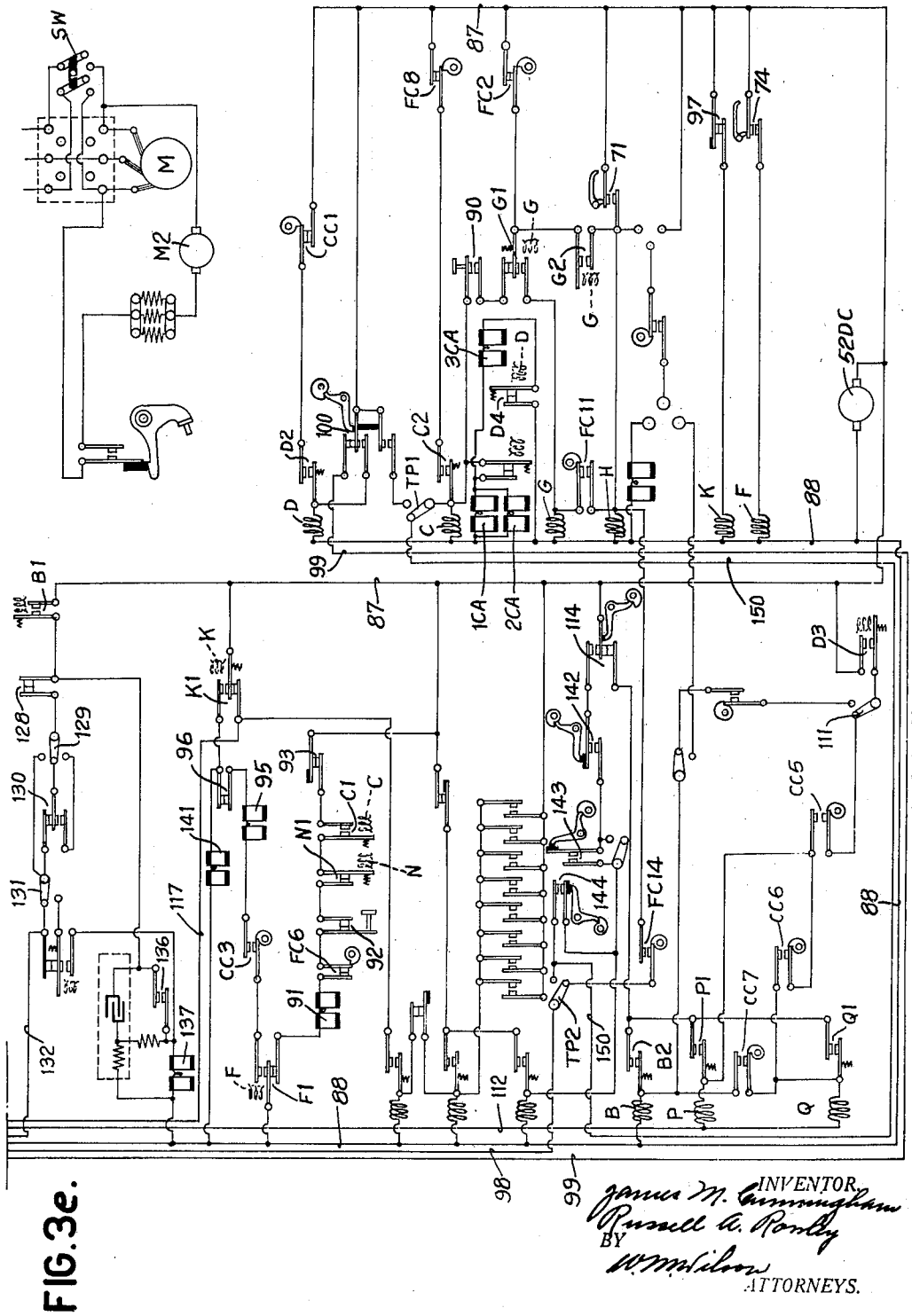


FIG. 3e.

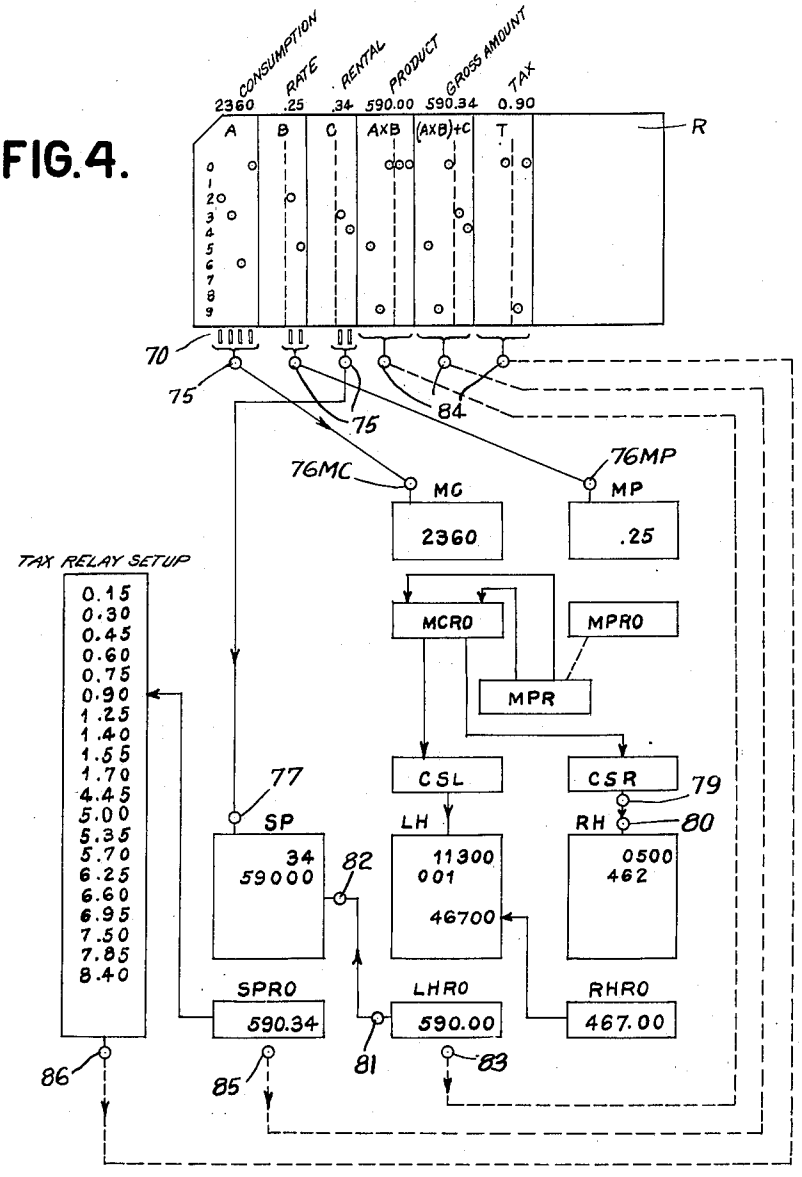
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MULTIPLYING MACHINE

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FIG. 4.



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April 2, 1940. J. M. CUNNINGHAM ET AL 2,195,850

MULTIPLYING MACHINE

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FIG.5.

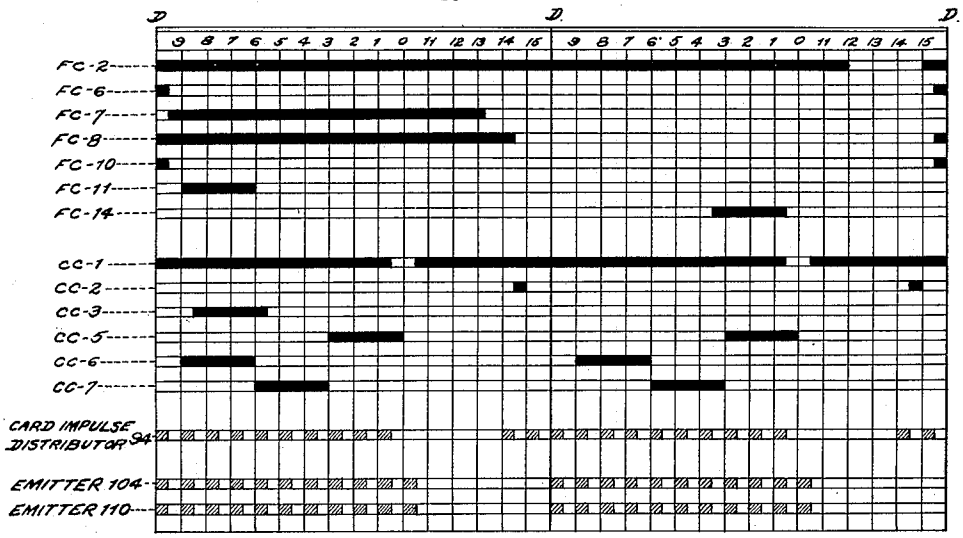
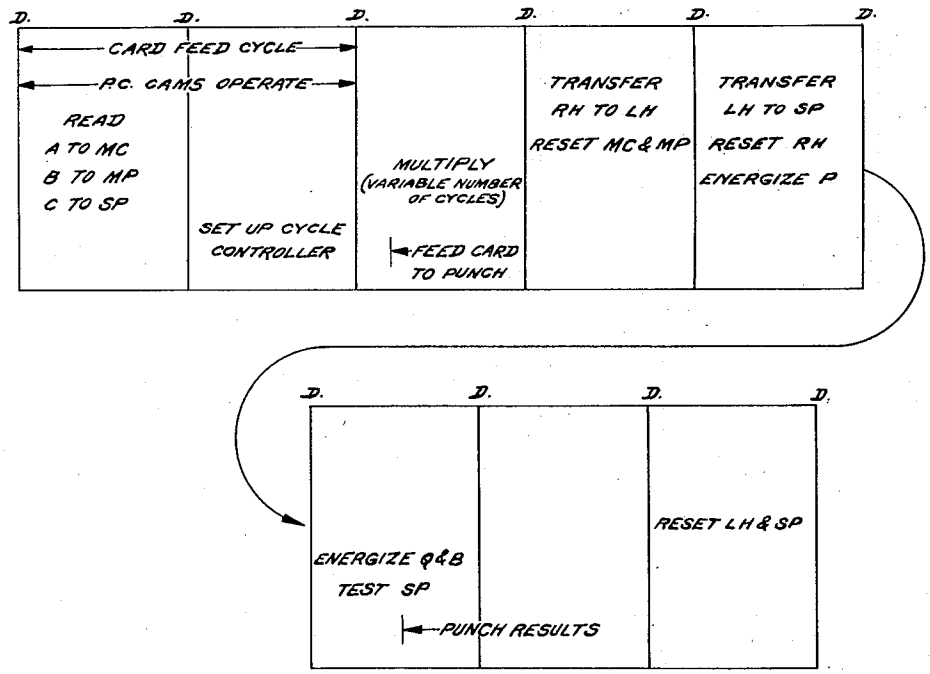


FIG.6.



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Patented Apr. 2, 1940

2,195,850

UNITED STATES PATENT OFFICE

2,195,850

MULTIPLYING MACHINE

James M. Cunningham and Russell A. Rowley, Endicott, N. Y., assignors to International Business Machines Corporation, New York, N. Y., a corporation of New York

Application December 21, 1934, Serial No. 758,593

5 Claims. (Cl. 235—61.7)

This invention relates to improvements in multiplying machines and more particularly multiplying machines of the record card controlled type.

The principal object of the invention is to provide a multiplying machine of improved selectivity of operation and of increased utility to the general end that the machine may perform the solution of a greater diversity of problems.

A further object of the present invention resides in the provision of an accounting machine in which multiplying operations may be carried out with means for augmenting the calculated products by another amount, then determining the relative magnitude of this intermediate result and selecting an amount from a plurality of amounts in accordance with the relative magnitude of such result and then recording the product, the intermediate result, and the selected amount.

A further object of the present invention resides in the provision of a calculating machine with improved means for automatically ascertaining by the operation of the machine itself the relative magnitude of the result computed by the machine and for then selecting an amount from a plurality of amounts in accordance with the relative magnitude of such previously computed amount and for recording such amount.

A further object of the present invention resides in the provision of a calculating machine adapted to effect calculations in the general form $(A \times B)+C=D$ and to select an amount from a plurality of amounts in accordance with the relative magnitude of D.

A further object of the present invention resides in the provision of a machine adapted to effect the foregoing calculations and to finally record A×B, D, and T where T is the selected amount.

A further object resides in the provision of mechanism for interrupting further operation of the machine when the magnitude of D is greater than the highest of the plurality of amounts from which selection is to be made.

A still further object resides in the provision of mechanism for suppressing selection of any of the plurality of amounts when the magnitude of D is less than a predetermined value.

Another object of the machine resides in the provision of mechanism for effecting cross-adding of amounts in two fields of a record card, then determining the relative magnitude of the sum so obtained and selecting an amount from a plurality of amounts in accordance with such determination.

Another object resides in the provision of mechanism for sensing an amount on a record card, determining its relative magnitude and selecting an amount from a plurality of amounts in accordance with such determination and recording the selected amount on the card containing the originally sensed amount.

Various other objects and advantages of the invention will be obvious from the following particular description of one form of mechanism embodying the invention or from an inspection of the accompanying drawings; and the invention also constitutes certain new and novel features of construction and combination of parts hereinafter set forth and claimed.

In the drawings:

Figs. 1 and 1*a*, taken together, show a diagrammatic view of the various units of the machine and also show the train of the driving mechanism of the machine.

Fig. 2 is a vertical sectional view taken through the card handling and reading section of the machine.

Figs. 3*a*, 3*b*, 3*c*, 3*d*, and 3*e*, taken together and arranged vertically in the order named, show the complete wiring diagram of the electric circuits of the machine.

Fig. 4 is a diagrammatic view showing the flow of entries in the machine and the manner in which a typical computation is handled.

Fig. 5 is a time chart of the essential cam contacts of the machine.

Fig. 6 is a diagram showing the sequence of operations involved in the solution of the problem.

Before describing the detailed operation of the machine, a general explanation will be made in connection with Fig. 4 to explain the general solution of problems which the machine is capable of handling. Record cards R are prepunched in fields A, B, and C, which, in the problem chosen and which relates to a public utility problem, the field A is perforated with an amount representing consumption of electricity expressed in kilowatt hours, field B contains an amount representing the rate to be charged, and the field C contains an amount representing a fixed rental charge for meters or the like. The amounts in fields A, B, and C are analyzed by the sensing devices of the machine and these amounts are entered into accumulators MC, MP, and SP. The machine then proceeds to multiply the amount 2360 in the MC accumulator by the amount .25 in the MP accumulator. In the proc-

ess of multiplication, the joint control of the read-out device MCRO of the MC accumulator, the read-out device MPRO of the MP accumulator, and the multiplying relays MPR determine the several partial products which are appropriately entered into the LH and RH accumulators through the column selecting devices CSL and CRS.

After all the partial products have been determined and entered into accumulators LH and RH, the total standing in the read-out mechanism RHRO of the RH accumulator, which in the present problem is 467.00, is transferred to the LH accumulator in the proper denominational allocation whereupon the complete product of 2360 and .25 will be contained in the read-out mechanism LHRO of the LH accumulator. This product is then transferred to the SP accumulator where it is added to the amount 34, previously entered, resulting in the amount 590.34 as indicated in the read-out section SPRO of the SP accumulator. This amount represents the gross amount of the customer's bill in addition to which he is required to pay a tax based upon the amount of this gross figure. The amount of tax is predetermined in accordance with the following table where, for amounts up to 5, there is no tax. For amounts from 5.01 to 100 there is a tax of .15, and so on.

Amounts of bill	Tax
Up to 5.00	.00
From 5.01 up to 100.00	0.15
100.01 up to 200.00	0.30
200.01 up to 300.00	0.45
300.01 up to 400.00	0.60
400.01 up to 500.00	0.75
500.01 up to 600.00	0.90
600.01 up to 700.00	1.25
700.01 up to 800.00	1.40
800.01 up to 900.00	1.55
900.01 up to 1,000.00	1.70
1,000.01 up to 1,100.00	4.45
1,100.01 up to 1,200.00	5.00
1,200.00 up to 1,300.00	5.35
1,300.01 up to 1,400.00	5.70
1,400.01 up to 1,500.00	6.25
1,500.01 up to 1,600.00	6.60
1,600.01 up to 1,700.00	6.95
1,700.00 up to 1,800.00	7.50
1,800.01 up to 1,900.00	7.85
1,900.01 up to 1,999.99	8.40

For each figure in the column headed "Tax" in the table above, there is provided a relay arrangement whose function is to control the recording of its related tax amount. After the gross amount has been determined, the magnitude of the amount standing in the read-out section SPRO is tested and the appropriate tax relay is selected for operation. In the present problem, the amount 590.34 lies between 500.01 and 600 for which, in accordance with the table, a tax amount of .90 is specified. After the determination of the amount of tax has been made the machine proceeds to record back in the record card R the product 590.00 which represents the consumption times the rate, the gross amount 590.34 and the tax amount .90.

Where there is no fixed charge entered in field C the tax amount will, of course, be determined in accordance with the product of the amounts in fields A and B and it will also be apparent that if there is no entry in field A the tax is determined solely in accordance with the rental amount in field C since there would be no product resulting from the initial multiplication of amounts in fields A and B.

In certain problems it may be desirable to determine a tax amount in accordance with the sum of two amounts such as may be entered in fields A and C. In such event the field B is perforated with a "1" which will cause the multiplication of the amount in field A by "1" which product will be added to the amount in field C and will in effect be a cross addition of the amounts in fields A and C.

The machine is thus capable of selecting a tax amount in accordance with a result which is the product of amounts entered in two fields of a record card; the summation of such two amounts or which is determined by a single amount in one field of the card.

Before describing the detailed operation of the machine, a general description will be given of the various units and their location in the machine. The machine embodies a card feeding and card handling section which is shown in the upper right hand corner of Fig. 1*a* and also shown in cross section in Fig. 2. This part of the machine is arranged to feed cards and derive readings therefrom and afterwards pass the cards into a punch section of the machine which is a punch of the successive column punching type. The accumulators and receiving devices of the machine are as follows:

In the upper part of the machine, there are shown a pair of accumulators LHA and LHB in Fig. 1 and a pair of accumulators RHA and RHB in Fig. 1*a*. Also shown in the upper part of the machine is a summary products accumulator designated SP. In the lower part of the machine there are two accumulators which are used as multiplier and multiplicand entry receiving devices which are designated as MP and MC on Fig. 1. The machine also includes a multiplying relay unit in the lower part of Fig. 1*a* generally designated MPR. In the lower part of the machine there is also provided a column shift relay unit generally designated CS.

Machine drive

The machine, which in its mechanical construction is substantially that shown in Patent No. 1,944,665, granted to D. J. Oldenboom, January 23, 1934, is adapted to be driven by a constantly running motor M (Fig. 1*a*). This motor, through a belt and pulley drive, drives an A. C.-D. C. generator **52**. The A. C. end of this generator is adapted to generate the impulses for actuating the various accumulator magnets and certain of the relay magnets in the machine and has a D. C. take-off section. In other words, it is provided with slip rings for taking off the A. C. impulses and commutators and brushes for taking off direct current.

The motor M, when in operation, is adapted to drive a vertical shaft **51** (**54** of Patent 1,944,665) which through gearing **53** drives a horizontal shaft **56** in the upper part of the machine and through gearing **54** drives a horizontal shaft **56***b* in the lower part of the machine. Shafts **56** and **56***b* are known as the accumulator drive shafts from which the accumulators are driven in the customary manner. The shafts **56** and **56***b* through Geneva gearing generally designated **57** and **57***b* drive horizontal reset shafts **58** and **58***b* (**63** of Patent 1,944,665), respectively. Each of the accumulators is provided with the usual reset clutch whereby the accumulators may be coupled to the reset shafts for zeroizing purposes. The manner in which the various clutches are called into operation will be more fully explained in connection with the circuit diagram.

In the lower part of Fig. 1*a* the accumulator

drive shaft 56b is provided with cam and follower devices generally designated 59 and 59b (65 of Patent 1,944,665) which operate certain shifting mechanism for the relays contained in units CS and MPR.

Card feeding and analyzing section

Referring to Fig. 1a, the shaft 56 at its extreme right hand end drives a train of gears 60 (68, 69, 70 of Patent 1,944,665) which, through a one-revolution clutch 61 (76, 78, of Patent 1,944,665), operates the shaft 62 (75 of Patent 1,944,665). With the clutch 61 engaged, the shaft 62 will operate in unison with the shaft 56 and with the clutch disengaged shaft 62 will remain stationary. Secured to shaft 62 is the card transfer and contact cylinder 63 (87 of Patent 1,944,665) (see Fig. 2). As shown, the driving element 64 of the one revolution clutch 61 is provided with two notches and through the compound gearing 60 is given one half revolution for each revolution of shaft 56. Accordingly, whenever the clutch is engaged, the contact cylinder 63 will make one complete revolution during two cycles of the accumulator drive shaft.

Drive to contact devices

Driven from shaft 62 through gearing 65 (90, 91, 92 of Patent 1,944,665) are a number of contact actuating cams which are designated with the prefix FC. The arrangement of these cams is such that they make one revolution per card feed cycle whenever the card feeding mechanism is in operation.

Card picker drive

Shaft 62 has secured to it at its left end (Fig. 1a) a box cam 66 (97 of Patent 1,944,665) which serves to operate the picker mechanism 67 (104 of Patent 1,944,665) (see also Fig. 2) which advances a single card from the bottom of the magazine and into the bite of feed rollers 68 (82 of Patent 1,944,665) which advance it to the contact cylinder 63. Intermediate the rolls 68 and cylinders 63 there is provided an advance card sensing station which comprises a brush 69 (106 of Patent 1,933,714). A curved guide is provided around the contact cylinder and the advancing card is carried around by the forward rotation of the cylinder and by the rotation of the feeding rollers so as to be passed under the main card sensing brushes generally designated 70 (109 of Patent 1,944,665) in Fig. 2. Also in cooperation with the card is a pivoted card lever which serves to close a pair of contacts 71 (112 of Patent 1,944,665). After the card has been sensed by the brushes 70 it is advanced and delivered into the tray of the punching section of the machine. The location of the tray is generally indicated at 72 in Fig. 2 and the position of the card in this tray is indicated at 73 (R of Patent 1,944,665) in Fig. 1a. A pair of card lever contacts 74 (120 of Patent 1,944,665) (Fig. 2) is also provided and arranged to close when a card is lodged in the tray of the punching section.

The foregoing description has briefly outlined the manner in which a card is withdrawn from the supply magazine and the manner in which the card is carried past the advance sensing brush 69, the sensing brushes 70 and the manner in which the card is delivered into the punching section of the machine. With the traverse of the card past the sensing brushes 70, the amount of the multiplier, multiplicand and other amounts will be read from the card, and entered into appropriate accumulators or other entry receiving devices. Thus, in accordance with the problem outlined in Fig. 4 the amount representing consumption is entered into the MC accumulator, the rate is entered into the MP accumulator and the rental charge is entered into the SP accumulator.

The MP and MC receiving devices, the LH, RH, and SP accumulators are of the uusal type as customarily used in tabulating machines and are provided with electromechanically actuated clutches. All of these accumulators are provided with commutator type read-out devices.

The mechanism thus far described is substantially similar to that shown and described in greater detail in the patent to Oldenboom referred to above and in the patent to J. M. Cunningham, No. 1,933,714, granted November 7, 1933. In this patent the detailed manner of operation of the punching section of the machine is also set forth in detail and since the operation of the punching mechanism is similar to that described in said patent the description thereof will not be given herein.

Plug connections

Before proceeding with the description of the circuit diagram, the various preliminary plug connections for properly directing the various entries will be explained. In Fig. 3a are shown the usual plug sockets 75 (211 of Patent 1,944,665) of the card analyzing brushes 70. These sockets are connected to sockets 76MC (212 of Patent 1,944,665) of the MC accumulator to connect the field A of the card R of Fig. 4 for entry into the MC accumulator. In Fig. 4, the line extending between sockets 75 and 76MC indicates graphically that the field A and the MC accumulator are plug connected. Similar conections are made between the sensing brush sockets 75 which sense field B of the card and sockets 76MP related to the MP accumulator. Still further connections are made from sockets 75 related to the C field to sockets 77 (Fig. 3d) which are connected through normally open relay contacts 3CA1 to the adding magnets 78SP of the SP accumulator. Further plug connections are made from plug sockets 79 (Fig. 3c) of the column shift relay mechanism CSR to plug sockets 80 connected to normally closed relay contacts 1CA2 associated with the adding magnets 78RH of the RH accumulator. Plug connections are made from the read-out sockets 81 (Fig. 3d) of accumulator read-out LHRO to sockets 82 which are connected to the normally closed contacts 3CA2 associated with the adding magnets 78SP.

The foregoing are the connections required for entering and transferring operations. For the control of the punching operations, plug connections are made from the read-out sockets 83 of the LHRO section of the LH accumulator to sockets 84 in the punching section of the machine, the selected sockets 84 being those related to the card columns in which the product A×B is to be punched.

Further connections are made between the plug sockets 85 of the read-out section SPRO of the SP accumulator to appropriate sockets 84 and still further connections are made from sockets 86 of the tax relay unit to the sockets 84 in card column positions which are to receive the tax amount T.

The machine is provided with a plurality of switches which, for the solution of the problem

of Fig. 4, are set in tne positions shown on the circuit diagrams.

Operation of the machine

The complete operation of the machine will now be explained with particular reference to the circuit diagram in connection with which the sequence of operations will be set forth and the various functions of the machine described with particular reference to the solution of the problem outlined in Fig. 4.

After the aforedescribed plug connections have been made, the main line switch SW (200 of Patent 1,944,665) (Fig. 3e) is closed which places the motor M in operation. The motor M drives the A. C.-D. C. generator so labelled (Figs. 3a and 3e) to supply direct current to D. C. lines 87 and 88. Alternating current is likewise supplied to ground and to a line 89 (Fig. 3a). The start key contacts 90 (196 of Patent 1,944,665) (Fig. 3e) are now closed by depression of the start key button which completes a circuit from the D. C. line 88, through a relay coil C, contacts 90 now closed, upper contacts G1, cam contacts FC2, to line 87. The coil C establishes a holding circuit through its contacts C2 and cam contacts FC8.

In parallel with relay coil C are relay magnets 1CA, 2CA, and 3CA, which will be energized and the circuits therethrough held together with relay coil C. Relay magnet 3CA shifts its contacts 3CA1 (Fig. 3d) to closed position thereby connecting sockets 77 to the adding magnets 78SP.

The coil C, when energized, also closes a pair of contacts C1 which will complete a circuit from line 88, normally closed relay contacts F1, card feed clutch magnet 91 (222 of Patent 1,944,665), cam contacts FC6, stop key contacts 92 (197 of Patent 1,944,665), relay contacts N1, contacts C1, punch feed-rack contacts 93 (P—1 of Patent 1,944,665), to line 87. Energization of clutch magnet 91 will cause withdrawal of a card from the magazine and will advance it to the analyzing brushes 70. During this movement of the card, the card lever is engaged to close card lever contacts 71 which complete a circuit from line 87, through card lever contacts 71, relay magnet H, to line 88. In starting up the machine, it is necessary to hold down the start key to maintain contacts 90 closed during the first complete card feeding cycle or, alternatively, to depress the start key a second time. At the beginning of the second card feed cycle, the closure of cam contacts FC11 will energize relay magnet G through a circuit including the card lever contacts 71. Relay magnet G will close its normally open contacts G1, setting up a holding circuit through cam contacts FC2 and will also close relay contacts G2 to provide a further holding circuit through the card lever contacts 71. These two holding circuits alternate in maintaining relay magnet G energized as long as cards continue to feed from the magazine. The relay magnet H is also provided with a holding circuit which extends through card lever contacts 71 or serially through relay contacts G2 and cam contacts FC2.

The relay contacts H1 (Fig. 3a) are shifted to the reverse of the position shown in this figure, thereby supplying current to the impulse distributor 94 (188 of Patent 1,944,665). The circuit extends from the A. C. side of generator 52, through line 89, to the now closed contacts H1, cam contacts FC7, distributor 94, contact roll 63, from which circuits will be completed through the analyzing brushes 70 to effect entries in the accumulators MC, MP, and SP. These circuits extend from the brush sockets 75 to plug sockets 76MC, 76MP (Fig. 3a) and 77 (Fig. 3d) to effect energization of the adding magnets of the related accumulators which magnets are denoted at 78MC, 78MP and 78SP. After the first card has traversed the brushes 70 it continues into the tray of the punching machine and, upon its arrival there, it causes closure of punch card lever contacts 74 (Fig. 3e) which cause energization of relay magnet F. With relay coil F energized relay contacts F1 will be shifted from the position shown, thus interrupting the circuit to the card feed clutch magnet 91 to suspend card feeding. The closure of the normally open contacts F1 establishes a circuit from line 88, now closed contacts F1, cam contacts CC3, magnet 95 (143 of Patent 1,944,665) of the punching mechanism, to call the clutch mechanism of the punching unit into operation, the circuit continuing through eject contacts 96 (P—3 of Patent 1,944,665) and relay contacts K1, which at this time are in position reverse to that shown. The contacts K1 are controlled by relay magnet K which is energized through contacts 97 (P—5 of Patent 1,944,665) in the punching machine.

These are the so-called last card column contacts closed whenever the card advancing carriage of the punching machine is in last card column punching position, which position it occupies when the operation of the entire machine is first started so that upon starting, relay K is energized and its contacts K1 are in shifted position. The cards are handled in the card punching mechanism in the customary manner as set forth in the above mentioned Oldenboom and Cunningham patents. As the analyzed card is being advanced to the punching mechanism, a circuit is completed upon closure of cam contacts FC14 which extends from line 87, card lever contacts 71, cam contacts FC14, switch TP2, wire 98 (Figs. 3e to 3a), through relay magnets M and N in parallel to line 88. Relay magnet M closes its contacts M2 to provide a holding circuit for the relays extending from line 88, relays M and N, contacts M2, wire 99 (Figs. 3a—3e) to the normally closed contacts 100 (195 of Patent 1,944,665) and thence to line 87. Contacts 100 are open during the operation wherein the MC accumulator is reset and until such time, relay magnets M and N will remain energized. These are the master relay magnets of the cycle controlling unit and they call the cycle controller into operation to determine the location of the significant figures in the multiplier. The circuit through wire 98 also extends to the zero segments of the MPRO read-out. If any of the brushes of the MPRO read-out stand at zero, selected ones of the magnets 101 (Yu, Yt, etc., of Patent 1,944,665) will be energized according to which multi-denominational orders of the multiplier contain zeros.

The magnets 101 (Yu—2, Yt—2, etc., of Patent 1,944,665) control contacts 101a through which circuits are completed to the column shift relay magnets 102 (CSu, CSt, etc., of Patent 1,944,665) and to the multiplying relay magnets 103 (X1, X2, etc., of Patent 1,944,665) (Fig. 3b). In those positions in which the multiplier digit is zero, the associated magnet 101 will be energized and the related contacts 101a will be shifted from the position shown in the diagram so that the related magnet 102 will be disconnected from the circuit which is traceable from line 89, cam contacts CC2, relay contacts M1, normally closed contacts 101a, relay magnet 102, through the appropriate

read-out spot in one order of the read-out section MPRO to the corresponding relay magnet 103 and thence to ground.

In the example of Fig. 4, with the multiplier digit "5," this circuit would be completed through the "5" commutator segment in the units order. The function of the contacts 101a is to direct the multiplying relay selecting circuit through only those positions in which significant figures occur in the multiplier and to skip the positions in which zeros occur. With magnet 103 energized (for example, the X5 magnet 103) the related contacts shown on Fig. 3b will become closed and with the emitter 104 (185 of Patent 1,944,665) in operation, impulses will be emitted through the contacts of the times 5 multiplier through the MCRO read-out and thence through the column shift relay contacts CSL and CSR shown in the upper part of Fig. 3c and partial product entries will be directed into the LH and RH accumulators accordingly. The CSL and CSR relay contacts are controlled by the relay magnets 102 and serve to effect the proper denominational allocation of the partial products entries. Thus, when multiplying is being effected by the units digit of the multiplier, the units magnet 102 is energized and the units order set of contacts CSL and CSR are closed.

Energization of a relay magnet 102 will also close a pair of contacts 102b (Fig. 3a) which will cause energization of the relay magnet 101 in the order in which multiplying is taking place. This in turn will shift the related pair of contacts 101a so that when cam contacts CC2 again close, the aforetraced circuit will be directed through the magnet 102 in the order containing the next higher significant figure and will skip the magnets 102 in positions in which zeros are present.

The machine continues multiplying operations during which the partial products are entered in succession into the LH and RH accumulators. After a multiplying cycle has been effected for each significant multiplier digit, all of the magnets 101 will have been energized and all of the contacts 101a will be in their shifted positions so that on the next following cycle the closure of cam contacts CC2 will complete the circuit which extends through all of the now closed contacts 101a to the relay magnet 105 (1—CR of Patent 1,944,665) and reset magnet 106MC (223MC of Patent 1,944,665). A parallel circuit also extends through cam contacts FC10 and reset magnet 106MP (223MP of Patent 1,944,665). The latter magnets (see also Fig. 1) connect the MC and MP accumulators for resetting operations which will take place during the next cycle to zeroize these accumulators. Relay magnet 105 closes its contacts 105a (Fig. 3c) to connect the read-out section RHRO to the entering magnets 78LH of the LH accumulator to permit the transfer of the sum of the right hand partial products into the LH accumulator to produce the complete product. The circuits involved in this transferring operation extend from the emitter 104 (Fig. 3b) through the group of wires 107 which terminate in plug sockets 108 which may be connected to corresponding sockets 109 associated with the read-out section RHRO.

In accordance with the manner in which the sockets 108 and 109 are connected, the amount standing in section RHRO may be transferred in the form in which it stands therein or in the form of the nine complement. For the purpose of the problem of Fig. 4, the connection is made for reading out the true number and the circuits will continue from the RHRO section through contacts 105a to adding magnets 78LH. During this cycle in which the MC accumulator is reset concurrently with the RH to LH transfer operation, the normally closed contacts 100 (Fig. 3e) which are operated by a cam on the MC reset shaft, will open to interrupt the circuit to the cycle controlling relay magnets 101, thus causing deenergization of all these magnets and the interruption of their related circuits.

The operation of the machine as thus far described is substantially the manner in which multiplying operations are performed in the patents referred to. At this point in the operation of the machine the LH accumulator will contain the amount 590.00, as indicated in Fig. 4; the RH accumulator will contain the amount 467.00; the SP accumulator will contain the amount 34; and the MC and MP accumulators will have no significant entries therein. The next step in the performance of the computation is to transfer the amount in the LHRO section to the SP accumulator. This is brought about in the following manner: When the contacts 100 are shifted from the position shown in Fig. 3e the circuit is completed from line 87 to the now closed contacts 100 and relay magnet D. Magnet D closes its contacts D2 setting up a holding circuit through cam contacts CC1.

The relay magnet D also closes a pair of relay contacts D1 (Fig. 3c) which serves to connect the emitter 110 (187 of Patent 1,944,665) to line 89 so that during the next cycle, impulses are emitted from emitter 110 to the LHRO read-out section and circuits completed therethrough to the plug sockets 81 (Fig. 3d) from whence, through suitable plug connections to sockets 82, the amount standing in the LHRO section will be entered in magnets 78SP. During this transfer operation the contacts 3CA2 are closed due to the deenergization of relay magnet 3CA, which is brought about by the opening of relay contacts D4 (Fig. 3e) in series with the relay magnet 3CA. The transfer relay magnet 105 closes an additional pair of contacts 105b (1—CR—17 of Patent 1,944,665) (Fig. 3b) which permits the completion of a circuit near the end of the cycle extending from emitter 104, through relay contacts 105b and reset magnets 106RH (223RH of Patent 1,944,665) to effect resetting of the RH accumulators. Also near the end of the cycle, a circuit is completed from line 87, through relay contacts D3 (Fig. 3e), switch 111, cam contacts CC5, relay magnet P, wire 112, switch 113 (Fig. 3d) to line 88. Magnet P closes its contacts P1 to provide a holding circuit from line 88, switch 113, wire 112, magnet P, contacts P1, normally closed contacts 114, operated by the LH reset mechanism, to line 87. Later in the next cycle, closure of cam contacts CC6 will close to permit energization of relay magnet Q through the circuit traceable from line 87, normally closed contacts 114, contact P1, contacts CC6, magnet Q, wire 112, switch 113, to line 88. Magnet Q closes its contacts Q1 to provide a holding circuit which parallels that of relay magnet P. The magnet Q controls the testing circuits which determine the magnitude of the amount standing on the read-out section SPRO and the detail manner in which this is effected will be described presently.

Determining the magnitude of $A \times B + C$

In Fig. 3d is shown the read-out mechanism SPRO of the SP accumulator. The commutator

brushes are positioned to represent the number 590.34 with the units order standing on the "4" segment, the tens on the "3," the hundreds on the "0" and so on, the higher order positions to the left of the first significant figure standing at "0." The various commutator segments are interconnected, as illustrated, and the operation is such that a circuit will be completed through one of the tax relay magnets 115 and one of the relay magnets 116 appropriate to the number standing on the read-out mechanism. For the number 590.34 it has been shown in connection with Fig. 4 that the 0.9 relay 115 is to be selected. This is effected through a circuit which is traceable from line 87, normally closed contacts K1 (Fig. 3e) through a wire 117 (Fig. 3d), read-out strip 118 in the fifth order from the right, read-out brush 119 now standing in the "5" position, segment 120, wire 121, normally closed contacts X2, normally closed contacts W2 in the "6" position, relay magnet 115 labelled "0.9", "0" relay magnet 116, normally closed relay contacts V1, relay contacts B3, switch 113, to line 88. Contacts B3 are closed by a relay magnet B (Fig. 3e) which is energized upon closure of cam contacts CC7 which complete a circuit from line 88, relay magnet B, contacts CC7, contacts Q1 and 114 to line 87. Magnet B closes its contact B2 to provide a holding circuit whose period of energization is co-extensive with that of relay magnets P and Q.

An examination of the table above in accordance with which the tax relay magnets 115 are selected will disclose that the right hand figure of each tax amount terminates in either 0 or 5. On the circuit diagram (Fig. 3d) those relay magnets 115 which select tax amounts with a right hand figure of 0 are each wired in series with the zero relay magnet 116 and the others are wired with the "5" relay magnet 116 so that whenever one of the former group is energized, the zero relay magnet 116 will also be energized and the "5" relay magnet will be energized whenever the latter group is energized.

The operation of the device may best be explained by tracing the various circuits involved in the selection of certain of the tax relays. Let it be assumed that the amount standing on the device is 5.00, which, according to the table, is the highest non-taxable figure. The units and tens order brushes 119 will stand at zero and the circuit will be completed from line 87, closed contacts K1, wire 117, units strip 118, brush 119, to units segment 120 in the zero position, wire 122, to the brush 119 of the tens order, relay magnet Y, contacts Q2, switch 113, to line 88. Magnet Y will open its contacts Y2 which are connected between the "5" and "6" segments 120 in the hundreds order. Since the hundreds order brush is standing at "5" there will be no circuit traceable through this brush. Since the thousands and higher orders are standing at zero, a circuit will be traceable from wire 117, through strip 118 in the tens of thousands order, brush 119, zero segment 120, normally closed contacts Z1, 0.0 relay magnet 115, zero relay magnet 116, to line 88. In this manner, the relay magnets 115 and 116 are selected to subsequently record 0.00 on the record card.

With the amount 5.01 standing on the accumulator, the tax relays representing 0.15 are to be selected. This is brought about as follows: Relay magnet Y is not energized for this condition since the units and tens brushes are not both standing at zero which is a requisite for the energization of magnet Y. Consequently, contacts Y2 are closed and a circuit is traceable from wire 117, thousands order strip 118, brush 119 in the zero position of this order, wire 123, to strip 118 in the hundreds order, brush 119 in the "5" position, contacts Y2, the "6" to "9" segments 120 in the hundreds order and serially through the "9" to "1" segments in the thousands order, relay magnet Z, Q2, switch 113, to line 88. Energization of relay magnet Z will shift its contacts Z1 from the position shown in the circuit so that the 0.0 relay magnet 115 is disconnected from the circuit. Since the brush in the tens of thousands order is standing at zero, a circuit will be completed as before to the Z1 contacts, this then passing through the now closed side, through normally closed contacts X2, W2, 0.1 relay 115, the "5" relay 116, V1, B3, switch 113 to line 88. In this manner, the relays controlling selection of the tax amount 0.15 are selected.

As the taxable amount increases in size, the 0.1 relay will be selected for amounts up to 100. Let us now assume that the amount standing in the unit is 100.01. For this condition, the relay magnet Y is not energized and since the tens of thousands order brush 119 is standing at "1" the circuit is traceable from wire 117, brush 119 in the "1" position of the tens of thousands order, contacts X2, W2 to the 0.3 magnet 115 and zero magnet 116.

Had the number been 100.00, the relay magnet Y would have been energized closing its contacts Y1 so that a further circuit traceable from wire 117, thousands order strip 118, brush 119 in the zero position, wire 123, to hundreds order brush 119 also in the zero position, relay magnet X, contacts Y1, Q2, switch 113, to line 88 would also have been completed. The X magnet by shifting its contact X2 from the position shown would have directed the circuit just traced from the brush 119 in the "1" position of the tens of thousands order to the now closed contacts X2 in the "2" position through the normally closed contacts W2 in the "1" position and thence through the 0.1 relay magnet 115 and "5" relay 116. Inspection of the wiring connections will show that the brush 119 in the tens of thousands position selects the relay magnet 115 directly through the normally closed contacts X2, W2, if any of the four lowest orders contains a significant figure. If the four lowest orders are at zero, however, the consequent energization of the "X" relay will cause the aforementioned brush to select the tax relay of next lower value.

This system of selection holds true until the amount becomes 1000.00 or more. With the brush 119 in the hundreds of thousands order standing at "1" a circuit is completed from wire 117 to strip 118 in the same order, "1" segment 120, relay magnet W, Q2, switch 113, to line 88.

If all the lower order positions stand at zero, a circuit will also be traceable from wire 117, strip 118 in the tens of thousands position, brush 119 in the zero position, now closed, left hand, contacts Z1, now closed X2 contacts in the "1" position, contacts W2 in the 1 position now closed, 1.7 relay magnet 115 and zero relay magnet 116. For the completion of this circuit the relay magnets W, X and Z are energized. The W relay is energized through the circuit previously traced, the "X" relay magnet is energized due to the presence of zeros in all lower orders as pointed out above, and the "Z" relay magnet is energized through contacts W3 which are closed by magnet W,

thereby placing the magnet Z in parallel with the magnet W.

When the amount becomes 1000.01 the magnet X fails to energize and the circuit then follows from the brush 119 in the tens of thousands order, through the now closed contact Z1, the upper closed contacts X2 in the "1" position, the lower, now closed, contacts W2 in the "1" position, through the 4.4 relay 115 and the "5" relay 116. The selection of the successively higher value tax relays will be selected in a similar manner for values up to 1999.99. For this amount, relay W is energized as before and the circuit is controlled by the brush 119 in the tens of thousands order standing at 9 to select the 8.4 relay 115 and the zero relay 116.

When the amount in the hundreds of thousands position is "2" or greater relay magnet V is energized through a circuit from line 117, strip 118 in the hundreds of thousands order, brush 119 in any position from "2" to "9," relay magnet V, contacts Q2, switch 113, to line 88. Relay magnet V opens its contacts V1 so that the circuits to relay magnets 115 and 116 cannot be completed. The action of the various relays may be briefly summarized as follows:

Relay magnet V is energized whenever the amount is greater than 2000.00. W is energized whenever there is a "1" in the sixth denominational order position. X is energized when there are zeros in the first four positions. Y is energized when there are zeros in the first two positions. Z is energized whenever there is a taxable amount under 100.00 and when W is energized.

The timing of the parts is such that the cam contacts CC6 (Fig. 3e) close to energize relay magnet Q before contacts CC7 close to energize magnet B so that the magnets V to Z are adjusted before contacts B3 close to complete the circuit to the selected relay magnets 115 and 116. If the amount is excessive, contacts V1 will be open at the time contacts B3 close and no relay selection will be made.

Each of the tax relays 115 is provided with two pairs of contacts 115a labelled appropriately. The relay magnets 116 also control pairs of contacts 116a. One side of each pair of contacts is connected to one of sockets 86 in accordance with the denominational order in which they are to control punching.

The other side of each pair of contacts is connected to one of a group of wires 125 numbered "0" to "9," which are connected through cable 126 to the punch selecting magnets 127 of the punching machine. Thus all the contacts 115a labelled "0" are connected to the zero magnet 127; all the ones to the "1" magnet; all the twos to the "2" magnet, and so on.

The detail operation of the punching mechanism is set forth in the patent referred to and the same will be but briefly described herein to explain the circuits involved in the operation. Energization of the relay magnet B effects closure of associated contacts B1 (Fig. 3e) which completes a circuit from line 87 through contacts B1, normally closed cam contacts 128 (154 of Patent 1,944,665), switch 129, normally closed contacts 130 (209 of Patent 1,944,665), switch 131, wire 132 (Fig. 3d) to the common strip 133 (613 of Patent 1,933,714) of the column selectors in the punching unit. As the punched card carriage advances, the brush 134 (614 of Patent 1,933,714) connects the strip 133 to segments 135 (612 of Patent 1,933,714) in succession as corresponding columns of the record card are in punching position. From the segments 135 which are connected to the plug socket 8A connections are made to the read-out sockets 83 and 85 of the LHRO and SPRO read-out devices and similar connections are made to the tax relay sockets 86 in the orders in which it is desired to have the information punched on the card.

For the example shown in Fig. 4, plug connections are made so that the punching is controlled from the several devices in the order indicated. It will be understood, however, that this order may be re-arranged simply by changing the plug connections.

For example, the tax amount "T" may be placed in the first punching field and the A×B amount may be placed in the second field and the A×B+C amount in the last field. When the tax field is in punch receiving position, the circuit just traced continues from socket 8A through plug connection to one of the sockets 86 and if it be assumed that the hundreds order position is under the punches, the circuit will continue through the left hand pair of contacts 115a associated with the selected relay through one of the wires 125, cable 126, to the correspondingly numbered punch selecting magnet 127 (792 of Patent 1,933,714), thence to line 88. Energization of any magnet 127 will cause closure of a pair of contacts 136 (805 of Patent 1,933,714) (Fig. 3e) to complete a circuit to the punch magnet 137 (237 of Patent 1,944,665) which effects a perforation in the appropriate index point position of the card column and also effects an operation of the escapement mechanism to advance the card to the next column to receive punching. When the column to receive the units order of the tax amount is at the punches, the circuit to units plug socket 86 will extend to the pair of contacts 116a and will continue through either the zero or the "5" punch selecting magnet 127 according to which of the relay magnets 116 is energized. Where none of the relays 115 and 116 are energized, as under the condition of excessive magnitude explained above, there will be no punch selecting circuits completed when the tax receiving columns are at the punching position and as a consequence, further punching and advancing of the record card are interrupted. This is a signal to the operator that the aforementioned condition exists and since the indicating wheels of the SP accumulator are visible, he will inspect the amount and determine from tables the appropriate tax amount and enter the same manually by depression of the usual punch operating keys.

It will thus be obvious that the point at which the operation of the machine is interrupted depends upon the order in which the tax amount is punched. If punching takes place in the order designated (Fig. 4) the punching mechanism will fail to function after the product and gross amount fields have been perforated. If the tax amount were arranged to punch in the first punching field, interruption of the operations would take place at such point.

After all the selected columns have been perforated in accordance with the controlling data, the card carriage escapes to the so-called last column position in which the contacts 97 are closed, energizing relay magnet K. This relay closes its contacts K2 (Fig. 3a) so that a circuit may be completed from line 89, contacts CC2, contacts K2, L2, switch 139, reset magnet 106SP to ground. A further circuit extends from con-

tacts K2 through normally closed contacts L2, switch 140 to reset magnets 106LH. These magnets control the resetting of the SP and LH accumulators.

Relay magnet K also shifts its contacts K1 (Fig. 3e) thus completing a circuit from line 87, now closed contacts K1, eject magnet 141 (151 of Patent 1,944,665), to line 88. The operation of magnet 141 ejects the now punched card from the machine. On the reset shaft of the LH accumulator are cam operated contacts 114 (191 of Patent 1,944,665) which open during the resetting of the accumulator to drop the holding circuit for relay magnets P, Q and B. A circuit is also completed through the now closed contacts 114, contacts 142 closed concurrently therewith, contacts 143 closed by the reset shaft of the SP accumulator, contacts 144 on the LH accumulator reset shaft, wire 150, switch TP1, relay magnet C to line 88.

Energization of relay magnet C will re-initiate a new series of operations during which the next card is fed from the magazine to the analyzing station and the data thereon entered into the MC, MP and SP accumulators as before.

While there has 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 its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention therefore to be limited only as indicated by the scope of the following claims.

What is claimed is as follows:

1. In a machine of the class described, an amount receiving device comprising a plurality of denominationally ordered elements, means for entering an amount therein, a plurality of controlling devices each selectable in correspondence with a predetermined range of amounts standing in the receiving device, means for ascertaining into which of a plurality of predetermined ranges of amounts an amount standing in said receiving device falls and for selecting the controlling device corresponding to said range of amounts, said ascertaining means including a plurality of devices at least one of which is separately controlled by a plurality of said elements less than all in accordance with their aggregate setting and means controlled by a predetermined one of said elements for preventing selection of any of said controlling devices when the amount in the receiving device exceeds the upper limit of the highest predetermined range.

2. In a machine of the class described, an amount receiving device comprising a plurality of denominationally ordered elements, each settable to represent any digit, setting means therefor, a plurality of relays each utilized for controlling the recording of a different amount, means controlled by the denominational element in a predetermined order of said receiving device for initially selecting one of said relays in accordance with the setting of said element, a device controlled by a higher order element in accordance with the setting thereof, a further device controlled by lower ordered elements in accordance with the aggregate setting thereof and means controlled by said devices for modifying said initial selection and causing the selection of a different relay by said denominational element in a predetermined order.

3. In a machine of the class described, an amount receiving device comprising a plurality of denominationally ordered elements, means for effecting a setting of said elements to represent an amount in said device, a device operated under the joint control of the four lowest ordered elements when their aggregate setting represents a predetermined value, a further device operated under control of the sixth ordered element when it is set to represent a predetermined value, a plurality of relays each selectable in correspondence with a predetermined range of amounts standing in the receiving device and means jointly controlled by said last two devices and the fifth ordered element for selecting one of said relays.

4. In a machine of the class described, an amount receiving device comprising a plurality of denominationally ordered elements, means for entering an amount therein, a plurality of relays each selectable in correspondence with a predetermined range of amounts standing in the receiving device, means controlled solely by a predetermined ordered element of said device for initially selecting the relay representing the range of amounts within which the amount represented by the setting of said elements of itself falls, means controlled by the other elements of said device for ascertaining whether the entire amount standing in said receiving device falls in the range of said relay, means controlled thereby for modifying said initial selection and for selecting the relay corresponding to a different range of amounts, when the entire amount does not fall in the range of said first selected relay, and means for preventing selection of any of said relays when the amount in the receiving device exceeds a predetermined amount.

5. In a machine of the class described, an amount receiving device comprising a plurality of denominationally ordered elements, means for entering an amount therein, a plurality of controlling devices each utilized to control the selection of a different amount for recording operations, means controlled solely by a predetermined ordered element of said device for initially selecting the controlling device representing the range of amounts within which the amount represented by the setting of said elements of itself falls, means for testing the setting of the remaining elements of said receiving device, after said amount has been entered therein, to ascertain into which of a plurality of predetermined ranges of amounts the entire amount standing in the receiving device falls, and means controlled by said testing means when the amount does not fall within the range represented by the initially selected device for modifying said selection and for selecting another one of said controlling devices for operation in accordance with the predetermined range into which a given amount in the receiving device falls.

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