March 20, 1945. C. M. FRIDEN 2,371,752

CALCULATING MACHINE

Filed May 2, 1938 17 Sheets-Sheet 1

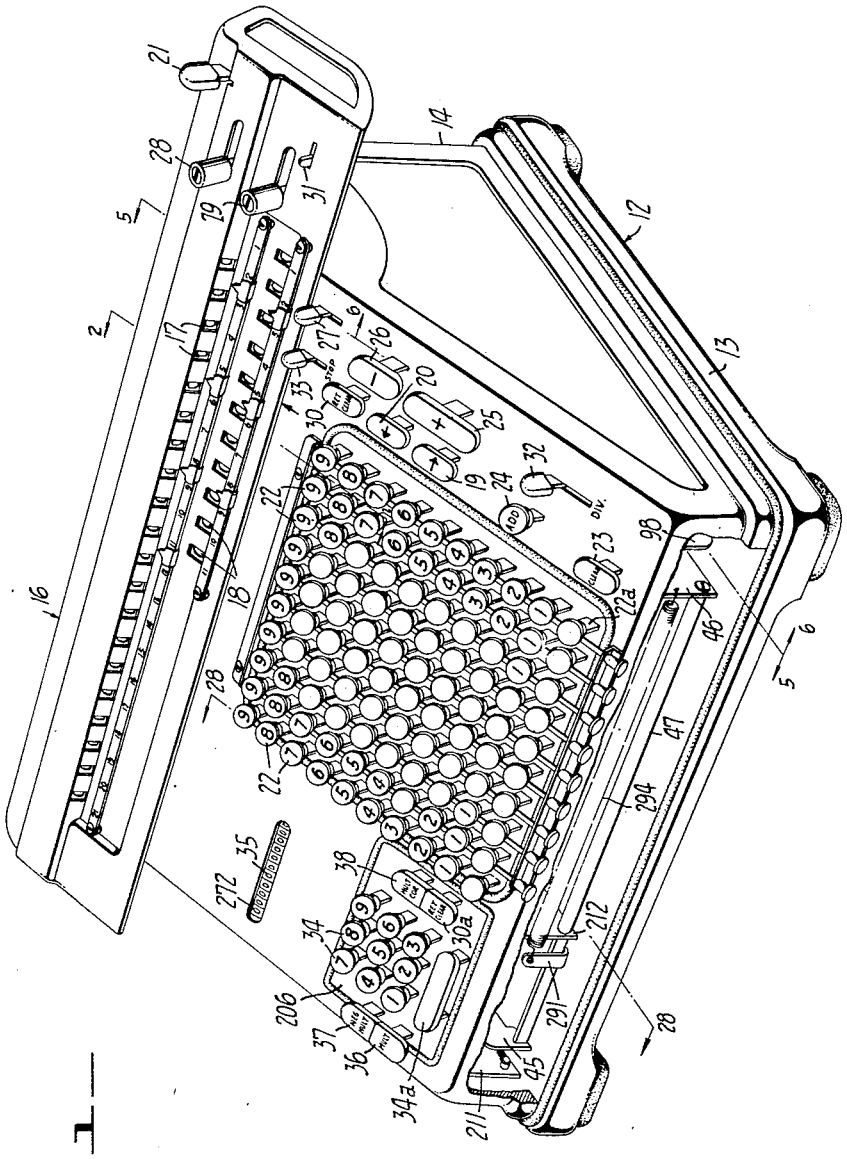

FIG. 1

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CALCULATING MACHINE

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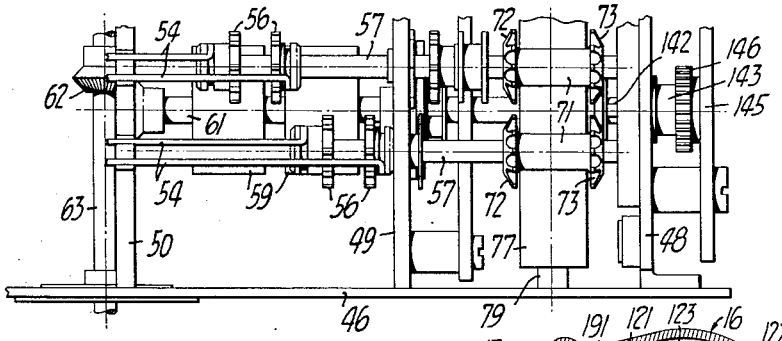

FIG. 3.

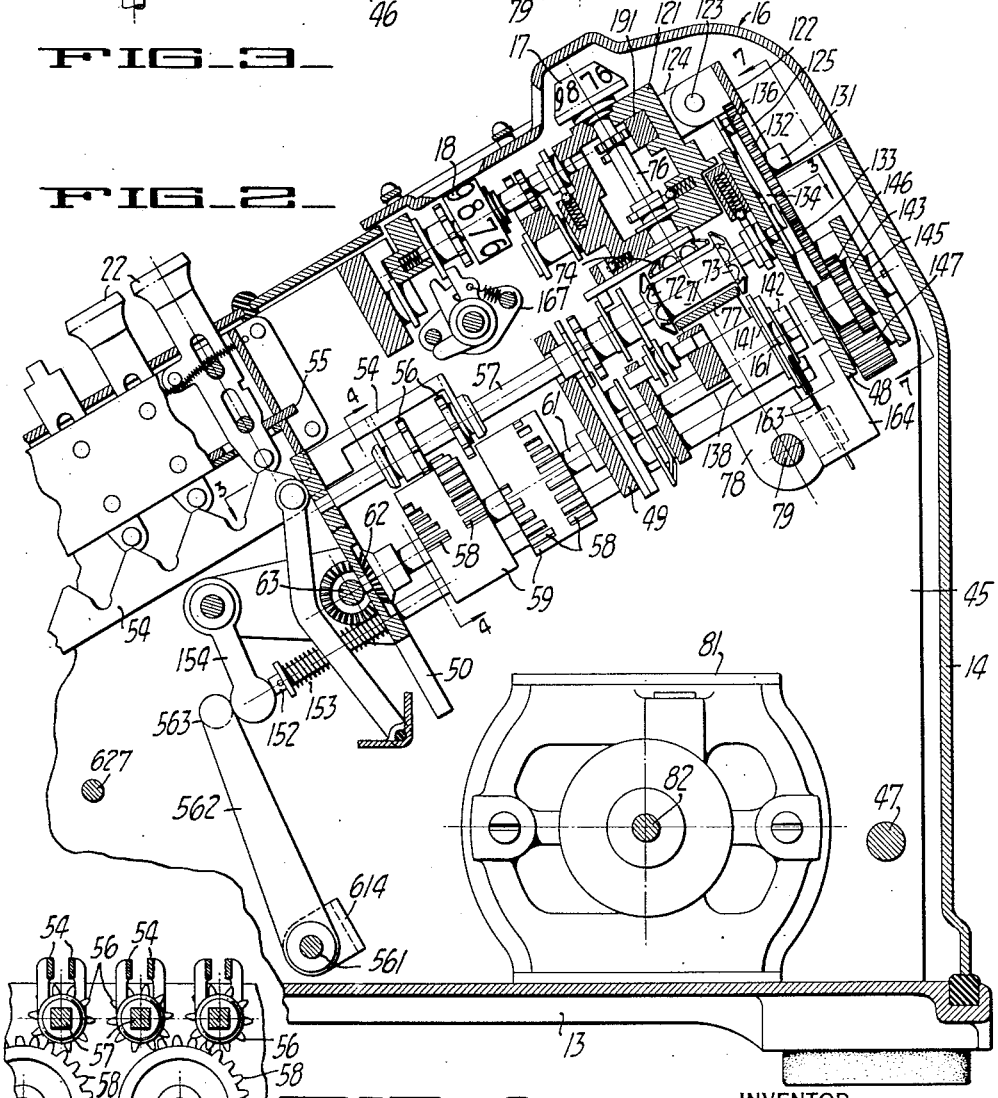

FIG. 2.

FIG. 4.

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CALCULATING MACHINE

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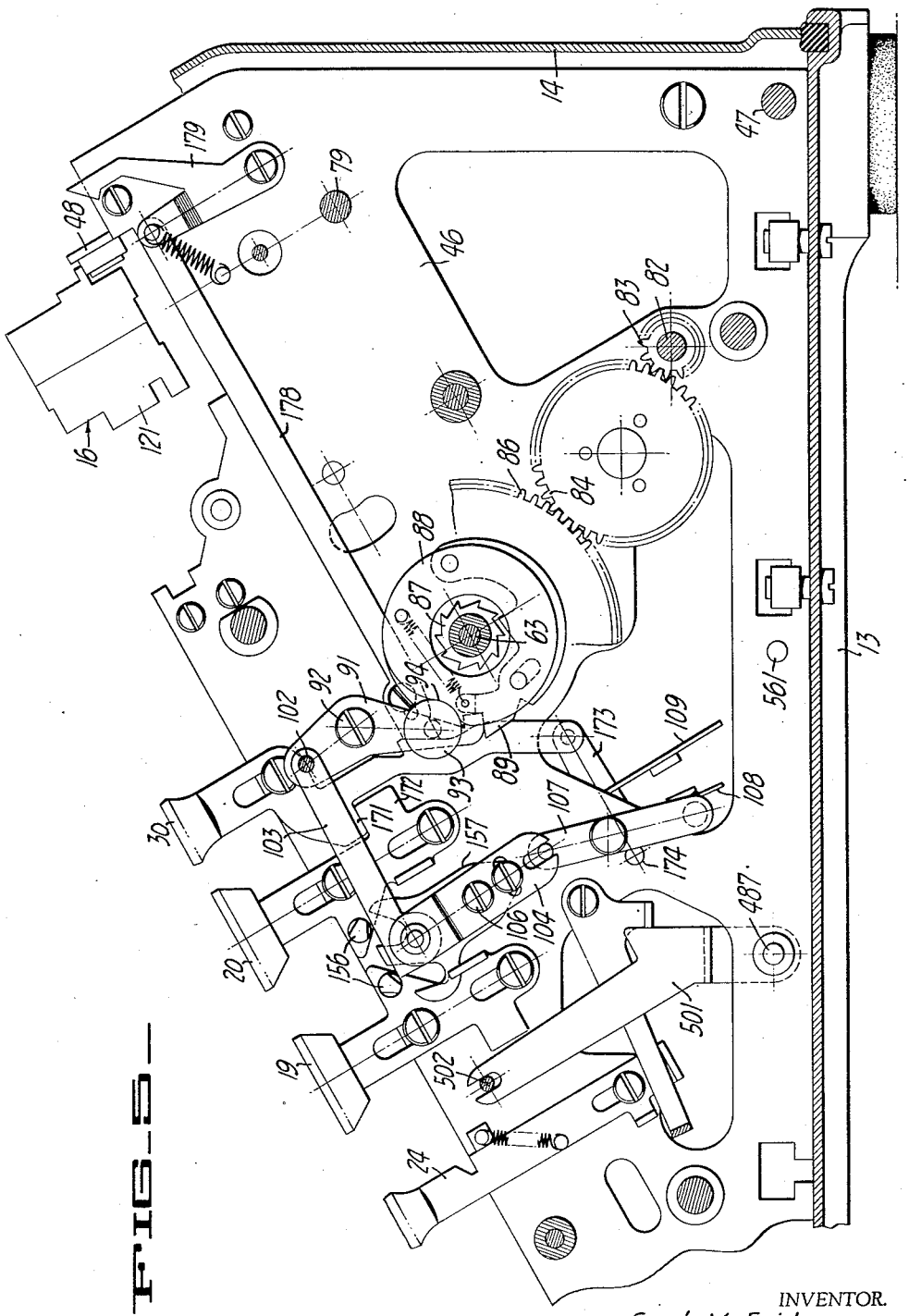

FIG. 5

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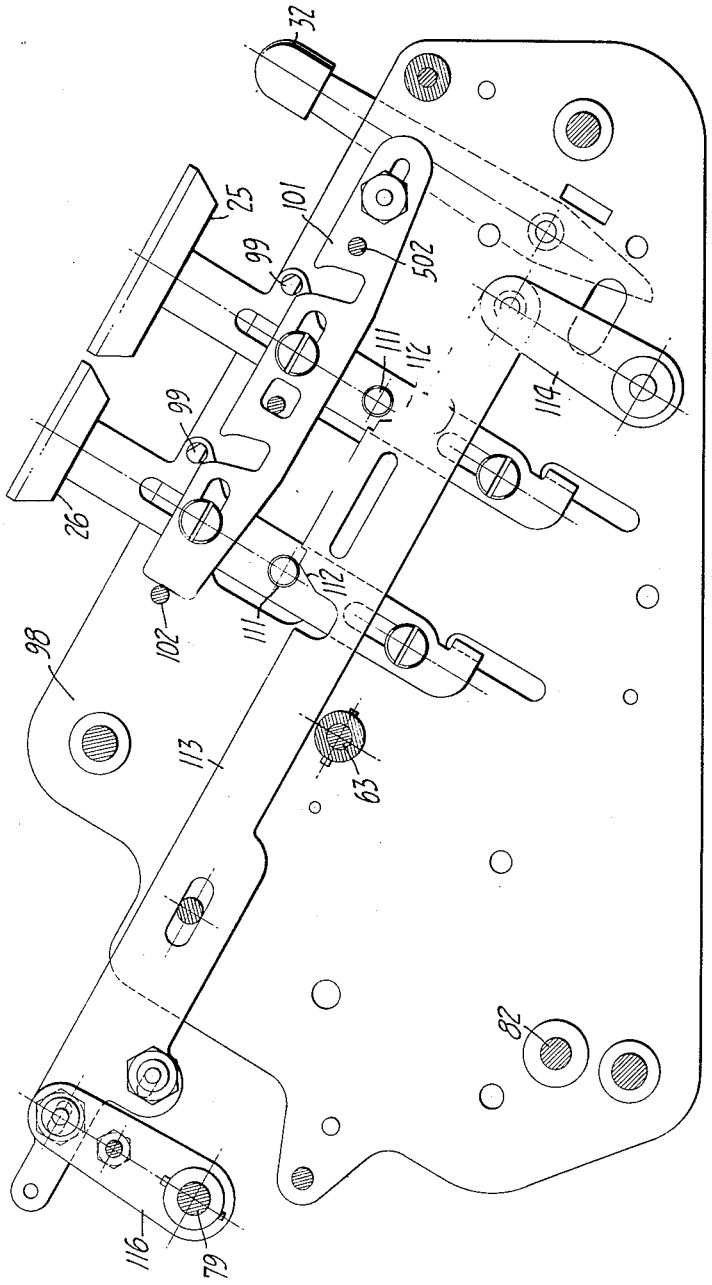

FIG. 6

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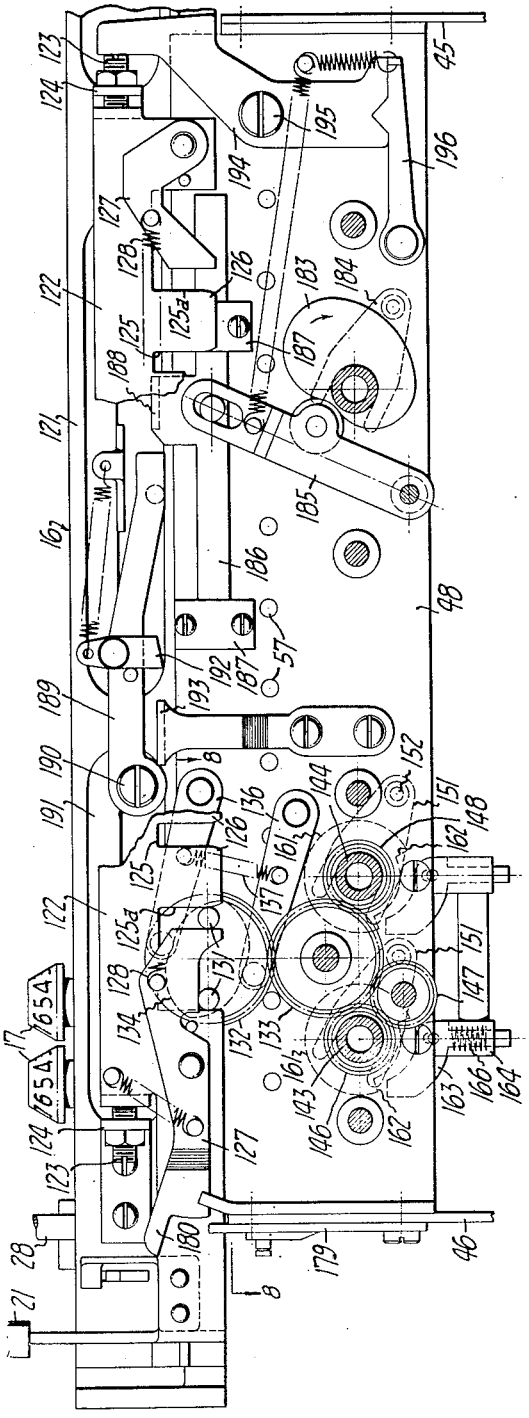

FIG. 7.

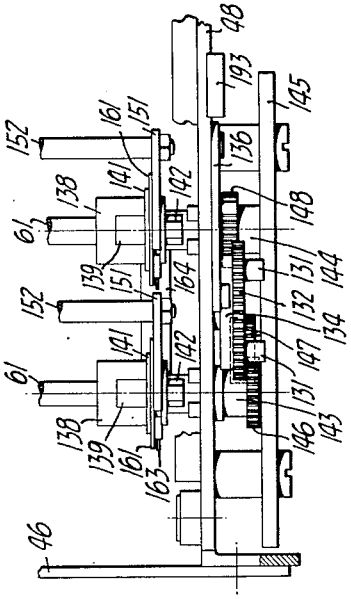

FIG. 8.

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FIG. 9

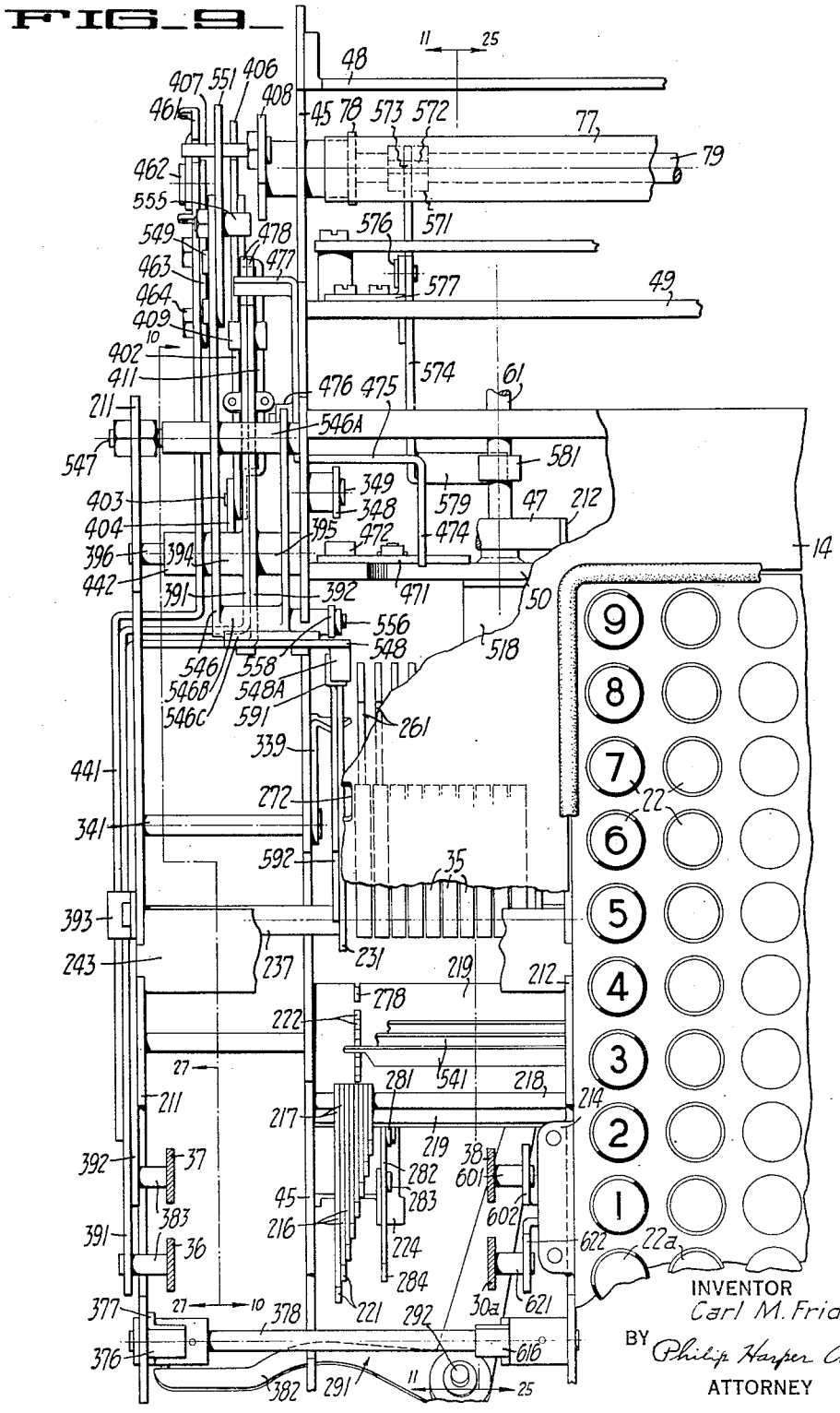

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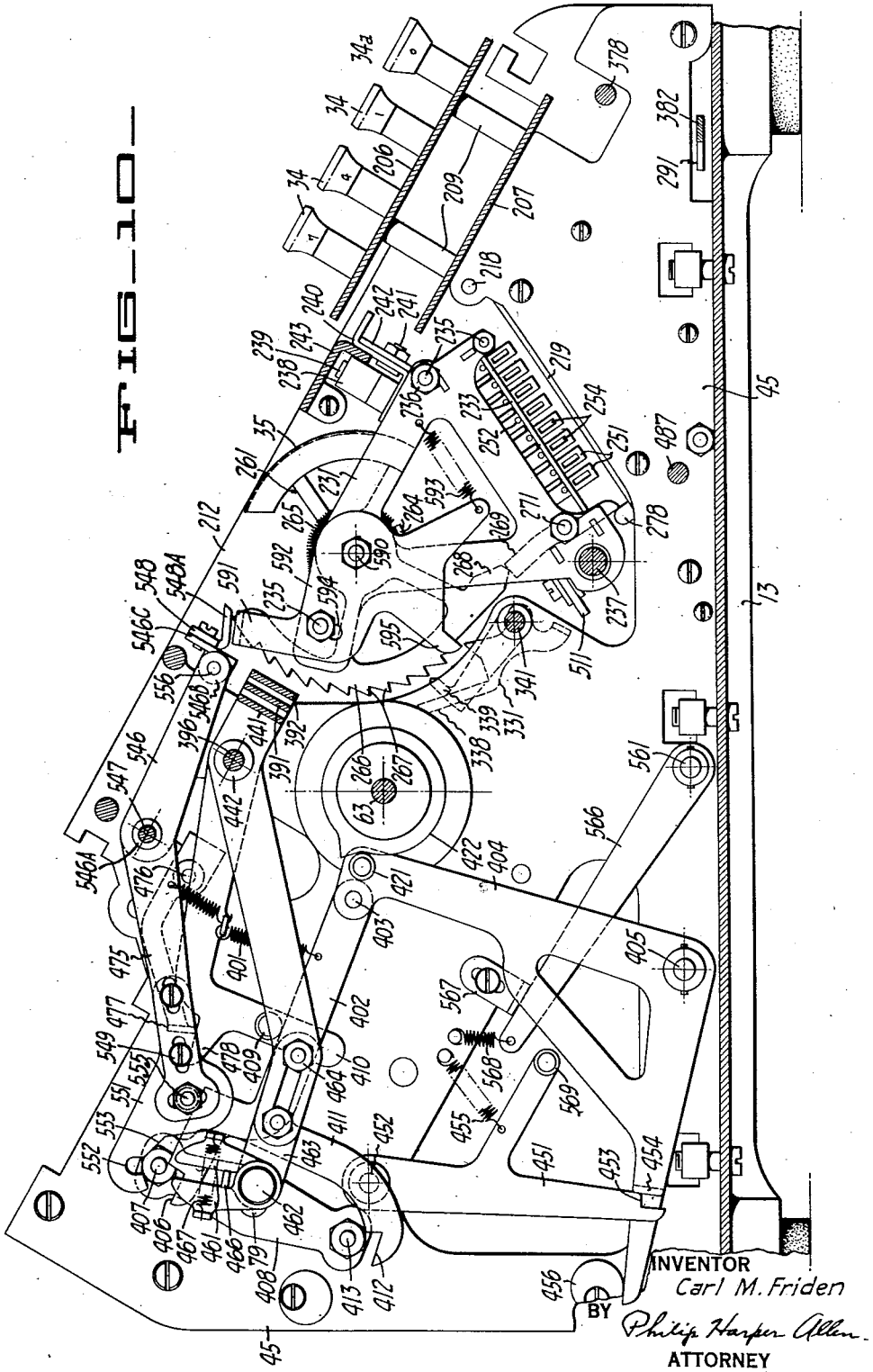
FIG-10



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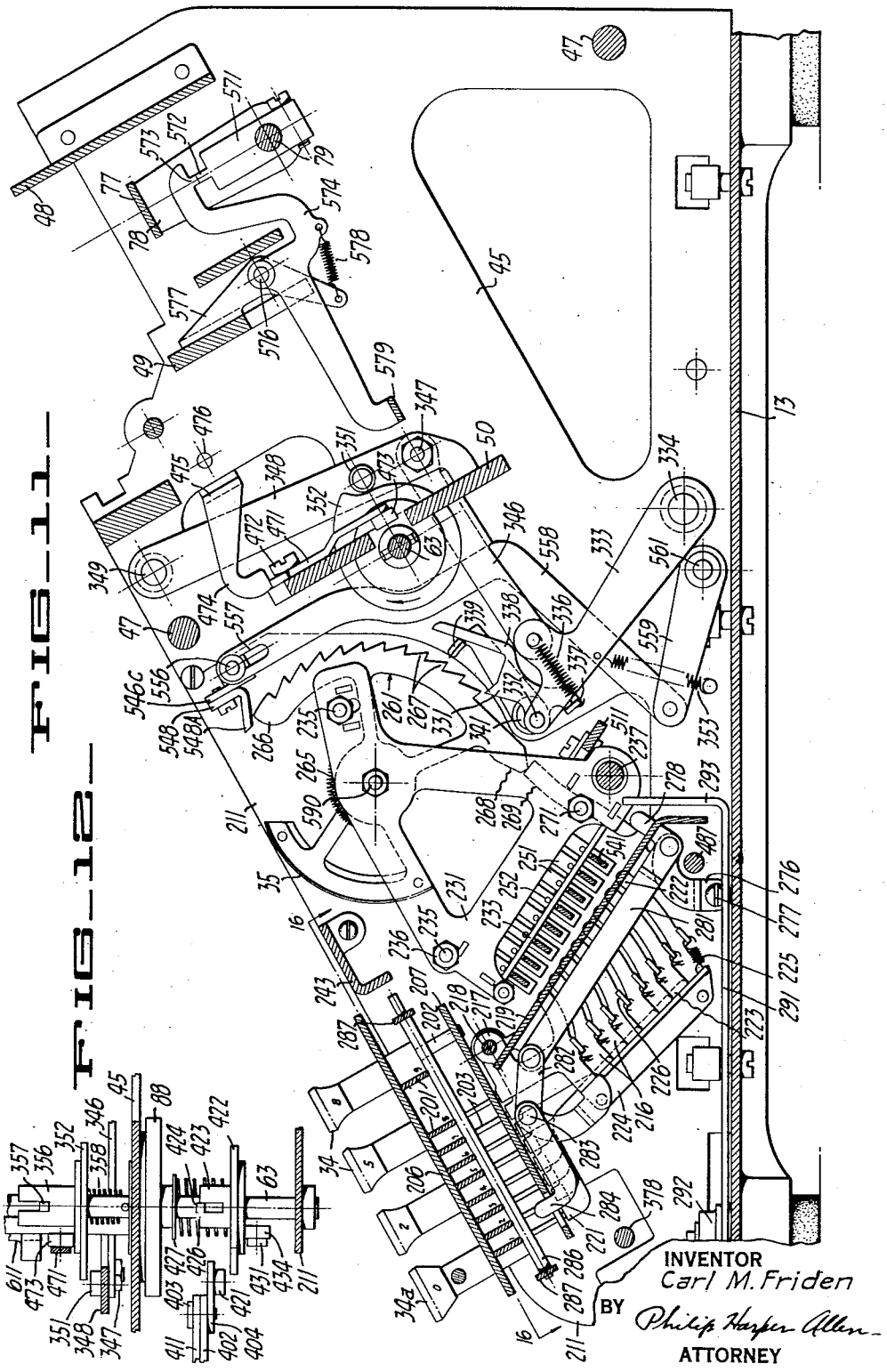

FIG. 11

FIG. 12

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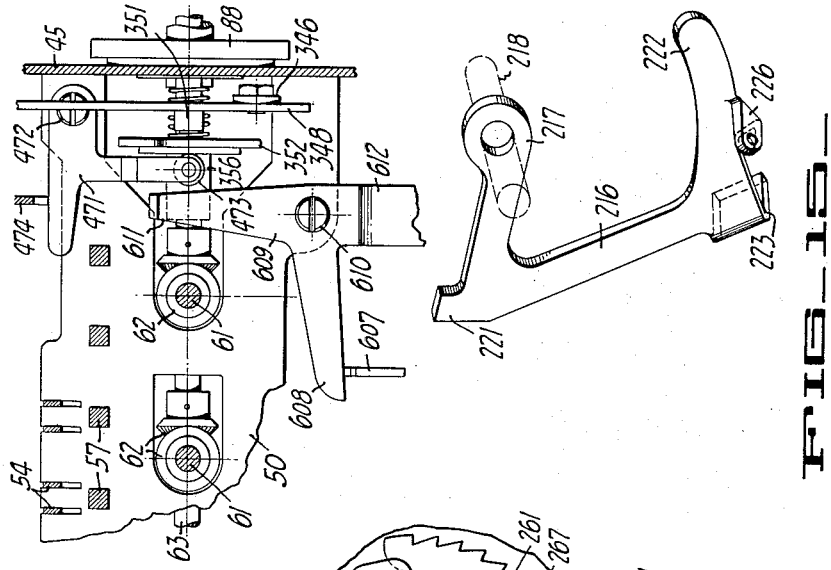

FIG. 15

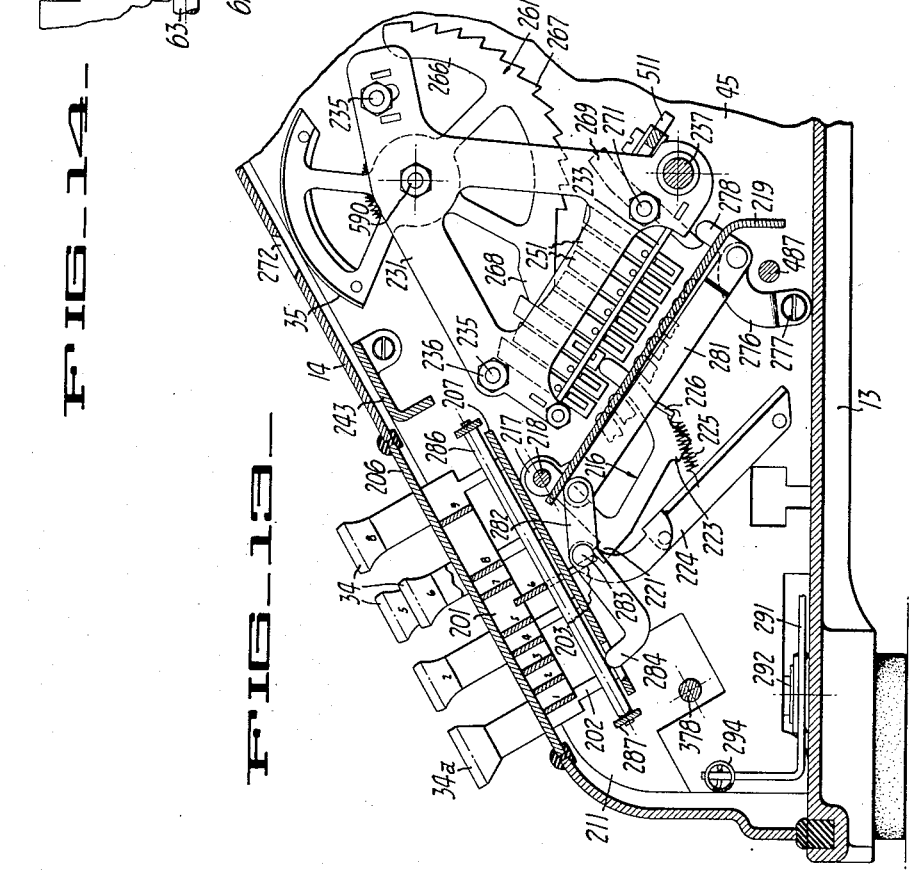

FIG. 14

FIG. 13

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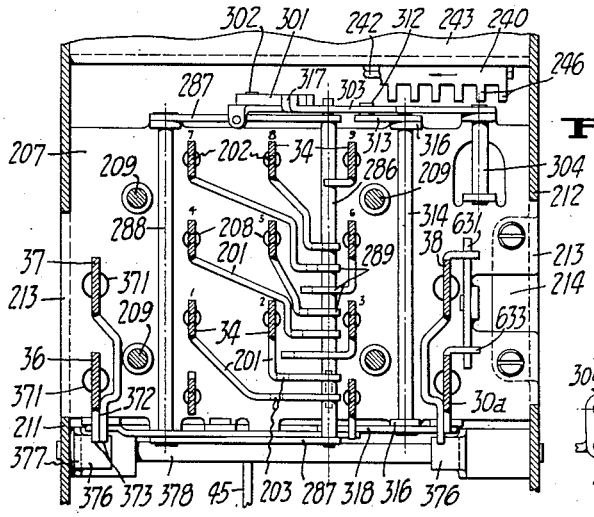

FIG_16_

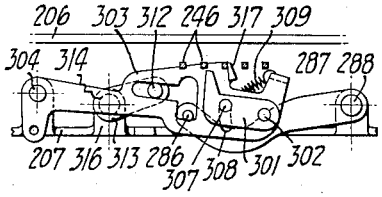

FIG_19_

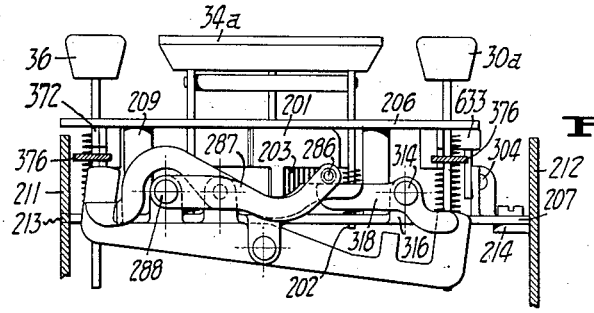

FIG_17_

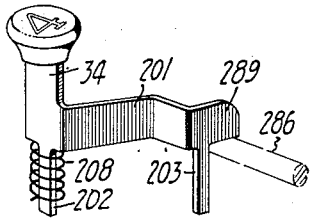

FIG_20_

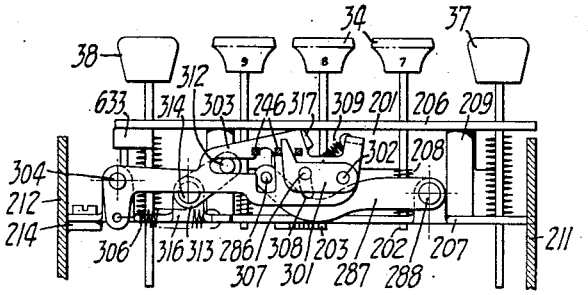

FIG_18_

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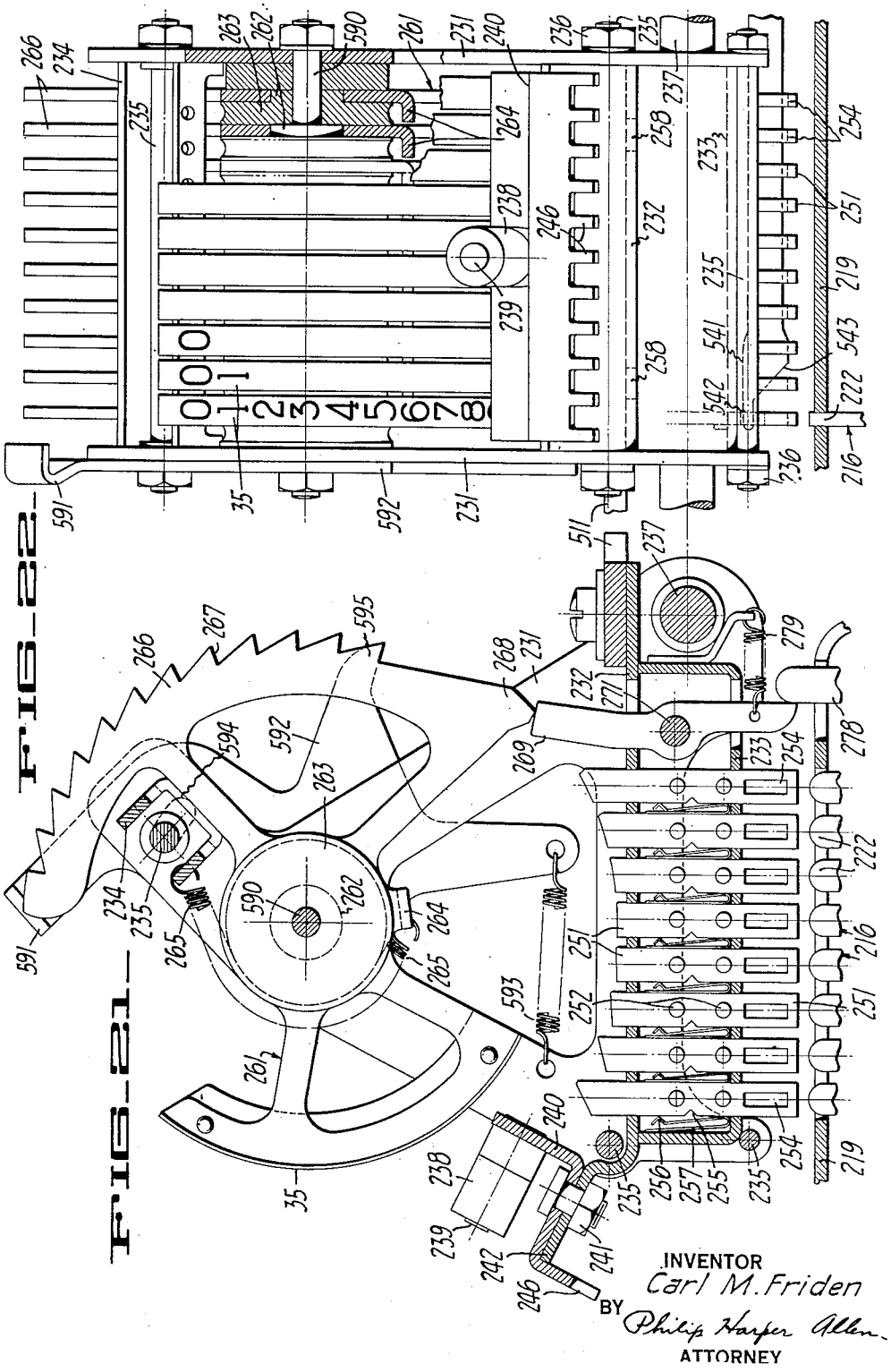

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FIG. 23

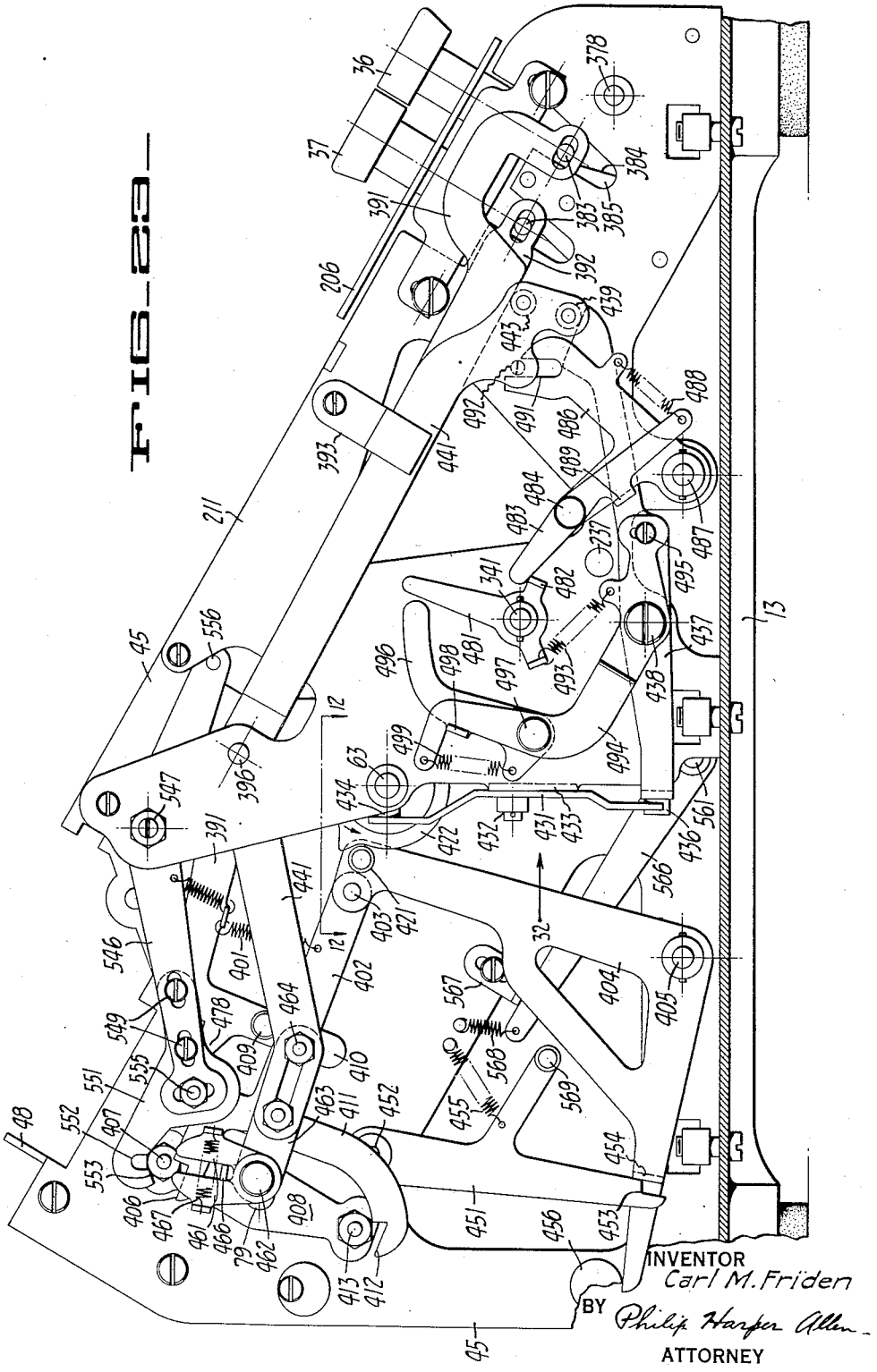

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FIG. 24

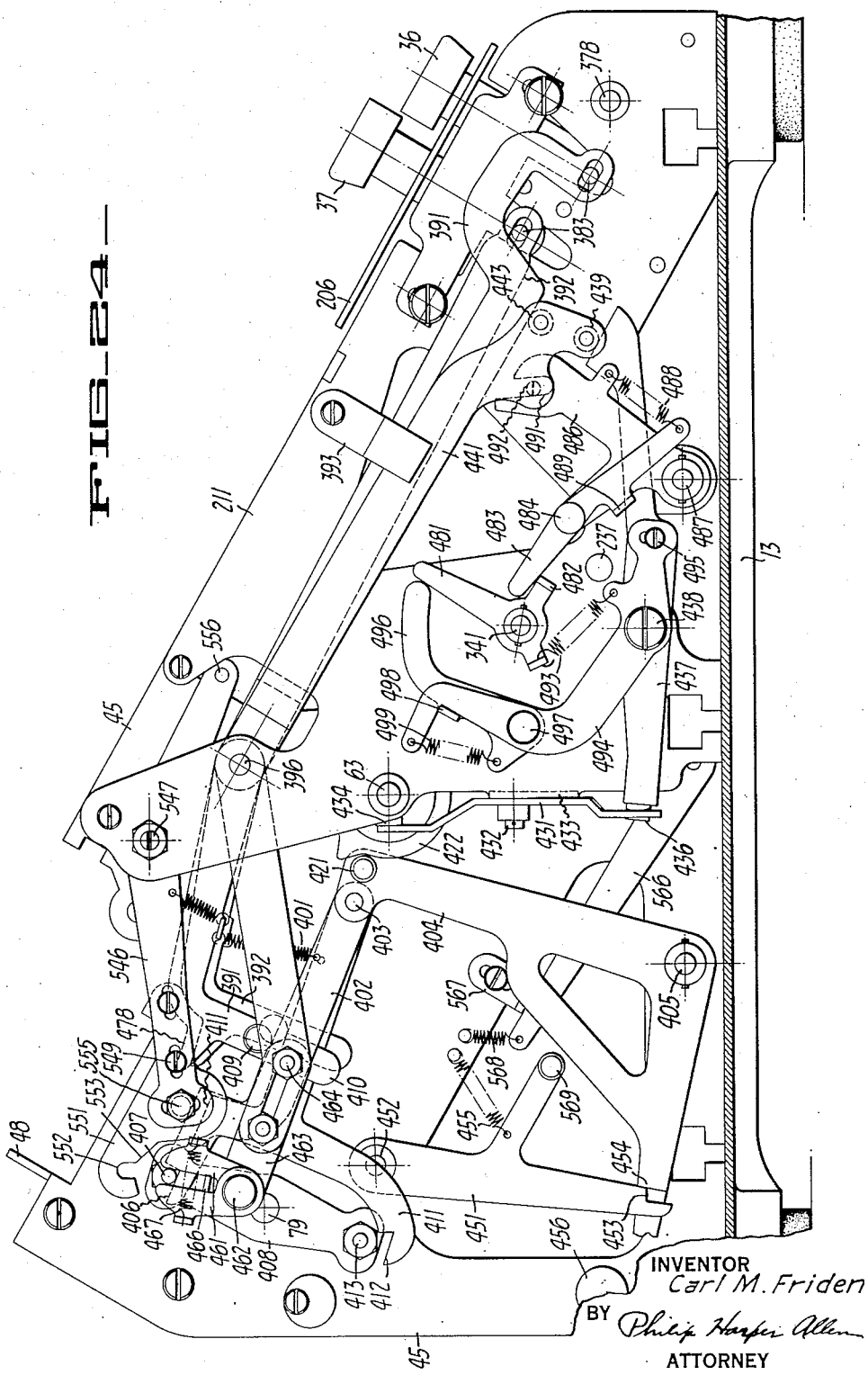

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FIG. 25

FIG. 26

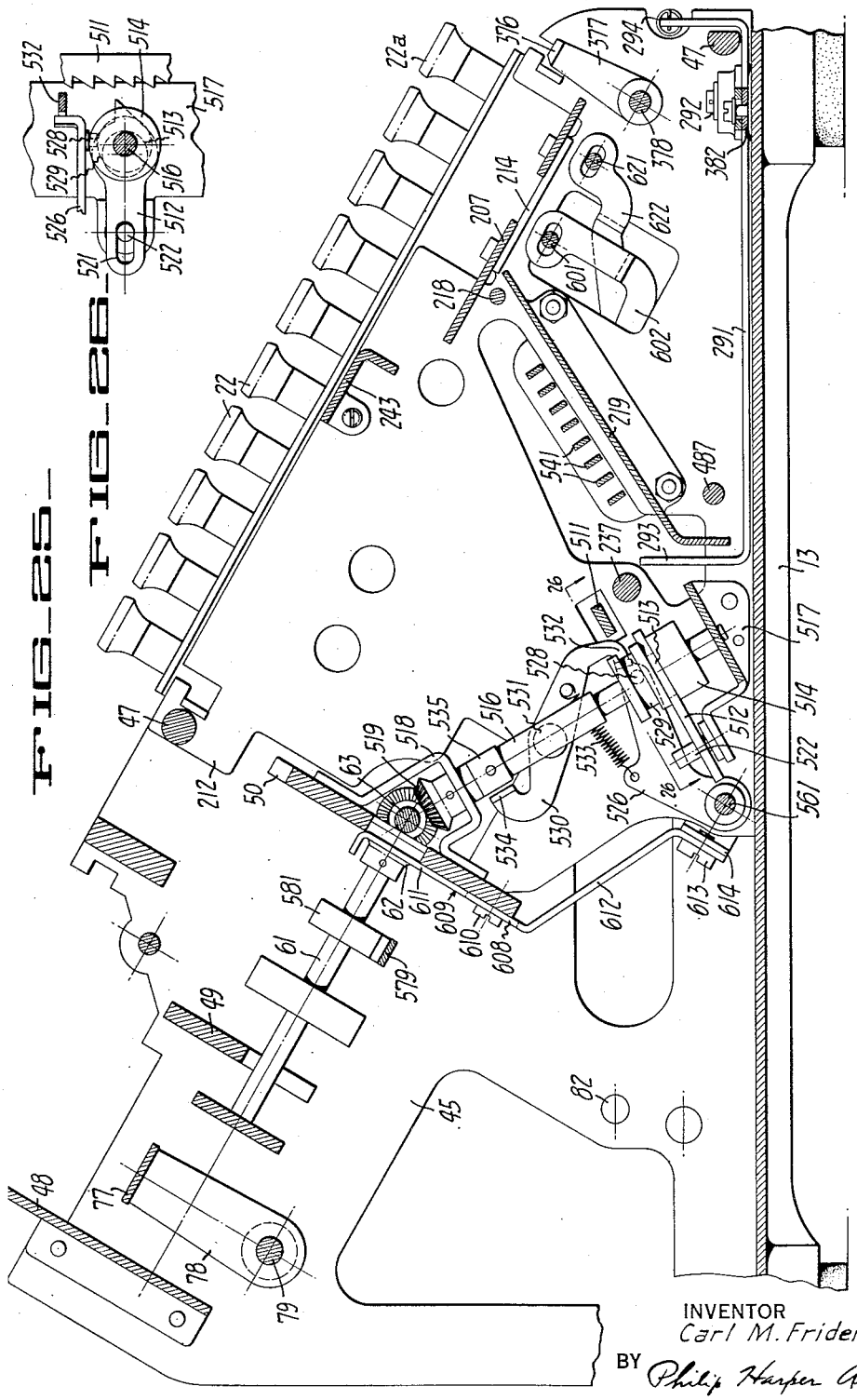

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FIG. 27.

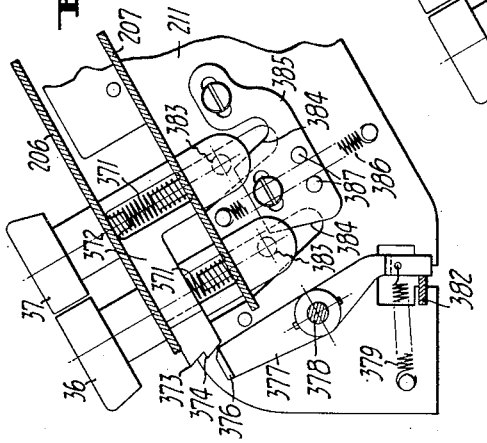
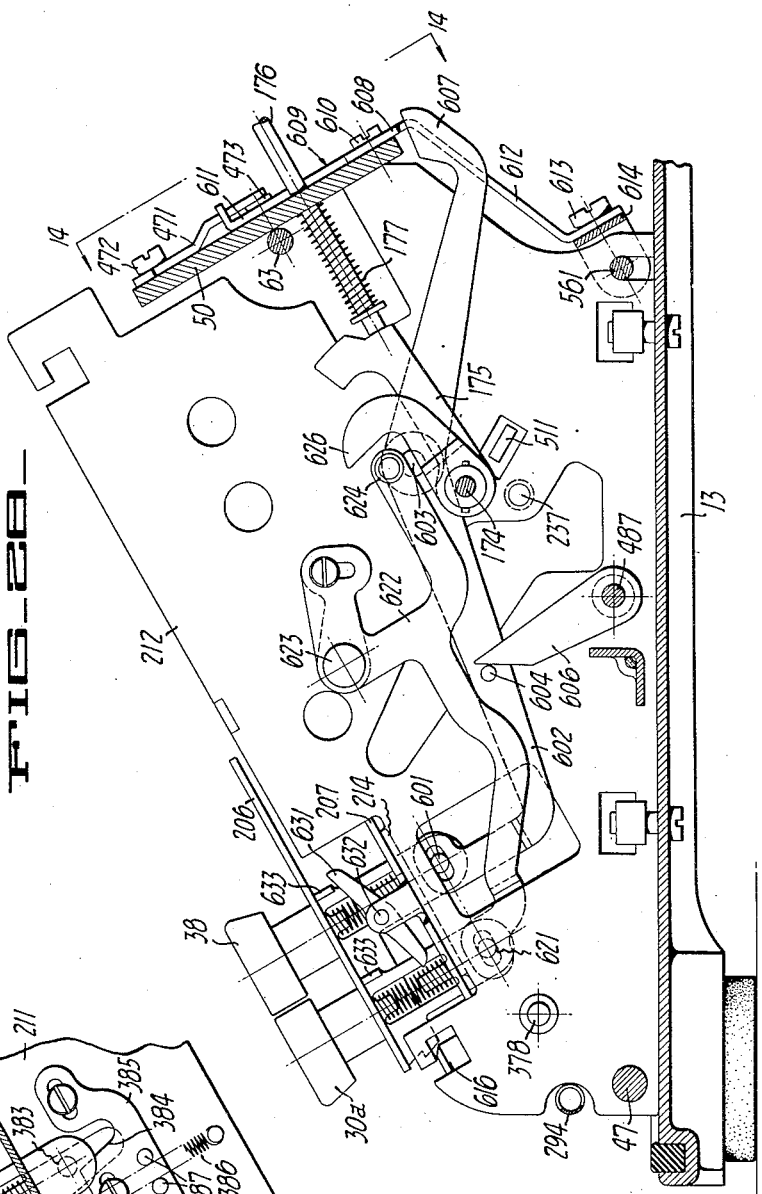


FIG. 28.



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CALCULATING MACHINE

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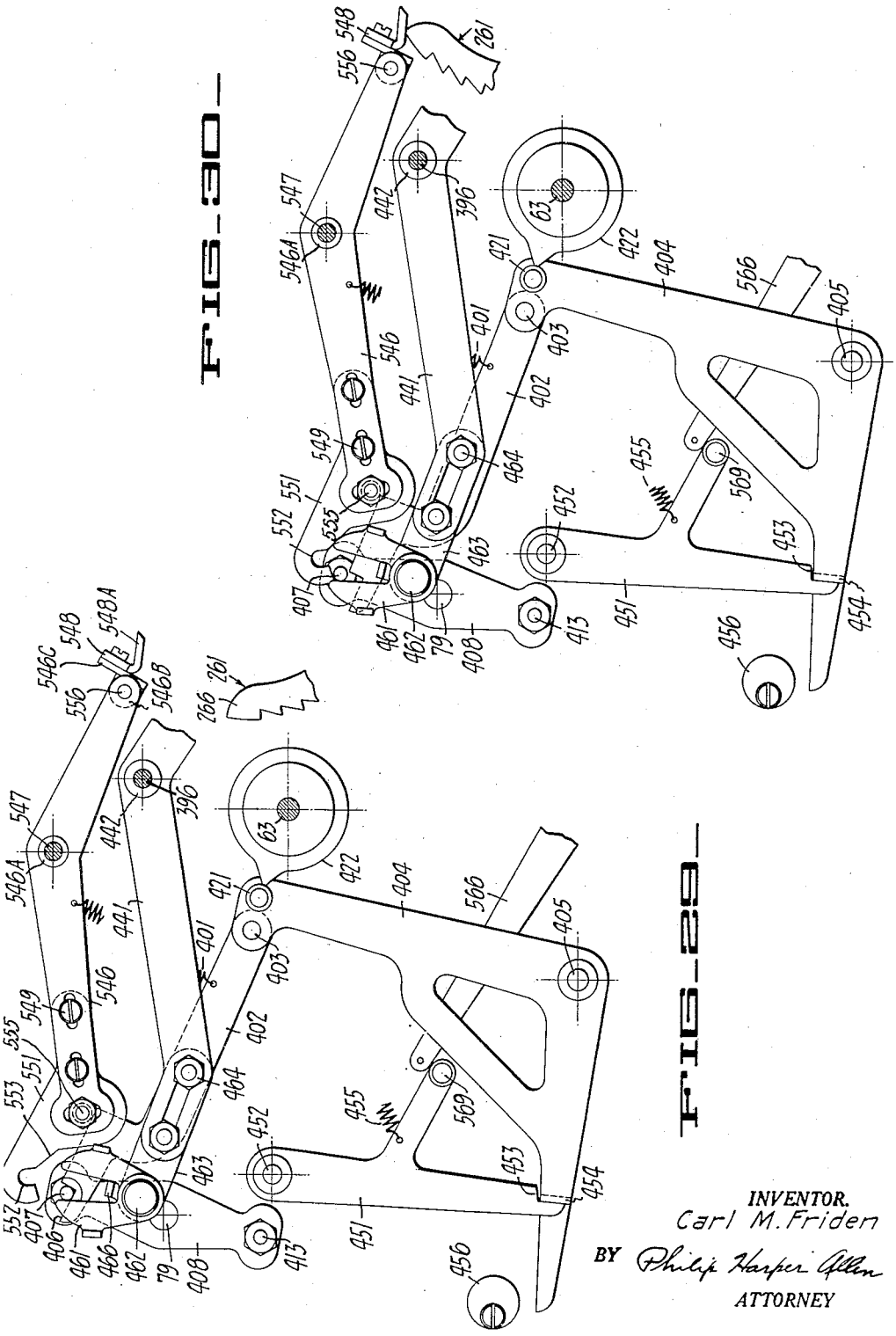

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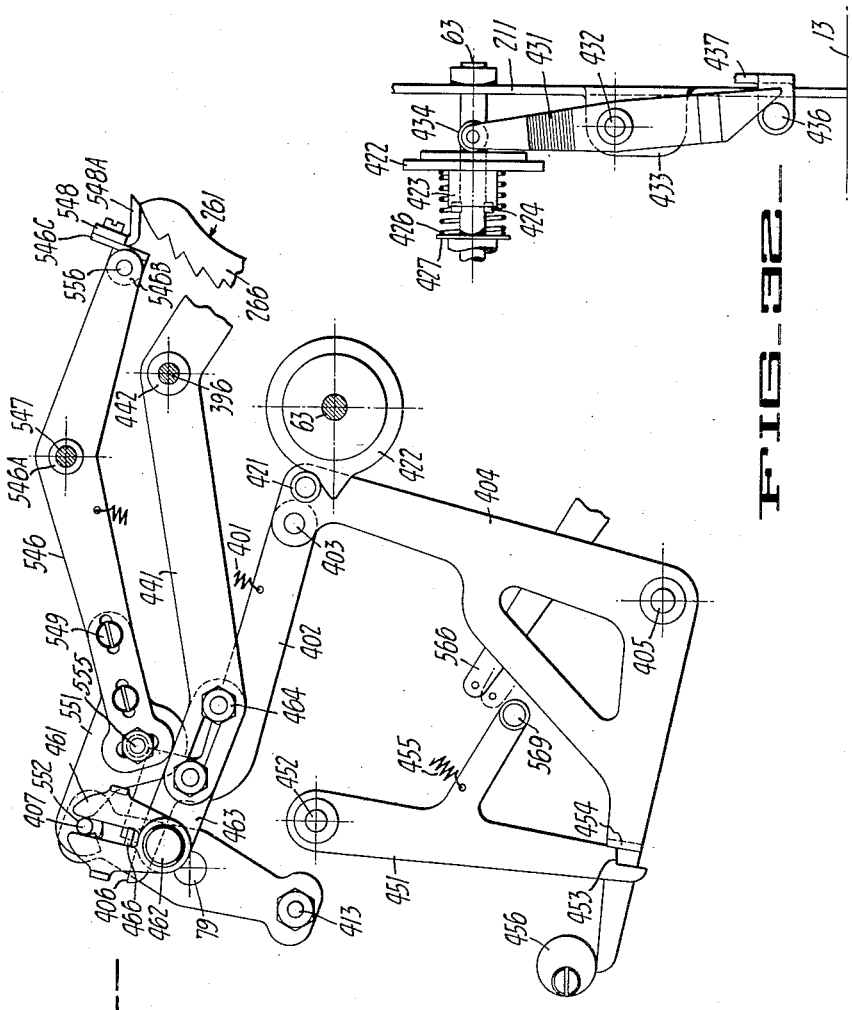

FIG. 32.

FIG. 31.

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Patented Mar. 20, 1945

2,371,752

UNITED STATES PATENT OFFICE

2,371,752

CALCULATING MACHINE

Carl M. Friden, Oakland, Calif., assignor to Friden Calculating Machine Co., Inc., a corporation of California

Application May 2, 1938, Serial No. 205,546

15 Claims. (Cl. 235—63)

This invention is concerned with calculating machines, and relates more particularly to the provision of improved mechanism for performing plural order multiplications in an automatic manner.

It is a general object of the invention to provide improved automatic mechanism for performing plural order multiplication problems.

Another object of the invention is to provide an improved calculating machine of the type employing uni-directionally operable actuating means and embodying improved means for performing plural order multiplying operations.

A further object of the invention is to provide an improved calculating machine embodying plural order multiplying mechanism in which the entire multiplying operation is carried out during continuous uninterrupted operation of the driving and actuating means through a single path of power flow.

A further object of the invention is to provide an improved calculating machine embodying plural order multiplying mechanism in which the clutch providing the sole drive connection from the source of power remains engaged from the beginning to the end of a multiplying operation.

A further object of the invention is to provide an improved calculating machine embodying plural order multiplying mechanism in which the product can be entered either additively or subtractively in the accumulator.

A further object of the invention is to provide an improved calculating machine having plural order multiplying mechanism and means for returning a shiftable register to a selected position and for then resetting the register to zero, in which the multiplier can be set into the machine during operation of the register return and resetting means.

Another object of the invention is to provide an improved plural order multiplying mechanism for calculating machines in which the various machine controls are adjusted to and from active position by power, when enabled by the control keys therefor.

Another object of the invention is to provide an improved plural order multiplying mechanism for calculating machines in which the multiplier selection mechanism can be zeroized in the event an erroneous multiplier digit is set therein.

Another object of the invention is to provide an improved plural order multiplying mechanism for calculating machines in which the digits of the multiplier digit are displayed to enable checking thereof before the multiplying operation is started.

Other objects and advantages of the invention will be apparent from the following description of a preferred embodiment taken in connection with the accompanying drawings.

Description of Figures

Fig. 1 is a perspective view of a calculating machine embodying my invention, the casing being partly broken away to show the arrangement of the frame plates.

Fig. 2 is a longitudinal sectional elevation through the rear portion of a calculating machine, the view being taken in a vertical plane through the line 2—2 in Fig. 1.

Fig. 3 is a fragmentary plan view of a part of the selecting and actuating mechanisms and is taken as indicated by the line 3—3 in Fig. 2. The teeth of the actuating cylinders are omitted to clarify the view.

Fig. 4 is a transverse sectional elevation illustrating a part of the actuating and selecting mechanisms and is taken in the plane of the line 4—4 in Fig. 2.

Fig. 5 is a longitudinal sectional elevation through the machine taken in a vertical plane through the line 5—5 in Fig. 1, and illustrates part of the drive mechanism and certain of the control mechanism associated therewith including the carriage shift keys and one of the carriage return and clear keys.

Fig. 6 is a sectional elevation of a part of the operation control mechanism including the plus and minus keys and the division lever, the view being taken in a vertical plane through the line 6—6 in Fig. 1.

Fig. 7 is a rear elevation of the calculating machine with certain parts shown in section, the view being taken as indicated by the line 7—7 in Fig. 2.

Fig. 8 is a fragmentary plan view of the shift drive mechanism with certain parts of the mechanism omitted, the view being indicated by the line 8—8 in Fig. 7.

Fig. 9 is a plan view of the left side of the machine with the casing partially broken away and the carriage omitted to disclose parts of the multiplier mechanism.

Fig. 10 is a sectional elevation of a part of the multiplier mechanism as viewed from the left, the view being taken as indicated by the line 10—10 in Fig. 9.

Fig. 11 is a sectional elevation of a part of the multiplier mechanism as viewed from the right

side, the view being taken in the plane of the line 11—11 in Fig. 9.

Fig. 12 is a fragmentary plan view, partly in section of a portion of the multiplier control mechanism, the view being taken as indicated by the line 12—12 in Fig. 23.

Fig. 13 is a fragmentary view similar to the front portion of Fig. 11, but showing the parts as positioned with one of the multiplier keys depressed.

Fig. 14 is a fragmentary sectional elevation thru a part of the multiplier mechanism as indicated by the line 14—14 in Fig. 28.

Fig. 15 is a detail perspective view of one of the selection levers of the multiplier mechanism.

Fig. 16 is a horizontal sectional view thru the multiplier keyboard mechanism taken in the plane of the line 16—16 in Fig. 11.

Fig. 17 is an elevational view of the lower or front end of the multiplier keyboard with the supporting plates therefor shown in section.

Fig. 18 is an elevational view of the multiplier keyboard from the upper or rear end with the supporting plates therefor shown in section.

Fig. 19 is a fragmentary view similar to Fig. 18, but showing the parts as conditioned with one of the multiplier keys depressed.

Fig. 20 is a detail perspective view of one of the multiplier keys.

Fig. 21 is an enlarged sectional elevation of the multiplier selection pin carriage.

Fig. 22 is a plan view partially in section of the multiplier selection pin carriage.

Fig. 23 is a left side elevational view of the multiplier mechanism as seen with casing removed.

Fig. 24 is a view similar to Fig. 23 but showing the parts as positioned with a multiplication key depressed.

Fig. 25 is a sectional elevation of a part of the multiplier mechanism and is taken in the plane of the line 25—25 in Fig. 9.

Fig. 26 is a sectional elevation of the pin carriage shift mechanism taken in the plane of the line 26—26 in Fig. 25.

Fig. 27 is a fragmentary elevational view partly in section of the positive and negative multiplication keys and associated mechanism as indicated by the line 27—27 in Fig. 9.

Fig. 28 is a right side elevational view partly in section of the multiplier correction key and the return clearance key adjacent thereto, together with certain parts controlled thereby as indicated by line 28—28 in Fig. 1.

Fig. 29 is a fragmentary elevational view, partly in section, of a portion of the control means for the multiplication mechanism, similar to the rearward portions of Figs. 23 and 24. The parts are shown in the relative positions occupied near the beginning of an actuating cycle prior to the last actuating cycle of an ordinal multiplication, i. e. when the cam 422 has turned in a counterclockwise direction from the position shown in Figs. 23 and 24 to that shown in Fig. 29.

Fig. 30 is a fragmentary elevational view, partly in section, similar to Fig. 29, the parts being shown in the relative positions occupied during the last actuating cycle of an ordinal multiplication at the same time of the cycle as that shown in Fig. 29.

Fig. 31 is a fragmentary elevational view partly in section, similar to Figs. 29 and 30, the parts being shown in the relative positions occupied near the beginning of the shift cycle of an ordinal multiplication, when the active rack 261 is at the top of its overstroke and the high point of cam 422 has moved past the associated roller 421.

Fig. 32 is a fragmentary elevational view of the means for enabling the cam which effects setting of the plus-minus gears to active position, the view being taken as indicated by the arrow 32 in Fig. 23.

General Description

(Fig. 1, Sheet 1)

The invention is described in a preferred form as adapted to a Thomas type calculating machine. Referring to Fig. 1, the machine includes body 12 comprising base 13 and casing 14 suitably secured thereon, and in which the actuating, selecting, and control mechanisms are mounted, and carriage 16 which is mounted for endwise shifting movement transversely of body 12 and which carries numeral wheels 17 and 18 of the accumulator and revolutions counter, respectively. Carriage 16 can be shifted by power in either direction by manipulation of respective shift keys 19, 20 through mechanism described hereinafter, or manually by manipulation of carriage release lever 21.

Values are entered into the machine by depression of numeral keys 22 of the usual keyboard in the various ordinal rows thereof, keys 22 being releasable individually by depression of ordinal clear keys 22A, or collectively by depression of keyboard clear key 23. Values introduced into the machine may be registered additively or subtractively on accumulator numeral wheels 17 by depression of plus key 25 or minus key 26, respectively, while the number of registrations or its complement can be entered in counter numeral wheels 18 by proper setting of control lever 27. If desired, add key 24 may be depressed to cause clearing of the keyboard in the usual manner after a single registration in the accumulator.

Values registered in numeral wheels 17 and 18 can be erased, i. e. the registers can be zeroized, by manipulation of respective manually operable resetting handles 28, 29, or by power through depression of either of return and clear keys 30 and 30*a*. Depression of key 30 (or key 30*a*) first effects return of carriage 16 to its farthest left position and subsequently effects resetting of accumulator numeral wheels 17 alone, or both numeral wheels 17 and counter numeral wheels 18 as selected by the setting of control lever 31.

The machine is adapted to perform automatic plural order division by means of conventional construction including division starting control lever 32, and division stop lever 33 by means of which a division operation can be terminated at the end of any selected ordinal division. Automatic predetermined multiplication can also be performed by depression of multiplier selection keys 34 to set up the desired multiplier figure as indicated on dials 35, and by depression of one of positive and negative multiplication keys 36 or 37 to start the multiplying operation. If it is desired to correct an erroneously entered multiple figure, multiplier correction key 38 may be depressed to zeroize the multiplier selection mechanism. The multiplying mechanism and the associated control means form the principal subject matter of the instant invention, and are described later in detail.

With the above general organization of parts in mind, various of the above noted mechanisms will be described in detail insofar as deemed

necessary or desirable to an understanding of the present invention, it being understood that the mechanism which is not described fully may be of conventional construction, for example, of the type disclosed in my co-pending application, Serial No. 724,482, filed May 8, 1934.

Selecting and Actuating Mechanisms

(Figs. 1–4, Sheets 1 and 2)

Within casing **14**, the frame includes left and right side plates **45**, **46** (Figs. 1, 2 and 3) which are suitably mounted on base **13** and are interconnected by various cross frame members including one or more tie rods **47** and transverse plates **48**, **49** and **50** for supporting various mechanisms including the selecting and actuating mechanisms.

The values to be introduced into accumulator numeral wheels **17** are selected by means of a plurality of similar orders of selecting mechanism associated with numeral keys **22**. For this purpose, each bank or order of keys **22** (Fig. 2) cooperates with a pair of similar parallel spring-urged value selecting slides **54** (Figs. 2–4) mounted for endwise movement by a suitable supporting linkage and extending through suitable slots in cross frame plate **50**. Each slide **54** is provided with cam surfaces of varying inclination for cooperation with suitable pins on certain of keys **22** to effect a differential movement of slide **54** on depression of a key **22**. One slide **54** of each order cooperates with the "1" to "5" keys **22** of a bank, while the other slide **54** of an order cooperates with the "6" to "9" keys **22** of the bank.

Each bank of keys **22** (Fig. 2) has a latching slide **55** of conventional construction associated therewith to latch any depressed key **22** releasably in depressed position against the tension of the spring associated therewith. To release depressed numeral keys, the latching slides **55** may be operated in any convenient manner by zero and clear keys **22***a* and **23** and by power as controlled by depression of add key **24**.

Each selecting slide **54** (Figs. 2–4) is connected at its rear end with a ten-tooth gear **56** slidably and non-rotatably mounted on longitudinal square shaft **57**, whereby movement of slide **54** serves to position the associated gear **56** on shaft **57** with respect to stepped teeth **58** of the associated actuating cylinder **59** in accordance with the value of the depressed numeral key **22**. A pair of actuating cylinders **59** for adjacent orders of the machine are mounted on each longitudinal actuating shaft **61**, wihch is suitably journalled in cross plates **49** and **50** and has a bevel gear connection **62** with transverse shaft **63**. Shaft **63** is operable cyclically in a single direction from clutch controlled driving means as described hereinafter to provide the only path of power flow from the motor.

As seen in Fig. 3, the pair of square shafts **57** associated with each actuating shaft **61** are positioned above and to either side thereof, while the sets of gears **56** on respective square shafts **57** are offset longitudinally of the machine for cooperation with the similarly offset actuating cylinders **59**. By the above arrangement and upon each rotation of the actuating means, a selected number of increments of movement can be imparted to each shaft **57** by the associated actuating cylinder **59** in accordance with the adjusted position of gears **56**.

Each shaft **57** (Figs. 2 and 3) is suitably journalled in cross plates **48**, **49** and **50**, and between plates **48** and **49** has associated therewith selectively settable plus-minus gears for driving an aligned numeral wheel **17**. The plus-minus gears of each order of the machine include a spool **71** slidably and non-rotatably mounted on shaft **57** and having opposed ten-tooth bevel gears **72**, **73** arranged for selective engagement with gear **74** on numeral wheel shaft **76**. The engagement of gears **72** and **73** with gear **74** is controlled by strap **77** which extends transversely of the machine between each set of plus-minus gears **72**, **73** and is mounted by similar spaced arms **78** on transverse shaft **79**, which is suitably journalled in side plates **45** and **46**. Shaft **79** is controlled in a manner hereinafter described to determine positive registration by meshing gears **72** with gears **74**, and negative registration by meshing gears **73** with gears **74**. In the neutral position shown in Fig. 2 in which gears **72** and **73** may be held normally by suitable spring-urged centralizing means associated with strap **77**, carriage shifting can be effected.

During both additive and subtractive registration of values in numeral wheels **17**, suitable transfer mechanism of conventional construction may be operative to effect the tens transfer as disclosed, for example, in said application.

Drive Mechanism

(Figs. 2 and 5, Sheets 2 and 3)

As stated above, the actuating means is operable cyclically to effect registration in the accumulator of the values set into the machine by depression of the numeral keys. For this purpose a clutch controlled drive is provided for the actuating mechanism which preferably forms the sole drive means for all power driven parts of the machine. The source of power of the drive means comprises electric motor **81** (Fig. 2) provided with drive shaft **82** carrying drive gear **83** (Fig. 5) which is connected by idler gear **84** with gear **86** journalled on transverse shaft **63** and carrying driving clutch element or ratchet **87** on its hub. Driven clutch element **88** is secured on shaft **63** and has pivoted thereon spring-urged clutch pawl **89** having a tooth for engagement with the teeth of ratchet **87** to establish the drive connection. Pawl **89** is spring-urged to operative position but is restrained in the neutral or full cycle position of the parts by clutch control lever **91** pivoted at **92** on side plate **46**. Lever **91** carries roller **93**, which seats in depression **94** on clutch element **88** in the full cycle position thereof, and in other positions thereof maintains lever **91** in its clutch engaging position for a purpose later referred to.

It is seen, therefore, that one or more cycles of operation of the actuating mechanism can be determined by oscillation of clutch control lever **91**.

Simultaneously with movement of control lever **91**, the circuit for motor **81** is established, and for this purpose pin **102** (Fig. 5) on the upper arm of clutch control lever **91** is connected by link **103** with lever **104** pivoted at **106** on side plate **46** and connected at its lower end with lever **107** also pivoted on plate **46**. Lever **107** has a suitable insulated pin in overlapping relation with spring mounted contact **108** normally spaced from similar contact **109**. Thus, clockwise movement of clutch control lever **91** serves through link **103** and lever **104** to oscillate lever **107** in a counterclockwise direction, whereby contact **108** is engaged with contact **109** to establish the circuit for the motor. It will be noted that roller **93** in main-

taining control lever 91 in clutch engaging position when the actuating means is out of full cycle position also serves to maintain contacts 108 and 109 closed, so that the motor circuit can be interrupted only in the full cycle position of the parts.

Plus and Minus Keys

(Figs. 1–3, 5 and 6, Sheets 1–4)

Means are provided for selectively determining positive or negative registration on the numeral wheels in the form of plus key 25 (Figs. 1 and 6) and minus key 26 which are slidably mounted for endwise movement on auxiliary frame plate 98, which is mounted in spaced relation from side plate 46. Depression of either of keys 25, 26 serves to engage the clutch, close the motor circuit, and select the sign character of the registration.

To enable the drive, keys 25 and 26 (Fig. 6) have respective pins 99 in operative relation with suitable cam surfaces on clutch control slide 101 which is suitably mounted for endwise movement on plate 98. To effect control of the clutch by such movement, pin 102 (Figs. 5 and 6) on the upper arm of clutch control lever 91 abuts the rear end of slide 101, so that the rearward movement of slide 101 oscillates lever 91 in a clockwise direction as viewed in Fig. 5 to release clutch dog 89 for engagement with drive ratchet 87. This movement also serves through link 103 and levers 104 and 107 to close contacts 108 and 109 of the motor circuit as described above.

To determine the sign character of the registration, plus and minus keys 25 and 26 (Fig. 6) have respective rollers 111, disposed in operative relation with opposed cam surfaces 112 on plus-minus slide 113. Slide 113 is mounted for endwise movement at its front end by link 114 and at its rear end by arm 116 secured on shaft 79. As described above, shaft 79 (Figs. 2 and 3) carries transversely extending strap 77 which controls the engagement or disengagement of gears 72 or 73 with numeral wheel gears 74. Thus, depression of plus key 25 moves slide 113 rearwardly of the machine and rocks shaft 78 and strap 77 to effect meshing of gears 72, 74, determining positive registration on numeral wheels 17 of the value set in the keyboard. Similarly, depression of minus key 26 determines one or more negative registrations of such values by meshing gears 73, 74.

Carriage Shift Mechanism

(Figs. 1, 2, 5, 7 and 8, Sheets 1, 2, 3 and 5)

Means are provided for shifting the carriage in either direction from one ordinal position to another by power driven means controlled by manually operable keys. The power driven means preferably comprises a part of the actuating means for entering values into the accumulator register. Carriage 16 (Figs. 2 and 7) includes frame 121 having shift plate 122 extending along the rear side thereof with its ends pivotally supported by pins 123 in similar brackets 124. Plate 122 is provided with vertical slots 125 (Fig. 7) formed between teeth 126, the ends slots 125a being formed in part by respective yieldable pawls 127 which are connected by spring 128. Slots 125 are adapted for engagement by opposite shift pins 131 on shift gear 132 suitably journalled on cross plate 48. Shift gear 132 can be rotated selectively in either direction thru idler gear 133 to shift the carriage thru any desired number of ordinal spaces by the cooperation of pins 131 and teeth 126, each one-half rotation of gear 132 effecting one ordinal spacing of the carriage. Shift gear 132 is centralized by means of cam 134 and centralizing arms 136 having spring 137 connected therebetween.

In order to rotate shift gear 132 selectively in either direction the two right hand actuating shafts 61 (Figs. 2, 7 and 8) are extended and are provided with similar controllable drive connections with gear 132. Each connection includes a collar 138 fixed on the associated shaft 61 adjacent the end thereof and having opposite slots slidably engaged by corresponding teeth 139 of shiftable collar 141, which is mounted for sliding movement at the end of shaft 61. Respective collars 141 have smaller teeth 142 for operative engagement with corresponding slots in gear sleeves 143 and 144. Gear sleeve 143 is suitably journalled in cross plate 48 and bracket 145 secured in spaced relation on plate 48, and carries gear 146 meshing with wide idler gear 147 (Figs. 2 and 7) which also meshes with idler gear 133. Similarly gear sleeve 144 (Fig. 7) has gear 148 which meshes with idler gear 133, and has a similar controllable drive connection with an actuating shaft 61.

Thus, by selective shifting of collars 141 to establish a drive connection, rotation of one of actuating shafts 61 may be utilized to determine rotation of shift gear 132 in a selected direction to effect shifting of carriage 16 in either direction.

Similar mechanisms are provided to control shifting of collars 141. Each mechanism includes a fork 151 (Figs. 7 and 8) at the rear end of rod 152 and engaging a suitable annular groove in the associated collar 141. Rod 152 (Fig. 2) is slidably mounted in cross plates 48 and 50 and is spring-urged to the position shown by spring 153. Each rod 152 has associated therewith a depending arm 154 which may be oscillated by one of the shift keys to shift the associated rod 152 by depression of the shift key through any suitable form of linkage. Keys 19 and 20 carry respective pins 156 (Fig. 5) overlying suitable cam surfaces of cam plate 157 (Fig. 5) secured on lever 104, so that depression of a shift key rocks lever 104, clutch control lever 91, and circuit control lever 107 to thereby engage the clutch and close the motor circuit as described in connection with plus and minus keys 25, 26.

Means are provided for maintaining each shift drive connection engaged for a full cycle of the actuating means, and, as each such means is of identical construction, only one will be described. Each shiftable collar 141 (Figs. 2, 7 and 8) carries a disc 161 which has cut-away portion 162 in its periphery so positioned that in the full-cycle position of the parts, cut-away portion 162 is registered with full-cycle latching pawl 163 in the direction of shifting movement of collar 141. However, when collar 141 is inactive, as shown in Figs. 2 and 8, disc 161 is positioned out of the plane of pawl 163 and immediately to the left thereof as seen in Fig. 2. Pawl 163 is mounted for vertical sliding movement in slotted bracket 164 secured on cross frame plate 48 and is urged to the upper active position thereof illustrated, by spring 166 seated in bracket 164. As seen in Fig. 2, disc 161, which is positioned normally to the left of pawl 163, will, upon shifting of collar 141 to engage teeth 142 with collar 143, be moved to the right of pawl 163, such shifting movement being possible because of the alignment of pawl 163 and cut-away disc portion 162. Subsequent rotation of the disc 161 with collar 141 and shaft

61, moves the unbroken part of the periphery of disc 161 into registry with pawl 163 so that collar 141 is held in active position for a full rotation of disc 161 and the drive connection is maintained for a full cycle of operation of the actuating means. Also, if collar 141 is not shifted to operative position at the beginning of a cycle of actuation, such movement is prevented until the end of the cycle. The spring 166 permits yielding of the pawl 163 if disc 161 begins rotating while in the plane of the pawl 163.

Thus, carriage 16 carrying numeral wheels 17, 18 can be shifted selectively in either direction through one or more ordinal positions by depression of keys 19 and 20 to control the cyclic operation of the actuating means, and the engagement and disengagement of the shift drive connection can be made only with the parts at or adjacent full cycle position.

To effect manual shifting of the carriage, lever 21 (Figs. 1 and 7) is suitably mounted on an extension of shift rack 122 and may be operated to oscillate shift rack 122 about its pivotal supports 123 out of engagement with pins 131 of shift gear 132. In this condition of the parts, carriage 16 can be shifted freely in either direction.

Revolutions Counter

(Fig. 2, Sheet 2)

Numeral wheels 18 (Fig. 2) of the revolutions counter register the number of actuations of accumulator numeral wheels 17 in a conventional manner by the operation of counter actuator 167, as disclosed, for example, in said application Serial No. 724,482.

Return and Resetting Mechanism

(Figs. 5, 7 and 28; Sheets 3, 5 and 15)

As stated in the general description, depression of either carriage return and register resetting key 30 or key 30*a* is operative to effect return of the carriage to its left end position from any displaced position thereof, and to cause operation of the resetting mechanism with the carriage in this position to return the accumulator to zero registration. The operation will be described in connection with key 30, which will be referred to as a "return and clear" key.

To determine the shifting operation key 30 (Fig. 5), which is suitably mounted for vertical sliding movement on plate 46, has ear 171 overlapping lug 172 on shift key 20 so that depression of return and clear key 30 operates by depression of key 20 to engage the shift drive, engage the clutch and enable the motor circuit as previously described.

To control the resetting mechanism, key 30 at its lower end is pivotally connected to arm 173 secured on transverse shaft 174 extending between side plates 45 and 46. Shaft 174 (Fig. 28) carries cam arm 175 which is operatively related to control rod 176, slidably mounted in cross plates 48 and 50 (Figs. 7 and 28) and urged forwardly of the machine by spring 177 (Fig. 28). Thus, depression of return and clear key 30 serves to rock arm 175 in a clockwise direction as viewed in Fig. 28, this movement serves to engage a drive for power driven resetting mechanism including cam 183 (Fig. 7) which may be driven from one of actuating shafts 61 under control of fork 184 on rod 176 in the same manner as the shift mechanism. To maintain key 30 depressed during the accumulator return and resetting operation, latch means is associated therewith comprising latch link 178 suitably mounted for endwise movement on plate 46 and pivotally connected to latch release lever 179. Lever 179 (Fig. 7) is operatively related to extension 180 of pawl 127 to be operated thereby to move latch link 178 to inactive position at the end of the return and resetting operation.

Resetting cam 183 (Fig. 7) operates thru arm 185 to reciprocate slide 186 in its guides 187, and at the end of the carriage return operation determined by key 30 when the carriage reaches its left end position, laterally projecting ear 188 of slide 186 engages the end of lever 189 pivoted at 190 on accumulator resetting rack 191 of conventional construction, to reciprocate the rack and thereby reset the numeral wheels 17 to zero registration. The engagement of ear 188 with arm 189 is controlled by spring-urged pawl 192 and elevated sectional track 193 for the pawl to prevent such engagement until the cycle after the shifting cycle which moves the carriage into its left end position, when the adjacent pivot screw 123 engages stop 194 pivoted at 195 on plate 48 and having centralizing pawl 196 spring-urged into engagement with the lower end thereof. During the next cycle of the actuating means slide 186 and its ear 188 become effective to reciprocate the resetting rack 191. This same cycle also serves to return all parts of the return and resetting mechanism to normal position through the operation of pawl extension 180 by shift pins 131 so that return and clear key 30 is released to stop the operation.

The operation of carriage return and resetting key 30*a* is similar to that of key 30.

Return and clear key 30*a* (Fig. 28) is mounted adjacent multiplier correction key 38 described hereinafter, and is connected by pin 621 with lever 622 pivoted at 623 on plate 212 and having roller 624 operatively related to arm 626 on shaft 174 to provide for oscillation of shaft 174 upon depression of key 30*a*. It will be recalled that shaft 174 is connected to return and clear key 30 so that operation of the shaft serves to depress return clearance key 30, and determine operation of the resetting mechanism as described above.

The above description of the resetting mechanism is believed sufficient to illustrate its relation to the multiplier mechanism, and if a detailed disclosure thereof be desired, reference may be had to my co-pending application Serial No. 42,268, filed September 26, 1935.

Multiplication Mechanism

As explained briefly in the general description, the multiplication mechanism of this invention comprises means for performing predetermined plural order multiplying operations in which the respective multiplicand and multiplier figures are entered into the machine by respective keyboards. The respective keyboards with their associated mechanism, control the operation of the machine to perform the multiplication in accordance with the depression of the positive or negative multiplication keys to determine the sign character of the registration of the product in the accumulator. As is usual in this type of machine, the multiplicand keyboard comprises the conventional keyboard of the calculator which is used in other operations, while the multiplier keyboard is preferably of the so-called "ten key" type which may be operated to set-up successively the various digits of the multiplier. It will be understood that the term "ten key" as used is intended to differentiate from the usual 81 key

type employed for the multiplicand, although the latter type can be employed with other parts of the multiplier mechanism if desired. For the purpose of the instant description, the multiplier keyboard and selection mechanism which serve to set the multiplier figure into the machine will be described first, and thereafter the operation controlling mechanism by means of which the multiplicand is entered in the accumulator a number of times corresponding to the respective ordinal values of the multiplier.

Multiplier keyboard.—Figs. 1, 9, 11, 13, 15–18, and 20; Sheets 1, 6, 8, 9, and 10). Generally, the selection mechanism for the multiplier comprises a keyboard, which as shown is of the "ten key" type, and a pin carriage associated therewith, having ten ordinal rows of settable stop pins and ten ordinal differentially adjustable elements in the form of racks in which digits of the multiplier may be set successively for subsequent control of the multiplying operation. In order to set up the multiplier digits, each pin row includes eight pins corresponding to "1" to "8" keys and a fixed stop corresponding to the "9" key, so that a depressed multiplier key operates through an associate selection lever to set the corresponding pin of an aligned ordinal row to active position. At the same time that a pin of the pin carriage is moved to active position, the aligned rack is released to move into engagement with the pin and thereby be set differentially in accordance with the value of the depressed key. Subsequently, the depressed key operates an escapement mechanism to move the pin carriage one ordinal step with respect to the keyboard selection mechanism. In this manner as will be apparent from the following detailed description, the multiplier digits are set up in the multiplier selection mechanism, the setting operation beginning with the highest order digit of the multiplier in the embodiment illustrated.

Referring to Fig. 1, multiplier keys **34** from "1" to "9" are arranged in a square 3 by 3 relation, with zero key **34***a* located in front of the 1 to 9 keys. As seen most clearly in Figs. 16 and 20, the stem of each multiplier key **34** includes a laterally off-set portion **201** and spaced parallel guide extensions **202** and **203** extending in planes at a right angle to each other. Guide extensions **202** of the keys are continuations of the key stem proper while extensions **203** project downwardly from offset portions **201** so as to be in aligned relation as seen in Fig. 16 for a purpose later described. Keys **34** are slidably mounted in upper and lower plates **206** and **207** (Figs. 16–18) of the multiplier keyboard, with the upper portions thereof slidably received in suitable slots in upper plate **206** and with guide extensions **202** and **203** slidably received in appropriately located slots in lower plate **207**. Zero key **34***a* is mounted similarly but is provided with a pair of straight key stems. A spring **208** (Figs. 16, 18 and 20) is provided about each key extension **202** to urge the key to its upper position where offset portion **201** thereof engages the lower surface of the upper plate **206**. Multiplier keyboard plates **206** and **207** (Figs. 16–18) are connected in spaced apart relation by a plurality of posts **209** and the assembly is mounted in the machine between upright plates **211** and **212** by means of side extensions **213** of plate **207** engaging corresponding slots in plates **211** and **212**, and by suitable fastening screws extending through plate **207** and engaging bracket **214** on plate **212**.

As seen most clearly in Fig. 16, the respective extensions **201** of keys **34** are bent so that their outer ends are in parallel aligned relation for operating the multiplier escapement mechanism, which is referred to hereinafter, while their extensions **203** are aligned in staggered fashion for cooperation with a row of selection levers for setting the pin carriage mechanism as described hereinafter. The "9" multiplier key **34** is not provided with a key stem extension **203** because the "nine" setting of the differentially adjustable racks is effected by means of a fixed stop rather than a settable pin stop as occurs with the "1" to "8" multiplier keys. For convenience, the corresponding numbers of the keys have been applied adjacent the key stems in Fig. 16 to enable the arrangement of the extensions **201** in numerical order to be apparent.

Associated with the multiplier keys are a series of selection levers which provide means for moving a selected pin of an aligned ordinal row of the pin carriage to active position upon depression of the corresponding multiplier key. A selection lever **216** (Figs. 9, 11, 13 and 15) is provided for each of the "1" to "8" keys **34**. Each lever **216** is provided with arm **217** pivoted on transverse shaft **218** which extends between plates **45** and **212**, the series of arms **217** being disposed in side by side relation in a slot in plate **219** which is secured between plates **45** and **212** whereby the levers **216** are held against sidewise movement. Levers **216** are provided with upwardly projecting noses **221** disposed in an aligned staggered relation (Fig. 9) corresponding to the similar relation of extensions **203** of the multiplier keys as shown in Fig. 16, so that the respective projections **203** overly corresponding noses **221** of the selection levers.

Each selection lever **216** (Fig. 15) is provided at its lower end with an upwardly and rearwardly projecting pin setting finger **222** which extends through a suitable aperture in plate **219** (Figs. 9, 11 and 15), the fingers **222** of the various levers **216** being suitably offset to be disposed in a row as seen in Fig. 9. At the base of finger **222**, each lever **216** has laterally projecting stop **223** which normally seats against bracket **224** (Figs. 11 and 13) under the influence of a spring **225** tensioned between bracket **224** and ear **226** of the pin setting finger **222**. Bracket **224** is secured to and projects laterally out from side plate **45**. In this position of levers **216**, fingers **222** are retracted and noses **221** are positioned immediately below the corresponding key extensions **203**. The selection lever shown in perspective in Fig. 15 for the "5" multiplier key has its pin setting finger **222** lying substantially in the plane of its nose **221**, while the other selection levers are formed with off-sets in their pin setting fingers **222** to place the upper ends thereof in the same plane as shown in Fig. 9.

It is seen, therefore, that respective selection levers **216** are provided for multiplier keys **34** from "1" to "8" respectively, and that upon depression of a key **34** the corresponding lever **216** will be rocked about shaft **218** to project its finger **222** to active pin setting position as seen in Fig. 13. In the pin carriage, 8 pins are provided in each ordinal row for the keys "1" to "8" and a fixed stop is provided corresponding to the "9" key, the only function of the depression of the "9" multiplier key is to operate the escapement mechanism and to release the aligned rack on the pin carriage.

Multiplier carriage.—(Figs. 1, 10, 11, 13, 16–18, 21 and 22; Sheets 1 and 7–11). As explained above, the shiftable pin carriage which controls the multiplying operation carries the ordinal

rows of settable pins by means of which the multiplier digits are set into the machine, as well as the differentially settable racks, which are adjusted in accordance with the setting of the active pins and consequently the value of the multiplier digits. The machine illustrated has ten orders of pin rows and racks to provide for entry of a corresponding number of multiplier digits. When adjusted, the racks serve to display the selected multiplier value, and thereafter are returned successively in step by step fashion to their initial positions, and during such return control the operation of the mechanism in accordance with the successive multiplier digits.

The pin carriage frame comprises spaced-apart similar side plates 231 (Figs. 21 and 22) and respective upper and lower pin holding plates 232 and 233 extending between the lower ends of side plates 231 and U-shaped bar 234 extending between the upper ends thereof, both plates 232, 233 and bar 234 having suitable end projections engaging corresponding slots of plates 231. The frame assembly is held together by tie rods 235 having fastening nuts 236 threaded on the reduced ends thereof. The pin carriage is mounted in the machine by rod 237 (Figs. 10, 21 and 22) extending through aligned apertures of plates 231, and by roller 238 journalled by pin 239 on escapement rack bracket 240, which is secured by a plurality of bolts 241 on an extension 242 of upper pin plate 232. Roller 238 engages track 243 (Fig. 10) which is secured to and extends between plates 211 and plate 212. The downturned flange of track 243 extends between roller 238 and a face of escapement rack 240, which is provided at its edge with teeth 246 (Fig. 21) for cooperation with a step-by-step escapement mechanism as described.

Referring to Figs. 21 and 22, pin plates 232 and 233 of the pin carriage are provided with a series of rows of aligned slots to receive pins 251 for limited endwise sliding movement as determined by spaced apart pins 252 provided thereon between plates 232 and 233. Below plate 233 each pin 251 is provided with a transverse slot 254 for use in restoring the pin to its lower inactive position as shown in Fig. 21 in a manner later described, while the upper ends of the pins are of varying length to allow free movement of the associated settable rack past pins which are in their lower inactive position.

In order to latch a pin 251 in raised position, each pin is provided with latching notch 255 for cooperation with V-shaped end portion 256 of a slotted U-shaped spring plate 257, which is compressed between adjacent pins 251 of a row and is held in place between side plates 231. A plate 257 is provided to cooperate with each transverse series of pins in the respective rows. In assembling the pins 251 in pin plates 232 and 233, the pins are placed through the lower plate 233, and upper plate 232 is then pressed down over the ends of the pins until suitable slots therein engage with corresponding locating projections on the up-turned ends of the lower plate 233, as shown in dotted lines at 258 in Fig. 22.

For each order of settable pins, the carriage is provided with a differentially settable element in the form of a pivoted spring-actuated rack which is normally held in its "0" position, and which can be released to assume a differential adjustment in accordance with the pin of the associated row which is moved to active position by depression of a selected multiplier key. For this purpose, a plurality of ordinal axially aligned rack segments 261 (Figs. 21 and 22) are provided between side plates 231 of the carriage. Each rack segment 261 is journalled about reduced bearing portion 262 of a hub 263. Hubs 263 are apertured to receive fastening rod 590 by means of which hubs 263 are clamped in axially aligned position between side plates 231. Bearing portions 262 have an axial length slightly greater than the width of rack segments 261 whereby the segments are held in place but are free for pivotal movement. Each rack segment 261 is provided with an ear 264 from which spring 265 extends around associated hub 263 to U-shaped bar 234, whereby each segment 261 is urged in a clockwise direction as viewed in Fig. 21 by its associated spring 265. Each segment 261 is provided with arcuate rack sector 266 having twelve teeth 267 spaced from lower and stop end 268, which normally engages the upper end of holding pawl 269. The series of pawls 269, one for each rack segment 261, are pivoted on spacer shaft 271 extending between plates 231 and have their ends projecting through aligned slots in upper and lower pin plates 232 and 233. Each pawl 269 is urged in a counter clockwise direction as viewed in Fig. 21 by spring 279 connected thereto, whereby in the position shown, the associated rack segment 261 is held in its "0" position.

Opposite rack sector 266 each segment 261 is provided with an indicating sector or dial 35 having numerals from "0" to "9," one of which becomes visible thru sight opening 272 in case 14 (Figs. 1 and 13) to display the value of a multiplier digit set into the machine, in accordance with the adjusted position of the segment. For the values "1" to "8" such adjusted position is controlled by the active pin 251, which for the "9" position the upper end of sector 35 is adapted to engage U-shaped bar 234, which provides a stop for the "9" position of the respective rack segments.

Means is provided for releasing rack segment 261 of the active order of the pin carriage simultaneously with the movement of a pin to active position. Pawl 269 for releasing a rack segment 261 is moved to inactive position by means of arm 276 (Figs. 11 and 13) pivoted at 277 on plate 45 and having its upper end 278 (Fig. 21) operatively related to the lower end of the aligned holding pawl 269. Intermediate its ends, arm 276 is connected by link 281 with a lever 282 pivoted at 283 on bracket 224 and having finger 284 at its forward end bent upwardly to extend through plate 207 to a position under rod 286 (Figs. 11, 16, 17 and 18) extending between spaced arms 287 secured at the ends of rod 288 pivoted in suitable upturned ears of lower plate 207. Rod 286, as seen most clearly in Fig. 16, is associated with parallel ends 289 of key extensions 201, whereby upon depression of any key, the rod 286 will be moved downwardly to engage finger 284 and thereby depress lever 282. The resulting counterclockwise movement of lever 282 (Figs. 11 and 13) serves through link 281 to rock arm 276 and move pawl 269 to inactive position (Fig. 13) whereby the aligned rack segment 261 is released at the same time that pin setting extension 222 of the selection lever 261 becomes active to project the pin 251 into active position. This condition of the parts is shown in Fig. 13 where the "6" multiplier key is depressed.

Multiplier carriage escapement mechanism.—(Figs. 1, 9, 11, 13, 16, 18 and 19; Sheets 1, 6, and 8–10). As previously explained, the pin carriage is movable step by step transversely of the ma-

chine in accordance with the number of multiplier digits entered. The pin carriage is normally in its right end position (Fig. 9) as viewed from the front of the machine with indicating sectors **35** to the right of and not visible through sight opening **272**. The condition shown in Fig. 1 would obtain after successive depressions of zero key **34***a* to move the pin carriage to its left end position so that all sectors **35** are in value displaying position. The pin carriage is spring-urged towards its left end position by means of horizontally disposed bell crank **291** (Figs. 9 and 11) which is pivoted at **292** on machine base **13** by means of an adjustable eccentric, and has an upstanding arm **293** (Fig. 11) engaging right side plate **231** of the pin carriage. Another arm of bell crank **291** has spring **294** (Figs. 1 and 13) secured thereto whereby the bell crank is urged in counterclockwise direction as viewed in Fig. 9, and correspondingly, the pin carriage is urged from its right end position, which it occupies when no multiplier value is set in the machine.

Normally, the movement of the pin carriage under the influence of spring-urged bell crank **291** is prevented by means of stop pawl **301** (Figs. 16, 18 and 19) pivoted at **302** on pawl arm **303** which is pivoted at **304** on an upstanding ear of lower keyboard plate **207** and urged upwardly by spring **306**. Pawl **301** carries pin **307** which is guided in slot **308** of arm **303**, and tension spring **309** extending between pawl arm **303** and pin **307** to urge pawl **301** upwardly to active position into engagement with a tooth **246** of the carriage escapement rack **240** (Figs. 16 and 18) previously described. Pawl arm **303** is slotted longitudinally to receive pin **312** carried by arm **313** on rod **314** journalled in spaced ears **316** of lower keyboard plate **207**. Pawl arm **303** also carries laterally projecting tooth **317** which is normally positioned immediately above teeth **246** as shown in Fig. 18, and is disposed for downward movement between the pair of teeth adjacent and to the right of that contacted by pawl **301**.

Preferably, the escapement shift is performed in two stages, one stage occurring during depression of a multiplier key and the last stage occurring just before return of the key to raised position. When a multiplier key is depressed, shaft **314** is rocked by means of its arm **318** (Fig. 17) underlying key-operated rod **286**, whereby arm **313** (Fig. 18) and pin **312** serve to rock pawl arm **303** about its pivot in a clockwise direction thereby simultaneously lowering the tooth of pawl **301** and tooth **317** of pawl arm **303** from the position shown in Fig. 18 to that shown in Fig. 19. It will be noted the nose of pawl **301** is of sufficient length to remain in engagement with a tooth **246** until tooth **317** moves into alignment with the adjacent tooth **246**. As soon as the pawl **301** is disengaged from a tooth **246**, the first stage of the shift step occurs and the pin carriage moves to the right as viewed in Figs. 18 and 19 under the influence of the spring pressure thereon until a rack tooth **246** engages tooth **317** of arm **303** as shown in Fig. 19, where the parts are shown as positioned with a multiplier key fully depressed. The movement of the pin carriage during this stage of a shift step corresponds to the space between the tooth **317** and the rack tooth **246** adjacent thereto as seen in Fig. 18, the movement being sufficient to position the previously active tooth **246** over the nose of pawl **301** as shown in Fig. 19, but insufficient to allow engagement of the projected finger **222** (Fig. 13) with the next pin row to become active. Subsequently, as the depressed multiplier key is released, the parts start their return from the position shown in Fig. 19 to that shown in Fig. 18. Pawl **301**, however, is held depressed by the associated tooth **246** and can not return upwardly with the other parts until the inclined face of tooth **317** has permitted shifting of the pin carriage for an amount to move the associated tooth **246** from over the pawl **301** so that the pawl **301** will work upwardly into engagement with the next tooth **246** to the left of the tooth with which it was engaged before depression of the multiplier key. Shortly before the depressed key is restored to its upper position, the one step shift is completed whereby all of the pin setting and escapement shift parts will also be restored to normal position and the carriage will be conditioned for a subsequent shifting movement. The timing of the escapement operation to provide for shifting of the pin carriage substantially at the end of the return of the depressed key insures restoration of all the pin setting parts to a position out of the path of the pin carriage before the major part of the shifting movement thereof is effected.

From the foregoing description it will be seen that each time a multiplier key is depressed the aligned rack segment and selected pin of the pin carriage are set, while at the same time the carriage is escaped one step toward the left of the machine to display the set figure thru the multiplier sight opening **272**. This operation is repeated as the various digits of the multiplier are set into the machine. If a mistake is made in setting the multiplier digit such mistake can be corrected by resetting the multiplier racks as will be described hereinafter.

Multiplier rack restoring means.—(Figs. 9–12 and 14; Sheets 6–9). As previously stated, the differentially adjusted positions of racks **261** in accordance with the value of the respective multiplier digits are utilized to control the number of registrations of the multiplicand in the accumulator and to shift the accumulator from right to left after the multiplication by each multiplier digit to enable correct registration of the next ordinal product as well as to shift the pin carriage so that the next higher order rack **261** comes into controlling position with respect to the operation of the machine. In order to control the operation of the machine from the differentially adjusted position of racks **261**, means is provided for returning each adjusted rack step by step to its initial position and for controlling the number of registrations in the accumulator by such step by step return. The operation is successive from the adjusted rack of lowest order, shifting of the accumulator and the multiplier carriage being effected during the last step of movement of each rack to condition the machine for operation in the next higher order.

The operating mechanism for the racks **261** comprises feed pawl **331** (Figs. 10 and 11) which, with the pin carriage in its right hand position, is located one ordinal step to the left thereof as viewed in Fig. 9 under idler segment **592** described hereinafter. As each rack is adjusted by depression of a multiplier key and the pin carriage escapes one step to the left, the adjusted rack moves into alignment with the actuating pawl **331**. Thus, after the complete multiplier is set into the machine, the last adjusted rack **261** corresponding to the lowest digit of the multiplier will always be aligned with pawl **331** at the end of the multiplier setting operation. Pawl **331** (Fig. 11) is pivotally secured at **332** at the end of

arm 333 pivoted at 334 on side plate 45, pawl 331 being urged in a counterclockwise direction as viewed in Fig. 11 by spring 336 tensioned between a pin on arm 333 and lug 337 of pawl 331. Lug 337 engages beneath arm 333 to limit the movement of pawl 331 under the influence of spring 336. Pawl 331 is normally held in inactive position as shown in Fig. 11 by virtue of its upward extension 338 which is engaged by holding pawl 339 (Figs. 9, 10 and 11) secured at the end of shaft 341 pivoted in plate 45 and in multiplier plate 211. Pawl 339 is held in a manner later described in the position shown in Fig. 11 until depression of a multiplication operation key so that both feed pawl 331 and holding pawl 339 are maintained inactive until the multiplying operation is started.

In order to actuate pawl 331, arm 333 is pivotally connected to link 346 which extends rearwardly thru a suitable opening in bracket 50 and is pivoted at 347 (Figs. 11, 12 and 14) to actuating arm 348 pivotally mounted by stud 349 on plate 45. Arm 348 carries roller 351 journalled thereon for cooperative relation with actuating cam 352. Arm 348 (Fig. 11) is urged to the position shown through link 346 and arm 333 by spring 353 connected between the base and arm 333, the nose of arm 348 engaging bracket 50 to limit the movement of roller 351 towards cam 352. Cam 352 (Figs. 11, 12 and 14) is mounted on shaft 63 to be driven thereby and for endwise movement relative thereto, and for this purpose has a slotted hub 356 engaged by pin 357 secured in shaft 63. Cam 352 is normally urged to its inoperative position to one side of roller 351 as shown in Fig. 12 by spring 358 which is compressed between the cam and a suitable pin in shaft 63. At the beginning of a multiplying operation cam 352 is shifted into alignment with roller 351 as later described, whereby arm 348, link 346, arm 333 and pawl 331 will be reciprocated once by cam 352 for each subsequent rotation of the shaft 63.

The operation of pawl 331 occurs immediately at the beginning of each cycle as will be apparent from the direction of rotation of cam 352 as indicated in Fig. 11 and the relation of the high point of cam 352 to roller 351. Racks 261 are always actuated through one step more than the values to which they are set to provide for the shift cycle at the end of each series of digitations. However, each rack is provided with twelve teeth because of the spacing of pawls 331 and 339 two teeth apart, so that each pawl can be operatively associated with ten teeth of the rack. The last upward movement of the active rack at the end of its return to normal position enables holding pawl 269 to move into operative position relative to the associated rack 261, as well as to control and determine shifting of the accumulator and the pin carriage to align the next rack 261 with the pawl 331 as later described.

Multiplication keys.—(Figs. 1, 9, 16, 17, 23, 24 and 27; Sheets 1, 6, 10, 12, 13 and 15). The conditioning of the machine for the multiplying operation as controlled by the multiplication operation keys will now be described. When one of keys 36 or 37 (Fig. 1) is depressed and latched in depressed position, several functions of the machine are set into operation including enabling of the control which determines the sign character of the registration of the product, enabling of the power set means for operating the sign character control, enabling of the drive for actuating cam 352 for the racks, enabling of feed pawl 331 for the rack sectors, enabling the centralizer which is operative during multiplying operations only for controlling the position of the add-subtract gate, engaging of the clutch and enabling of the motor circuit. The mechanisms performing these functions in their relation to the multiplication keys 36 and 37 will now be described.

Keys 36, 37 (Figs. 16, 23 and 27) are mounted for endwise sliding movement in keyboard plates 206, 207 and are urged to raised position by respective springs 371 disposed in the slotted key stems and compressed between each key and lower plate 207. The raised positions of the respective keys is determined by respective latch arms 372 (Figs. 16 and 27) thereof engaging the under face of upper plate 206. At their outer ends, latch arms 372 are provided with latching teeth 373 and 374 for engagement with a single latching tooth 376 on latch lever 377 secured on transverse shaft 378 which is pivoted in keyboard plates 211 and 212. Latch lever 377 is urged in a clockwise direction as viewed in Fig. 27 to maintain tooth 376 in latching position by spring 379 tensioned between plate 211 and the lower end of lever 377. The lower end of lever 377 is also operatively related with arm 382 (Figs. 9 and 27) of bellcrank 291 whereby the latch for the depressed key 36 or 37 is released at the end of the multiplying operation as later described. Depression of either key 36 or 37 to effect engagement of latching tooth 376 with latching tooth 374 is sufficient to enable interlock means associated with the keys, whereby full depression of key 36 or 37 is enforced before the machine can be used after partial depression of either of the multiplication keys.

To prevent simultaneous depression of keys 36 and 37 (Fig. 27), the keys carry respective pins 383 for cooperation with opposite inclined faces 384 of interlocking slide 385 which is mounted for endwise movement on plate 211 by suitable studs. Slide 385 is held in the central position shown by vertically disposed spring 386 extending between spaced pins 387 on slide 385. When one of keys 36 or 37 is depressed, the upper flat edge of slide 385 is positioned below pin 383 of the other key, so that both of keys 36 and 37 cannot be depressed at the same time.

Registration sign character control—(Figs. 2, 9, 10, 12, 23, 24 and 32; Sheets 2, 6–8, 12, 13 and 17). Means are provided under control of the multiplication keys for selecting the sign character of the registration of the product in the accumulator to be positive if key 36 is depressed, and to be negative if key 37 is depressed, such means being enabled by depression of the selected key and subsequently operated by power means also enabled by depression of either multiplication key. Pins 383 (Figs. 9 and 23) of keys 36 and 37 extend thru plate 211 and engage in respective slots of the forward ends of levers 391 and 392 respectively, which are guided with respect to plate 211 by bracket 393 thereon, and which are offset laterally intermediate their ends to extend thru plate 211 (Fig. 9) and have their hubs 394 and 395 pivoted on shaft 396 extending between plates 211 and 45.

Lever 391 (Figs. 9, 10, 23 and 24) has its rearward end connected by spring 401 with arm 402 which is pivoted at 403 to power operating means therefor in the form of bellcrank 404 pivoted at 405 on plate 45. Arm 402 is urged upwardly by spring 401 against roller 409 on downwardly extending end 410 of lever 391. At its rearward upwardly offset end, arm 402 has notch 406 for

engagement with pin 407 at the upper end of lever 408 secured at the end of transverse shaft 79, whose rocking movement, as previously described, moves gate 77 (Fig. 2) to control the engagement of the plus-minus gears with the numeral wheel gears and determine the sign character of the registration.

Normally, notched end 406 of arm 402 is maintained below pin 407 by the engagement of arm 402 with roller 409 on lever 391 as shown in Fig. 23, but can move to active position in engagement with pin 407 under the influence of spring 401 when key 36 is depressed to move lever 391 to active position as shown in Fig. 24. Similarly, the rearward end of lever 392, which is associated with minus multiplication key 37, is connected to and controls arm 411 (Figs. 9 and 23) pivotally connected at 403 to actuating arm 404 and having downwardly offset notched end 412 for engagement with pin 413 at the lower end of lever 408. Thus, it will be noted that depression of key 36 as illustrated in Fig. 24 rocks arm 391 to raise the rearward end thereof to allow notched end 406 of arm 402 to move into engagement with pin 407, whereby upon counterclockwise movement of bellcrank 404, lever 408 and shaft 79 will be moved to mesh the plus gears with the numeral wheel gears. Similarly, if key 37 is depressed, lever 392 serves to control the engagement of notched end 412 of arm 411 with pin 413 thereby conditioning the plus-minus control mechanism to determine negative registration of the product in the accumulator.

As previously explained, the actual setting of the plus-minus gears is effected by power, and for this purpose actuating bellcrank 404 carries roller 421 (Figs. 12, 23 and 32) for engagement with power setting cam 422 slidably and nonrotatably mounted on shaft 63 by pin 424 engaging slotted hub 423 of the cam. Cam 422 is normally urged to inactive position as shown in Fig. 12 by spring 426 compressed between the cam and washer 427 on shaft 63.

Means are provided for enabling the power setting cam 422 upon depression of either of keys 36 or 37, and such means may comprise lever 431 (Figs. 23 and 32) pivoted at 432 on ear 433 of plate 211, and having roller 434 at its upper end engaging the face of cam 422. At its lower end, lever 431 is beveled to engage offset end 436 of lever 437 pivoted at 438 on plate 211 and having its forward end underlying roller 439 on lever 441 which is similar to the levers 391 and 392, and is similarly pivoted by its hub 442 (Fig. 9) on shaft 396. The front end of lever 441 (Fig. 23) also carries roller 443 which underlies both of levers 391 and 392 whereby depression of either lever serves to move the front end of lever 441 downwardly, and operate lever 437 to rock lever 431 and move power set cam 422 to active position, where it will remain while the operation key is latched in depressed position.

Cam 422 rotates in the direction of the arrow in Fig. 23 so that bellcrank 404 will be actuated immediately at the beginning of each cycle and the proper plus-minus gears meshed upon initial rotation of the actuating means and before registration is started in the accumulator.

Means is provided for latching power setting bellcrank 404 and thereby the plus-minus gears in active position, and such means may comprise latch arm 451 (Fig. 23) pivoted at 452 on plate 45 and having notched lower end 453 for engagement with offset ear 454 of bellcrank 404 under the influence of spring 455 to maintain bellcrank 404 in active position where its lower end is moved away from stop 456 which may be adjustably mounted on plate 45 in any suitable manner. The latch arm can be moved to inactive position by arm 566 in a manner later described.

From the above description it will be seen that the plus-minus gear control means is moved to active position by power derived from the clutch, and is held resiliently in such active position. For example, arm 402 is held in engagement with lever 408 by the tension placed on spring 401 by the lever 391. As later described, this yieldable positioning of the plus-minus control means provides for temporary disabling thereof, and for movement of the plus-minus gears to their central inactive position during carriage shifting.

Plus-minus centralizing means—(Figs. 9, 10, 23 and 24; Sheets 6, 7, 12 and 13). Depression of a multiplication key also enables resilient centralizing means for the plus-minus gate to provide for movement of the plus-minus gears to their central inactive position during shifting of the accumulator carriage. Such centralizing means may comprise opposed pawls 461 (Figs. 9, 10 and 23) pivoted at 462 on slide 463 which is slotted for adjustable connection to the slotted rearward end of lever 441 by fastening bolts 464. Pawls 461 are connected and urged together by spring 467 to engage opposite sides of lug 466 which projects upwardly from slide 463 and is interposed therebetween. As shown in Fig. 23, centralizing pawls 461 are normally positioned below pin 407 but may be moved into operative relation therewith as shown in Fig. 24 upon depression of key 36 and the resultant rocking movement of lever 441. The same operation will also occur upon depression of key 37. From the above description, it is seen that pawls 461, when in active position, resist movement of lever 408 and gate 77 from their central inactive position. Also, after adjustment of either the plus or minus gears to active position, pawls 461 provide a bias tending to return them to inactive position.

Multiplier feed enabling mechanism—(Figs. 9–12, 14 and 23; Sheets 6–9 and 12). To enable drive cam 352 for feed pawl 311 and thereby determine restoring racks 261 to their zero positions upon depression of a multiplication key, bellcrank 471 (Figs. 9, 11, 12 and 14) is pivoted at 472 on bracket 50, the vertical arm of the bellcrank being provided with roller 473 engaging the face of cam 352 while the horizontal arm of the bellcrank lies under offset end 474 of lever 475 pivoted at 476 (Figs. 9 and 10) on plate 45 and having bent rearward end 477 overlying similar projections 478 on levers 391 and 392. From the above description, it will be apparent that upward movement of the rearward end of either of levers 391 or 392 will rock lever 475 and bellcrank 471 to move cam 352 to active position.

To enable feed pawl 331 for racks 261, shaft 341 (Fig. 9) which carries holding pawl 339, extends thru plate 211 (Fig. 23) and carries lever 481 which is urged in a counter-clockwise direction by spring 493 secured thereto and to an ear of arm 494. Arm 494 is secured to lever 437 for movement therewith and for adjustment relative thereto by a pivotal connection at 438 and by an adjustable pin and slot connection at 495. At its upper end arm 494 carries "live" pawl 496 pivoted thereon at 497 and having offset ear 498 which overlaps the upper end of arm 494 and is connected thereto by spring 499. It will be recalled that lever 437 is moved in a clockwise direction

on depression of either of keys 36 and 37, so that arm 494, pawl 466, and lever 481 will be moved similarly, with pawl 496 serving to hold lever 481 resiliently in its adjusted position. The rocking movement of arm 481 and shaft 341 in a clockwise direction as viewed in Fig. 23 corresponds to counter-clockwise movement of shaft 341 and holding pawl 339 in Fig. 11 so that holding pawl 339 and actuating pawl 331 can both move to active position in engagement with an aligned rack 261. Thus, depression of either of multiplication keys 36 or 37 provides for enabling of both pawls 331 and 339, as well as enabling the drive for pawl 331.

Drive control means—(Figs. 5, 6, 23 and 24; Sheets 3, 4, 12 and 13). To engage the clutch and enable the motor circuit upon depression of either of keys 36 or 37, transversely extending shaft 487 (Figs. 5 and 23) is pivoted in frame plates 45, 46, 212 and 211. At its left end adjacent plate 211, shaft 487 (Fig. 23) carries bellcrank 486 having one end slotted at 491 to engage pin 492 on lever 441, so that upon depression of either of keys 36 or 37, and the consequent downward movement of lever 441, bellcrank 486 and shaft 487 will be oscillated in a counterclockwise direction from the position shown in Fig. 23 to that shown in Fig. 24. Adjacent its right end (Fig. 5) shaft 487 carries upwardly extending arm 501 which is forked at its upper end to engage pin 502 (Figs. 5 and 6) on clutch slide 101 (Fig. 6). It will be recalled that movement of clutch slide 101 to the left in Fig. 6 serves to engage the clutch and enable the motor circuit whereby the multiplying operation will start. Thus, upon depression of either of multiplication keys 36 or 37, clutch slide 101 is operated to enable the cyclically operable drive means.

As the machine starts to turn over, cam 422 (Fig. 24) becomes operative thru bellcrank 404 and arm 402 to rock lever 408 and shaft 79 and thereby engage the plus gears with the numeral wheel gears and determine positive registration. Latch arm 451 becomes active upon rocking movement of bellcrank 404 to maintain the parts in active position. At the same time, feed pawl 331 (Fig. 11) and its drive mechanism become active to start the return of the aligned rack 261 from the position shown in in Fig. 13, for example, to that shown in Fig. 11. As previously pointed out, the step-by-step return of rack 261 includes the number of steps of movement corresponding to the adjusted position thereof, at the end of which it is given an overistroke beyond its zero position where holding pawl 269 becomes active to enable the shifting means for both the accumulator and for the multiplier pin carriage.

Accumulator shift control—(Figs. 9–11, 23 and 25; Sheets 6–8, 12 and 14). At the end of an ordinal multiplying operation, means is brought into play as explained above by the overstroke of the active multiplier segment to engage the shift for the accumulator carriage, and the same means serves during the next to the last step of movement of the rack for conditioning the plus-minus control to restore the plus-minus gears temporarily to neutral position during the shifting operation.

For this purpose shift control lever 546 (Figs. 9 and 10) has its hub 546A pivoted on rod 547 between plate 211 and plate 45. The forward end of lever 546 includes spaced arms connected at their ends by hub 546A and boss 546B respectively, and boss 546B carries integral upstanding plate 546C to which plate 548 is secured by suitable screw and slot connections for endwise adjustment. Plate 548 has forwardly extending lip 548A which overlies the upper end of the active rack 261 so as to be actuated thereby in two successive steps, one step at the beginning of the next to last cycle of an ordinal multiplication, and the other step at the beginning of the last or shift cycle. Referring to Fig. 24, it will be noted that depression of multiplication key 36 serves through lever 391 to allow upward movement of one of plus-minus setting arms 402 or 411 (Figs. 23 and 24) which will act thru laterally projecting pin 555 on lever 546 to rock lever 546 in a clockwise direction from the position shown in Fig. 23, whereby lip 548A (Fig. 10) at the forward end thereof is moved downwardly to be engaged by the aligned rack 261 as it returns to zero position, i. e. during the cycle before the overstroke of the rack, and restored to its normal position shown in Fig. 23. This movement serves to delatch and disengage the means for holding the plus-minus gears in active position, arm 402, for example, being moved downwardly from the position shown in Fig. 24 to that shown in Fig. 23. Auxiliary latch means is provided, however, to prevent movement of the plus-minus gears to inactive position until the end of the cycle. Subsequently, at the beginning of the shift cycle, the plus-minus gears are centralized positively, the power setting bellcrank 404 is delatched and the accumulator and pin carriage shift mechanisms are enabled.

Means is provided for retaining control of the plus-minus gears during the last actuating cycle of an ordinal multiplication when the next to last step movement of the multiplier rack occurs, during the interval between the disengagement of the power setting arm and the end of the cycle of operation then in progress. For this purpose, shaft 79 (Fig. 11) has arm 571 clamped thereon having reduced upper end or tooth 572 which, in the neutral position of shaft 79, is in end to end engagement with corresponding tooth 573 on latch lever 574 pivoted at 576 on bracket 577 and urged by spring 578 in a clockwise direction. At its forward end, latch lever is provided with laterally extending ear 579 for cooperative engagement with cam arm 581 (Fig. 25) on one of shafts 61. The position of cam arm 581 is such that lever 574 is free to move under the influence of spring 578 to engage tooth 573 to one side of tooth 572 at the beginning of each cycle of operation if a registration is determined, and will be rocked to inactive position by cam arm 581 near the end of the cycle after the digitation and transfer operations are completed. Thus, in a multiplying operation, latch lever 574 moves to active position immediately before control lever 546 is operated and remains in engagement until just prior to the end of the last digitation cycle of the ordinal multiplying operation then in progress, and is moved to inactive position at the beginning of the shift cycle.

To provide for positive centralizing of the plus-minus gears at the time a shifting operation is initiated, the rearward end of lever 546 has adjustably mounted thereon, by means of pin and slot connections 549, a centralizing extension 551 having socket 552 formed between converging cam surfaces 553 overlying pin 407, whereby counterclockwise movement of lever 546 will serve to restore lever 408 and the plus-minus gears to their neutral position.

To initiate operation of the accumulator shift mechanism, boss 546C of lever 546 (Fig. 11) car-

ries pin 556 which is engaged in slot 557 of link 558. At its lower end, link 558 is pivotally connected to arm 559 secured on transversely extending shaft 561 suitably pivoted in plates 45, 212 and 46. Shaft 561 (Fig. 2) also carries arm 562 which has laterally extending pin 563 operatively related with control arm 154 for the shift mechanism whereby rocking movement of lever 546 as a result of the overstroke movement of the active rack 261 (Fig. 11) operates through link 557, arm 559, shaft 561, and arm 562 to engage the shift mechanism to initiate shifting of the accumulator carriage in the manner previously described.

At the time the shift is initiated, means is also provided to disable the latching holding power setting bellcrank 404 for the plus-minus gears in adjusted position, and for this purpose shaft 561 (Fig. 10) may carry latch release arm 566 which is normally held by spring 568 against stop 567 adjustably mounted on plate 45. When latch lever 451 moves to active position, roller 569 thereon moves into operative relation with latch release arm 566, so that when shaft 561 is rocked to initiate the shift, arm 566 engages roller 569 on latch 451 to move the latch to inactive position, whereby bellcrank 404 and the associated parts can return to the position shown in Fig. 23. Shaft 561 and lever 546 are maintained active during the first part of the shift cycle until the nose of cam 422 has moved past roller 421.

Multiplier carriage shift.—(Figs. 1, 9, 10, 11, 18, 25 and 26; Sheets 1, 6–8, 10 and 14). In order to effect shifting movement of the multiplier or pin carriage, the carriage is provided with laterally extending rack 511 (Figs. 10, 11, 25 and 26) for step-by-step actuation by normally inactive toothed shift actuator or lever 512 (Figs. 25 and 26) in cooperation with a portion of the escapement shift mechanism previously described. Shift lever 512 is apertured to engage eccentric portion 513 of shiftable collar 514 slidably and non-rotatably mounted on vertically extending shaft 516 journalled in brackets 517 and 518 (Fig. 25) secured on plate 212 and cross plate 50, respectively. The upper end of shaft 516 has bevel gear connection 519 with transverse clutch driven shaft 63, whereby the multiplier carriage shift is driven in cyclic time with the other driven mechanisms of the machine. Shift lever 512 is also guided in its movement by the engagement of slot 521 (Figs. 25 and 26) thereof with pin 522 on bracket 517.

Upon rotation of shaft 516 and collar 514, the tooth of shift lever 512 will become effective if moved to active position to move rack 511 and the pin carriage one step toward the right of the machine for each rotation of clutch driven shaft 63. The shifting of the pin carriage is effected against the urgency of spring pressed bellcrank 291 (Fig. 9) and the carriage is retained in position after each shifting movement by escapement pawl 301 (Fig. 18) whose inclined edge will be engaged and cammed down by the adjacent tooth 246 to the right thereof during each step of movement. Thus, the escapement shift mechanism provides the means for maintaining the pin carriage in position after a power shift, and the power shifting moves bellcrank 291 (Fig. 1) to re-energize spring 294 for a subsequent carriage escapement operation when the next multiplier value is set into the machine.

Shift lever 512 is normally in inactive position below rack 511 as shown in Fig. 25, and can be raised to operative position by arm 526 secured on transverse shaft 561 and having pin 528 engaging annular groove 529 in the collar 514. It will be recalled that shaft 561 is oscillated by the overstroke of the active multiplier rack 261, so that the pin carriage shift is enabled simultaneously with the accumulator carriage shift.

Means are provided for latching shift lever 512 in active position for substantially one cycle of operation of the machine. The latching means may comprise latch lever 530 pivoted at 531 on plate 212 and having nose 532 disposed for engagement under the bent end of lever 526 in the raised position thereof under the influence of spring 533, which also serves to urge lever 526, collar 514 and shift lever 512 to inactive position. The upper end of lever 530 has offset ear 534 operatively related to eccentric cam 535 on shaft 516. Cam 535 is related to lever 530 to effect delatching of lever 526 and thereby allow movement of shift lever 512 to inactive position at the end of the rotation in which it was moved to active position.

From the above description it is seen that at the end of each ordinal multiplication, the pin carriage is shifted one step simultaneously with the accumulator carriage to bring the multiplier rack 261 of next higher order into active position.

Pin restoring means.—(Figs. 9, 22, and 25; Sheets 6, 11 and 14). The shifting movement of the pin carriage during a multiplying operation is utilized to bring into play means for restoring an actively set pin to inactive position after it has served its purpose as a stop for the associated multiplier rack. The restoring means comprises a plurality of restoring fingers 541 (Figs. 9, 22, and 25) which are aligned with slots 254 in the pins so as to enter the slots when the pin carriage is in its inactive right hand position. Each finger 541 is provided with reduced end 542 from which cam surface 543 extends to the full width head of the finger whose width is substantially equal to the length of the slots 254. The width of end 542 is reduced to enable setting of a pin aligned therewith as shown for example in dotted lines in Fig. 22. It will be seen that shifting movement of the pin carriage to the right will serve to move the pin downwardly from the dotted to the full line position shown in Fig. 22.

Restoring fingers 541 are so related to the position of the pin carriage that they become active to restore a pin to neutral position on the first step of movement of the pin carriage immediately after such pin and its associated rack 261 have controlled an ordinal multiplying operation. The last step of a multiplying operation involves an idle shifting of the pin carriage to restore the set pin of the highest order pin row. When the last or lowest order rack 261 is returned to zero, the shift control is again operated in to produce an idle shifting movement of the pin carriage to reset the pin of the last row and to move arm 382 of bellcrank 291 to disable latch arm 377 and release the depressed multiplication key 36. In this position, tooth 548 (Fig. 10) is positioned over upper end 591 of idler segment 592 which is pivoted on shaft 590 and spring-urged in a counterclockwise direction by spring 593, the extent of movement being controlled by slot 594 engaged with tie rod 235 of the pin carriage frame. Segment 592 has single tooth 595 operatively aligned with actuator pawl 331, whereby depression of multiplication key with no multiplier set merely results in an idle cycle of the machine, the key being immediately delatched.

Multiplier correction means—(Figs. 1, 2, 5, 9, 23 and 28; Sheets 1–3, 6, 12 and 15). If the multiplier is set incorrectly in the multiplier racks **261** and it is desired to remove the multiplier setting without changing the registration in the accumulator or revolutions counter, means are provided for restoring the rack segments of the multiplier unit to zero under control of correction key **38** (Figs. 1, 9 and 28), whose depression enables the drive mechanism, and the actuating and shifting mechanism for the multiplier or pin carriage. Key **38** is mounted for vertical sliding movement in plates **206**, **207** similarly to keys **36** and **37** and at its lower end has pin **601** engaged with the slotted upper end of lever **602** pivoted at **603** on plate **212**. Lever **603** has pin **604** operatively related to arm **606** on shaft **487**, whereby upon depression of key **38**, the clutch is engaged and the motor circuit enabled through arm **501** (Fig. 5) in the manner previously described.

It will be recalled that feed pawl **331** and the drive therefor are enabled by movement of lever **481** (Fig. 23). To effect this control from key **38**, lever **481** is provided with ear **482** lying under the upper end of lever **483** pivoted at **484** on bellcrank **486** secured on shaft **487** adjacent plate **211**. Lever **483** is urged in a counterclockwise direction by spring **488** tensioned between an end of lever **483** and a lug on bellcrank **486**, offset ear **489** on lever **483** being provided for engagement with bellcrank **486** to limit such movement. Thus, rocking movement of shaft **486** upon depression of key **38** also serves to operate bellcrank **481** to move actuating and holding pawls **331** and **339** into operative relation with respect to the aligned rack **261**. As previously described, the upper arm of bellcrank **486** is slotted at **491** to engage pin **492** on lever **441** so that downward movement of the front end of lever **441** will move bellcrank **486** in a counterclockwise direction upon depression of either of keys **36** or **37**. However, the flatted construction of pin **492** enables movement of bellcrank **486** under control of key **38** without operating lever **441**.

To enable the drive for actuating pawl **331** upon depression of key **38**, rearward end **607** (Figs. 14 and 28) of lever **602** underlies horizontal arm **608** of bellcrank **609** pivoted at **610** on bracket **50** and having upwardly extending arm **611** overlying bellcrank **471**, whereby movement of lever **602** moves feed cam **352** to active position. At the same time a depending bent arm **612** of bellcrank **609** is connected at **613** with slide **614** on shaft **561** (Fig. 2) which is connected to the hub of arm **562** whereby arm **562** is moved out of alignment with accumulator carriage shift control arm **154** so that the shift for the accumulator carriage is disabled. With the above condition of the parts it will be understood that the operation insofar as restoring of racks **261** to zero position and shifting of the multiplier or pin carriage to its normal position will proceed in the same manner as in a multiplying operation, however, no registrations will occur in the accumulator or revolutions counter and no shifting of the accumulator carriage will take place. Key **38** is latched in depressed position by latch arm **616** (Figs. 9 and 28) on shaft **378** and is released in the same manner as keys **36** and **37**.

To prevent simultaneous depression of multiplier correction key **38** (Fig. 28) and return and clear key **30***a*, interlocking locking lever **631** pivotally mounted at **632** on plate **207** for cooperation with respective ears **633** on keys **38** and **30***a*.

MULTIPLYING OPERATION

As explained previously, the machine is conditioned for a multiplication by setting the multiplicand on the numeral keys **22** (Fig. 1) and by depressing the multiplier keys **34** successively from the highest to the lowest order of the multiplier digits to set the multiplier and to cause display thereof on the dials **35**. As illustrated in Fig. 1 the dials **35** are all visible through the sight opening **272** which condition is obtained by repeated depression of zero multiplier key **34A** to effect escapement of the multiplier carriage so that all of the dials **35** are aligned with the sight opening. However, during setting of a multiplier figure only the number of dials **35** corresponding to the number of digits in the multiplier figure will be seen through sight opening **272**.

The operation of setting the multiplier into the machine will be described first, and it will be recalled that upon depression of one of multiplier keys **34** (Figs. 1, 11 and 13), means are brought into play to release the multiplier rack segment **261** which is operatively related to the keyboard selection mechanism, to set a stop therefor, corresponding to the differential value of the depressed multiplier key, and to operate the carriage escapement mechanism so that the multiplier carriage will move one step to the left as viewed in Figs. 1 and 9 to move the highest order rack segment **261** into alignment with sight opening **272** where its indicator dial **35** will display a figure corresponding to the differentially adjusted position of the rack segment. As seen in Fig. 13, depression of a multiplier key **34**, as illustrated by the number "6" key, serves to move rod **286** downwardly to oscillate lever **282** which, thru link **281**, oscillates arm **276** so that its upper end **278** moves the aligned holding pawl **269** to inactive position to release the associated rack segment **261**.

At the same time that the rack segment **261** is released, the lower end of the depressed key **34** (Figs. 11 and 13) operates the corresponding selection lever **216** so that the pin **251** of the aligned pin row corresponding to the value of the depressed key is moved to active position as shown in Fig. 13 to provide a stop for rack segment **261** and thereby control the differential positioning thereof. The pin setting operation occurs only upon depression of the "1" to "8" keys. If the "9" key is depressed, the only action required is the release of the rack segment, which moves to its fullest extent when the end of dial portion **35** thereof is engaged with U-shaped bar **234**, as shown most clearly in Fig. 21.

To operate the escapement mechanism, the depression of a multiplier key operates thru rod **286** (Figs. 11, 13, 16 and 18) to rock pawl arm **303** downwardly whereby stop pawl **301** is moved from the active position shown in Fig. 18 to its inactive position shown in Fig. 19, and tooth **317** is moved downwardly into holding position permitting a partial step movement of the multiplier carriage under the influence of spring-urged bellcrank **291** (Fig. 11) to position one of teeth **246** over the upper end of stop pawl **301** as shown in Fig. 19. This partial step movement occurs simultaneously with the setting of the pin and the release of the rack and does not affect the cooperative relation of the parts. Subsequently, when the depressed multiplier key is released and moves to its upper position, tooth **317** moves upwardly to inactive position and permits further movement of the multiplier carriage until pawl **301** engages the next adjacent tooth **246** at the

completion of the one step movement of the multiplier carriage. Before tooth 317 releases the multiplier carriage, finger 222 of the active selection lever 216 and end 278 of pawl releasing arm 276 are retracted to normal position out of the path of movement of the cooperating parts on the multiplier carriage.

The above operation occurs each time a multiplier key 34 is depressed so that the entire multiplier figure is set-up and the multiplier carriage is moved to the left from the position shown in Fig. 9 a number of steps corresponding to the number of digits in the multiplier figure. At the end of the multiplier setting operation, the last adjusted rack segment 261 is in active relation to the actuating mechanism therefor, i. e., in alignment with holding pawl 339 (Fig. 9).

It is to be noted that the setting of the multiplier figure into the machine does not involve any power operation, so that in performing successive multiplying operations, the operator can depress one of the carriage return and clear keys 30 or 30a and then proceed to set the next multiplier figure into the machine while the carriage and clear mechanism is operating to normalize the machine. In this manner the successive normalizing and multiplying operations can be overlapped.

With the multiplier set into the machine as described, the operator starts the multiplying operation in either a positive or negative fashion by selective manipulation of the multiplication keys 36 and 37. The operation will be described in connection with a positive multiplying operation, and it will be understood that the operation will be similar if the negative multiplication key 37 is depressed. Depression of a multiplication key selects the sign character of the registration, enables power driven means for moving the sign character controlling means to active position, enables the feed mechanism for restoring the multiplier rack segments to normal position as well as the drive mechanism therefor, and also moves a centralizer into active position with respect to the plus-minus gears, as well as conditioning the control for terminating an ordinal multiplying operation to be actuated by the active multiplier rack segment during its restoration to inactive position. The depressed multiplication key also serves to engage the clutch which provides the sole path of power flow from the motor and to enable the motor circuit so that the multiplying operation will be started.

Figure 23 illustrates the multiplying control means with the parts thereof in their inactive positions, while Fig. 24 shows the positions thereof immediately following depression of multiplication key 36 and before the drive begins, key 36 being latched in depressed position by latch lever 377 (Fig. 27) which is engaged with upper tooth 373 on the key.

As shown in Fig. 24, depression of key 36 oscillates lever 391 in a clockwise direction to carry out the various controls exercised by the key. To enable the sign character controlling means, the oscillation of lever 391 moves roller 389 thereon upwardly so that plus setting arm 402 is also moved upwardly under the influence of its spring 401 to engage its notched end 406 with pin 407 of lever 408 on shaft 79 which controls the setting of the plus-minus gears. At the same time, arm 402 oscillates control lever 546 so that its forward end is moved downwardly into active position with respect to the associated rack segment 261 to be engaged thereby as described hereinafter.

Oscillation of lever 391 upon depression of key 36 also rocks lever 441 whereby centralizing pawls 461 are moved to active position, and at the same time, lever 441 thru roller 439 actuates lever 437 so that its rearward end 436 (Figs. 24 and 32) oscillates lever 431 to move cam 422 laterally into alignment with roller 421 on power setting bell crank 404. Thus, when the drive begins, bellcrank 404 will be oscillated and operate thru arm 402 to move the plus gears to active position.

To enable the feed mechanism for the rack segments, oscillation of lever 437 (Figs. 23 and 24) operates thru arm 494 to oscillate bellcrank lever and shaft 341 (Fig. 24) whereby respective actuating and holding pawls 331 and 339 (Fig. 11) are permitted to move inwardly to active position with respect to the associated rack segment 261 under the influence of spring 336. To enable the drive for feed pawl 331, the upward movement of arm 402 (Figs. 9 and 24) is active to rock lever 475 (Figs. 9 and 14) so that bellcrank 471 moves cam 352 into alignment with roller 351 on actuating arm 348 for feed pawl 331.

The operation of setting the above parts occurs before the machine begins to turn over, i. e., immediately before engagement of the clutch and closing of the motor circuit. The latter operations are effected by the oscillation of shaft 487 (Figs. 23 and 24) carrying bellcrank 486 which is rocked through pin 492 and lever 441 upon depression of key 36. Shaft 487 (Fig. 5) carries arm 501 which operates thru pin 502 (Figs. 5 and 6) to move clutch slide 101 to active position and thereby effect engagement of the clutch and enabling of the motor circuit in the manner previously described.

Immediately after the machine begins to turn over power setting cam 422 (Figs. 23, 24 and 29) becomes operative to enable the plus gears by moving bellcrank 404, arm 402, and lever 408 from the positions shown in Fig. 24 to those shown in Fig. 29, where they are latched in active position by the engagement of latch arm 451 with bellcrank 404. Such rocking movement of lever 408 rocks shaft 79 (Fig. 2) to mesh plus gears 72 with numeral wheel gears 74. This operation occurs before the actuating means becomes effective to start the digitation operation. Substantially in time with the operation of setting cam 422, and before the digitation operation begins, pawl 331 (Fig. 11) becomes active to advance the aligned rack segment 261 one step in a counterclockwise direction from its adjusted position, for example, that shown in Fig. 13. This one step advance of the active rack segment occurs during each successive cycle of the machine, i. e. during each rotation of the clutch, so that the number of successive digitations in each ordinal position of the accumulator carriage will correspond to the displaced position of the corresponding rack segment 261 from its normal position, i. e. the number of steps of movement required to engage control lever 546 for terminating an ordinal multiplication.

The control for ending each ordinal operation is exercised at the beginning of the last ordinal actuating cycle to condition the parts for a shift cycle, at the beginning of the ensuing shift cycle to initiate the shifting operation. During the last ordinal actuating cycle, i. e. when the active rack segment is given its next to last step of movement, the upper end of the rack segment 261 engages plate 548 to oscillate control lever 546 from the position shown in Fig. 29 to that shown in Fig. 30 whereby centralizing arm 551 is moved

to active position, and moves arm 402 to inactive position. Although arm 402 is moved to inactive position, lever 408 and the plus gears are maintained in active position during the last actuating cycle, by the operation of latch lever 574 (Fig. 11) whose tooth 573 is engaged to one side of tooth 572 before the control of arm 402 is disabled.

Immediately at the beginning of the last cycle of an ordinal multiplying operation, that is, the shift cycle, the active rack segment 261 is advanced by pawl 331 from its normal position shown in Fig. 30 when holding pawl 269 becomes active, to the overstroke position shown in Fig. 31 where control lever 546 is moved to its extreme position whereby centralizing arm 551 becomes active to move lever 408 and plus gears 72 to their neutral position before latch lever 574 is again lowered. The upward movement of the forward end of lever 546 at the beginning of the shift cycle also serves thru link 558 (Fig. 11) to rock shaft 561 to release the latch for the power setting means and to initiate the shifting operation.

Rocking movement of shaft 561 (Fig. 23) operates latch release arm 566 (Figs. 30 and 31) for latch lever 451 so that bellcrank 404 can return to the position shown in Figs. 24 and 31 after the high point of cam 422 has passed by roller 421.

As stated above, rocking movement of shaft 561 also serves to enable the shift for return of the multiplier carriage one step and to determine a one step shift of the accumulator carriage. To effect the one step shift of the multiplier carriage, shaft 561 (Fig. 25) carries arm 526 which moves shift lever 512 to active position with respect to rack 511 (Figs. 25 and 26) of the multiplier carriage, the tooth moving to inactive position at the end of the same cycle during which it was enabled by operation of latch release cam 535. During the shifting of the multiplier carriage, the last active stop pin 251 (Fig. 22) is moved from its active position shown in dotted lines to its inactive full line position by the associated resetting finger 541.

To enable the accumulator carriage shift, shaft 561 (Fig. 2) carries arm 562 which is operatively related to shift control arm 154 and rod 152 so that upon rocking movement of shaft 561 the shift drive connection associated with rod 152 is engaged and a one step shift of the carriage will occur.

At the end of the shift cycle, the shifted position of the multiplier carriage enables the next higher order rack segment 261 and, if it be adjusted to a value greater than "0," the control parts are again moved to the position shown in Fig. 29, and the digitation operation will start, as described above with respect to the highest multiplier rack segment 261. If a multiplier rack segment 261 is in its "0" position when it moves into active control position, a shift cycle is determined as the parts are positioned by the overstroke advance thereof by pawl 331 to the position shown in Fig. 31.

The operation continues as described above until the highest order rack segment 261 has been moved to its neutral or "0" position and the last cycle of the shift mechanisms occurs as described above to move the multiplier carriage to the position shown in Fig. 9. The last shift movement also causes bellcrank 291 (Figs. 1 and 9) to move into engagement with the lower arm of latch lever 376 for the depressed multiplication key 36, so that lever 376 is moved to inactive position and the multiplication key is released.

If a multiplication key 36 or 37 is depressed with the multiplier carriage in its inactive position, as shown in Fig. 9, actuating pawl 331 which is aligned with idler segment 591 (Figs. 9, 21 and 22) effects a one step movement thereof to operate control lever 546 similarly to the shift cycle control of a rack segment 261, whereby an idle shift cycle is initiated to effect release of the depressed multiplication key.

Multiplier Resetting Operation

As explained in the descriptive matter, when the operator has set an erroneous figure into the multiplier carriage, depression of the multiplier correction key 38 serves to restore the multiplier rack segments 261 to their zero positions without affecting the registration in the accumulator or the revolutions counter. This operation is identical with the multiplying operation described above except that the operative connections of the multiplier carriage and the mechanism thereon to the machine controls of the calculator are disabled so that no registration on or shifting of the accumulator will occur.

Referring to Fig. 28, it is seen that depression of multiplier correction key 38 serves to oscillate lever 602 which operates thru pin 604 and arm 606 to rock shaft 487, and thereby engage the clutch and enable the motor circuit in the same manner as previously described. The rocking movement of shaft 487 (Fig. 23) also serves thru arm 486 and lever 483 to rock lever 481 and enable the feed mechanism for restoring the rack segments 261 to normal position. The rearward end 607 of lever 602 (Figs. 14 and 28) underlies arm 608 of bellcrank 609 whose off-set upper end is moved to oscillate bellcrank 471 and move actuating cam 352 for the feed pawl to active position. To disable the accumulator shift control upon depression of key 38, the lower end of bellcrank 609 is operatively connected to slide 614 (Figs. 2 and 28) so that slide 614 is translated laterally on shaft 561 by movement of bellcrank 609 to move shift control arm 562 out of alignment with arm 154 so that the control for the accumulator shifting mechanism will not be operated by oscillation of shaft 561 in enabling the multiplier shift mechanism as described in the multiplying operation.

Subsequently, the operation of the machine proceeds in the same manner as described in connection with a multiplying operation, however, no registration can occur because the plus-minus gears have not been moved to active position and no change in the ordinal position of the accumulator can occur because the accumulator shift is disabled. At the end of the multiplier resetting operation, latch 616 for key 38 is disabled by the engagement of arm 382 of bellcrank 291 with latch lever 377 to rock the latch shaft 378 and latch lever 616 to release key 38 and thereby terminate the multiplier resetting operation.

While I have shown and described a preferred embodiment of my invention, it is to be understood that such invention is capable of both variation and modification from the form shown, and its scope, therefore, should be limited only by the scope of the claims appended hereto.

I, therefore, claim as my invention:

1. In a calculating machine, an accumulator, cyclically operable drive mechanism therefor having an invariable direction of operation, means for selecting the sign character of the registration on said accumulator by said drive mechanism, shifting means for said accumulator having a normally ineffective drive connection with said drive

mechanism, a multiplier carriage having ordinal differentially settable means for controlling a plural order multiplying operation, normally ineffective shifting mechanism for said multiplier carriage operated by said drive mechanism, means for restoring said differentially settable means sequentially and in step-by-step fashion from differentially adjusted position, said restoring means having a normally ineffective drive connection with said drive mechanism, control means for said shifting means and said shifting mechanism; said control means being associated with said multiplier carriage for successive operation by each of said differentially settable means during operation thereof by said restoring means, said control means being operated thereby at the beginning of an overstroke cycle of said step-by-step movement beyond the normal position of said differentially settable means to provide for shifting of said accumulator and said multiplier carriage during said overstroke cycle, and means for controlling setting of said sign character selecting means, for enabling the drive connection for said restoring means, and for initiating cyclic operation of said drive mechanism.

2. In a calculating machine, an accumulator, cyclically operable drive mechanism therefor, shifting means for said accumulator having a normally ineffective drive connection with said drive mechanism, a multiplier carriage having ordinal differentially settable means for controlling a plural order multiplying operation, normally ineffective shifting mechanism for said multiplier carriage operated by said drive mechanism, means for restoring said differentially settable means sequentially and in step-by-step fashion from differentially adjusted position, said restoring means having a normally ineffective drive connection with said drive mechanism, control means for said shifting means and said shifting mechanism; said control means being associated with said multiplier carriage for successive operation by each of said differentially settable means during operation thereof by said restoring means; and manually operable means for enabling the drive connection for said restoring means; for rendering said control means ineffective with respect to said accumulator shifting means, and for initiating cyclic operation of said drive mechanism.

3. In a calculating machine, an accumulator, cyclically operable drive mechanism therefore, shifting means for said accumulator having a normally ineffective drive connection with said drive mechanism, a multiplier carriage having ordinal differentially settable means for controlling a plural order multiplying operation, normally ineffective shifting mechanism for said multiplier carriage operated by said drive mechanism, means for restoring said differentially settable means sequentially and in step-by-step fashion from differentially adjusted position, said restoring means having a normally ineffective drive connection with said drive mechanism, control means for said shifting means and said shifting mechanism, said control means being associated with said multiplier carriage for successive operation by each of said differentially settable means during operation thereof by said restoring means, and a plurality of manually operable control keys for enabling the drive connection for said restoring means and for initiating cyclic operation of said drive mechanism, one of said keys being operatively related to said control means to render said control means ineffective with respect to said accumulator shifting means.

4. In a calculating machine for performing plural order multiplication operations having actuating means, a shiftable accumulator operatively related to said actuating means, cyclic drive means for said actuating means, and return and resetting means operated by said drive means for effecting shifting of said accumulator to a predetermined ordinal position thereof and for thereafter resetting said accumulator to zero registration; plural order multiplier selection mechanism, multiplier keyboard mechanism for effecting differential setting of said selection mechanism, drive mechanism for said selection mechanism having a drive connection with said cyclic drive means, and means for maintaining said drive mechanism normally disabled with respect to said selection mechanism, said selection mechanism being settable by operation of said keyboard mechanism during operation of said drive mechanism with said maintaining means effective whereby in successive multiplying operations a multiplier figure can be set in said selection mechanism during return and resetting of said accumulator.

5. In a calculating machine for performing plural order multiplication operations having actuating means, a shiftable accumulator operatively related to said actuating means, cyclic drive means for said actuating means; and return and resetting means operated by said drive means for effecting shifting of said accumulator to a predetermined ordinal position thereof and for thereafter resetting said accumulator to zero registration; plural order multiplier selection mechanism including a shiftable carriage and ordinal multiplier elements, escapement shift mechanism for said carriage, multiplier keyboard mechanism for setting said elements and operating said escapement shift mechanism; drive mechanism for said selection mechanism having a drive connection with said cyclic drive means, shifting means for said carriage having a drive connection with said cyclic drive means, and means for maintaining said shifting means and said drive mechanism normally ineffective with respect to said selection mechanism, whereby in successive multiplying operations a multiplier figure can be set in said selection mechanism during return and resetting of said accumulator.

6. In a calculating machine, numeral wheels, actuating means therefor, settable plus-minus gears movable in either direction from a central inactive position for establishing the drive for and determining the sign character of the registration on said numeral wheels, a gate for controlling the position of said plus-minus gears, a lever pivotally mounted intermediate its ends and operatively connected to said gate to effect movement thereof in opposite directions in accordance with the direction of rocking movement of said lever, normally inactive control means associated with said lever including a power driven cam and a member movable thereby having a pair of arms movably mounted thereon for cooperative engagement with said lever on opposite sides of the pivotal axis thereof, and plus and minus operation keys for initiating rotation of said cam and for selectively engaging said arms with said lever in accordance with the sign character of the depressed key.

7. In a calculating machine having an accumulator, actuating means therefor, means for controlling the sign character of registrations

on said accumulator, and means for shifting said accumulator relative to said actuating means; plural order multiplication mechanism for controlling successive registering and shifting operations during a multiplying operation, including normally inactive means for setting said sign character controlling means, manipulable means for moving said inactive setting means into operative position relative to said sign character controlling means, power driven means rendered effective by operation of said manipulable means for actuating said setting means to adjust said sign character controlling means, latch means associated with said setting means for maintaining said setting means and said sign character controlling means in actuated position, means for enabling said shift means at the end of each ordinal multiplying operation, and means controlled by said enabling means for moving said latch means and said setting means to inactive position during operation of said shifting means.

8. In a calculating machine having an accumulator, actuating means therefor, means for controlling the sign character of registrations on said accumulator, normally inactive means for setting said sign character controlling means, a control key for moving said inactive setting means into operative position relative to said sign character controlling means, power driven means rendered effective by said key upon operation thereof for actuating said setting means, and latch means associated with said setting means for maintaining said setting means and said sign character controlling means in actuated position.

9. In a calculating machine having an accumulator, actuating means therefor, means for controlling the sign character of registrations on said accumulator, normally inactive means for setting said sign character controlling means, a control key for moving said inactive setting means into operative position relative to said sign character controlling means, and power driven means rendered effective by said key upon operation thereof for actuating said setting means.

10. In a calculating machine, an accumulator, actuating means therefor, means for effecting relative shifting movement between said accumulator and said actuating means, a source of power, a clutch operatively related to said actuating means and said shifting means and providing the only path of power flow thereto from said source of power, said actuating means being connected for driving movement by said clutch during operation of said shifting means, multiplier mechanism for receiving a plural digit multiplier figure including a shiftable carriage and means for shifting said carriage, said multiplier mechanism being driven from said clutch and operatively related to said actuating means and said shifting means to control successive operation thereof by said clutch in accordance with the values of the successive multiplier digits, operation control means associated with said selection mechanism and said clutch for initiating a multiplying operation under control of said multiplier mechanism, said operation control means including a key depressible to engage said clutch, means for latching said key in depressed position, and means controlled by said carriage during the final step of shifting movement thereof for releasing said latching means at the end of a multiplying operation.

11. In a calculating machine for performing plural order multiplication operations, said calculating machine having actuating means, a shiftable accumulator operatively related to said actuating means, power driven cyclic drive means for said actuating means, and normalizing means cooperatively related to said accumulator for effecting resetting of said accumulator and for positioning said accumulator in a pre-determined position; plural order multiplier selection mechanism, multiplier keyboard mechanism for effecting differential setting of said selection mechanism, means having a normally disabled connection with said cyclic drive means for restoring said selection mechanism to zero position during a multiplying operation, said selection mechanism being settable under control of said multiplier keyboard during operation of said cyclic drive means whereby in successive multiplying operations a multiplier figure can be set in said selection mechanism during the normalizing of said accumulator.

12. In a calculating machine having an accumulator, actuating means therefor, selectively settable means for controlling the sign character of registrations on said accumulator by said actuating means, and means for shifting said accumulator relative to said actuating means; plural order multiplication mechanism for controlling successive registering and shifting operations during a multiplying operation, including selectively settable normally inactive means for controlling setting of said sign character controlling means, manipulable means for moving said settable means into operative position relative to said sign character controlling means, power driven means rendered effective by operation of said manipulable means for actuating said settable means to adjust said sign character controlling means, latch means associated with said setting means for maintaining said setting means and said sign character controlling means in actuated position, means for enabling said shifting means at the end of each ordinal multiplying operation, means controlled by said enabling means for moving said latch means and said settable means to inactive position during operation of said shifting means, and means brought into play during the operation of said shifting means for again causing operation of said settable means by said power driven means at the end of the shifting operation.

13. In a calculating machine having an accumulator, actuating means therefor, means for controlling the sign character of registrations on said accumulator, and means for shifting said accumulator relative to said actuating means; plural order multiplication mechanism for controlling successive registering and shifting operations during a multiplying operation, including normally inactive means for setting said sign character controlling means, manipulable means for moving said setting means into operative position relative to said sign character controlling means, a yieldable connection between said manipulable means and said setting means, power driven means rendered effective by operation of said manipulable means for actuating said setting means to adjust said sign character controlling means, and means operated at the end of an ordinal multiplying operation to cause a yielding of said yieldable means to render said setting means ineffective.

14. In a calculating machine, having an accumulator, actuating means for said accumulator, means for shifting said accumulator relative to said actuating means, means for controlling the sign character of registrations on said accumulator, and power driven means for operating said

actuating means and said shifting means; multiplication mechanism including multiplier selection mechanism having a plurality of differentially settable elements shiftable ordinally as a unit for controlling multiplying operations, means for restoring said settable elements sequentially to zero position, mechanism for shifting said differentially settable elements, means for selectively setting said sign character controlling means, power driven means for operating said setting means, and a control key for initiating a multiplying operation for setting said setting means, for enabling said power driven operating means for said setting means, and for enabling said restoring means.

15. In a calculating machine, having an accumulator, actuating means for said accumulator, means for shifting said accumulator relative to said actuating means, means for controlling the sign character of registrations on said accumulator, and power driven means for operating said actuating means and said shifting means; multiplication mechanism including multiplier selection mechanism having a plurality of differentially settable elements shiftable ordinally as a unit for controlling multiplying operations, means for restoring said settable elements sequentially to zero position, mechanism for shifting said differentially settable elements, means for selectively setting said sign character controlling means, power driven means for operating said setting means, a control key for initiating a multiplying operation for setting said setting means, for enabling said power driven operating means for said setting means and for enabling said restoring means, and means brought into play by each differentially settable element upon restoration thereof to zero for disabling said setting means and said restoring means and for enabling said shifting means and said mechanism.

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