May 29, 1945. C. M. FRIDEN ET AL 2,376,997

CALCULATING MACHINE

Filed Sept. 23, 1942 8 Sheets-Sheet 1

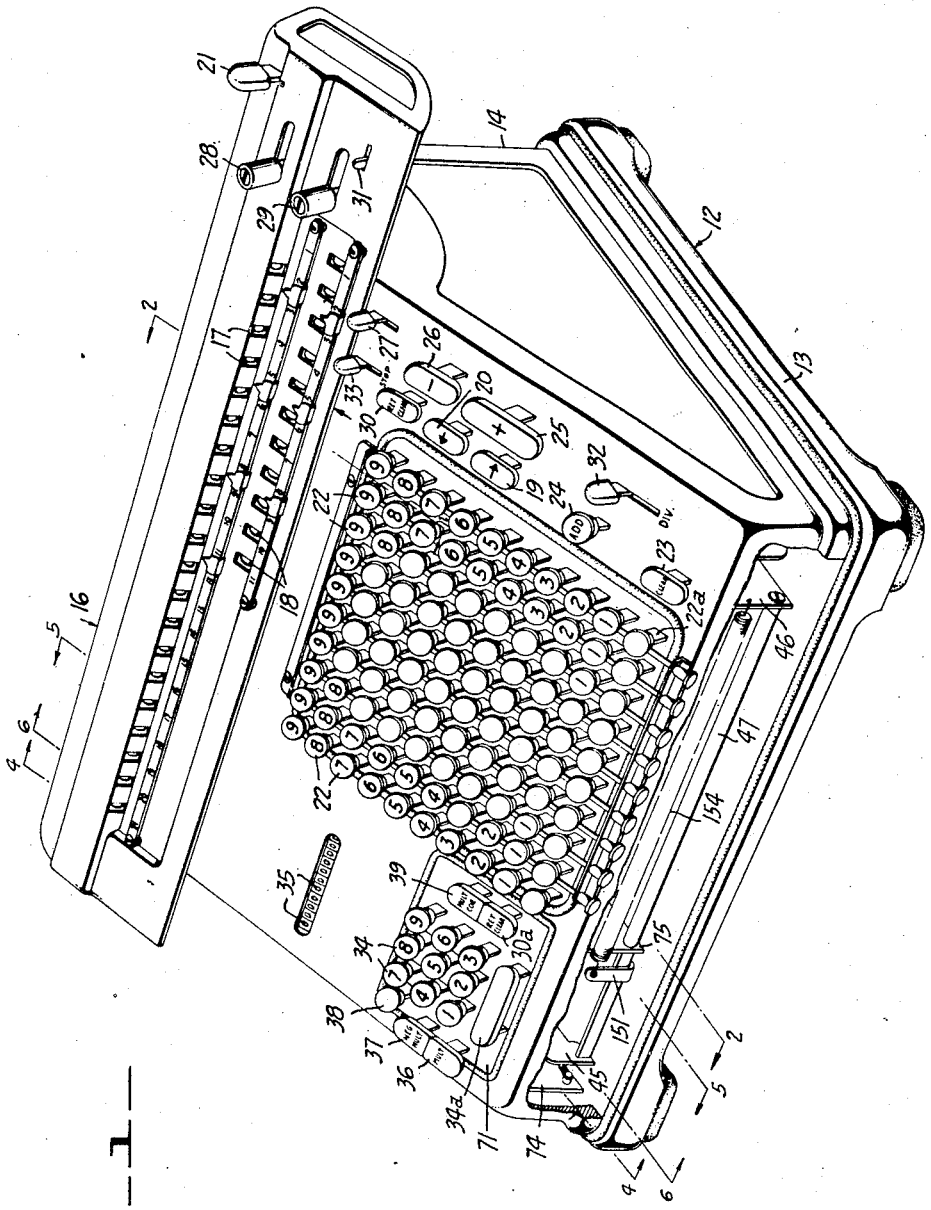

FIG. 1

INVENTORS
Carl M. Friden
Grant C. Ellerbeck
BY
Harper Allen
ATTORNEY

May 29, 1945. C. M. FRIDEN ET AL 2,376,997

CALCULATING MACHINE

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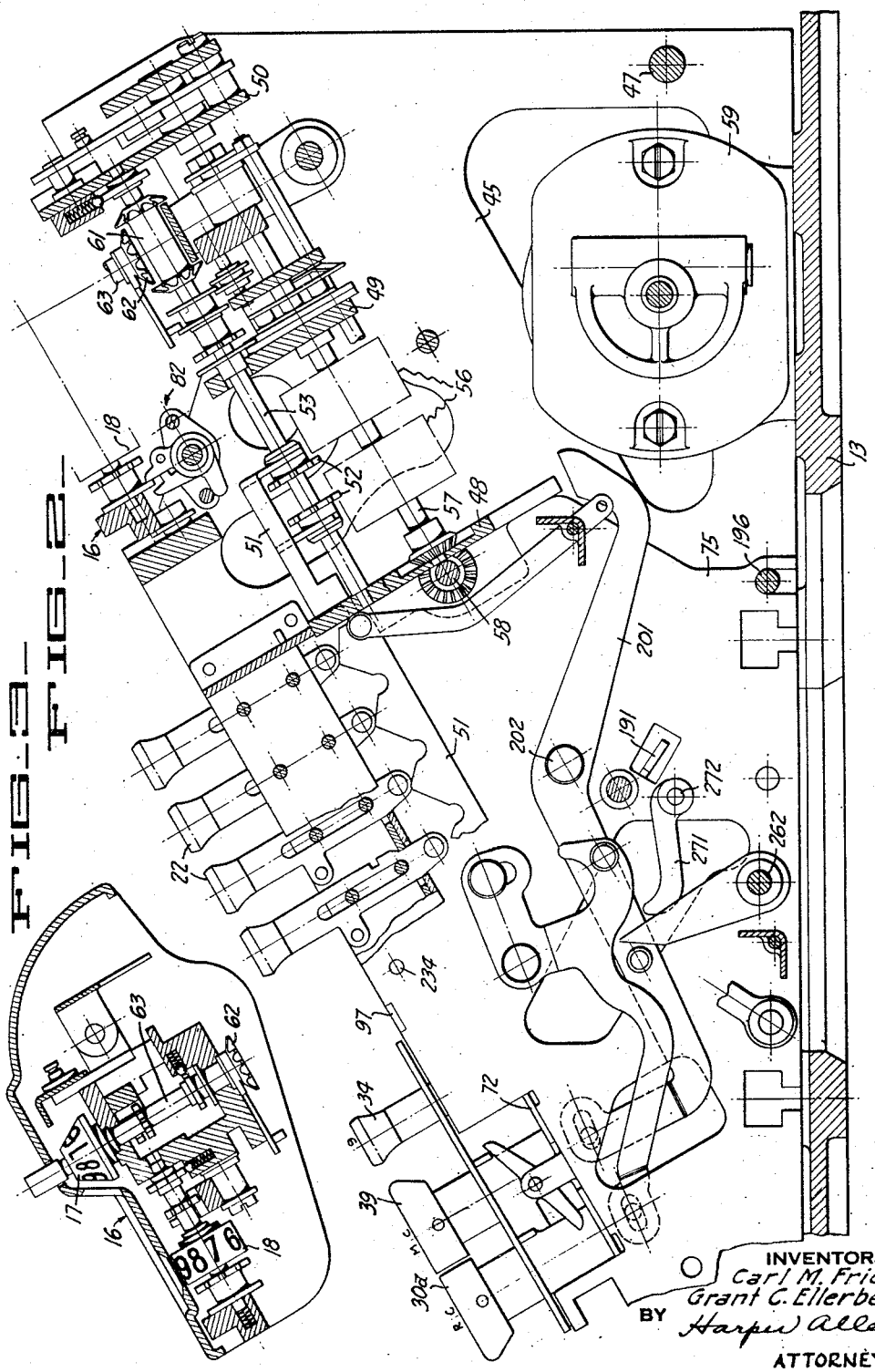

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CALCULATING MACHINE

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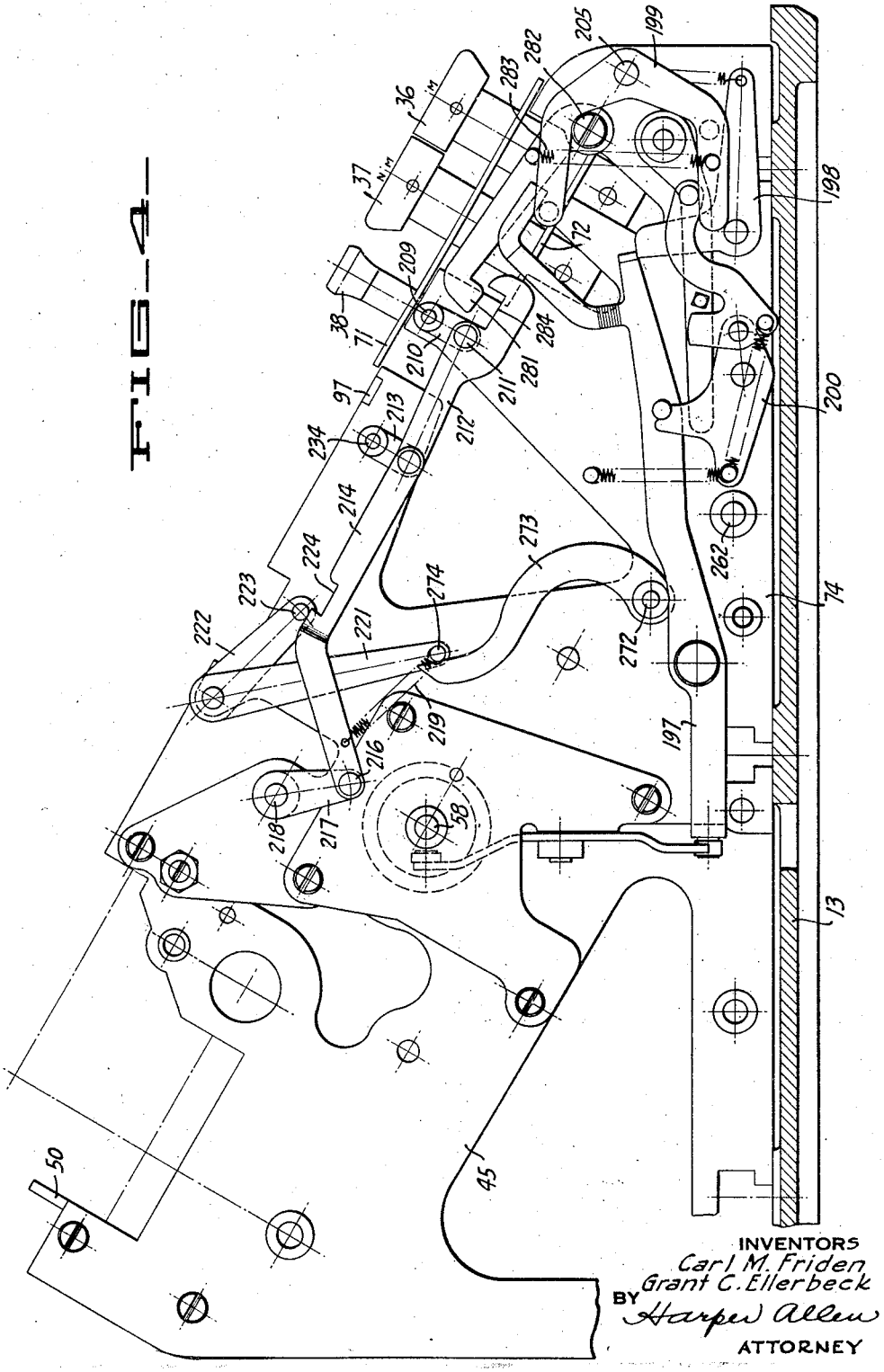
FIG-4



INVENTORS
Carl M. Friden
Grant C. Ellerbeck
BY Harper Allen
ATTORNEY

May 29, 1945. C. M. FRIDEN ET AL 2,376,997

CALCULATING MACHINE

Filed Sept. 23, 1942 8 Sheets-Sheet 4

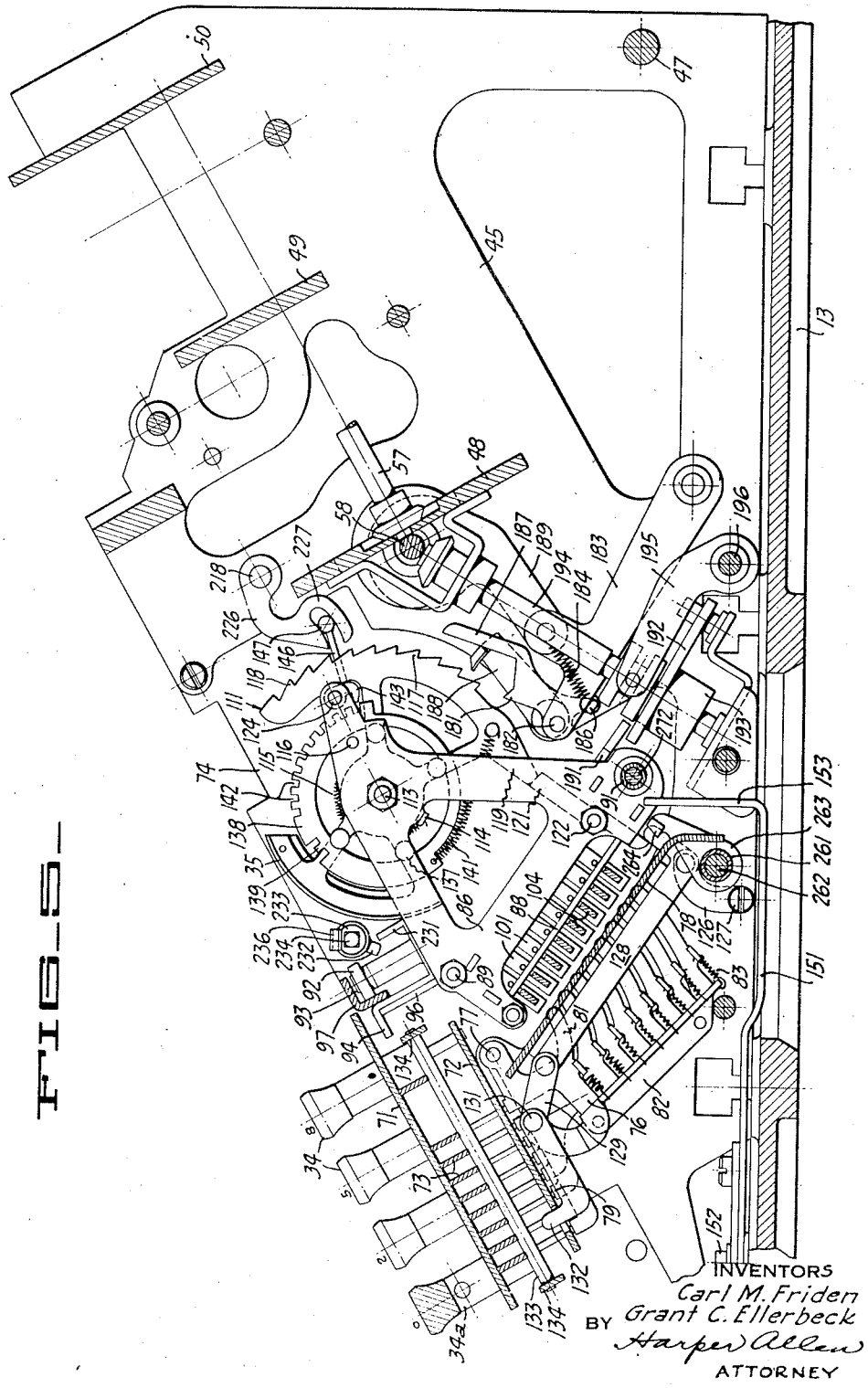


FIG. 5.

INVENTORS
Carl M. Friden
Grant C. Ellerbeck
BY Harper Allen
ATTORNEY

May 29, 1945. C. M. FRIDEN ET AL 2,376,997

CALCULATING MACHINE

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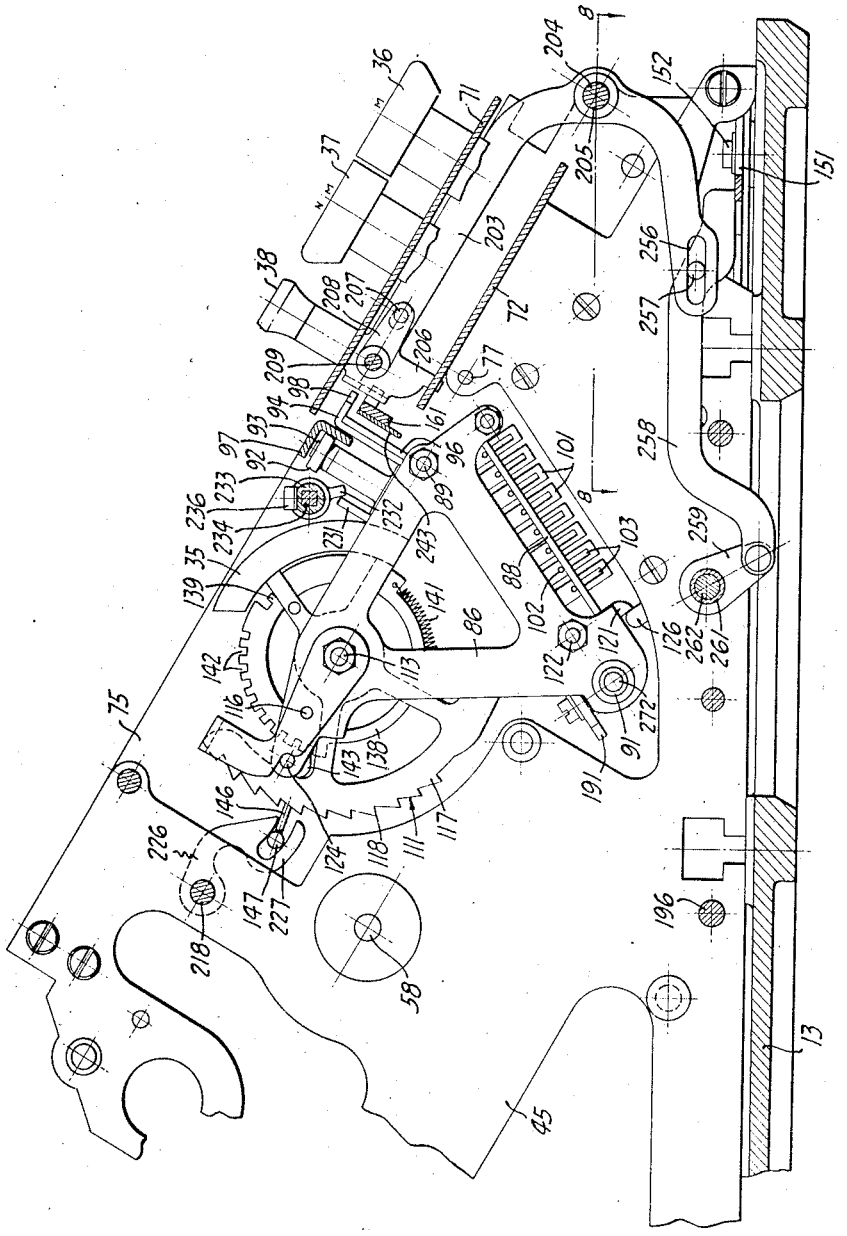
FIG-6-



INVENTORS
Carl M. Friden
Grant C. Ellerbeck
BY Harper Allen
ATTORNEY

May 29, 1945. C. M. FRIDEN ET AL 2,376,997

CALCULATING MACHINE

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FIG. 9.

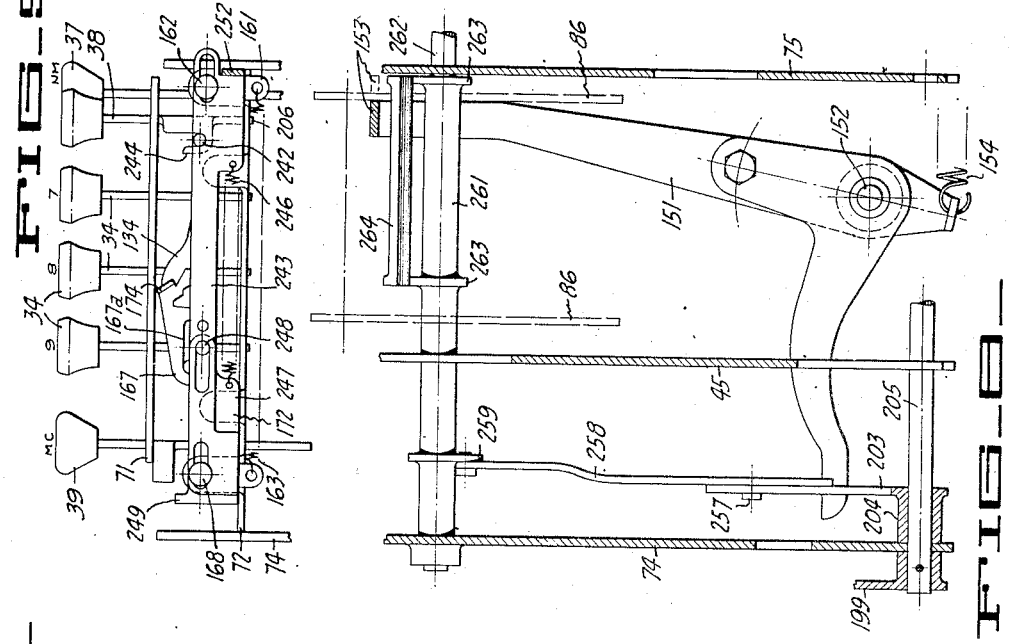

FIG. 8.

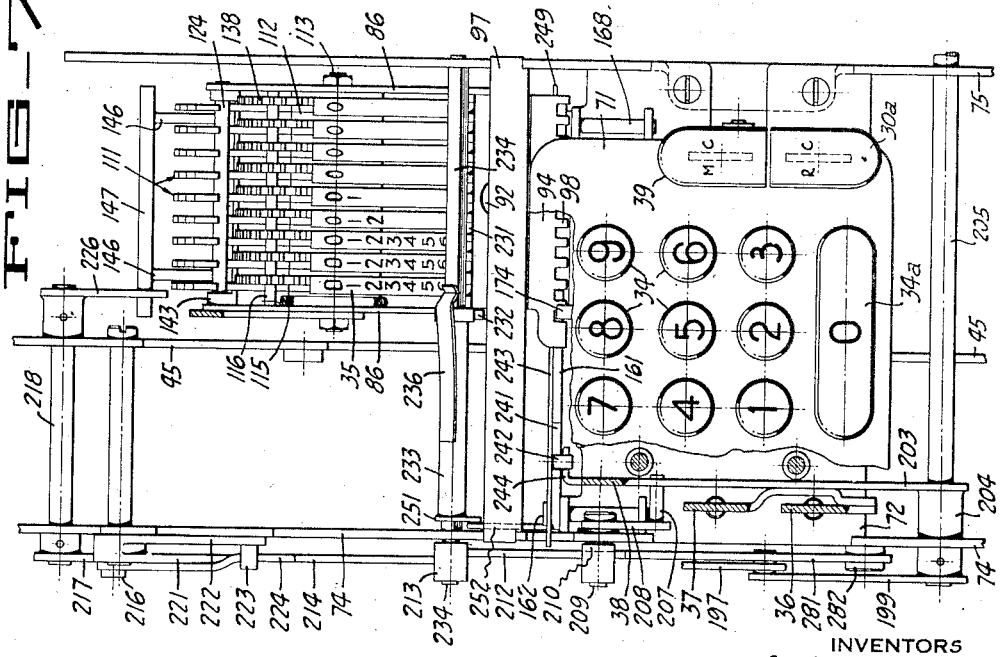

FIG. 7.

INVENTORS
Carl M. Friden
Grant C. Ellerbeck
BY Harper Allen
ATTORNEY

May 29, 1945. C. M. FRIDEN ET AL 2,376,997

CALCULATING MACHINE

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FIG. 11

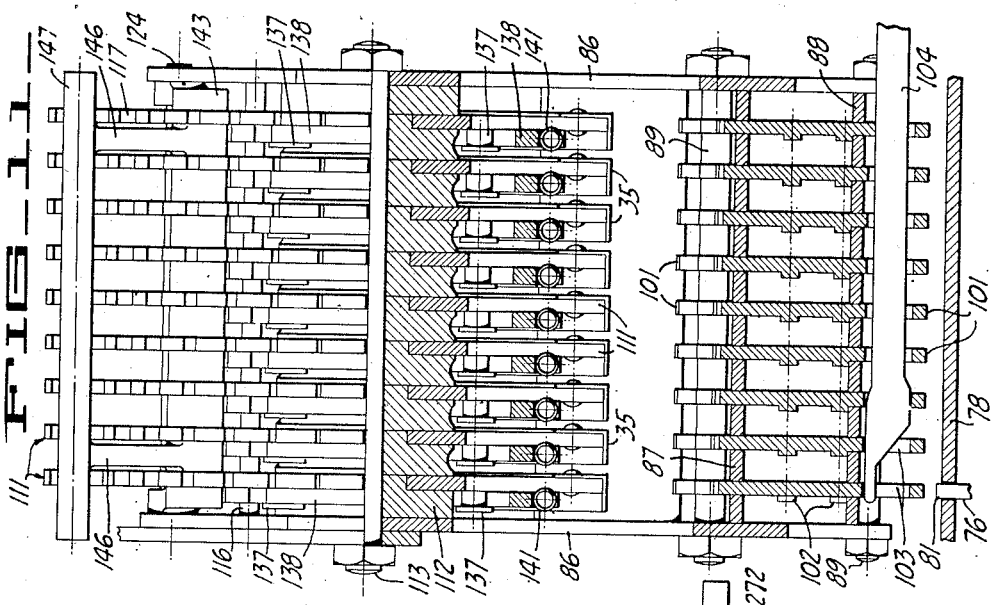
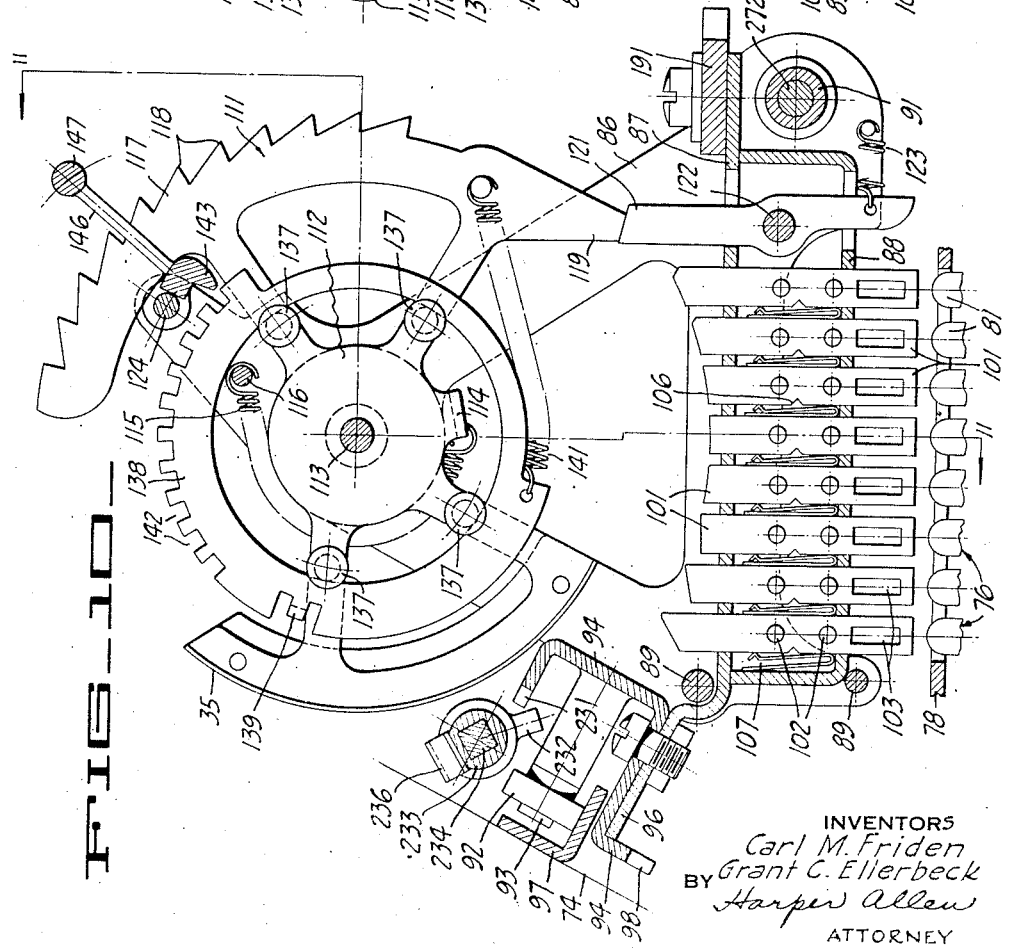


FIG. 10



INVENTORS
Carl M. Friden
BY Grant C. Ellerbeck
Harper Allen
ATTORNEY

May 29, 1945. C. M. FRIDEN ET AL 2,376,997

CALCULATING MACHINE

Filed Sept. 23, 1942 8 Sheets-Sheet 8

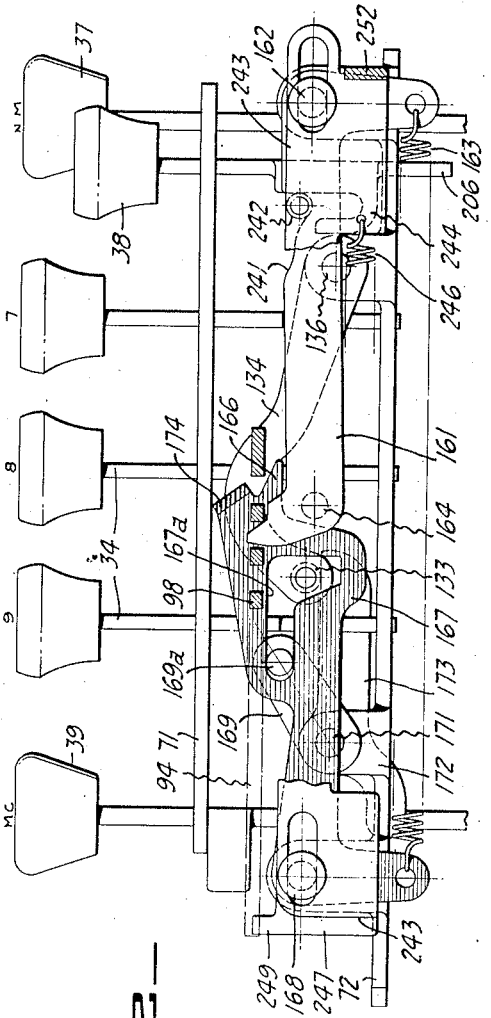


FIG. 12.

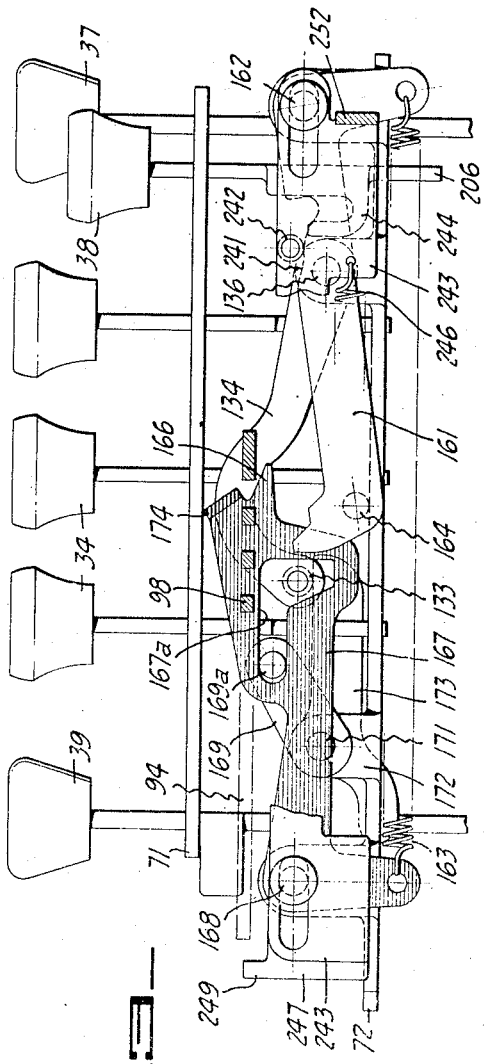


FIG. 13.

INVENTORS
Carl M Friden
BY Grant C. Ellerbeck
Harper Allen
ATTORNEY

UNITED STATES PATENT OFFICE

2,376,997

CALCULATING MACHINE

Carl M. Friden, Pleasanton, and Grant C. Ellerbeck, San Leandro, Calif., assignors to Friden Calculating Machine Co., Inc., a corporation of California

Application September 23, 1942, Serial No. 459,372

6 Claims. (Cl. 235—63)

This invention relates to calculating machines and is concerned more particularly with provision of improved multiplying mechanism therefor.

It is the general object of the invention to provide a multiplier mechanism for a calculating machine in which a constant multiplier may be employed.

Another object of the invention is to provide improved multiplier mechanism of the character referred to above in which the multiplier selecting mechanism can be set to the same multiplier value for a desired number of calculations.

Another object of the invention is to provide a multiplier mechanism of the character referred to above, which is simple in construction and which can be incorporated with a conventional multiplier selection mechanism with a minimum redesign of the parts.

Other objects and advantages of the invention will be apparent from the following description of a preferred embodiment as illustrated in the accompanying drawings, in which:

Figure 1 is a perspective view of a calculating machine embodying the invention.

Figure 2 is a sectional view taken in a plane indicated by the line 2—2 in Figure 1, with the carriage omitted.

Figure 3 is a sectional view of the carriage.

Figure 4 is a left side elevational view of the calculating machine taken as indicated by the line 4—4 in Figure 1.

Figure 5 is a sectional view of the multiplier mechanism taken as indicated by the line 5—5 in Figure 1.

Figure 6 is a sectional elevation of the multiplier mechanism taken from the left side as indicated by the line 6—6 in Figure 1.

Figure 7 is a plan view of the multiplier selection mechanism with certain parts omitted and others shown in section.

Figure 8 is a horizontal sectional view taken as indicated by the line 8—8 in Figure 6.

Figure 9 is a rear elevational view of the multiplier keyboard.

Figure 10 is an enlarged view of the multiplier selection carriage.

Figure 11 is a sectional view through the multiplier pin carriage taken as indicated by the line 11—11 in Figure 10.

Figure 12 is an enlarged view of the escapement mechanism of the multiplier selection mechanism.

Figure 13 is a view similar to Figure 12 showing the mechanism in a different operative position of the parts.

General Description

The invention is described as embodied in a conventional form of calculating machine as illustrated, for example, in the patent to Friden, #2,229,889, and the co-pending applications of Carl M. Friden, Serial #205,546, filed May 2, 1938; and Carl M. Friden and Anthony B. Machado, Serial #348,966, filed July 31, 1940.

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. Register carriage 16 is mounted for endwise shifting movement transversely of body 12 and 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 30a. Depression of key 30 (or key 30a) 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. Where repeated use of a multiplier factor is desired, repeat key **38** is depressed so that a factor previously entered by keys **34** is retained for subsequent use. If it is desired to correct an erroneously entered multiplier figure or to remove a "repeat" multiplier figure, a multiplier correction key **39** may be depressed to zeroize the multiplier selection mechanism. The multiplier selection mechanism and the associated repeat control means form the principal subject matter of the instant invention, and are described later in detail.

Within casing **14**, the frame includes left and right side plates **45**, **46** (Figs. 1 and 2) which are suitably mounted on base **13** and are interconnected by various cross frame members including one or more tie rods **47** and transverse brackets **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 conventional selecting mechanism associated with numeral keys **22**. For this purpose each bank of keys **22** (Figure 2) cooperates with a pair of similar spring-urged value selecting slides **51** in a conventional manner. Each slide **51** is connected at its rear end with a ten-tooth gear **52**, slidably and non-rotatably mounted on square shaft **53** so that movement of the associated selecting slide positions the gear differentially with respect to the stepped teeth of the associated actuating cylinder **56**. Each actuating cylinder **56** is mounted on a shaft **57** driven from a transverse drive shaft **58** having a cyclic clutch drive of the usual type from electric motor **59**.

Each square shaft **53** slidably and non-rotatably carries a spool **61** bearing plus and minus gears at its ends for selective engagement with ten-tooth gear **62** at the lower end of the shaft **63** carrying numeral wheel or dial **17**.

For addition and subtraction, the number of cycles of operation may be controlled in the usual manner from the plus and minus keys **25** and **26** while the ordinal relation of the accumulator with respect to the actuating mechanism, and consequently the point of entry of the values may be controlled by a suitable carriage shift mechanism under control of keys **19** and **20**.

Numeral wheels **18** (Figure 3) of the revolutions counter register the number of actuations of the accumulator numeral wheels **17** in a conventional manner by the operation of counter actuator **82** as disclosed for example in said patent.

Multiplication Mechanism

The multiplication mechanism disclosed herein 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.

Multiplier keyboard.—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 associated 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. Keys **34** and **34***a* are slidably mounted in upper and lower plates **71** and **72** (Fig. 5) of the multiplier keyboard and a suitable spring is provided about each key stem to urge the key to its upper position where offset portion **73** thereof engages the lower surface of the upper plate **71**. As seen in Fig. 5, the respective offset portions **73** of keys **34** are in parallel aligned relation for operating the multiplier escapement mechanism, which is referred to hereinafter. The "1" to "8" keys **34** also have their lowermost portions aligned in staggered fashion below plate **72** for cooperation with a row of selection levers for setting the pin carriage mechanism. A selection lever **76** (Fig. 5) is provided for each of the "1" to "8" keys **34**. Each lever **76** is pivoted on transverse shaft **77** which is suitably supported in the frame and each lever **76** is guided in a slot in frame plate **78**. Levers **76** are provided with upwardly projecting noses **79** disposed in an aligned relation with the multiplier keys for operation thereby.

Each selection lever **76** (Fig. 5) is provided at its lower end with an upwardly and rearwardly projecting pin setting finger **81** which extends through a suitable aperture in plate **78**, the fingers **81** of the various levers **76** being disposed in a row. Each lever **76** normally seats against bracket **82** under the influence of a spring **83** tensioned between the bracket **82** and the lever.

Multiplier carriage.—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 correspond-

ing 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 86 (Figs. 10 and 11), respective upper and lower pin holding plates 87 and 88 extending between the lower ends of side plates 86 and having suitable end projections engaging corresponding slots of plates 86. The frame assembly is held together by suitable tie rods 89. The pin carriage is mounted in the machine by rod 91 (Figs. 7 and 10) extending through aligned apertures of plates 86, and by roller 92 journalled by pin 93 on escapement rack bracket 94, which is secured by a plurality of suitable bolts on an extension 96 of upper pin plate 87. Roller 92 engages track 97 (Figs. 5 and 10) which is secured to and extends between plate 74 and plate 75. The down-turned flange of track 97 extends between roller 92 and a face of escapement rack 94, which is provided at its edge with teeth 98 which cooperate with a step by step escapement mechanism as later described.

Referring to Figs. 10 and 11, pin plates 87 and 88 of the pin carriage are provided with a series of rows of aligned slots to receive pins 101 for limited endwise sliding movement as determined by spaced apart pins 102 provided thereon between plates 87 and 88. Below plate 88 each pin 101 is provided with a transverse slot 103 for engagement by cam fingers 104 in restoring the pin to its lower inactive position as shown in Fig. 11. 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 101 (Fig. 10) in raised position, each pin is provided with latching notch 106 for cooperation with a V-shaped end portion of a slotted U-shaped spring plate 107, which is compressed between adjacent pins 101 of a row and is held in place between side plates 86. A plate 107 is provided to cooperate with each transverse series of pins in the respective rows.

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 111 (Figs. 10 and 11) are provided between side plates 86 of the carriage. Each rack segment 111 is journalled about a reduced bearing portion of a hub 112. Hubs 112 are apertured to receive fastening rod 113 by means of which the hubs are clamped in axially aligned position between side plates 86. Each rack segment 111 is provided with an ear 114 from which spring 115 extends around the associated hub 112 to transverse rod 116, whereby each segment 111 is urged in a clockwise direction as viewed in Fig. 10 by its associated spring 115.

Each segment 111 (Fig. 10) is provided with arcuate rack sector 117 having eleven teeth 118 spaced from lower and stop end 119, which normally engages the upper end of holding pawl 121. The series of pawls 121, one for each rack segment 111, are pivoted on spacer shaft 122 extending between plates 86. Each pawl 121 is urged in a counter-clockwise direction as viewed in Fig. 10 by spring 123 connected thereto, whereby in the position shown, the associated rack segment 111 is held in its "0" position.

Opposite rack sector 117 (Fig. 10) each segment 111 is provided with an indicating sector or dial 35 having numerals from "0" to "9," one of which becomes visible through a suitable sight opening in case 14 (Fig. 1) 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 101, while for the "9" position the upper end of sector 35 is adapted to engage cross rod 124, which provides a stop for the "9" position of the respective rack segments.

Means is provided for releasing rack segment 111 of the active order of the pin carriage simultaneously with the movement of a pin to active position. Pawl 121 for releasing a rack segment 111 is moved to inactive position by means of arm 126 (Fig. 5) pivoted at 127 on plate 45 and having its upper end operatively related to the lower end of the aligned holding pawl 121. Intermediate its ends, arm 126 is connected by link 128 with a lever 129 pivoted at 131 on bracket 82 and having finger 132 at its forward end bent upwardly to extend through plate 72 to a position under rod 133 extending between spaced arms 134 (Figs. 5, 12 and 13) secured at the ends of rod 136 pivoted in suitable upturned ears of lower plate 72. Rod 133, as seen most clearly in Fig. 5, is associated with horizontal portions of key stems 73, whereby upon depression of any key, the rod 133 will be moved downwardly to engage finger 132 and thereby depress lever 129. The resulting counter-clockwise movement of lever 129 (Fig. 5) serves through link 128 to rock arm 126 and move the aligned pawl 121 to inactive position, whereby the aligned rack segment 111 is released at the same time that pin setting extension 81 of the selection lever 76 becomes active to project the pin 101 into active position.

The above described mechanism is generally similar to that disclosed in said application Serial No. 205,546 and is operated by successive depression of multiplier keys 34 so that racks 111 are set successively to the selected values, the pin carriage shifting one step to the left as viewed from the front of the machine for each depression of a multiplier key.

The selection carriage also includes means for maintaining values set into the racks 111 for repeated setting of the racks to such values. Each rack 111 (Figs. 10 and 11) carries a plurality of flanged studs 137 spaced equal radial distances from the rack axis. Ring 138 is journalled about studs 137 of each rack 111 and is caused to follow clockwise setting movement of the associated rack by virtue of offset ear 139 which lies in front of an adjacent portion of rack 111. Spring 141 is connected between each rack 111 and its associated ring 138 so that ring 138 will yieldably follow counter-clockwise movement of its associated rack. Each ring 138 is provided with a series of ten equally spaced notches 142 corresponding to the "zero" to "nine" positions of racks 111. The aligned notches 142 are engageable by an elongated locking tooth 143 pivoted on rod 124 which extends between carriage side plates 86. Arms 146 connect tooth 143 with rod 147 by means of which tooth 143 is

moved into and out of engagement with notches 142 as later described.

As previously explained, the pin carriage is movable step by step transversely of the machine in accordance with the number of multiplier digits entered. The pin carriage is normally in its right end position (Fig. 7) as viewed from the front of the machine with indicating sectors 35 to the right of and not visible through the associated sight opening. The condition shown in Figure 1 would obtain after successive depression of "zero" key 34a 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 151 (Fig. 8) which is pivoted at 152 on machine base 13 and has an upstanding arm 153 (Figs. 5 and 8) engaging right side plate 86 of the pin carriage. Another arm of bell crank 151 has spring 154 (Figs. 1 and 8) secured thereto whereby the bell crank is urged in counter-clockwise direction as viewed in Fig. 8, 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 151 is prevented by means of bell crank stop pawl 161 (Figs. 9, 12 and 13) pivoted at 162 on an upstanding ear of lower keyboard plate 72 and urged upwardly by spring 163 into engagement with a tooth 98 of rack 94 as seen in Fig. 12. Pawl 161 carries pin 164 which lies beneath ear 166 of a second bell crank pawl 167 pivoted at 168 on lower plate 72. Spring 163 urges pawl 167 counterclockwise. Pawl 167 is provided with an L-shaped slot 167a whose horizontal portion receives pin 169a carried by arm 169 on rod 171 journalled in spaced ears 172 of lower keyboard plate 72. Rod 171 carries an arm 173 at its opposite end lying under an end of rod 133 to be operated thereby. The vertical portion of slot 167a receives the adjacent end of rod 133 as viewed in Figure 12. Pawl arm 167 also carries laterally projecting tooth 174 which is normally positioned immediately above teeth 98 as shown in Figures 12 and 13, and is disposed for downward movement between the pair of teeth adjacent and to the right of that contacted by pawl 161.

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 171 is rocked by means of its arm 173 (Fig. 12) underlying key-operated rod 133, whereby arm 169 and pin 169a serve to rock pawl arm 167 about its pivot in a clockwise direction thereby simultaneously lowering tooth 174 of pawl arm 167 from the position shown in Figure 12 to overlap the adjacent rack tooth 98. During continued movement of pawl 167 its ear 166 engages pin 164 and rocks pawl 161 to disengage it from the associated tooth 98. As soon as the pawl 161 is disengaged from a tooth 98, the first stage of the shift step occurs and the pin carriage moves to the right as viewed in Figure 12 under the influence of the spring pressure thereon until a rack tooth 98 engages tooth 174 of arm 167.

The movement of the pin carriage during this stage of a shift step corresponds to the space between the tooth 174 and the rack tooth 98 adjacent thereto, the movement being sufficient to position the previously active tooth 98 over the nose of pawl 161 but insufficient to allow engagement of the projected finger 81 (Fig. 11) with the next pin row. Subsequently, as the depressed multiplier key is released, the parts start their return from depressed position. Pawl 161, however, is held depressed by the associated tooth 98 and cannot return upwardly with the other parts until the inclined face of tooth 174 has permitted shifting of the pin carriage for an amount to move the associated tooth 98 from over the pawl 161 so that the pawl 161 will work upwardly into engagement with the next tooth 98 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.

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 through the multiplier sight opening. 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.—As previously stated, the differentially adjusted positions of racks 111 are utilized to control the number of registrations of the multiplicand in the accumulator, to shift the accumulator to the right 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 111 comes into controlling position with respect to the operation of the machine.

The operating mechanism for the racks 111 is conventional and comprises feed pawl 181 (Fig. 5) which, with the pin carriage in its right hand position, is located one ordinal step to the left thereof as viewed in Figure 7. 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 181. Thus, after the complete multiplier is set into the machine, the last adjusted rack 111 corresponding to the lowest digit of the multiplier will always be aligned with pawl 181 at the end of the multiplier setting operation.

Pawl 181 (Fig. 5) is pivotally secured at 182 at the end of arm 183 suitably pivoted on side plate 45. Pawl 181 is urged in a counterclockwise direction as viewed in Figure 5 by spring 184 tensioned between a pin on arm 183 and a lug 186 of pawl 181 which engages beneath arm 183 to limit the movement of pawl 181 under the influence of spring 184. Pawl 181 is normally held in inactive position as shown in Figure 5 by virtue of its upward extension 187 which is engaged by holding pawl 188 having a suitable pivotal support on the frame. Pawl 188 is held in the position shown in Figure 5 until depression of a multiplication operation key so that both feed pawl 181 and holding pawl 188 are maintained inactive until the multiplying operation is started.

In order to actuate pawl 181, arm 183 (Figure

5) is pivotally connected to cam follower 189 which engages a suitable cam (not shown) on the main drive shaft 58 as disclosed in said applications. During a multiplying operation pawl 181 is operated at the beginning of each cycle to restore the aligned rack 111 step by step to its inactive position. Rack 111 is always actuated one step more than the value to which it is set to provide for the shift cycle at the end of each ordinal multiplication. The last movement of the active rack at the end of its return to normal position enables holding pawl 121 to move into operative position relative to the associated rack 111, as well as to control and determine shifting of the accumulator and the pin carriage to align the next higher order rack 111 with the pawl 181 as described in said applications.

Pin carriage shifting means.—As seen in Figures 5 and 10, the pin carriage is provided with a shift rack 191 secured on cross frame plate 87. Rack 191 is adapted for operation by an operating pawl 192 (Figure 5) carried by an eccentric portion of collar 193 which is slidable on and operated by drive shaft 194. Collar 193 normally positions pawl 192 below rack 191 as seen in Figure 5, but the collar and the pawl can be raised by a suitable operation of arm 195 on control shaft 196 to lift pawl 192 into the plane of rack 191 and effect a one-step shift of the pin carriage during a multiplying operation. The direction of this shift is towards the right as viewed in Figure 7. The shifting of the pin carriage is controlled in the course of a multiplying operation as described in said application Serial No. 205,546.

Multiplication control mechanism.—The multiplication keys 36 and 37 (Figure 4) and the mechanism controlled thereby are of the character disclosed in said applications and so will not be described in detail. It is sufficient for the purposes of the present invention to understand that depression of either key 36 or 37 initiates operation of the multiplying mechanism to cause step-by-step return of the adjusted racks 111 in sequence from the lowest through the highest order thereof, with a one-step shift of the accumulator and of the pin carriage occurring between each ordinal multiplication. Certain parts of this multiplication control mechanism are shown in Figure 4 for a better understanding of the relation of the parts of the repeat mechanism to the conventional parts of the multiplication mechanism. The parts shown include control lever 197 which functions in connection with the setting of the plus-minus gears, latch bellcrank 198 therefor, and latch lever 199, which is brought into play temporarily during the shift cycle of the multiplying operation. Latch bellcrank 198 is disabled by bellcrank 200 which rocks counter-clockwise upon depression of either keys 36 or 37.

Multiplier correction control.—Multiplier correction key 39 (Figures 1 and 7) controls the portion of the multiplication operation control means which enables the drive mechanism to restore the adjusted racks of the pin carriage and to return the pin carriage to its normal inoperative position in the event a correction of a multiplier figure is required because of erroneous setting. This control is exercised by the key 39 by operation of lever 201 (Figure 2) pivoted at 202. Lever 201 is moved counter-clockwise by the key 39 to perform the various necessary setting functions as fully described in said applications.

Multiplier repeat mechanism

Multiplier repeat control key 38 (Figures 4 and 6) is formed integrally at the upper end of a bellcrank 203, having hub 204 pivoted on cross shaft 205. Key 38 has a bottom extension 206, suitably guided in lower plate 72 of the multiplier keyboard mechanism.

Key 38 is shown in its inactive position in Figure 6, and depressio of the key performs several functions to bring the repeat mechanism into play including locking of the adjusted positions of the auxiliary stop rings 138, conditioning of the repeat escapement control to cause automatic tabulation of the multiplier pin carriage at the end of each multiplying operation to the correct adjusted position, and conditioning of a rack release mechanism whereby all of the racks 111 are released at the end of each multiplying operation to move to their respective adjusted positions represented by the auxiliary stop rings 138.

To control the locking of the stop rings 138, the bellcrank 203 (Figure 6) is slotted to receive a pin 207 on arm 208 which is carried by shaft 209 pivoted in frame plate 74. Shaft 209 (Figure 4) carries depending arm 210 pivotally connected at 211 to a link 212, which has a second pivotal supporting link 213. At the pivotal connection to 213, link 212 is also connected to a second link 214 which is pivotally connected at 216 to an arm 217 on a shaft 218. The links 212 and 214 (and key 38) are urged to the positions shown in Figure 4 by spring 219, secured between link 214 and depending arm 221 of a pivoted latch assembly including a second arm 222. Arm 222 has a pin 223 adapted to engage a latching notch 224 of the link 214.

Upon depresison of key 38 (Figure 6) the arm 208, shaft 209 and arm 210 (Figure 4) are oscillated clockwise to move links 212 and 214 rearwardly so that pin 223 moves into holding engagement with latching notch 224 under the influence of spring 219. The rearward movement of link 214 causes clockwise rocking movement of arm 217 and shaft 218 (Figure 4) which also moves arm 226 (Figure 6) carried by shaft 218 and having a slotted end 227, engaging rod 147. As previously described, rod 147 controls locking tooth 143 for the repeat rings 138.

Thus, after setting the multiplier by the keys 34 (Fig. 1) which adjust the racks 111 (Fig. 5), if the repeat key 38 is depressed, the repeat rings 138 having been adjusted with the racks 111, will be locked in their set position by lock tooth 143. As the racks 111 are restored to their initial positions during the multiplying operation, the rings 138 remain set at the multiplier value, the respective springs 141 being tensioned as the racks are restored. At the end of the multiplying operation the racks 111 are restored to zero and latched by latches 121.

Repeat escapement control.—It will be recalled that the pin carriage is allowed a one-step escapement movement for each value set into the pin carriage until the pin carirage occupies the ordinal position at which the multiplying operation is to begin. Means is provided for automatically returning the pin carriage to the starting position at the end of each repeat multiplying operation.

To effect the above purpose the pin carriage has one edge of its U-shaped bracket 94 (Figs. 7 and 10) formed to provide a rack 231 whose teeth correspond to the teeth 98 of rack 94. Dur-

ing shifting of the pin carriage while the multiplier racks 111 are being set, rack 231 is shifted with respect to a tooth 232 carried at one end of a stop element in the form of a sleeve 233, slidably and non-rotatably mounted on square shaft 234 and normally disposed at the left end of the shaft as shown in Fig. 7. Leaf spring 236 tends to frictionally hold sleeve 233 in its normal position on shaft 234 as shown in Fig. 7 where it abuts extension 252 of slide 243 described hereinafter. Shaft 234 is pivotally mounted in plates 74 and 75 and at its left end carries supporting arm 213 (Fig. 4) for links 212 and 214. Thus, depression of repeat key 38 after a multiplier value has been set causes shaft 234 to be rocked clockwise as viewed in Figure 4 or counterclockwise as viewed in Figure 10 to engage tooth 232 with the aligned notch of the rack 231. Because this connection occurs after the shifting of the pin carriage to a selected ordinal position controlled by the setting of the multiplier, the point of connection of tooth 232 with racks 231, and correspondingly the relative position of sleeve 233 to the pin carriage provides an indication of the number of steps of shifting movement of the pin carriage (i e., the number of digits in the multiplier). After connection of sleeve 233 to the pin carriage it provides a stop to permit a plural step escapement of the pin carriage to the desired position thereof in accordance with the number of digits in the multiplier value.

To control disabling of the escapement holding pawl 161 (Figures 9, 12 and 13) pawl 161 is provided with a cam surface 241 for engagement by a pin 242, carried by a slide 243, slotted to engage with respective rods 162 and 168 and normally held in the position shown in Figures 9 and 12. Pin 242 normally occupies a seat at the foot of cam surface 241 and does not interfere with normal operation of pawl 161. With key 38 raised, notched extension 244 thereof, engages pin 242 to maintain this condition as shown in Figure 9.

Upon depression of key 38 to the position shown in Figure 12, slide 243 is free to move to the left when so controlled under the influence of spring 246 connected thereto and to a second slide 247, slidably guided on rod 168 and having a pin 248 engaging a slot in slide 243. Spring 246 is normally untensioned so that upon depression of key 3 as seen in Figure 12, slide 243 will remain in this inactive position.

During return of the pin carriage in a multiplying operation, the last step of movement of the pin carriage (the movement following the last ordinal multiplication) causes its shifting rack 94 to engage upstanding ear 249 of slide 247 so that spring 246 is tensioned and slide 243 is moved from the position shown in Figure 12 to that shown in Figure 13. During this movement of slide 243, its pin 242 engages cam surface 241 and moves the holding pawl 161 downwardly out of engagement with the teeth 98 of rack 94. Slide 243 remains in this position, pin 242 withholding pawl 161 from rack 94 until the pin carriage tabulates to the starting position.

Thus at the end of each multiplying operation, and when the multiplier repeat key is set, the escapement mechanism is tripped to allow movement of the pin carriage back to the left as viewed in Figure 7 under the influence of lever 151 and spring 154. When extension 251 (Figure 7) on sleeve 233 engages outwardly extending ear 252 of slide 243 the slide 243 is returned to the inactive position shown in Figure 12 and the pin carriage is arrested in the starting position. Return of slide 243 removes pin 242 to the right, releasing pawl 161. Thus depression of the multiplier repeat key 38 conditions an escapement control mechanism whereby after a multiplying operation the pin carriage will be automatically returned to the starting position which it previously occupied as a result of the multiplier setting operation.

Multiplier rack release.—To enable the control for release of the multiplier racks 111 at the end of a multiplying operation, the lower arm of bellcrank 203, Figure 6, is slotted at 256 to engage a pin 257 on a link 258. The link 258 is pivotally connected at its rearward end to an arm 259 on a sleeve 261 pivoted on transverse shaft 262. Sleeve 261 (Figures 5 and 8) carries a pair of upstanding arms 263, connected by a transverse bar 264. The bar 264 is so positioned in the machine that with the pin carriage located as shown in Figure 7 (to which position it is returned at the end of a multiplying operation) the bar 264 is associated with the tails of all of the holding pawls 121. Upon counterclockwise movement of the bar 264 as viewed in Figure 5 all of the holding pawls 121 will be released and the racks 111 will be free to move to the respective positions represented by the adjusted stop rings 138.

Normally the link 258 (Figure 6) has its nose positioned above the tail of bellcrank 151 which operates with the pin carriage. However, as the bellcrank moves with the pin carriage, it will be moved from beneath the link 258 during setting of the multiplier so that when the key 38 is depressed, the nose of link 258 is moved into the path of the bellcrank to be operated thereby during the overstroke shifting movement of the pin carriage at the end of the multiplying operation, that is, at the same time that the pin carriage is released to escape to its previously tabulated position, the racks 111 will be released to move to their adjusted positions. As a result the pin carriage will be set and positioned to begin a subsequent multiplying operation using the same multiplier as used in the previous multiplication.

To condition the machine for non-repeat multiplication, the multiplier correction key 39 is operated. As previously pointed out, the key 39 (Figure 2) operates lever 201 in a counter clockwise direction. Underlying the left hand arm of lever 201 is an arm 271 secured on a transverse shaft 272. Shaft 272 (Figure 4) carries a second arm 273, lying in front of pin 274 on latch arm 221, so that clockwise movement of shaft 272 and arm 273 as viewed in Figure 4 will rock arm 221 and arm 222 to release link 214 from pin 223. Upon such release, spring 219 can become effective to restore the parts positioned by the multiplier repeat key (including the repeat key itself) to its normal inactive position. Thus at the end of the actuation of the racks and the pin carriage which is initiated by the multiplier correction key, the pin carriage is positioned to its inactive or "home" position shown in Figure 7 and all of the racks 111 are adjusted to "zero." The stop rings 138 are also released and will return to their "zero" positions with the racks 111.

To prevent depression of repeat key 38 during a multiplying operation, a suitable interlock means is provided. Referring to Figure 4, interlock arm 281 is pivoted at 282 and is urged by

spring 283 to follow counter-clockwise movement of bellcrank 199 which occurs upon initiation of a multiplying operation. A nose of arm 281 lies normally above a notch 284 in link 212 which is moved rearwardly upon depression of key 38. When the nose of arm 281 is seated in notch 284 of link 212 during a multiplying operation, key 38 cannot be depressed.

Operation.—The operator sets the constant multiplier by means of the keys 34 (Fig. 1) which adjust the racks 111 and cause escapement of the pin carriage to the position where the multiplication is to begin. The operator then depresses the repeat key 38 which is held down by the latch 222 (Fig. 4) and causes the rings 138 (Fig. 6) to be locked in positions representing the constant multiplier by engaging the tooth 143 with the racks 142, and which engages the tooth 232 of the sleeve 233 with the rack 231 on the pin carriage.

The operator then sets the first multiplicand in the keyboard 22 and depresses either key 36 or 37 to initiate the desired multiplication operation which results in the racks 111 being restored to zero and latched by the latches 121 and in the pin carriage being returned to the right in Figure 7. Upon being moved one step beyond the end position the carriage engages the projection 249 (Fig. 9) on the slide 247 which tensions the spring 246 to move the slide 243 to the left in Figures 9 and 12, pin 242 disabling pawl 161. Spring 154 (Fig. 8) and lever 151 return the pin carriage to the left until flange 251 (Fig. 7) on sleeve 233 engages projection 252 on slide 243, thereby returning the slide to inactive position releasing pawl 161 and arresting the carriage.

During the overstroke in returning the carriage to the right at the end of the multiplying operation the lever 151 (Fig. 8) actuates the lever 258 to rock the bail 264 which unlatches the latches 121 (Fig. 5) allowing the racks 111 to return to the setting of the rings 138.

In this manner at the conclusion of the multiplying operation the multiplier racks are automatically reset to the constant multiplier value and the pin carriage is tabulated to the starting position. The operator then sets the next multiplicand in the keyboard and initiates the next multiplying operation by depressing either the key 36 or the key 37.

We claim:

1. In a calculating machine having a register, actuating means therefor, and means for controlling operation of said actuating means to perform a plural order multiplying operation, said last-named means including a multiplier selection carriage having a plurality of ordinal elements urged in a setting direction, means for holding said elements in an inactive position, said elements being settable therefrom to represent the digits of a multiplier figure, said elements being returned to the inactive positions thereof during a multiplying operation, means for moving said carriage in one direction from a normal position during the setting of a multiplier figure therein, and means for returning said carriage step-by-step in the opposite direction during the multiplying operation, a multiplier repeat mechanism including ordinal differentially settable means in said carriage and movable with said elements upon setting thereof, means for holding said settable means in set position independently of return of said elements during a multiplying operation, means controlled by return movement of said carriage at the conclusion of the multiplying operation for releasing said element holding means to permit said elements to be urged to positions representing the values to which said settable means are set, and means controlled by movement of said carriage at the end of a multiplying operation to cause said carriage moving means to move said carriage toward the position occupied thereby at the end of the setting of the multiplier figure therein.

2. In a calculating machine having a register, actuating means therefor, and means for controlling operation of said actuating means to perform a plural order multiplying operation, said last-named means including a multiplier selection carriage, having a plurality of ordinal elements normally held in an inactive position and settable therefrom to represent the digits of a multiplier figure, said elements being returned to the inactive positions thereof during a multiplying operation; means for moving said carriage step-by-step in one direction from a normal position during the setting of a multiplier figure therein, and means for returning said carriage step-by-step in the opposite direction during the multiplying operation; means for resetting said elements to a repeat multiplier value, means for returning said carriage to the position of said carriage after setting of a multiplier value, and means controlled by movement of said carriage at the conclusion of the multiplying operation for rendering operative said means for resetting said elements and said means for returning said carriage to the position of said carriage after setting of the multiplier.

3. In a calculating machine having a product register, registration control means including means settable to represent a multiplicand and means settable to represent a multiplier, said means for representing a multiplier comprising a plurality of orders of coaxial differentially adjustable elements in a transversely shiftable carriage, means for differentially adjusting said elements and for positioning said carriage in accordance with a multiplier value, means for initiating a multiplying operation, said registration control means including means operated cyclically during the multiplying operation for restoring said elements one by one to zero position and means for returning said carriage step-by-step to initial position: a mechanism for conditioning the machine for repeated use of the same multiplier value comprising a plurality of members, one for each of said differentially adjustable elements, each element when positioned by said differential adjusting means serving to set the member associated therewith to a position corresponding in differential value to that of the element, and means operable after said elements and said carriage have been positioned in accordance with a multiplier value and before operation of said means for initiating a multiplying operation for locking said members in their set positions, whereby upon operation of said initiating means said elements are restored to zero during the multiplying operation but the multiplier value is retained in the setting of said members.

4. In a calculating machine having a product register, registration control means including means settable to represent a multiplicand and means settable to represent a multiplier, said means for representing a multiplier comprising a plurality of orders of spring-urged racks in a shiftable carriage, a latch for each rack to hold it in zero position, means for differentially adjusting said racks one by one in accordance

with the multiplier value, means for moving said carriage from its normal position one ordinal step for each figure of the multiplier, means for initiating a multiplying operation, said registration control means including means operated cyclically during the multiplying operation for restoring said elements one by one to zero latched position and means for returning said carriage step-by-step to said normal position: a mechanism for conditioning the machine for repeated use of the same multiplier value comprising a plurality of differentially settable stops, one for each of said racks, each rack when positioned by said differential adjusting means serving to set the associated stop to a position corresponding in differential value to that of the rack, means operable after said racks and said carriage have been positioned in accordance with the multiplier value and before operation of said means for initiating a multiplying operation for locking said stops in their differentially set positions, and means automatically operable at the conclusion of the multiplying operation when all said racks have been latched in zero position and said carriage has been returned to normal position for unlatching said racks whereupon said racks are released and reengage their associated stops to resume their differentially adjusted positions and thus again represent the multiplier value which is to be repeated in the next multiplying operation.

5. In a calculating machine having a product register, registration control means including means settable to represent a multiplicand and means settable to represent a multiplier, said means for representing a multiplier comprising a plurality of orders of spring-urged racks in a shiftable carriage, a latch for each rack to hold it in zero position, means for differentially adjusting said racks one by one in accordance with the multiplier value, means for moving said carriage from its normal position one ordinal step for each figure of the multiplier, means for initiating a multiplying operation, said registration control means including means operated cyclically during the multiplying operation for restoring said elements one by one to zero latched position and means for returning said carriage step-by-step to said normal position: a mechanism for conditioning the machine for repeated use of the same multiplier value comprising a plurality of differentially settable stops, one for each of said racks, each rack when positioned by said differential adjusting means serving to set the associated stop to a position corresponding in differential value to that of the rack, means operable after said racks and said carriage have been positioned in accordance with the multiplier value and before operation of said means for initiating a multiplying operation for locking said stops in their differentially set positions, and means controlled by movement of said carriage beyond normal position at the conclusion of the multiplying operation for unlatching said racks whereupon said racks are released and reengage their associated stops to resume their differentially adjusted positions and thus again represent the multiplier value which is to be repeated in the next multiplying operation.

6. In a calculating machine having a product register, register control means including means settable to represent the multiplicand and means settable to represent the multiplier, said means for representing the multiplier comprising a plurality of orders of differentially adjustable elements in a transversely shiftable carriage, means including means to urge said elements to differentially set position for adjusting said elements in accordance with a multiplier value, means including means for urging said carriage from a normal position to a set position for setting said carriage in a position where said elements will be ordinally arranged in accordance with a multiplier value, means for initiating a multiplying operation, said registration control means including means operated cyclically during a multiplying operation for restoring said elements one by one to zero position, and means for returning said carriage step-by-step to normal position: a mechanism for conditioning the machine for repeated use of the same multiplier value comprising a plurality of members, one for each of said differentially adjustable elements, each element when positioned by said differential adjusting means serving to set the member associated therewith to a position corresponding in differential value to that of the element, means operable after said members and elements have been positioned in accordance with a multiplier value which is to be repeated for locking said members in their set positions, and means operable after said carriage has been ordinally positioned in accordance with the multiplier value which is to be repeated for connecting a tabulator stop to said carriage adapted after the multiplying operation to cooperate with a stop on the frame of the machine for repositioning said carriage in the said ordinal position for the repeat multiplication, means operable by movement of said carriage at the conclusion of the multiplying operation for causing said element-urging means to return said elements to the set positions determined by said members, and for causing said carriage-urging means to move said carriage to the position determined by said tabulator stop to reposition said carriage in accordance with the multiplier value which is to be repeated.

CARL M. FRIDEN.
GRANT C. ELLERBECK.