April 8, 1941. W. W. LANDSIEDEL 2,237,881

COMPUTING MACHINE

Filed Jan. 22, 1938 16 Sheets-Sheet 1

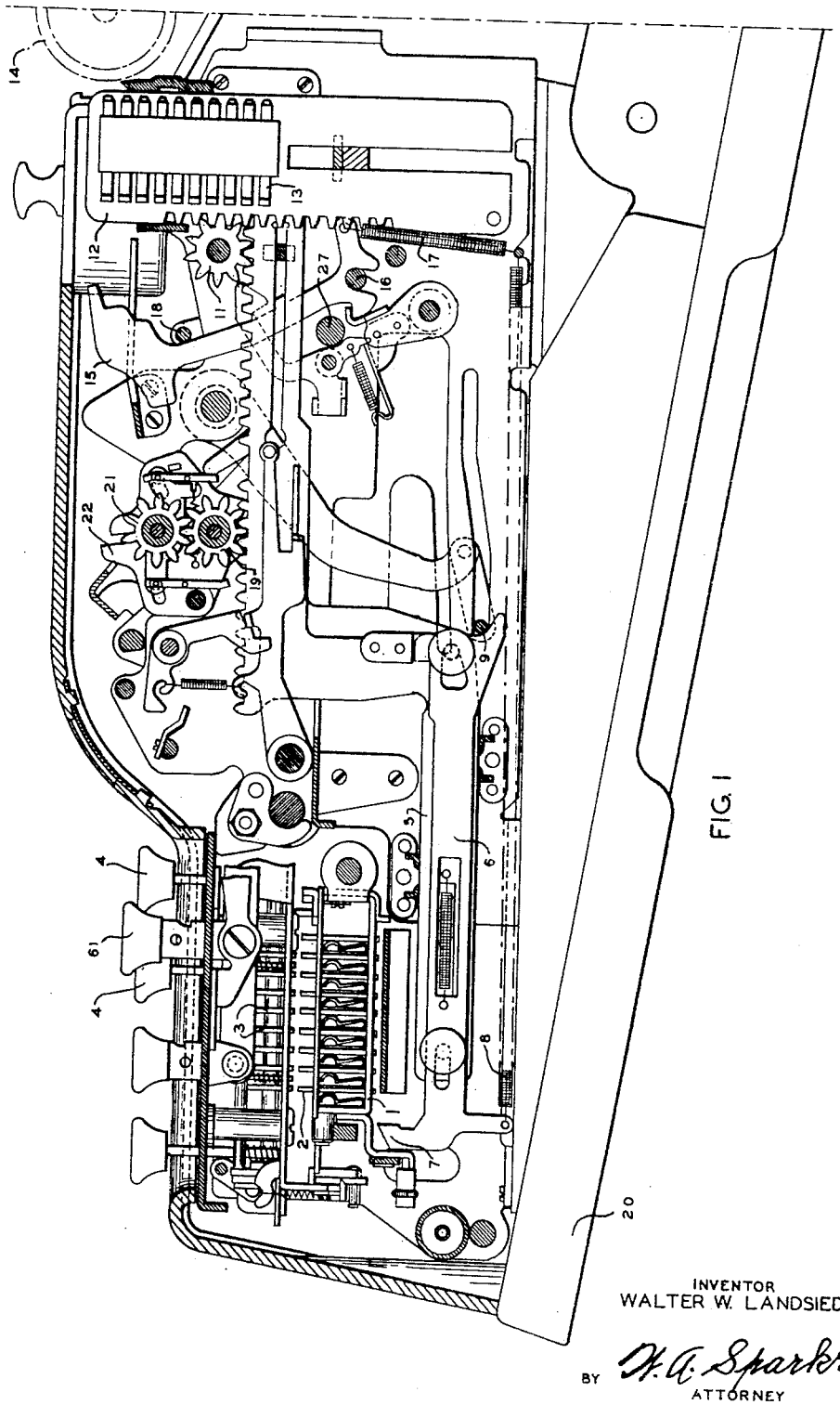

FIG. 1

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COMPUTING MACHINE

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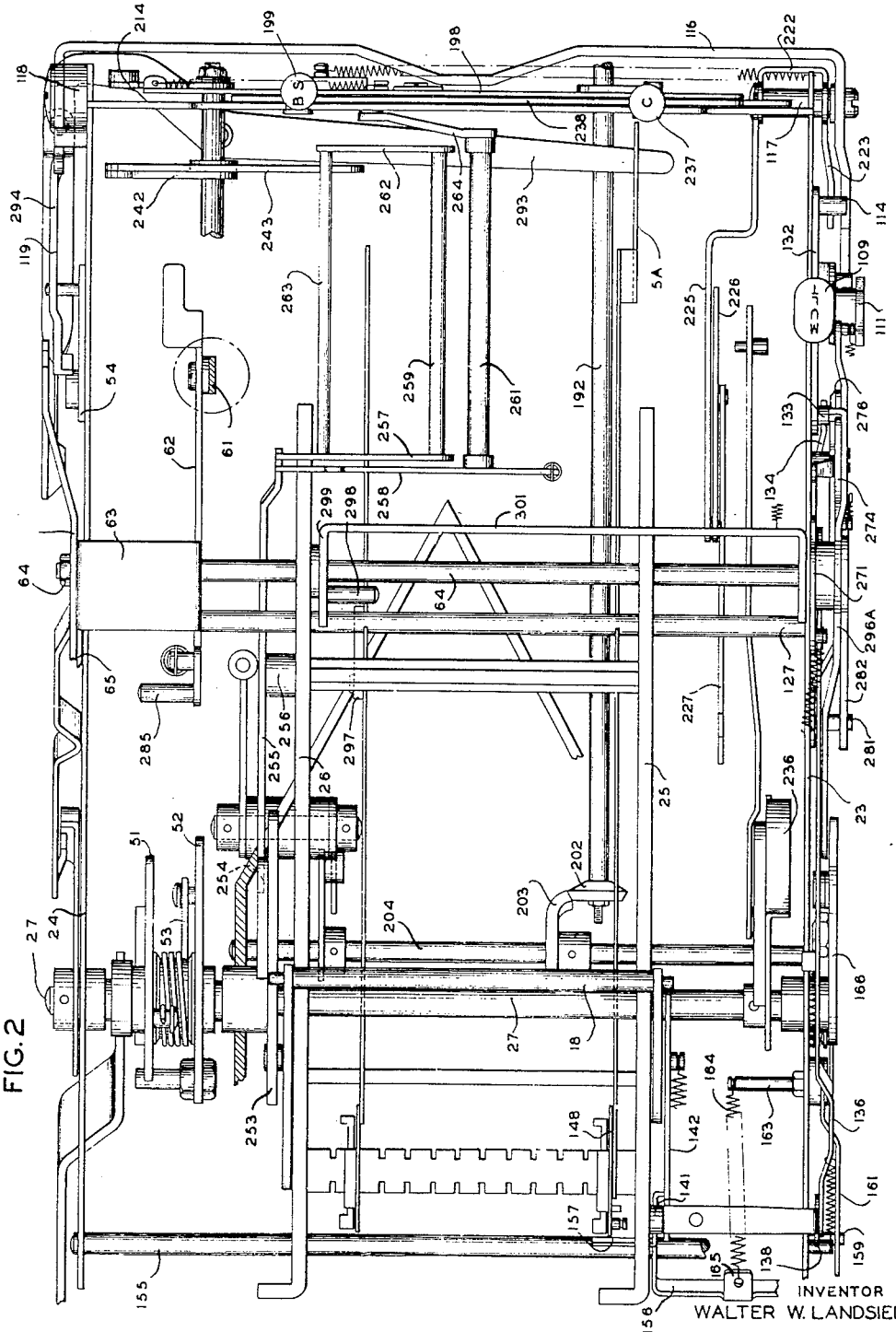

FIG. 2

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April 8, 1941. W. W. LANDSIEDEL 2,237,881

COMPUTING MACHINE

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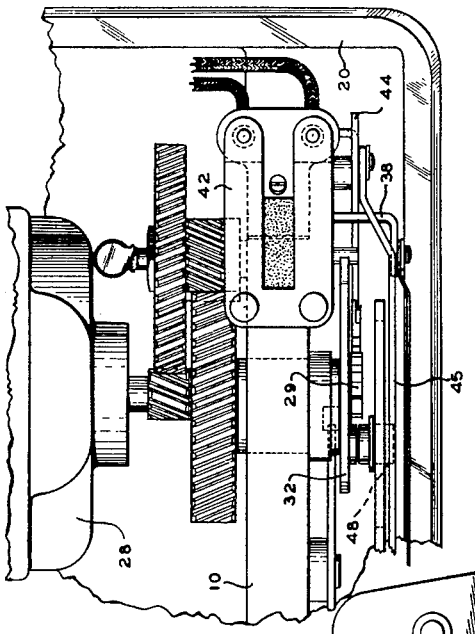

FIG. 3

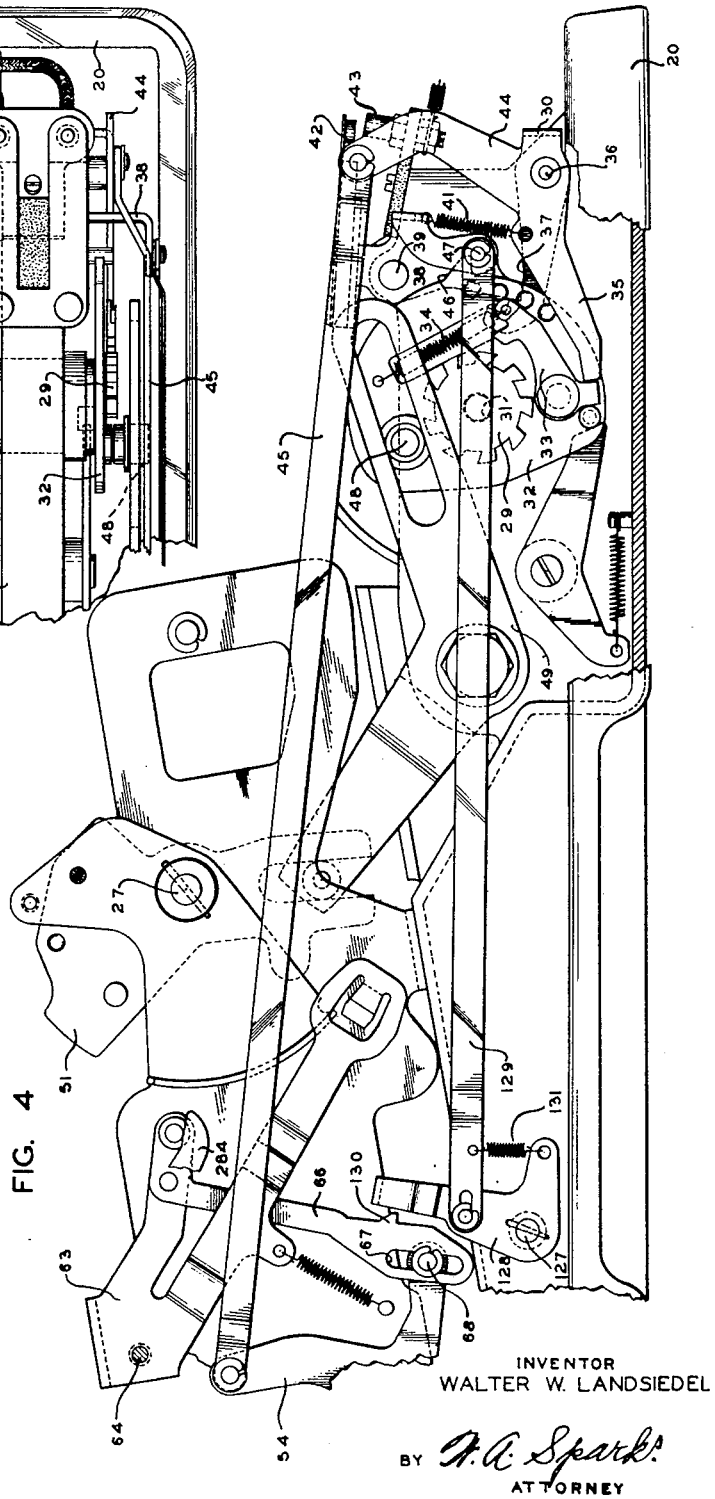

FIG. 4

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FIG. 5

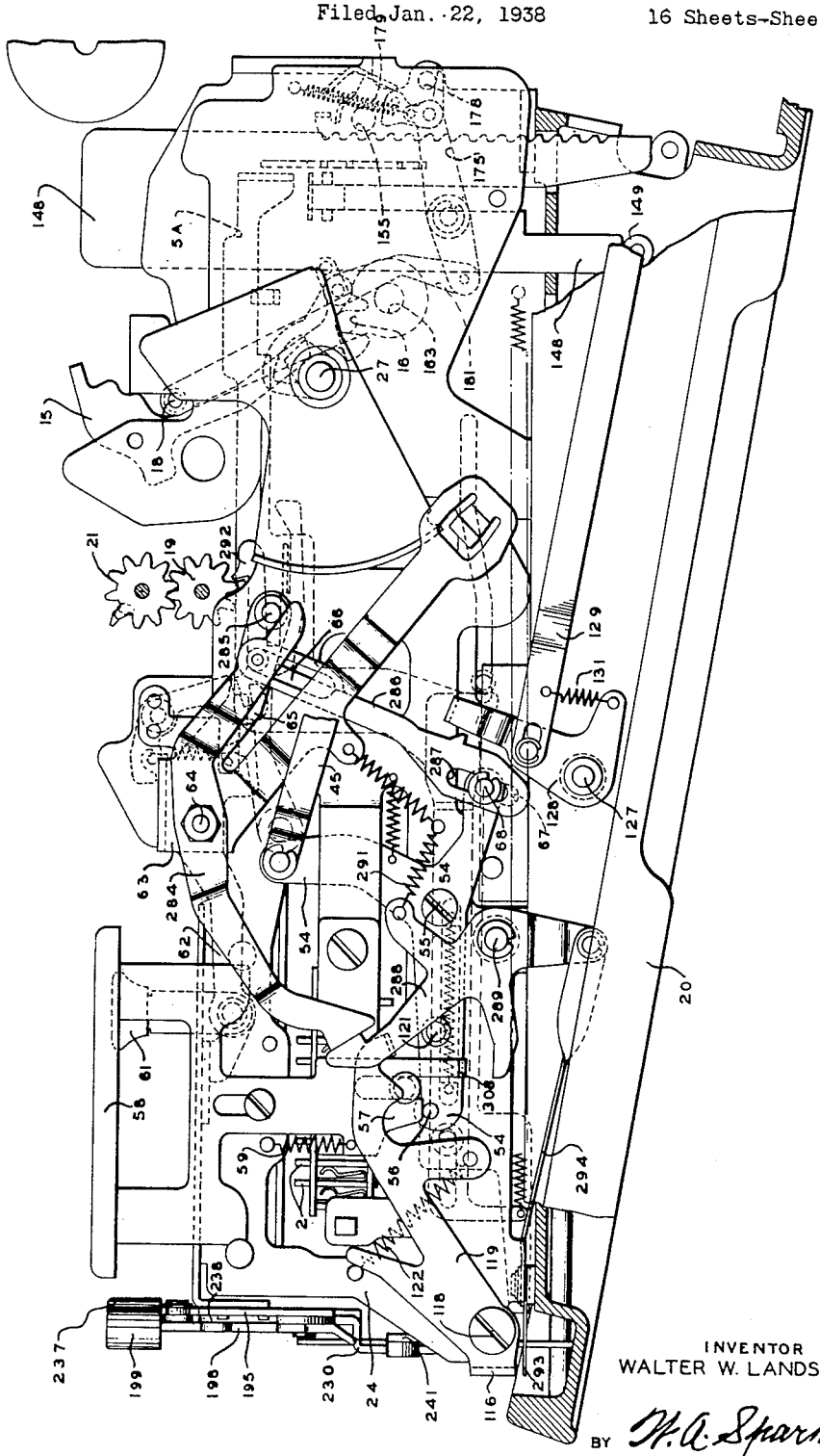

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FIG. 6

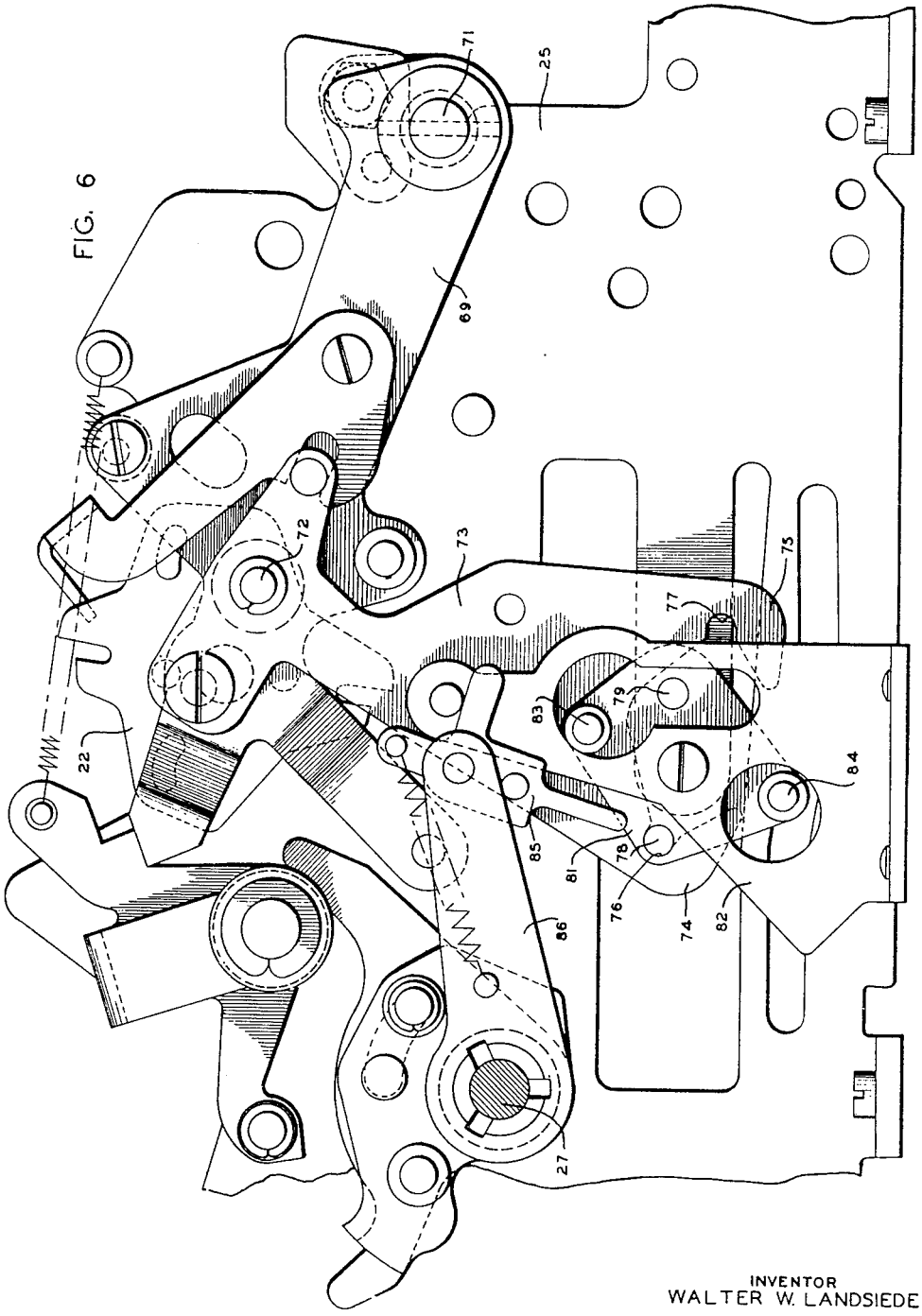

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FIG. 7

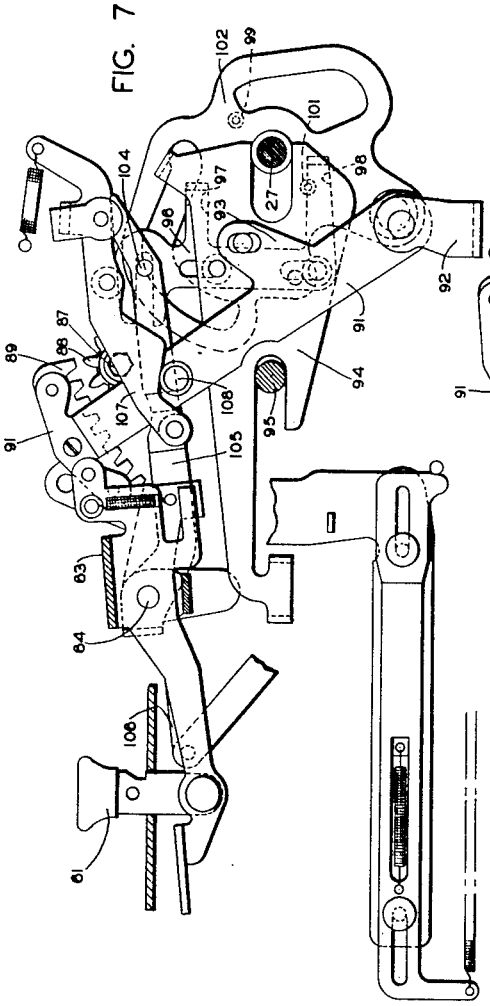

FIG. 8

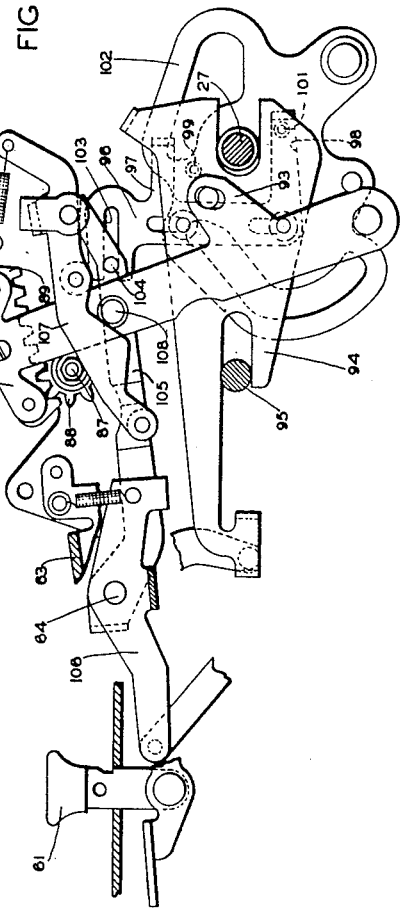

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FIG. 9

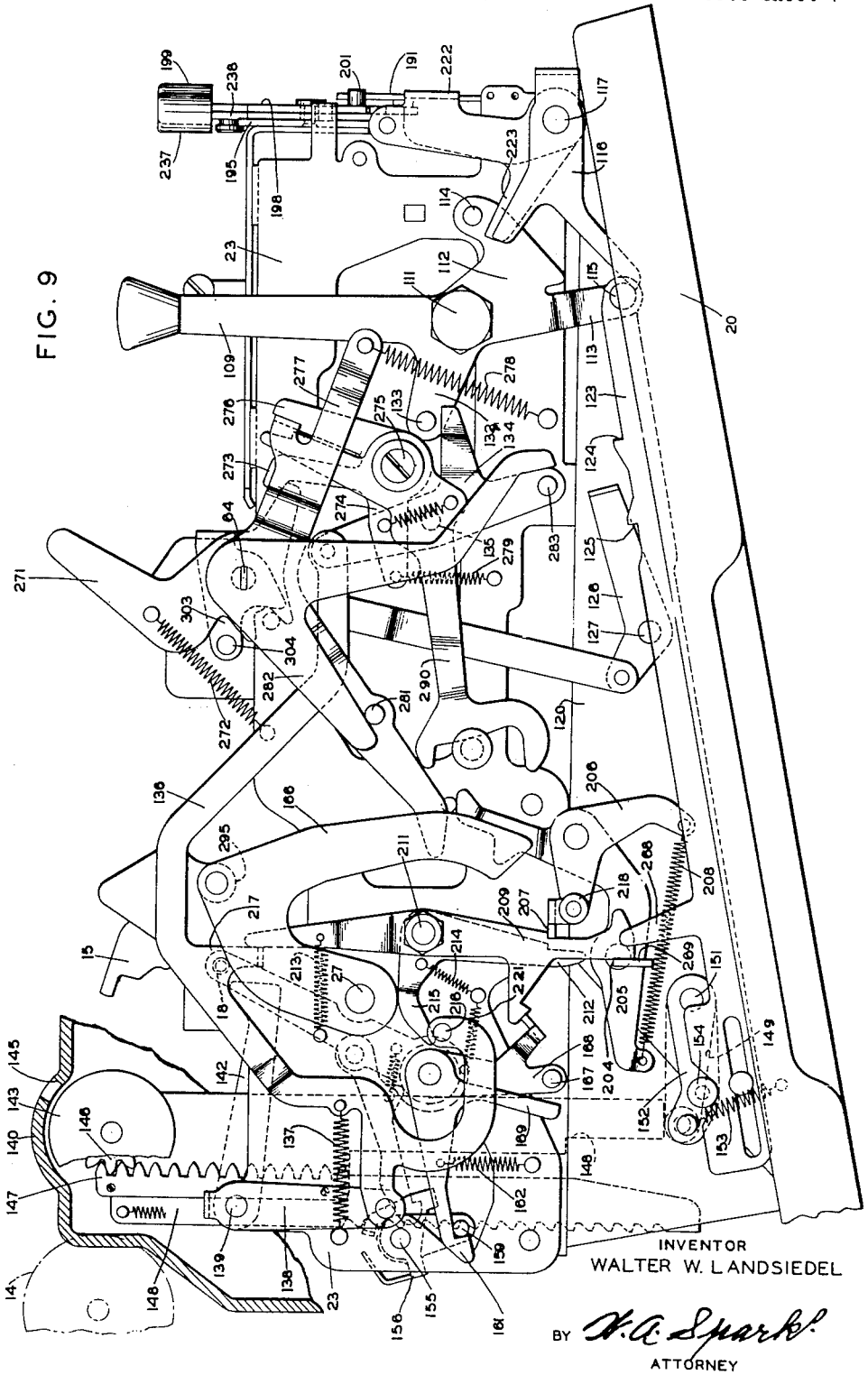

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FIG. 10

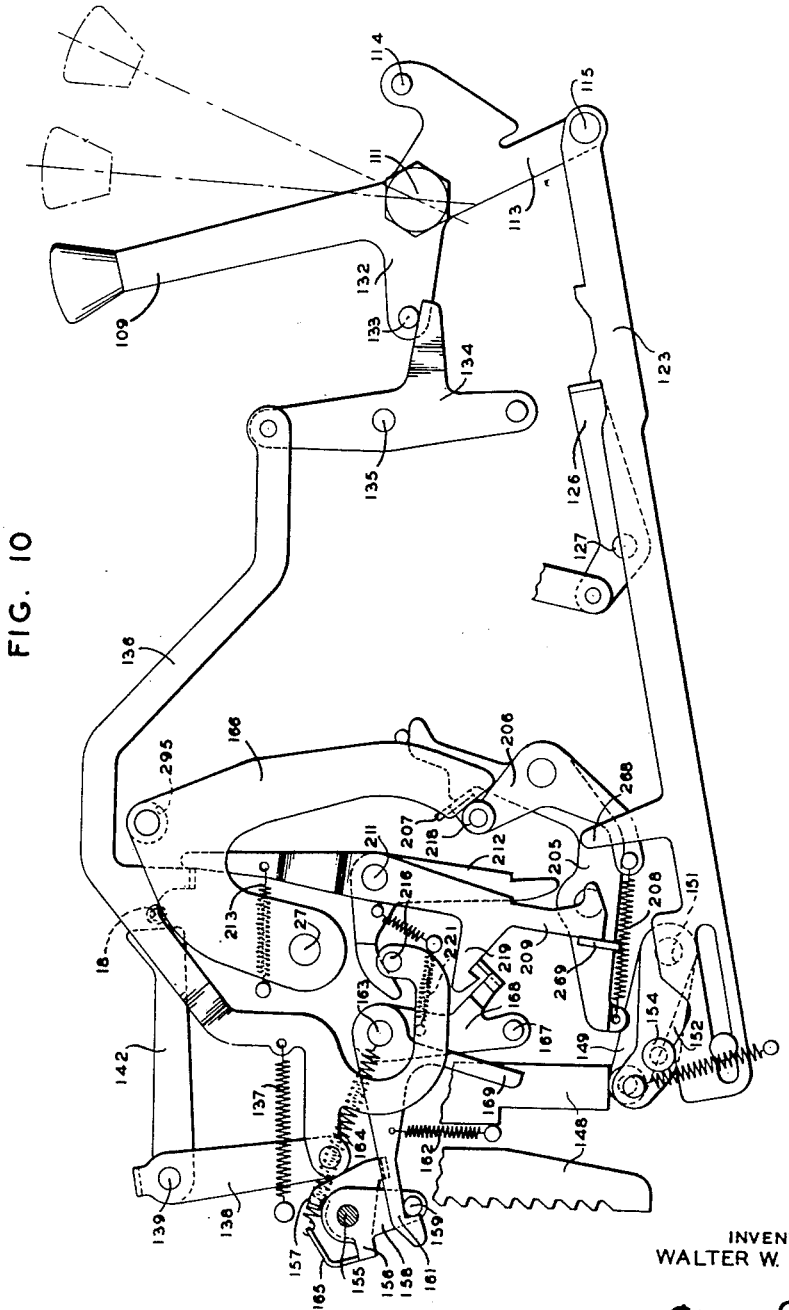

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FIG. 11

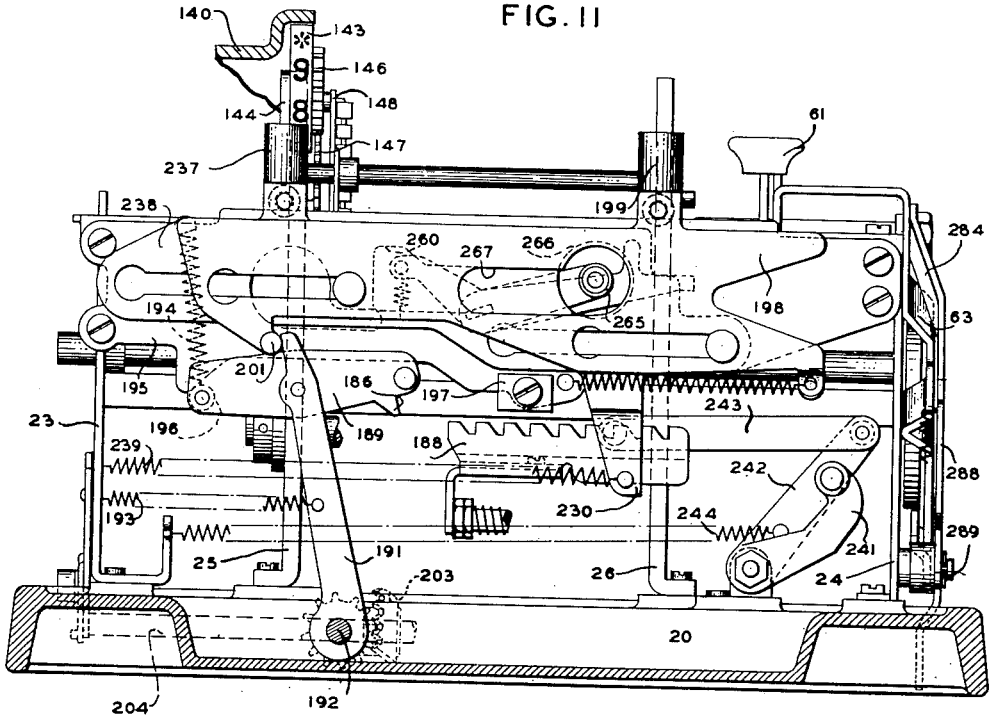
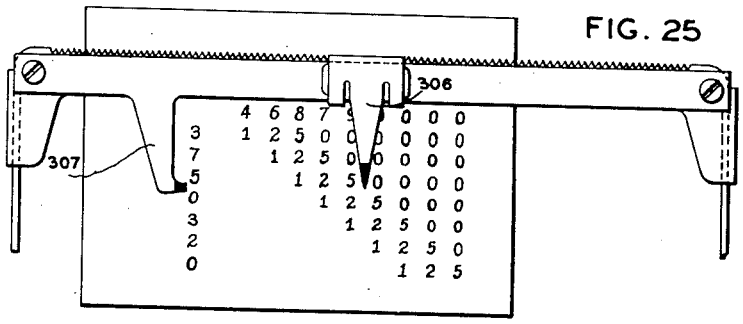


FIG. 25



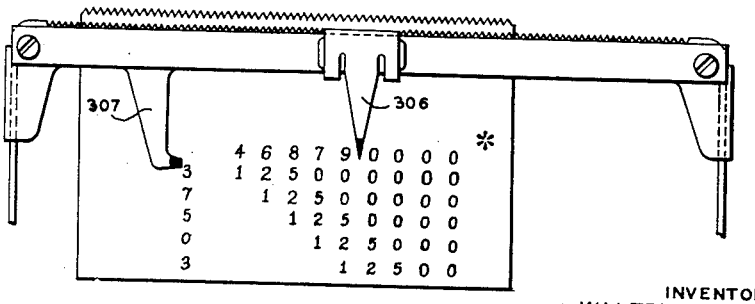


FIG. 26

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April 8, 1941. W. W. LANDSIEDEL 2,237,881

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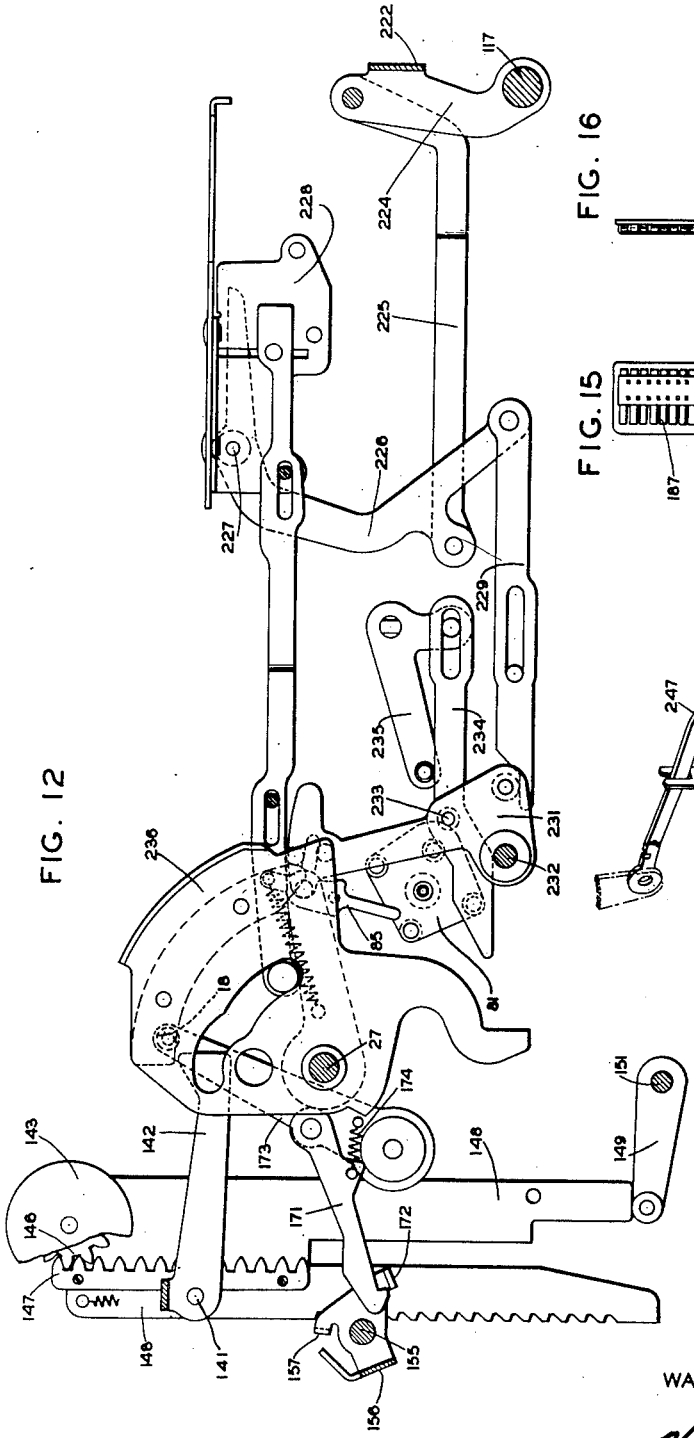

FIG. 12

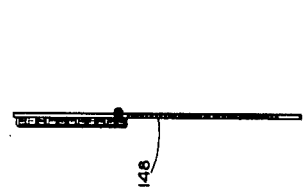

FIG. 16

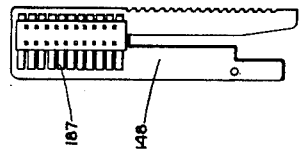

FIG. 15

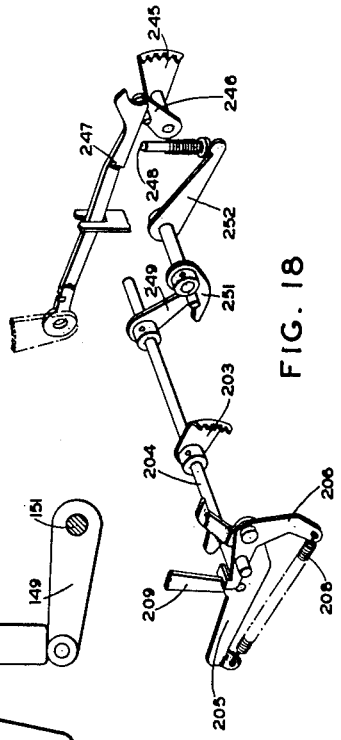

FIG. 18

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April 8, 1941. W. W. LANDSIEDEL 2,237,881

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FIG. 13

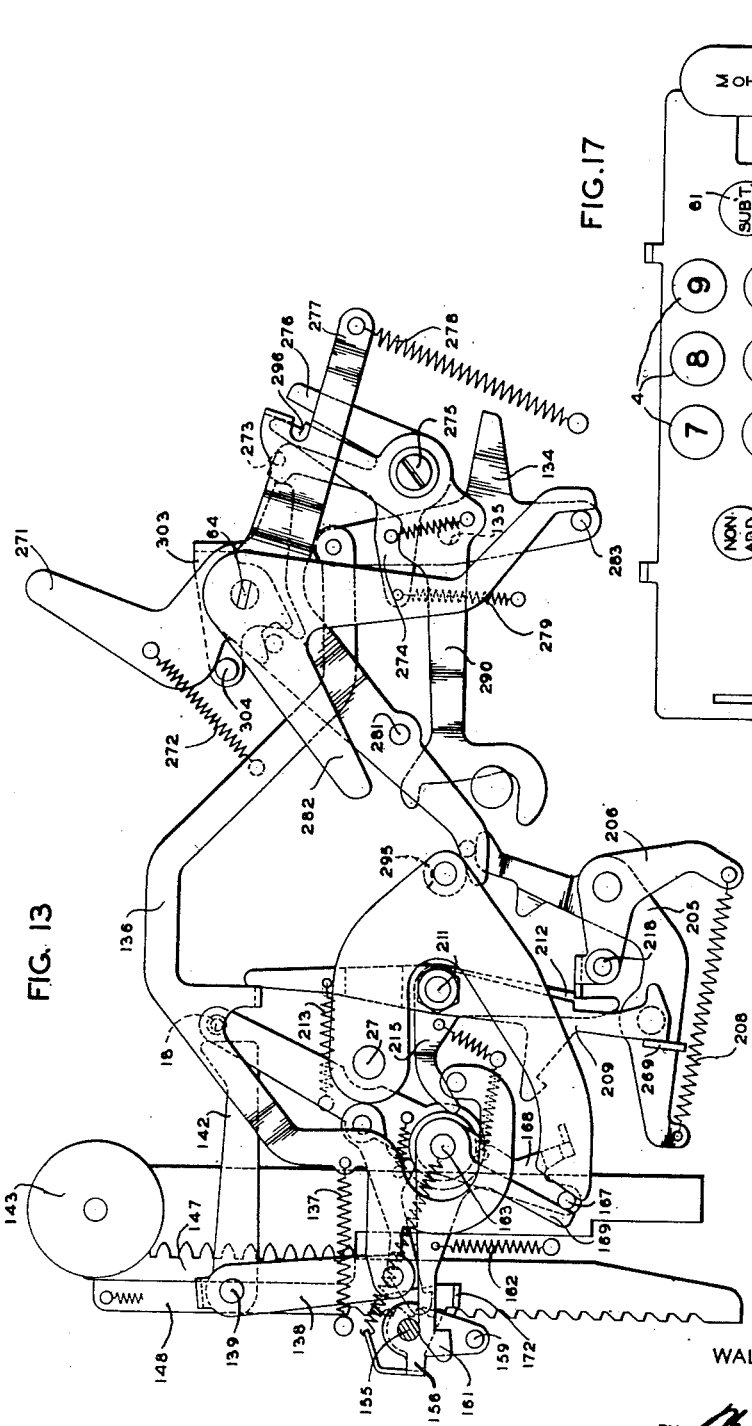
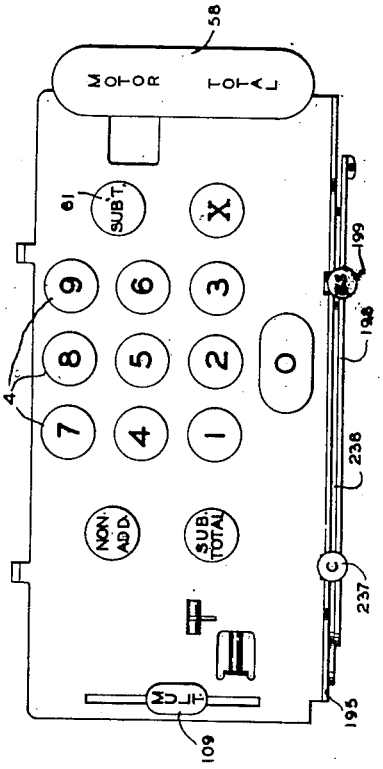


FIG. 17



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April 8, 1941. W. W. LANDSIEDEL 2,237,881

COMPUTING MACHINE

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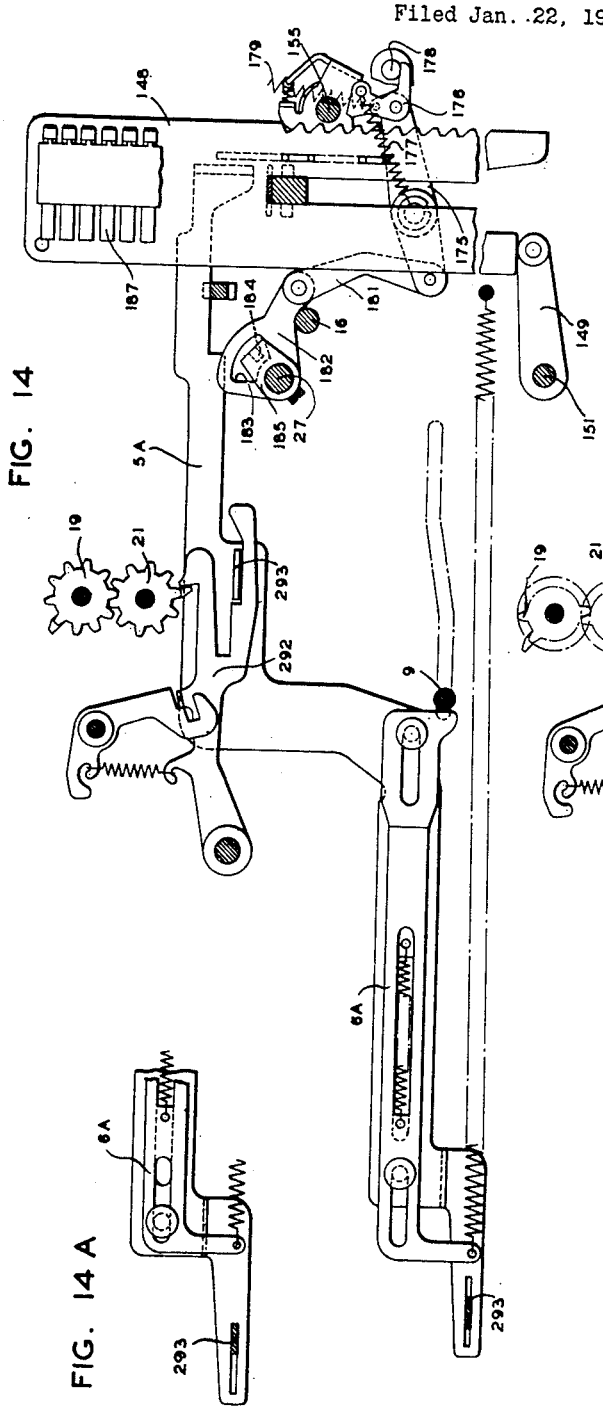

FIG. 14

FIG. 14 A

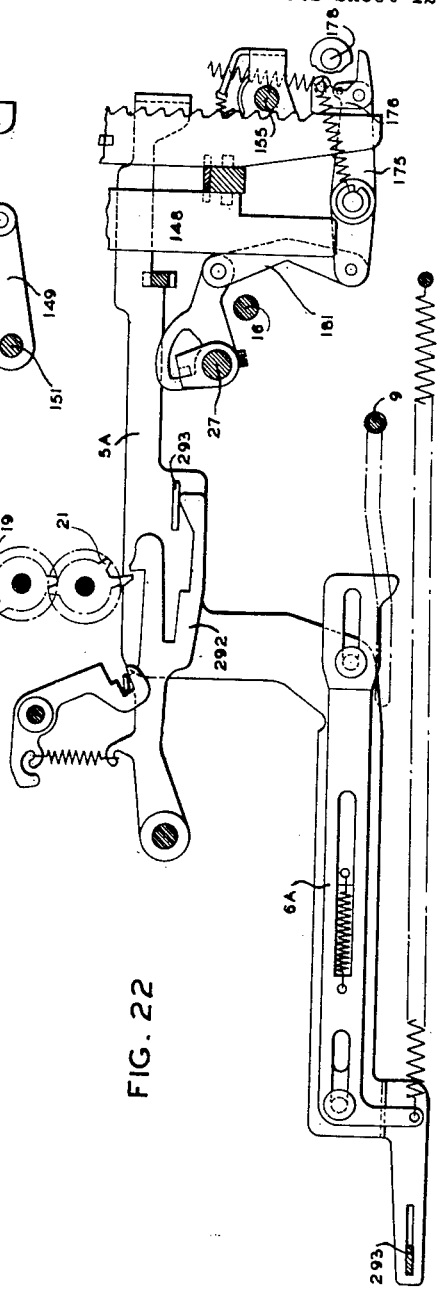

FIG. 22

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COMPUTING MACHINE

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FIG. 19

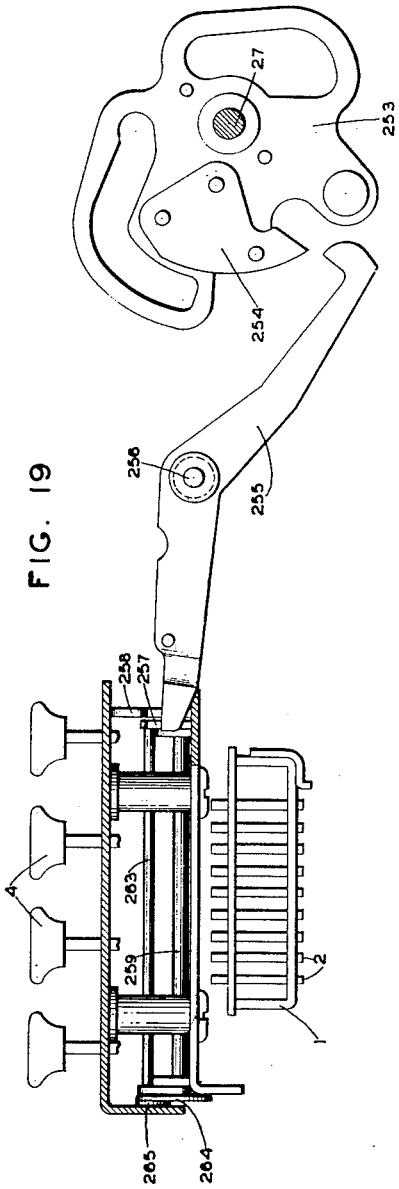
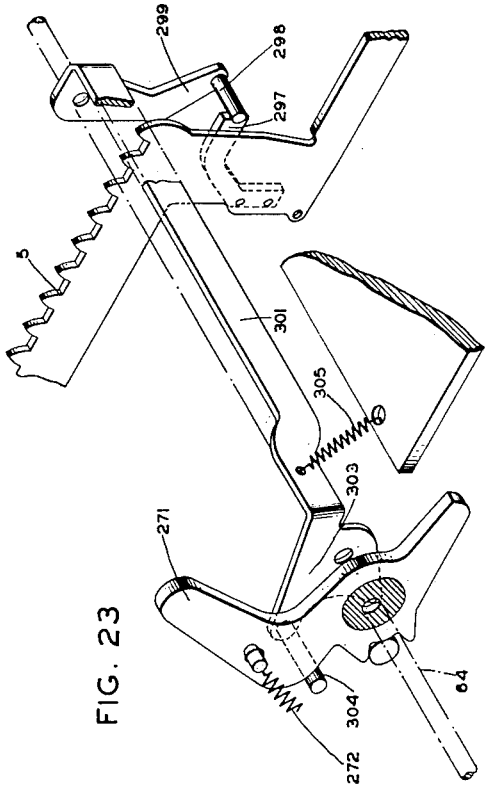


FIG. 23



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COMPUTING MACHINE

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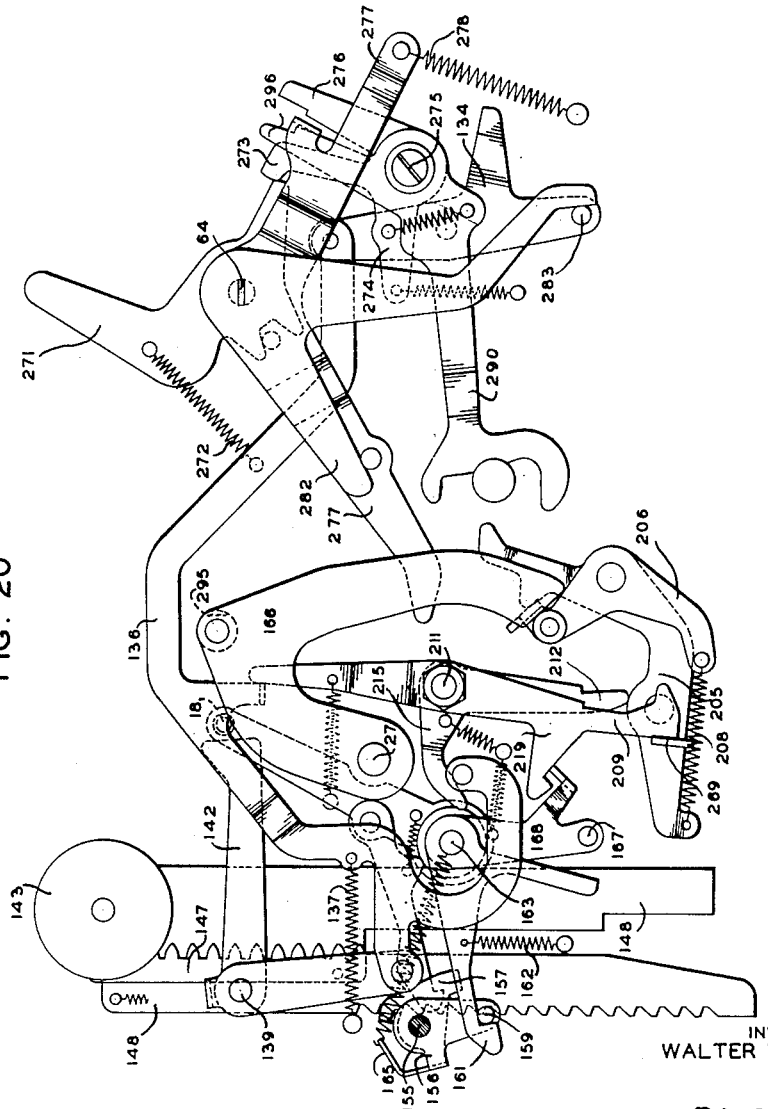
FIG. 20



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COMPUTING MACHINE

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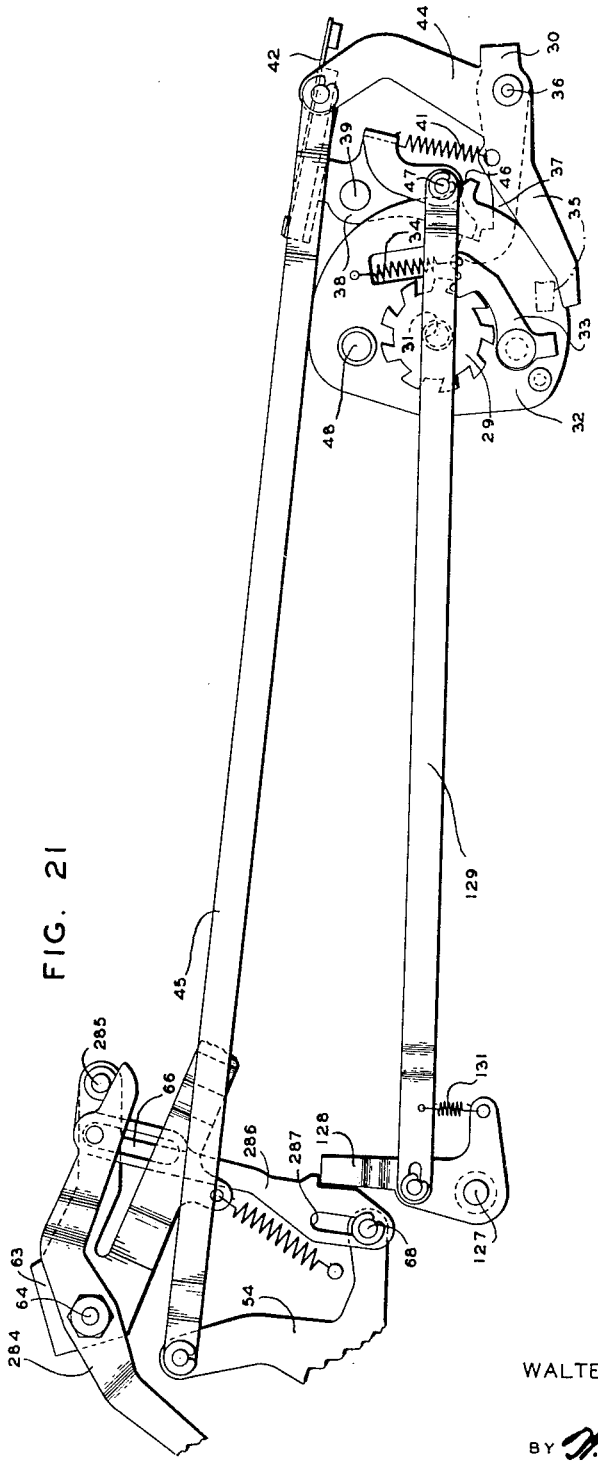

FIG. 21

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April 8, 1941. W. W. LANDSIEDEL 2,237,881

COMPUTING MACHINE

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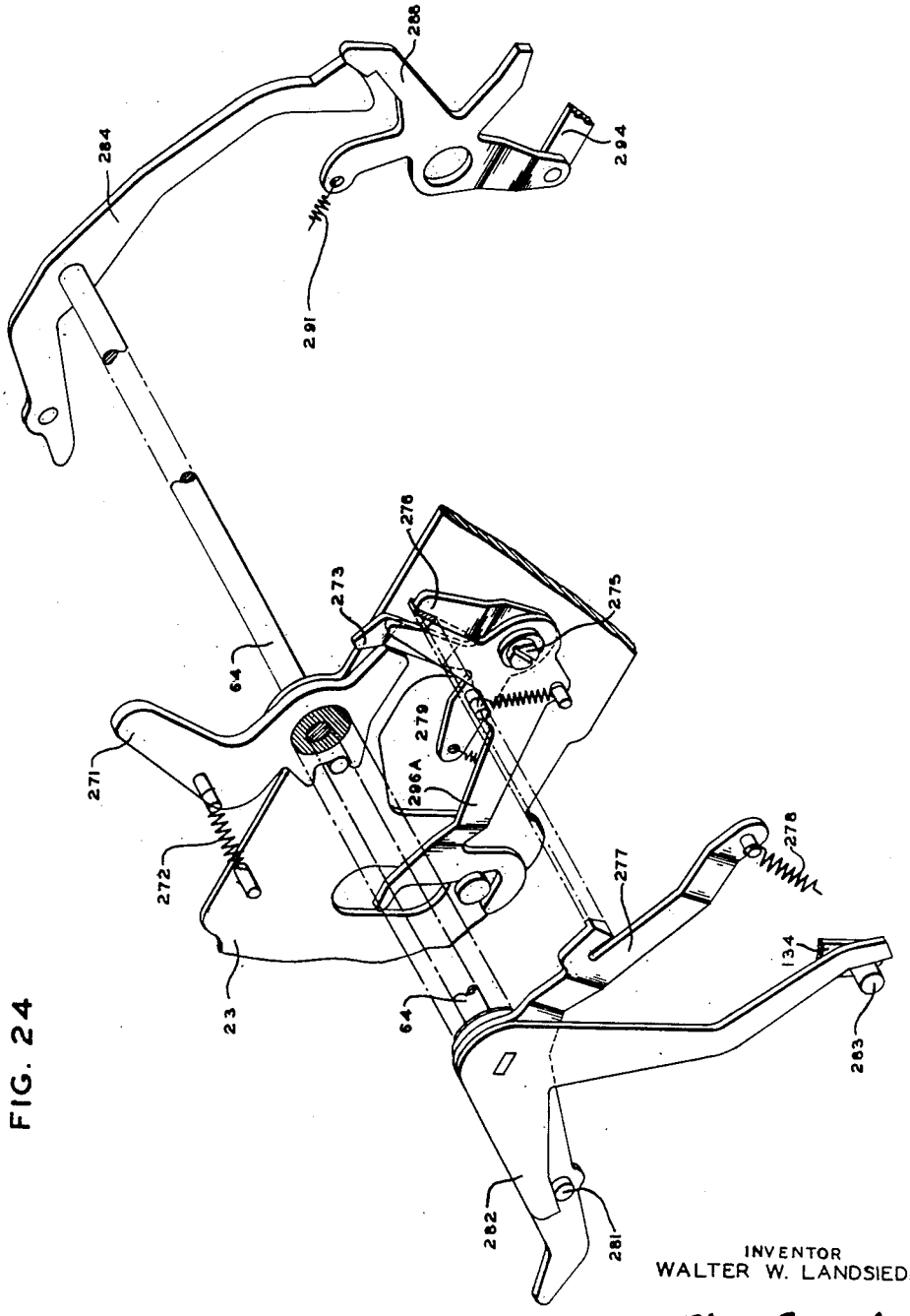

FIG. 24

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Patented Apr. 8, 1941

2,237,881

UNITED STATES PATENT OFFICE

2,237,881

COMPUTING MACHINE

Walter W. Landsiedel, Elmira, N. Y., assignor to Remington Rand Inc., Buffalo, N. Y., a corporation of Delaware

Application January 22, 1938, Serial No. 186,459

4 Claims. (Cl. 235—60)

This invention relates generally to calculating machines and, more particularly, to a machine upon which problems in multiplication and division may be performed and which prints, upon a tally roll or record sheet, all the essential factors of such problems.

The machine of the present invention is an improvement upon the machine disclosed in my prior application Ser. No. 125,704, filed February 15, 1937 and, like the machine of that application, goes back to the adding and listing machine disclosed by Mehan in his Patent No. 1,899,444, issued February 28, 1933 for many of its basic points of structure and operation. The Mehan machine as disclosed in the above patent has been improved upon in a manner other than that shown in the application S. N. 125,704, such improvement being shown in Patent No. 2,203,336, issued June 4, 1940 and Patent No. 2,229,908, issued January 28, 1941, both of which were made by the present applicant, Walter W. Landsiedel. Patent No. 2,203,336 discloses principally a novel accumulator capable of direct subtraction, while Patent No. 2,229,908 discloses the manner in which the operation of this machine has been simplified and speeded up by adapting the machine to operation by an electric motor. In the previously mentioned application S. N. 125,704, the features of multiplication and division were added to the machine and in the present application these features are further refined and improved upon.

Division is accomplished in both the previous and present applications by entirely automatic means in almost exactly the same manner. The theory of its operation is one of repeated subtraction from a single accumulator in successively lower denominational orders of the accumulator. In operating the machine the dividend is first entered into the accumulator and is printed at the same time. The divisor is then set up on a laterally movable pin carriage which is so positioned as to place the first or highest significant digit of the divisor directly beneath the highest digit of the dividend. Then the repeat key is latched down to prevent the return of the pin carriage to normal after each machine cycle, and the machine started by operation of the "division lever." The machine is automatically set for subtraction and the suppression of printing upon operation of the division lever, so that the divisor is subtracted successively from the dividend without printing until an over-subtract cycle occurs. At this time, subtraction is momentarily suspended and on the following cycle the divisor is added back into the accumulator and printed. Also printed at this time in a separate printing zone to the left of the divisor is the number corresponding to the number of subtract cycles which took place before over-subtraction occurred. This is the first digit of the quotient. During this same cycle the pin carriage is automatically backspaced, and without stopping, the machine begins a new series of subtract cycles, continuing as above, over-subtracting, backspacing, and printing until the dividend has been completely subtracted from the accumulator or until the remainder therein is smaller than the divisor. At this time the machine automatically stops and, if there is a remainder, it may be printed by totaling the machine. During division operations, printing occurs only during backspace cycles. The quotient is printed, one digit under another, on the left-hand side of the sheet, while the true divisor will be printed upon the last printing operation before the machine stops.

In accomplishing multiplication on the present machine substantially the same procedure is applied except, of course, that repeated addition instead of subtraction is performed. With the accumulator cleared the multiplicand is set up on the pin carriage and there is added to it a number of zeros which is one less than the number of digits in the multiplier. For example, if the multiplicand were 543 and the multiplier 201, then the multiplicand would be set up as follows, 54300. The repeat key is latched down, and the "multiply lever" is pushed rearward to start the machine. The lever is held rearward for the proper number of cycles signified by the first digit of the multiplier, and is then released. A suitable dial is provided for visually counting machine cycles. These cycles are add and nonprint cycles and, in order to print the result of this first multiplication, the multiply lever is pulled forward and immediately released, thereby causing a print, non-add and backspace cycle. The multiplicand is printed on a single horizontal line during this cycle, while the first digit of the multiplier is printed to the left of the sheet through the same means which effected printing of the quotient in division. This procedure is repeated throughout all the digits of the multiplier, then the pin carriage is manually returned to normal and the machine totaled to obtain the product.

For reasons to be explained in greater detail later on, the machine of the previous application S. N. 125,704 was unable to print a zero in the multiplier. When a zero appeared in the multiplier it was necessary to backspace the carriage manually, rotate the platen one step by hand and write in the zero at the proper point. Through the provision of the multiply lever mentioned above this difficulty has been eliminated since, by merely tripping this lever, a non-add, line space, backspace cycle will be effected and a zero printed at the proper point. Another dis-

'antage present in the previous machine and rcome herein has to do with the accidental)ping of the division lever when the pin car- ge is resting at normal position with none of pins set up. If such a thing occurred in the vious machine, the mechanism for automati- y stopping the machine would be prevented n operating, as will be later explained, and machine would continue running until a :h inside the machine be manually disabled. he present machine, the latch may be released ply by depression of the motor bar so that an)roper operation of the division lever is of no ticular consequence. Other features of nov- and improvement will be given in the detailed :ription to follow.

)ne object of this invention is a multiplying :hine wherein every digit of the multiplier in- ling zeros may be printed.

nother object of the invention is a simple and ctive means for stopping the machine if it is 'ted through an improper operation of the sion lever.

nother object of this invention is an improve- it upon certain interlocking mechanism be- en the correction key and the main operating ft of the machine in order to simplify and :d up the performance of multiplication on machine.

ther objects and structural details of the :ntion will be apparent from the following :ription when read in conjunction with the)mpanying drawings, wherein:

ig. 1 is a view in right-hand cross section he machine as disclosed in a previous appli- on showing several features of basic opera- but none of the mechanism of the present ntion;

g. 2 is a plan view showing the framework he machine and the relative arrangement he mechanism of the invention;

g. 3 is a fragmentary plan view showing the or drive mechanism;

g. 4 is a view in right-hand side elevation he start-stop and drive mechanism of the hine;

g. 5 is a view in right-hand elevation dis- ng the general operating mechanism of the hine;

g. 6 is a detailed elevational view of the mulator engaging and disengaging mecha- ı;

gs. 7 and 8 are views in operating position he mechanism for tumbling or switching accumulator cradle from add to subtract :ion;

g. 9 is a view in left-hand elevation of the :iplication and division control mechanism, vn in normal position;

g. 10 is a detailed view of the multiplication rol mechanism in operating position;

g. 11 is a front elevational view of the ma- e showing the manual carriage return and :space mechanism;

g. 12 is a detailed view in left-hand elevation ring principally the non-add mechanism of machine;

g. 13 is a detail view in left-hand side eleva- showing principally the backspace and divi- mechanism;

g. 14 is a detail view showing the mechanism actuating the special multiplier-quotient carrier and the means for suspending sub- :ion during division when the accumulator er-subtracted;

Fig. 14A is a detail view of a portion of the mechanism shown in Fig. 14;

Figs. 15 and 16 are detail views of the special multiplier-quotient type carrier;

Fig. 17 is a detail plan view of the keyboard of the machine;

Fig. 18 is a detail isometric view of portions of the automatic backspace and carriage return mechanism;

Fig. 19 is a detail view of the interlock between the main shaft of the machine and the manual controls operated from the keyboard;

Fig. 20 is a detail view of the division and backspace mechanism in operating position;

Fig. 21 is a detail view of the motor control mechanism in operating position;

Fig. 22 is a detail view in operating position of the mechanism shown in Fig. 14;

Fig. 23 is a detail view in isometric of the means for automatically restoring the division lever;

Fig. 24 is a detail isometric view of certain division control mechanism in normal position; and

Figs. 25 and 26 are views of a sample division problem as printed on the record sheet and also illustrate the mechanical decimal finding means.

General description

Inasmuch as the present invention is in the form of an improvement upon a machine, the original features of which are already well known in the art, only a brief description will be given herein of the machine's basic points of operation and construction. For a detailed discussion of these points, reference should be made to the aforementioned Patents Nos. 1,899,444, 2,203,336, and 2,229,980.

Referring first to Fig. 1, which is a view in cross section taken from the right-hand side of the machine, there is shown therein several essential features of the machine including the keyboard, traveling pin carriage, accumulator and actuating means therefor, and the printing mechanism. This view is identical in every mechanical respect to Fig. 1 of Patent No. 2,203,336, and is included in the present drawings in order to provide a basis for illustration of the present invention. Some of the mechanism of Fig. 1 is not used in the machine of this application, and some has been replaced by similar mechanism of a modified form. These changes and the reasons therefor will be noted in the course of the description to follow.

Considering briefly the general operation of the machine, the previously mentioned pin carriage is indicated in Fig. 1 by the reference character **1** and there is mounted therein a plurality of rows of pins **2** adapted to be depressed by the stems **3** of digit keys **4**. The key stems **3** have their lower ends positioned in a single line just over a column of pins **2**, the carriage **1** being normally so positioned as to place the extreme left-hand or highest order column beneath the stems. The carriage is spring-tensioned towards the left and suitable escapement mechanism (not shown herein) is provided in order that the carriage may shift one step leftward upon each operation of a digit key **4**, to place a new column of pins **2** beneath the stems **3**. Positioned beneath the pin carriage **1** is a set of longitudinal actuating racks **5**, each of which is connected by means of pin and slot to an associated slide **6**, formed with an upturned toe **7**. The racks **5**

and slides 6 are normally held in their forward position, against the tension of a spring 8, by means of a bail rod 9. Once for each cycle of the machine the bail rod 9 is moved rearwardly, permitting the racks 5 and slides 6 to follow until the toes 7 engage respective depressed pins 2. As shown the racks 5 project rearwardly in the machine and are formed with a series of teeth along their upper edge for actuation of the accumulator wheels and for rotating a set of pinions 11. The pinions 11, besides engaging the actuating racks 5, also engage associated printing racks 12 and elevate these racks in accordance with the extent of movement permitted the actuating racks 5. Each printing rack 12 carries the usual series of type elements 13 through which printing is effected against a platen 14. The type elements 13 are adapted to be struck by hammers 15, pivoted on a tie rod 16 and urged rearwardly by springs 17. The hammers 15, normally latched in ineffective position, are released for operation once for each machine cycle and are restored to normal by a bail rod 18.

Accumulator

In all respects, save one to be noted below, the accumulator illustrated herein is the same as the accumulator disclosed in Patent No. 2,203,336. Referring to Fig. 1, it is seen to comprise two sets of intermeshing wheels 19 and 21 supported between a pair of plates 22 (one shown). The pair of plates 22 constitutes a cradle for the wheels 19 and 21 and, through means later to be described, is adapted to be raised and lowered to disengage and engage the wheels and the actuating racks 5, and also to be turned a distance of 180° to cause the engagement of one or the other of the sets of wheels with their racks, according to the type of operation to be performed. The wheels 19 may be termed the add wheels, since they engage the racks 5 during add cycles while the wheels 21 may be called the subtract wheels since they engage the racks during subtract cycles. The wheels 19—21 normally engage the racks 5 and move to disengaged position at the start of each accumulating cycle. At approximately the middle of the cycle, and just before the racks 5 start to return to normal, the wheels 19—21 reengage the racks and, as the racks return to normal, each of the wheels is turned a number of tooth spaces determined by the extent of movement of its respective rack. During total taking cycles the wheels 19—21 remain in engagement with the racks during the first portion of the cycle, thereby positioning the printing racks 12 directly from the wheels, as is well known in the art. The point of difference mentioned above between the present accumulator and that shown in Patent 2,203,336 lies in the fact that there is no "fugitive one" mechanism in the present machine. Thus, although subtraction may be performed on the machine in the same manner as before, a negative total will be printed in its complementary form instead of in its true form as was done before. The fugitive one mechanism has been replaced in the present machine by the previously mentioned over-carry and add-back mechanism necessary to the automatic performance of division.

Framing and drive

Referring now to Figs. 1 and 2, it will be seen that the mechanism of the machine is mounted upon a base plate 20 and is further supported by a pair of outer side frames 23 and 24 and a pair of inner frames 25 and 26. The main operating shaft 27 of the machine is supported between the side frames 23 and 24. This shaft is driven in a reciprocal rocking motion, through means now to be described, once for each machine cycle. The shaft 27 is driven by an electric motor in the same manner as is disclosed in the above mentioned Patent No. 2,229,908. Referring to Fig. 3, the motor 28 is shown mounted at the rear of the machine and connected by suitable speed reducing gearing to a clutch disc 29 (see also Fig. 4) secured to the outer end of a stub shaft 31 which extends through a wall 10 of the base 20. Loosely mounted upon the stub shaft 31, just inside the disc 29 is a plate 32 upon which is pivoted a pawl 33 cooperable with the disc 29. A spring 34 tensioned between the plate 32 and the pawl 33 urges the pawl in a counter-clockwise direction (as shown in Fig. 4) into engagement with the clutch disc 29. The pawl is, however, normally held in the disengaged position shown in Fig. 4, by one arm 35 of a three-armed bail lever 30 pivoted at 36 to the wall 10. A second arm 37 of the bail lever 30 extends forwardly and is formed with a pair of steps at its forward end adapted to engage the toe of a lever 38 pivoted at 39 to the wall 10. A spring 41 connecting the lever 38 and the arm 35 urges the lever 38 in a clockwise direction (Fig. 4) and in the normal stopped position of the machine the toe of the lever limits the bottom step of the arm 37. The lever 38 is substantially bail-shaped, as shown in Fig. 3, and straddles the wall 10. Secured to the top of the lever 38 is a conductor 42 cooperable with a pair of contacts 43, forming a part of the motor circuit. As shown in Fig. 4, the conductor 42 normally lies above the contacts 43 and the motor circuit is broken or open. If, however, the lever 38 is permitted to move clockwise under tension of spring 41, the conductor will come to rest upon the contacts, thereby closing the circuit, starting the motor 28, and rotating the clutch disc 29. The motor will continue to run as long as the circuit remains closed. The lever 38 is permitted to rock through counter-clockwise movement of the bail lever 30, this movement enabling the toe of lever 38 to move on to the second step of arm 37. This bail lever 30 is formed with a third upstanding arm 44 connected to a forwardly extending link 45. Through means soon to be described, the link 45 is moved forward when it is desired to start the machine, thereby rocking the bail lever 30 in a counter-clockwise direction. As previously mentioned the arm 35 of the above bail lever normally holds the pawl 33 disengaged and it will be seen that counter-clockwise movement of the bail lever, besides starting the motor to rotate the disc 29, will also permit the pawl 33 to engage the teeth of the disc, thereby causing the plate 32, upon which the pawl is mounted, to move with the disc. The direction of movement of the plate 32 and disc 29 is counter-clockwise as viewed in Fig. 4, so that the plate will be disengaged from the disc upon the restoration of the arm 35 to normal position, since the forward end of the arm will reengage the pawl 33. A means is provided whereby in problems other than multiplication and division, the machine will automatically stop after one cycle of operation. The plate 32 is formed with a cam nose 46 on its outer periphery, this cam nose being adapted to cooperate with a stud 47 mounted in the lever 38. In the normal position of the machine, as viewed in Fig. 4, the stud 47 is positioned just below and to the right of the cam nose 46 and, as the lever 38 moves

kwise to start the machine, the stud moves vardly to a spot just beneath the cam nose 46. v, near the end of the cycle of plate 32, the e 46 cams the stud 47, and thereby the lever rearwardly in a counter-clockwise direction break the motor circuit. Also, inasmuch as toe of lever 38 holds arm 37 depressed during operation of the machine, this arm will be re- ed and the entire lever comprising arms 35, and 44 will be forced to return to normal under sion of spring 41. If, however, the previously itioned link 45 is held in its forward operating tion for more than one cycle, the bail lever vill be unable to return to normal and a new e of operation will begin immediately, with halt between cycles.

he rotating motion of the plate 32 is caused nove the previously mentioned main machine ft 27 in a reciprocable rocking motion in the al manner, through a stud 48 on the plate, a erating lever 49, an arm 51 loose on the t 27 and operable by the lever 49, arm 52 Fig. 2) fast on the shaft 27 and coil spring onnecting the two arms 51 and 52. Through chain of mechanism the shaft 27 is rocked counter-clockwise direction (Fig. 4) during first 180° of rotation of the plate and is rned in a clockwise direction during the nd 180° of rotation of the plate.

nsidering now the means for operating link 45 to start the machine, it will be seen , as shown in Figs. 4 and 5, the forward of the link is connected to an upstanding of a triple armed bell-crank lever 54 pivoted 5 (see Fig. 5) to the side frame 24. A second normally horizontal arm of lever 54 extends vardly and bears a stud 56 at its forward

Overlying the stud 56 is the stem 57 of usual operating lever or motor bar 58 slidably nted on the side wall 24. The motor bar s urged upward to the position shown in 5 by a spring 59 and is positioned at the t-hand side of the keyboard. The motor is adapted to be manually depressed, and n so operated will rock the bell-crank lever n a counter-clockwise direction (Fig. 5) to the link 45 forward and start the machine escribed. It is thus seen that anything which s the lever 54 will start the machine. Sev- means, other than the motor bar 58, are ided for operating the lever 54, one of these g the subtract key 61 (Fig. 5). The lower of the subtract key 61 is pivoted to one arm f a bail-shaped lever 63, loosely mounted shaft 64 supported by the side frames 23 24. An arm 65 of lever 63 extends rear- lly and has secured to its far end a down- lly extending link 66 (see also Fig. 4) ed with a slot 67 at its lower end. A pin n the lever 54 extends through the slot 67, nat depression of the subtract key 61 will link 66, thereby rocking lever 54 to start nachine.

Accumulator control

ferring now to Fig. 6, there is shown therein mechanism for raising and lowering the nulator wheels 19 and 21 from and into gement with their actuating racks 5. The ously mentioned cradle plates 22, between n are mounted the accumulator wheels 19 21, are supported by a pair of arms 69 shown) fast on a shaft 71 supported be- n the inner frame pieces 25 and 26. Pivoted to the left-hand arm 69 is a depending plate 73 shaped somewhat in the manner of an inverted Y. Thus the lower end of the plate 73 is formed as with two prongs 74 and 75, and along the inner edges of each prong is a respective notch 76 and 77. Adapted to be engaged by the notches 76 and 77 is a pair of pins 78 and 79 mounted on opposite ends of a plate 81 pivoted to a fixed bracket 82. The pins 78 and 79 are mounted on the right-hand side of the plate 81 (as viewed from the front of the machine) and on the left-hand side of the plate are two studs 83 and 84 cooperable in the usual manner with a wipe pawl 85 pivoted on the outer end of an arm 86 fast on the main shaft 27. In Fig. 6 the above mechanism is shown in its normal position with the notch 76 engaging the pin 78 and the wipe pawl 85 held out of engagement with either stud 83 or 84. As previously mentioned the accumulator wheels are normally in mesh with their actuators. Now as the shaft 27 begins to turn at the beginning of a cycle (clockwise, as viewed in Fig. 6) a shoulder of the wipe pawl contacts the stud 83 and as the main shaft continues to turn, the plate 81 is rocked in a clockwise direction, thereby elevating member 73 to rock arms 69 upward and disengage the accumulator. This occurs at the start of the machine cycle before the actuating racks 5 move rearward, and as the rock shaft 27 continues its forward motion the wipe pawl 85 pivots idly about the second stud 84. At the start of the return stroke of the shaft 27, but before the actuators 5 begin their return stroke, the opposite shoulder on the wipe pawl 85 contacts the stud 84 and rocks the plate 81 counter-clockwise back to normal, thereby lowering the arms 69 and engaging the accumulator wheels and their racks, in order that the amount set up on the racks may be added to or subtracted from the wheels. Through means not herein shown the plate 73 is shifted a short distance in a clockwise direction (Fig. 6) during total strokes to engage notch 77 and pin 79 and disengage notch 76 and pin 78. The mode of operation is thus reversed and the accumulator wheels 19 and 21 remain in mesh with the racks 5 during the forward stroke of the machine and are cleared as is well known in the art. All of the above mechanism, as well as some illustrated but not described herein, is exactly the same as that disclosed in the above-mentioned Patent No. 2,203,336.

Also disclosed in the above application is the previously mentioned mechanism for rotating the accumulator cradle to place either the wheels 19 or the wheels 21 into mesh with the racks 5, according to whether the amount to be entered is positive or negative. This mechanism is briefly described hereinafter.

Projecting from the center of the right-hand cradle frame piece 22, in a manner not completely shown herein, is a stud 87 (see Figs. 7 and 8) and fast on this stud is a pinion 88. Adapted to engage and rotate the pinion 88 is a rack 89 fixed to the upper end of a lever 91 pivoted to a fixed bracket 92. The lever 91 is formed with an arm 93 which engages, through a pin and slot connection, a slide 94 loosely mounted for free forward and rearward movement upon the main shaft 27 and a fixed cross bar 95. Mounted for limited vertical movement upon the slide 94 is a plate 96 formed with rearwardly extending arms 97 and 98 adapted to cooperate respectively with pins 99 and 101 integral with a cam 102 fast on the shaft 27. Cut in the upper

end of the plate 96 is a horizontal slot 103 through which projects a pin 104 formed on an arm 105. The arm 105 is pivoted to the previously mentioned shaft 64 and is operable by the subtraction lever 63, through an intermediate lever 106, as is fully disclosed in the above mentioned Patent No. 2,203,336. During adding operations the lever 91 is positioned as shown in Fig. 7 with the right-hand end of the rack 89 overlying the pinion 88. When the subtract key 61 is depressed, the arm 105 is rocked in a counter-clockwise direction about its pivot 64, thereby raising the plate 96 to its highest elevated position. These several parts are shown in Fig. 7 in the position they assume immediately upon depression of the subtract key. Now, it will be seen that, as the shaft 27 begins to rock (counter-clockwise as viewed in Fig. 7), the pinion 88 will be raised into engagement with the rack 89, through means previously described, and the pin 101 on cam 102 will strike the bent-over end of lower arm 98 on plate 96 and will subsequently move the assembly comprising plate 96, slide 94 and lever 91 rearwardly to the position shown in Fig. 8. During the course of this movement the pinion 88 and the accumulator cradle to which the pinion is secured are turned a distance of 180°. A spring-pressed detent 107, cooperating with a roller 108 on the lever 91, is provided to retain the lever in either its add or subtract position and also to add impetus to the movement of the lever when the roller passes the high point of the detent. It is evident that as long as the subtract key 61 remains depressed the accumulator cradle will remain in its Fig. 8 position and on each operation of the cam 102, the pin 99 thereon will pass idly beneath the arm 97 without effect. When the subtract key is released, however, the lever 105 will immediately move in a clockwise direction to its normal position, thereby lowering the plate 96 to place the arm 97 in the path of the pin 99 and at the same time placing the arm 98 out of the path of pin 101. Thus, during the first part of the cycle following the release of the subtraction mechanism, the accumulator cradle will be rocked back to add position where it will remain until the subtract key is again depressed.

As is fully disclosed in Patents Nos. 2,203,336 and 2,229,908 totaling is performed on these machines simply by cycling the machine twice in succession with nothing set up on the keyboard. The mechanism for this purpose is not shown herein but may be found in the above patents.

The description of the machine has, up to this point, been limited to its fundamental features of construction and operation already previously disclosed in one or the other of the above two patents or the previously mentioned Mahan Patent No. 1,899,444. The remaining portion of the specification will be directed towards a disclosure of the multiplication and division mechanism in general and the novel features of the present invention in particular.

Multiplication

Considering first the multiply mechanism, in my prior application S. N. 125,704 a multiply key is provided and also a stub key operable by the multiple key. As provided therein, after the pin carriage 1 is set in accordance with the digits of the multiplicand the multiply key is depressed and held depressed for the number of machine cycles represented by the first digit of the multiplier. The multiply key is then released but the stub key remains depressed for an additional cycle causing the machine to go through one more cycle of operation. It is during this cycle that the pin carriage is backspaced, and the multiplicand printed. Printing does not occur during any other cycle in multiplication. Mechanism is also provided for counting and printing the number of machine cycles. It will be seen that the use of this stub key makes it impossible to operate the machine for only one cycle of operation by depressing and immediately releasing the multiply key, since the stub key always causes a second cycle. Now, since the above counting operation occurs at the end of each cycle and printing occurs at the middle of the cycle and, since the counter stands at zero upon operation of the multiply key, it is evident that a one is the lowest digit which could be printed in the multiplier. The machine of the previous application, therefore, was unable to print a zero in the multiplier and one of the features of the present invention is the provision of mechanism for this purpose.

Multiply lever

Instead of the multiply key of the previous application, the present machine employs multiply lever 109 (see Fig. 9) movable either forward or rearward from its normal intermediate position shown in Fig. 9. Either direction of motion serves to start the machine. The lever 109 is pivoted at 111 to the left-hand side wall 23 and is formed with two arms 112 and 113 which bear respective studs 114 and 115, which studs overlie separate branches of a bail-shaped lever 116. Referring also to Figs. 2 and 5, it will be seen that the lever 116 is pivoted at its left-hand end to a stub shaft 117 mounted in the side wall 23, and that the lever extends across the front of the machine and is pivoted at its right-hand end, at a point 118, to the right-hand side wall 24. The right-hand end of the lever 116 is in the form of a rearwardly extending arm 119 and the extreme rear end of this arm is bent off in the form of a lug, and overlies a stud 121 formed on the previously mentioned motor operating bell-crank lever 54. A spring 122 tensioned between the arm 119 and a fixed stud on the side wall 24 serves to retain the lever 116 in the normal position illustrated, and also indirectly urges the lever 109 into its normal upright position. It will be evident, however, that movement of the lever 109 either forwardly or rearwardly will cause one or the other of the studs 114 and 115 to rock the bail lever 116 (counter-clockwise as viewed in Fig. 9), thereby operating bell-crank lever 54 and starting the machine. The machine will continue to run without interruption as long as the lever 109 is held operated. Latching means is provided for holding the lever 109 in operated position for at least one complete cycle in order that certain mechanism (later to be described), under the control of the lever, may be held operated until the end of a cycle. As shown in Fig. 9, the lowermost extension 113 of the lever 109 is connected to the forward end of a rearwardly extending link 123 slidably mounted upon the base wall 10. Formed on the upper edge of the link 123 is a pair of shoulders 124 and 125 adapted to cooperate with a latch 126 secured to the left-hand end of a shaft 127 supported between the base walls 10 and 120. The front end of the latch 126 is bent leftward and normally rests just above the link 123 between the shoulders 124 and 125. At the start of each machine cycle, and through means soon to be described, the latch is spring-

pressed into engagement with the link so that upon movement of the link in either direction, by the lever 109, the latch will drop behind one or the other of the shoulders 124 and 125, thereby holding the link 123 and the lever 109 in operating position. The latch 126 is disabled at the end of each machine cycle, through the following means and, unless the lever 109 is manually held operated, the lever and the link 123 will return to normal at this time permitting the machine to stop. Referring to Figs. 4 and 5, it will be seen that the shaft 127, to which the latch 126 is secured, extends through the right-hand base wall 10, and on the extreme right-hand end of the shaft is secured a bell-crank lever 128 to which is connected one end of a longitudinal link 129. The other end of the link 129 is connected to the stud 47 (Fig. 4) on the lever 38 previously described. The point of connection between the lever 128 and the link 129 is a pin and slot arrangement which enables each member to move a short distance independently of the other. A spring 131 tensioned between the link 129 and an arm of the lever 128 serves to retain the pin which is formed on the lever in the forward end of the slot which is cut in the link. Due to the fact previously mentioned that the toe of the lever 38 normally engages the lower step on arm 37, the lever 128 is normally held rearward in the position shown in Fig. 4, and the latch 126 on the opposite end of the shaft 127 (Fig. 9) is normally positioned with its bent-over end just above the link 123. At the very beginning of each machine cycle, however, the lever 38 rocks clockwise as was previously described and moves the link 129 a short distance forward. The spring 131 causes the lever 128 to follow this movement, thereby rocking the shaft 127 to move the latch 126 to effective position as above described. The shaft 127 will remain rocked for one complete machine cycle until it is positively returned through the cooperation of cam nose 46, on the plate 32, and stud 47 on the lever 38. If, however, the motor control lever 54 is still held rocked, a new machine cycle will begin and the above mechanism will return immediately to operating position. The bell-crank lever 128 also serves as a latch by engaging a nose 130 formed on the side of the subtract link in order that the subtract mechanism may be held operated for the duration of a cycle.

Non-print-add-cycle counting

Returning to the function of the multiply lever 109, it will be recalled that, when this lever is pushed rearwardly, the machine is caused to perform add and non-print cycles and certain counting mechanism is rendered effective which registers the number of cycles the machine goes through during the time the multiply lever is held operated. Fig. 10 shows the lever 109 in its rear operating position. Referring to Figs. 9 and 10, the lever 109 is formed with a rear extension 132 bearing a stud 133 which overlies an arm of a lever 134 pivoted at 135 to the side wall 23. Rearward motion of the lever 109 will thus rock the lever 134 in a clockwise direction (Fig. 9) about its pivot 135. Connected to the upper end of the lever 134 is the front end of a rearwardly extending link 136 urged toward the rear of the machine by a spring 137 anchored to a stud on the side wall 23. The rearmost end of the link 136 is connected to the lower end of an arm 138 which forms one portion of a bail-shaped lever pivoted, as is shown particularly well in Fig. 2, at 139 to the outer side wall 23 and at 141 to the inner frame piece 25. Also forming a part of this bail lever is a forwardly extending arm 142 normally positioned, as shown in Fig. 9, with its front end just below and to the rear of the previously mentioned bail rod 18 which lies in the path of the printing hammers 15 and serves to restore the hammers after printing. It will be seen that forward movement of the link 136, caused by the rocking of lever 134, will rock the above mentioned bail lever in a counter-clockwise direction (Fig. 9) to place the toe of arm 142 in the path of the bail rod 18, thereby preventing printing by disabling the hammers 15 (see Fig. 10). Through this means printing is disabled as long as the lever 109 is held rearward.

The second function of the machine during multiplying operations is that of adding the multiplicand into the accumulator once each machine cycle. This is accomplished, as previously mentioned, by first setting up the number on the pin carriage and then latching down the repeat key to prevent automatic return of the carriage after each machine cycle. The mechanism provided for this purpose is old and well known in this type of machine and need not be further discussed here.

The third function of the machine during multiplying operations is that of counting the machine cycles. In the present machine as well as in the machine of application S. N. 125,704, this is done by advancing a visible dial one step for each machine cycle. This dial is mounted at the upper rear, left-hand corner of the machine and is shown in Figs. 9 and 11 indicated by the reference character 143. The dial 143 is supported by a bracket 144 (Fig. 11) secured to the left-hand inner frame piece 25, in a manner not completely shown herein, and may be read through an opening 145 (Fig. 9) in the outside machine casing 140. Inscribed on the dial in the usual order are the ten numerals from 9 to zero, and in addition to these an asterisk or star is provided, this designating mark being positioned between the 9 and the zero, as shown in Fig. 11. In the normal position of the dial the asterisk is in line with the opening 145. Secured to the right-hand side of the dial 143 is a pinion 146 the teeth of which are engaged by a rack 147 fastened to the side of a special type carrier 148. The type carrier 148 is mounted slightly to the left of the regular type bars 12 and, as shown in Fig. 9, extends into the base portion of the machine where a part of its bottom edge overlies a roller mounted on the rear end of an arm 149 (see also Fig. 12). The arm 149 is fast on the right-hand end of a short shaft 151 supported in the base wall 120. The left-hand end of the shaft 151 extends leftwardly outside the base wall and has fast thereto an arm 152 tensioned downward, or counter-clockwise as viewed in Fig. 9, by a spring 153. Mounted on the side of the arm 152 is a roller 154 which normally rests in a notch cut in the upper rear edge of the previously mentioned link 123. It will be seen that movement of the link 123 in either direction will force the roller 154 out of its notch, thereby rocking the shaft 151 in a clockwise direction (Fig. 9) to raise the rack 148 a short distance upward through arm 149 (see Fig. 10). The distance the rack 148 is elevated by the link 123 is proportionately equal to the distance between the numerals on the dial 143 so that when the rack is elevated in this manner the dial is turned one step in a clockwise direction (Fig. 9) through the cooperation between rack 147 and

pinion 146, to place the zero on the dial opposite the sight opening 145.

Through the following means, the rack 148 is detented in its elevated position and is advanced an additional step once for each machine cycle. Rigidly mounted between the side walls 23 and 24, near the rear of the machine, is a shaft 155 (see Figs. 2 and 10) positioned just behind the rack 148. Loosely mounted on the shaft 155 just inside the the side wall 23 is a bail-shaped member 156 formed with a detent finger 157 (see also Fig. 12) adapted to engage teeth cut in the rear of the rack 148. The left-hand end of the bail-shaped piece is formed as a downwardly extending arm 158 (Fig. 10) upon the lower end of which is mounted a stud 159. Adapted to engage the stud 159 is a hook 161 drawn downward into engaging position by a spring 162, and pivotally mounted on a stud 163 set in the side wall 23. As shown in Figs. 9 and 10 the hook 161 normally engages the stud 159 and holds the detent finger 157 out of engagement with the teeth on rack 148, against the tension of a spring 164 anchored at one end to the stud 163 and connected at its other end to a bent-over ear 165 formed on the bail-shaped piece 156. Midway during each machine cycle, the hook 161 is rocked in a clockwise direction against the tension of the spring 162, thereby releasing the stud 159 and permitting the bail-shaped piece 156 to rock under tension of the spring 164, until it is limited by engagement of its detent finger 157 with one of the teeth on rack 148. The disabling of hook 161 is done by a cam 166 (Figs. 9 and 10) fast on the left-hand end of the main operating shaft 27. The cam 166 is shaped in the form of a bent finger and on the forward stroke of the machine moves in a clockwise direction (as viewed in Fig. 9) with the shaft 27. Near the end of the forward stroke the tip of the finger-shaped cam 166 contacts a stud 167 on a latch 168 (later to be described) and, through this stud, operates an arm 169 of the hook 161. The hook 161 is thus raised to the position shown in Fig. 13, allowing the detent 157 to become effective as above described, in which position the hook will remain until the cam 166 moves away from operating position. As the cam 166 returns to normal the hook 161 drops downward under tension of the spring 162 but at the moment is unable to reengage the stud 159 since the bail-shaped piece 156 is rocked out of its normal position. Thus the nose of the hook 161 will limit against the stud 159 and the hook will not again become effective until the bail-shaped piece 156 is moved back to the normal position. The return of the detent piece 156 to normal is accomplished by an arm 171 (see Fig. 12) which is adapted to engage a bent-over ear 172 formed on the piece 156. The arm 171 is pivotally connected to the left hand one of a pair of arms 173 (one shown) which support the previously mentioned restoring bail 18. As previously described, the bail 18 and, therefore, the arms 173 also move rearward and forward in a reciprocating motion once for each machine cycle unless prevented from moving by the arm 142 under conditions above described. The rearmost end of the arm 171 is formed as a hook and normally overlies the bent-over ear 172 of member 156. The arms 173 and bail rod 18 move rearward at about the middle of the machine cycle, and, as they do, the arm 171 turns slightly counter-clockwise under the tension of a spring 174 and engages the ear 172. Now, as the arms 173 return to normal, the detent member 156 is rocked in a counter-clockwise direction, thereby disabling finger 157 and rendering hook 161 again effective.

In order that the rack 148 may be elevated once for each machine cycle, the following mechanism is provided. As shown in Figs. 5 and 14, a rock lever 175 is pivoted at its mid-point to the inside of the inner frame wall 25 alongside the special rack 148. Pivotally mounted on the rear of the lever 175 is a pawl 176 adapted to engage the teeth on the rear of the rack 148. The pawl 176 is urged in a counter-clockwise direction (Fig. 14) into engagement with the rack 148 by a spring 177, but is normally held in the disengaged position shown in Fig. 14 by reason of the contact between a rearwardly extending finger of the pawl and a fixed stud 178 set in the frame piece 25. A spring 179 tensioned between the rear end of the lever 175 and a stud on the frame 25 (see Fig. 5) serves normally to retain the lever in its Fig. 14 position. Connected to the forward end of the lever 175 is a link 181 also connected to a lever 182 loosely mounted on the main shaft 27. Cut in the lever 182 is a slot 183 into which extends a lug 184 formed on an arm 185 fast on the shaft 27. The lug 184 is normally positioned near the right-hand end of the slot 183 (as viewed in Fig. 14) and inasmuch as the direction of movement of the shaft 27 during its forward stroke is counter-clockwise (Fig. 14) the lug 184 does not contact the left-hand edge of the slot 183 until nearly the mid-point of the cycle. When the point of contact is reached, the lever 182 moves with the arm 185 until the shaft 27 completes its forward stroke. This counter-clockwise movement of the lever 182 lifts the link 181, thereby rocking the lever 175 clockwise against the tension of spring 179 to lower the pawl 176 to the position shown in Fig. 22 and permit its engagement with a tooth on rack 148. Now on the return stroke of shaft 27 the assembly comprising lever 182, link 181, lever 175, and pawl 176, is returned to normal by spring 179, and, since the pawl is at that time engaging the rack 148, the rack will also be moved upward. A tie rod 16 extending between the inner frames 25 and 26 limits the clockwise movement of the lever 182 and prevents an overthrow by the spring 179. The mechanism just described is so arranged as to feed the rack 148 upward one tooth space for each machine cycle, this step being equivalent to the distance between the numerals on the dial 143. The time of advancement is shortly after the start of the return stroke of the machine, and just following that point in the cycle at which printing ordinarily occurs. Thus, when the dial has been turned to the representation of the desired multiplier digit, the operator releases the multiply lever 109 and at the end of that cycle the machine stops.

Print—Backspace—Non-add

Referring again to Fig. 9, consider now the operation of the machine when the multiply lever 109 is pulled forward. It will be remembered that this is done in order that printing may be effected and the pin carriage automatically backspaced. It has been previously described how the movement of the lever 109 in either direction will start the machine. Forward movement of the lever is a clockwise movement as viewed in Fig. 9 so that it will be seen that stud 133 on arm 132 of lever 109 is not effective at this time to rock the lever 134. Therefore, the link 136

will not be pulled forward and printing will not be blocked by arm 142, but will take place at its usual point in the cycle. Printed on the record sheet at this time is the multiplicand as set up on the pin carriage and also the proper multiplier digit as represented by the dial 143. As shown in Figs. 14, 15, and 16, the special rack 148 carries a set of type elements 187 arranged in the same order as the numerals inscribed on the dial 143. In the case of the type elements the asterisk is the lowest element, being positioned beneath the nine. These elements 187 being integral with the carrier 148 move in conjunction with the dial 143 so that whichever numeral on the dial is visible through the opening 145 will be represented by the corresponding type element 187 positioned at the printing line.

Near the end of this machine cycle the pin carriage is automatically backspaced. The manner of backspacing the carriage in the present machine is identical in almost every respect to that disclosed in the previous application S. N. 125,704, and will be only briefly described herein. Referring to Fig. 11 there is shown therein a toothed rack 188 secured in a manner not herein shown to the movable pin carriage 1. Adapted to engage the teeth on rack 188 is a pawl 189 pivoted at about its mid-point to the upper end of an arm 191 fast on a longitudinal shaft 192. A spring 193 tensioned between the arm 191 and the side wall 23 serves normally to retain the arm and the pawl 189 in the left-hand position shown in Fig. 11. Another spring 194 tensioned between the left-hand end of the pawl 189 and an upper fixed frame piece urges the pawl in a clockwise direction (Fig. 11). The movement of the pawl in this direction is limited by a fixed frame piece 195 against the lower edge of which a roller 196 on the pawl bears. The lower edge of the frame piece 195 is formed with an inclined cam surface and it is evident that if the arm 191 is caused to move in a clockwise direction (Fig. 11) the pawl 189 will rotate slightly about its pivot and near the end of the stroke of the arm a tooth 183 on the pawl will engage the rack 188 to force it and the pin carriage to which it is secured back one step toward the right-hand side of the machine. A block 197 fixed to the frame piece 195 limits the movement of the pawl 189. As previously mentioned there is provided suitable escapement mechanism (not herein shown) which retains the pin carriage in any position to which it may be set. The arm 191 may be rocked to backspace the pin carriage either automatically, by rocking the shaft 192, or manually in the following manner. Mounted for free lateral movement upon the frame piece 195 is a slide 198, formed with an upright finger piece 199 and, on its lower left-hand surface, a stud 201 contacting the upper end of the arm 191. The stud 201 acts as a limit stop to prevent overthrow of arm 191 by spring 193 and it will be seen that, if the slide 198 is manually moved in a right-hand direction the arm 191 will be rocked and the carriage backspaced as above.

In comparing the present means for manually backspacing the carriage with that disclosed in the prior application S. N. 125,704 it will be seen that in the present machine the finger piece 199 by which the slide 198 is operated is formed integral with the slide and is positioned at the front of the keyboard (see Fig. 17) easily accessible to the operator. In the previous machine the finger piece for operation of the backspace mechanism was located below the keyboard and extended horizontally out of the front of the machine. It is evident that the present arrangement is more efficient and advantageous.

Referring to Figs. 2, 9, and 11, consider now the means for rocking the shaft 192 to effect automatic backspacing. As shown in Fig. 2 the shaft 192 extends rearwardly in the base of the machine and there is fast on its far end a bevel gear 202 in constant engagement with a gear segment 203 fast on a shaft 204 (see also Fig. 18). The shaft 204 is supported by certain wall portions of the base and its left-hand end extends a short distance outside the left-hand frame wall. Secured, at about its mid-point, to the left-hand end of the shaft 204 is a lever 205 (Fig. 9) the forward end of which extends upwardly and has pivoted thereto an arm 206. The arm 206 is formed with a bent-over ear 207 and is urged in a clockwise direction by a spring 208 tensioned between the arm and the rear of lever 205, but is normally held against the tension of spring 208 by a latch 209 which engages the ear 207 and is pivoted on a fixed stud 211. Also cooperable with the ear 207, but not normally in engagement therewith is an auxiliary latch 212 also pivoted on the stud 211, and positioned just to the right of the latch 209. Both latches 209 and 212 are urged in a counter-clockwise direction by springs, the latch 209 by a spring 213 and the latch 212 by a spring 214. The latch 212 is formed with a curved rearwardly extending finger 215, the rear end of which bears upon a stud 216 on an extension of the previously mentioned link 136. In the normal position of the link 136 (Fig. 9) the stud 216 holds the latch 212 disengaged from the ear 207 on arm 206. The upper end of the latch 209 lies just in front of an arm 217 also formed on the link 136. It will be recalled that at the beginning of a multiplying operation, the multiply lever 109 is pushed rearwardly and consequently the link 136 is drawn forwardly. It will be evident that forward motion of the link 136 will cause its arm 217 to disable the latch 209 whereupon the arm 206 immediately snaps to the upright position shown in Fig. 10. Simultaneously, with the disabling of latch 109, the auxiliary latch 212 is permitted to move to effective position by reason of the forward movement of stud 216. The latch 212, however, is not released soon enough to engage arm 206 but merely occupies an effective position ready to engage the arm when it is returned to normal. In the upright position of arm 206 as shown in Fig. 10, the bent-over ear 207 thereof bears against the rear edge of the lever 205 while a roller 218 on the arm is positioned directly in the path of the fingerlike cam 166. The shifting of these several elements occurs as a result of rearward movement of the lever 109. Now, as the machine begins to operate, the cam 166 moves in a clockwise direction, as previously described, thereby rocking the arm 206 back to normal position where it is engaged and held by the auxiliary latch 212 as is shown in Fig. 13. It will be seen that, as long as the multiply lever 109 is held rearward, the latches 209 and 212 will retain the position shown in Fig. 13 and the cam 166 will reciprocate idly over the top of the roller 218. When the machine has been cycled the proper number of times, the lever 109 is released and at the end of that cycle the lever is permitted to return to normal, thereby releasing the link 136 and permitting it to return to normal. As the link 136 moves rearward, the auxiliary latch 212 is disabled by the stud 216 and at the

same time arm 217 on the link moves away from the upper end of latch 209, freeing it to swing back to normal. At this time, however, the latch 209 is unable to return to effective engaging position since a rear extension 219 of the latch is engaged by the previously mentioned latch 168. Latch 168 is drawn into contact with extension 219 by a spring 221 and is normally positioned as shown in Fig. 9. When the latch 209 is disabled as above described, the latch 168 moves in front of the shoulder on extension 219 to the position shown in Fig. 10. The latch 168 is moved out of effective position once each machine cycle by the cam 166, but it is always returned to normal shortly after the mid-point of each cycle. Thus, at the end of the cycle above mentioned, when the lever 109 returns to normal, the latch 212 is disabled by stud 216 and latch 209 is held disabled by latch 168. Arm 206 is, therefore, immediately released and moves to its upright position. The next step in a multiply operation is a printing and backspacing cycle effected by pulling the link 109 forward. When this cycle is begun cam 166 immediately cams the arm 206 down to normal, but since neither of the two latches 209 and 212 are in effective position at this time, the arm will again spring to its upright position as soon as the cam has passed by the roller 218. Now, on the return stroke of cam 166 the front edge of the cam strikes the opposite or rear side of the roller 218 and, as the cam continues to move, forces the arm and the lever 205 to which the arm is pivoted in a clockwise direction (as viewed in Fig. 10), thereby rocking the shaft 204 to backspace the carriage through gear segment 203, gear 202 and shaft 192 as above described. This backspace operation occurs during the latter part of the return stroke after printing has been effected.

Inasmuch as this cycle of the machine, occasioned by pulling the lever 109 forward, is intended to be merely a printing and backspacing cycle, it is evident that this motion of the lever must be made to set the non-add mechanism of the machine to prevent addition during this cycle. The non-add mechanism shown herein is exactly the same as that shown in application S. N. 125,704 and is substantially the same mechanism that has long been used in this type of machine. The function of this mechanism is to prevent the accumulator wheels from engaging their actuating racks at the usual time and to retain them out of mesh until the end of the cycle. Referring to Figs. 2 and 9, it will be seen that a bail-shaped lever 222 is pivoted to the previously mentioned stub shaft 117 and has a rearwardly extending arm 223 underlying the stud 114 on lever 109. It is evident that movement of the lever 109 forward will not only rock lever 116 to start the machine, but will also rock lever 222 in a counter-clockwise direction (Fig. 9). As shown in Fig. 12 the lever 222 is also formed with an arm 224, on the opposite side of the side wall 23, to the upper end of which is connected a rearwardly extending link 225. At its far end the link 225 is connected to a lever 226 pivoted at 227 to a fixed plate 228. The lever 226 is operable in a manner not herein shown by the regular non-add key of the machine and is connected at its lower end to a slide 229. The rear end of the slide 229 is formed with an inclined cam edge and cooperates with an arm 231 pivoted to a fixed stud 232 set in the side wall 23. Pivotally connected at 233 to the arm 231 is a link 234 also supported by a lever 235 associated in a manner not herein shown with the signal printing mechanism. The rearward end of the link 234 is formed with an inclined cam edge and is adapted to engage a pin extending laterally from the previously mentioned wipe pawl 85. In the normal position of the slide 234 the operation of the wipe pawl is not affected and it proceeds in the usual manner to raise and lower the accumulator cradle. If, however, the bail shaped piece 222 is rocked rearwardly by the lever 109, the link 234 will be moved rearward out of its normal position and, as the wipe pawl 85 begins to descend, it first raises the accumulator wheels out of mesh and is subsequently prevented from returning them to mesh through contact with the inclined edge of the link. The arm 231 extends upward and cooperates with a flange on cam 236 fast to main shaft 27 in order that the non-add mechanism may be retained in either its effective or ineffective position during the course of a machine operation.

Carriage return and interlock

Also contained in the machine and necessary indirectly to the performance of multiplication herein is the carriage return mechanism operable automatically through well known means and manually by the correction key or finger piece 237 shown in Figs. 2, 11, and 17. The key 237 is an upstanding portion of a slide 238 supported at the front of the machine by the same means which support the backspace slide 198, and mounted in the next adjacent plane to that slide (see Fig. 17). The slide 238 is tensioned towards the left of the machine by a spring 239 (Fig. 11) anchored at one end to the frame-work of the machine and connected at its other end to a downward extension 230 of the slide 238. The extension 230, besides providing a point of connection for the spring 239, is also adapted to operate an arm 241 connected through arm 242 and link 243 to the pin carriage 1. The pin carriage may thus be restored to normal position against the tension of a spring 244 through operation of the correction key 237. It should be understood that, as disclosed in the above mentioned Mehan patent, the return of the pin carriage to normal causes the set-up pins 2 also to return to normal. As is also disclosed in the Mehan patent a normally effective automatic carriage return mechanism is provided as standard mechanism in machines of this type and serves normally to return the pin carriage at the end of each machine cycle. A portion of this carriage return mechanism is shown in Fig. 18 and comprises gear segment 245, arm 246 and carriage return link 247 operable from a cam on the main shaft 27. The link 247 is movable to the ineffective position shown by the repeat key and by a pin 248 operable from the backspace shaft 204 through elements 249, 251, and 252. As is fully disclosed in the prior application, S. N. 125,704, the pin 248 acts as a safeguard to prevent operation of the carriage return mechanism during backspace cycles. This is desirable in order to prevent damage to the mechanism as is disclosed in the above application.

The correction key 237 must be operated at the end of each multiplying operation, that is, the pin carriage 1 must be returned and the machine totaled to release the product stored in the accumulator. In order to speed up the operation of the machine and render it more foolproof in its operation, a certain feature of improvement (described below) is provided in the present ma-

chine, in connection with the manual carriage return mechanism. It will be evident that, during the time the pin carriage is being returned to normal, it would not be desirable to begin a machine operation since a misoperation would result and it is possible that either the pins **2** of the carriage or the slides **1** would be damaged. Therefore, in the machine of both the prior and present application the correction slide **238** and the backspace slide **198** are connected to the regular interlock mechanism between the numeral keys and the main shaft. Thus, when a numeral key **4** is depressed or a slide **238** or **198** operated the main shaft **27** in locked against operation and also, during the course of movement of the main shaft, it is impossible to operate the correction and backspace slide. Referring to Fig. 19 there is shown therein a cam **253** fast on the shaft **27** and a locking plate **254** secured to the side of the cam. Cooperable with the locking plate **254** is a lever **255** pivoted at **256** to the right-hand inner side wall **26** (see also Fig. 2). The lever **255** extends forwardly of its pivot **256** and its forward end underlies the right-hand end of a pair of arms **257** and **258** secured to respective shafts **259** and **261** (Fig. 2) which shafts are supported for free rocking movement by the fixed framework of the keyboard. The arm **257** is fast to the rear end of the shaft **259** and there is another arm **262** fast to the opposite end of the shaft. Supported between the arms **257** and **262** is a bail rod **263** positioned beneath offset shoulders of the numeral key stems **3**, so that depression of any digit key **4** will rock the bail rod **263** and consequently arm **257** downward, thereby rocking the lever **255** counter-clockwise about its pivot **256** (Fig. 19). As a result of this motion, it will be seen that the hooklike far end of the lever **255** engages the plate **254** on cam **253** so that if the lever is held in this position and the machine started, the main shaft **27** will be unable to rotate, and the power from the motor will be absorbed by the previously mentioned spring **53** (Fig. 2). It will also be seen that, at any point during the course of movement of the shaft **27** and cam **253**, the digit keys are locked against operation, since the lever **255** is kept from motion through contact with the outside edge of the plate **254**. The lever **255** is operable in a similar manner by the arm **258** under the control of the correction and backspace slides. Secured to the forward end of the shaft **261** is an arm **264** (Figs. 2 and 11) formed with a roller **265** extending through an opening in the frame plate **195** and through slots **266** and **267** cut in the respective slides **238** and **198**. In the normal position of the slides the roller **265** extends through circular portions of the slots **266** and **267** and, therefore, normally stands in the ineffective position illustrated. As either of the slides **238** or **198** is operated, however, the arm **264** and its associated parts are rocked downward to operating position as the roller **265** is forced into the narrow groove-like portions of both slots **266** and **267**. In operating the backspace slide **198** it will be evident that the interlock operated thereby will remain effective during the entire course of operation of the slide so that the machine cannot be operated until the slide has returned to normal. In the case of the correction slide **238**, however, its slot **266** is formed not only with the circular and narrow positions mentioned above but has a wider portion **260** cut at its left-hand end in order that the roller **265** and arm **264** may rise to their normal position when the slide **238** is fully operated. Since in a multiplying operation the pin carriage must be returned and the machine totaled to obtain the product in the accumulator, the conformation of the above slot **266** provides a means whereby these two manual operations may be performed quickly with little or no time lost between operations. The operator has merely to move the correction slide to fully operated position and, while he holds it there, put the machine through two successive cycles of operation by depressing the motor bar **58**.

Zero printing

There remains but one point to be described in connection with the multiply mechanism and that is the manner in which zeros are printed in the multiplier. This is done merely by pulling the multiply lever **109** forward and immediately releasing it to put the machine through one cycle, this cycle being, as described, a print, non-add, backspace cycle. At the time this cycle takes place the special rack **148** (Fig. 9) is at its lowest position ready to be elevated one step upon movement of the slide **123**, as described. The rack **148** normally stands with its topmost or zero type element one space below the printing line, in order that nothing may be printed through this rack when the machine is used for ordinary addition or subtraction. However, when the lever **109** is pulled forward with the rack **148** standing at normal, the rack is elevated sufficiently by arm **149** to place the zero type element at the printing line, so that, when printing occurs at about the middle of the cycle the zero will be printed in its proper place in the multiplier. It will be recalled that the advancement of the rack **148** under control of the main shaft does not occur until near the end of each cycle so that this operation does not affect the printing of the zero.

In order that backspacing may be effected during this cycle the slide **123** is formed with an upstanding portion **268** (Fig. 9) adapted to contact a bent-over ear **269** of the latch **209** and disable this latch to permit the cam **166** to operate arm **206** and lever **205** as before described.

It is believed that the operation of the machine, with respect to multiplication has been entered into in sufficient detail as to render an actual example unnecessary. My previous application S. N. 125,704 illustrates and describes each machine cycle in a multiplying operation, and the present machine operates in the same general manner and in the same number of machine cycles as the previous machine. A brief résumé of a multiplication operation is given in the introduction to the present specification and the following is the way in which a problem would appear on the tally roll. Assume the problem to be one previously mentioned, 543 multiplied by 201.

2	54300
0	5430
1	543
	109143

Division

As mentioned earlier in the description, division in this machine is a fully automatic operation, requiring only the entering of the dividend into the accumulator, the setting up of the divisor on the pin carriage **1** and tripping of the division lever to start the machine. The present division mechanism is a slightly modified and improved

form of similar mechanism disclosed in the application S. N. 125,704, but in all its essential details and in its manner of operation is the same as the mechanism shown therein.

As shown in Fig. 9 the previously mentioned division lever is located on the left-hand side of the machine just to the rear of the keyboard and is indicated by the reference numeral 271. The lever is pivotally mounted on the previously mentioned shaft 64, which is the subtraction shaft of the machine, and is urged in a counterclockwise direction (Fig. 9) by a spring 272. A forward extension of the lever 271 normally limits against a nose 273 on a latch 274 pivoted at 275 to the side wall 23. An arm 276 of the latch 274 normally engages and holds a lever 277, also pivoted on the shaft 64, against the tension of a spring 278 anchored to the side wall 23. In operating the lever 271 it is pushed rearward or counter-clockwise as viewed in Fig. 9 thereby rocking the latch 274 clockwise against the tension of a spring 279, and releasing member 277 which also rocks in a clockwise direction about the shaft 64. The lever 277 extends rearwardly and, through a stud 281 formed on the rear extension thereof, operates another lever 282 which is fixed to the extreme left-hand end of the shaft 64. A downward extension of the lever 282 is adapted to contact a stud 283 on the previously described element 134, so it will be seen that operation of the division lever will bring about the almost simultaneous rocking of the subtraction shaft 64 and forward movement of the link 136. Operation of the link 136, as was described, disables the printing mechanism and reverses the setting of the latches 209 and 212 associated with the backspace mechanism, while the rocking of shaft 64 serves to start the machine and set the subtraction mechanism for operation, and the various parts assume the position shown in Fig. 20. Fast on the opposite or right-hand end of the shaft 64 is a lever 284 (see Fig. 5) extending both forwardly and rearwardly of the shaft. The rearward end of the lever 284 underlies a pin 285 on the previously mentioned arm 65 which forms a part of the subtraction mechanism. The direction of movement of the shaft 64, when operated from the division lever, is counterclockwise as viewed in Fig. 5 and, through the lever 284 and pin 285 the rocking of this shaft is caused to set the machine for subtraction. Near the rearward end of the lever 284 there is connected a downwardly extending link 286 similar to the previously mentioned link 66, the two links being arranged side by side with link 286 on the outside as viewed in Fig. 5. The link 286 is formed with a slot 287, at its lower end, through which extends the stud 68 on the motor operating lever 54. The stud 68 also extends through a slot in the link 66 so that the elevation of either link 66 or 286 will start the motor. It will be seen however, that the slot 287 is somewhat shorter than the slot 67 so that when the link 286 is lifted to start a division operation, the bell-crank 68 will be rocked a farther distance than if it were rocked merely by link 66. This additional movement given to the lever 54 is transmitted through its associated link 45 to the bail lever 30 (Fig. 4) rocking this lever a proportionately greater distance than it is normally moved (see Fig. 21). This extra movement is enough so that when the motor bell-crank 54 is released and the lever 30 starts to return to normal the distance it must travel is too great to permit its arm 30 to engage and disable the clutch dog or pawl 33 during that same cycle, so that the machine will continue running for an additional cycle. The release of lever 54 normally occurs at or about the end of a cycle, as was previously described, but in division the lever is held latched until an oversubtract cycle causes its release as will soon be described. The lever 54 is released upon an oversubtract cycle but inasmuch as the machine must run for an additional cycle to print the divisor and a digit of the quotient, the above means is provided to prevent immediate stopping of the machine. As shown in Fig. 5 the means for holding the motor bell-crank 54 rocked during a division operation is a latch 288 cooperable with the forward end of the lever 284 and pivoted to a stud 289 set in the right-hand side wall 24. A spring 291 urges the latch 288 into contact with the lever 284.

It will be recalled that in setting up a division problem, the dividend is first entered into the accumulator and then the divisor is set up on the pin carriage 1 with its first or highest order digit occupying the same denominational position as the first digit of the dividend. The repeat key is latched down and as the division lever 271 is tripped a series of subtract operations begins and continues until an oversubtract cycle occurs at which time it is necessary to add back and print the amount subtracted on the previous cycle, print the number which indicates the number of machine cycles which took place before oversubtraction, and then backspace the carriage and begin a new series of subtract operations. The mechanism for temporarily suspending subtraction when oversubtraction occurs is controlled in the same manner through the highest order accumulator wheel, as the fugitive one mechanism of Patent No. 2,203,336. There is no fugitive one mechanism in the present machine. As shown in Fig. 14 there is positioned to the left of the accumulator wheels 19 and 21 of highest order a special rack 5A and an associated slide 6A which are controlled by the bail rod 9 in the same manner as the regular actuating racks 5 and 6. The special rack 5A does not actuate an accumulator wheel nor is it positioned by a column of digit stops 3. Associated with the rack 5A is the usual transfer pawl 292 cooperable with a lug 293 on the side of the rack. When an oversubtract cycle occurs the wheel 21 of highest order will be turned negatively beyond its zero position thereby camming the pawl 292 downward in the usual manner and allowing the rack 5A an additional step of movement forward as the bail rod 9 is returned at the end of that cycle (see Fig. 14A). At its forward end the rack 5A is slotted and into this slot extends the left-hand end of a lever 293 (see also Fig. 2) pivoted to the base of the machine and extending to the right-hand side of the machine. As shown in Fig. 5 the right-hand end of the lever 293 is connected to a link 294 which is in turn connected to a downwardly extending arm of the latch 288. Thus at about the end of the machine cycle in which the accumulator was oversubtracted, the latch 288 is disabled and if the subtraction shaft 64 is not held rocked, the motor bell-crank is free to return to normal. As previously described, however, the machine will not stop but will continue on into another cycle.

Returning now to a consideration of the mechanism shown in Figs. 9 and 20 it will be recalled that immediately after the operation of the division lever the parts assumed the position shown in Fig. 20. Now as the main shaft 27 turns on the first cycle a roller 295 on the cam 166 contacts

the rearmost upper edge of the lever **277**, near the end of the forward stroke, and rocks the lever counter-clockwise to the position shown in Fig. 13 in position to be engaged and held by a latch **296** pivoted at **275** to the side frame. As the cam **166** returns to normal the lever **277** drops slightly until it is positively engaged by the latch **296**. As long as the machine continues subtracting the lever **277** will stay in this position while the lever **282** and the shaft **64** remain in operated position due to the latch **288**. As soon as this latch is released, however, at the end of the oversubtract cycle the subtraction mechanism returns immediately to normal ineffective position under spring tensioning means not herein shown and the machine begins its extra cycle of operation. At the very start of this operation the accumulator cradle is rocked back to its add position so that this will be an add cycle. The restoration of the lever **282** to normal having released the link **136** the printing mechanism will also be released, and the backspace latch **212** disabled to permit backspacing of the carriage. Printing will be effected midway in the cycle of the first digit of the quotient and the divisor exactly as it was set up on the pin carriage. In connection with the printing of the quotient through the rack **148**, it should be remembered that the rack normally stands one step below zero and that it is advanced one step at the end of each machine cycle. Therefore at the end of the first cycle it is at zero, at the end of the second at one, etc. Thus its final step is taken at the end of the oversubtract cycle which brings the proper number to the printing line. At the end of the printing cycle the rack **148** is permitted to drop to normal to prepare for a new series of operations. The back-space operation takes place at, of course, the same time near the end of the cycle and in the same manner as in multiplication. In order that the machine may continue running after this cycle and begin a new series of subtract operations with the carriage in its new position, a means is provided whereby the shaft **64** may be again rocked before the end of this cycle. As shown in Figs. 9 and 20 the previously mentioned latch **296** is formed with a rearwardly extending arm **290** positioned below and in the same plane with the bent over forward end of the backspace lever **205**. Thus, during a backspace operation lever **205** contacts and rocks arm **290** in a counterclockwise direction (Fig. 9), thereby disabling latch **296** and permitting lever **277** to rock shaft **64**, as before described. Lever **276**, which normally holds the lever **277** from operation, remains held disabled by the division lever **271**. It will thus be seen that as long as the division lever **271** remains in operating position, the machine will continue running, subtracting and backspacing until the mechanism for automatically releasing the division lever is rendered effective. This mechanism operates under the control of the actuating rack **5** of units order, since this rack remains stationary until the lowest significant digit of the divisor reaches units order. As described below, movement of this rack releases the division lever so that on the following oversubtract operation the machine will run one additional cycle to print and will then stop.

As shown in Fig. 23 there is secured to the side of the above-mentioned rack **5** of units order, a fingerlike piece **297** which normally engages a pin **298** on an arm **299** formed at the right-hand end of a bail-shaped lever **301** pivotally mounted as shown in Fig. 2, on the subtraction shaft **64**. The left-hand end of the lever **301** is formed as an arm **303** on which is mounted a laterally extending pin **304**, underlying the division lever **271** to the rear of its pivot **64**. A spring **305** (Fig. 23) tensioned between the lever **301** and a fixed portion of the keyboard serves to urge the lever in a clockwise direction (Fig. 9) and maintains the pin **298** in contact with the finger **297**. It will be evident that, as soon as the lowest order rack **5** moves rearward, the bail lever **301** will rock in a clockwise direction and, through pin **304**, will disable the division lever **271** returning it to normal. The lever **274** is thus free to return to normal and will reengage the lever **277** when this lever is rocked by the cam **166** as previously described. The division lever is thus disabled but inasmuch as the subtraction shaft **64** is at this time latched in operating position, the machine will continue running until an over-subtract cycle occurs. As previously described, over-subtraction of the accumulator causes the release of the latch **288** (Fig. 5) and the consequent return of shaft **64** to normal. The control mechanism being thus restored to normal the machine will run for its usual additional cycle and then stop. Now, in order to complete the division operation, the pin carriage is manually returned to normal (if it is not already there) and the machine totaled. If there is a remainder in the accumulator it will be printed at this time.

Division, in the present machine, is performed in the same manner as it is in the machine of S. N. 125,704. Figs. 25 and 26 herein are fragments of a record tape and illustrate the manner in which the machine prints out a division problem. The top line is the dividend, the bottom line (Fig. 25) is the divisor and the vertical line to the left is the quotient. The pointers **306** and **307** constitute a simple and effective means for placing the decimal point in the quotient. This means is fully described in the above application.

As noted earlier in the specification there is provided herein a simple means for stopping the machine if the division lever **271** is accidentally tripped with nothing set up in the pin carriage.

It is evident that with the pin carriage in normal position, it is impossible to either disable the latch **288**, which holds the subtraction shaft rocked, or restore the division lever through the regular automatic means described above. When the division lever is accidentally tripped, therefore, it must first be restored to normal manually and then the motor bar **58** must be depressed to disable the latch **288**. As shown in Fig. 5 the stem **57** of the motor bar **58** is formed with an extension **308** which overlies an arm of the latch **288** so that depression of the motor bar will disable the latch.

The present machine, like that of the previous application, is adapted to detect and indicate errors in the setting of the pin carriage in the performance of division. The manner of indicating such an error is exactly the same in the present application as in the previous one, and consists in printing an asterisk through the special multiplier-quotient rack **148** if the machine goes through more than ten successive cycles without over-subtracting the accumulator. As disclosed in the application S. N. 125,704 the eleventh successive subtract cycle in division brings the asterisk type element on rack **148** to the printing line and at the same time special rack **5A** (Fig. 22) is conditioned to disable the latch **288**, as previously described, to cause a print-backspace operation on the following cycle.

The mechanism for performing the function is exactly the same in both the prior and present applications and will not, therefore, be further described herein.

Claims to the basic mechanism related to multiplication, division, automatic backspacing, multiplier and quotient printing, and automatic machine stopping in division operations, are contained in the application S. N. 125,704.

While I have described what I consider to be a highly desirable embodiment of my invention, it is obvious that many changes in form could be made without departing from the spirit of my invention, and I, therefore, do not limit myself to the exact form herein shown and described, nor to anything less than the whole of my invention as hereinbefore set forth, and as hereinafter claimed.

What I claim as new and desire to secure by Letters Patent, is:

1. In a printing calculating machine, the combination of a power source, main operating mechanism normally disconnected from said power source, printing mechanism including a special type carrier, printing hammers and a control element for said hammers, means for preventing operation of said control element, means operable by said main operating mechanism for advancing said type carrier one step upon each operation of said main operating mechanism, a detent mechanism for said type carrier, means normally acting to hold said detent mechanism ineffective, means operable by said main operating mechanism for disabling the means normally holding the detent mechanism ineffective, means operable by the control element for said printing hammers for disabling said detent mechanism and restoring said detent mechanism to the control of the means normally acting to hold the same ineffective, a control lever movable to a plurality of operating positions, means operable by said control lever in each of its operating positions for connecting said power source and said main operating mechanism, said control lever in one of its operating positions enabling the means for preventing operating of said control element to thereby prevent printing and the disabling of said detent mechanism.

2. In a printing calculating machine, the combination of a power source, main operating mechanism normally disconnected from said power source, printing mechanism including a special type carrier, printing hammers and a control element for said hammers, means for preventing operation of said control element, means operable by said main operating mechanism for advancing said type carrier one step upon each operation of said main operating mechanism, a detent mechanism for said type carrier, means normally acting to hold said detent mechanism ineffective, means operable by said main operating mechanism for disabling the means normally holding the detent mechanism ineffective, means operable by the control element for said printing hammers for disabling said detent mechanism and restoring said detent mechanism to the control of the means normally acting to hold the same ineffective, a control lever movable to a plurality of operating positions, means operable by said control lever in each of its operating positions for connecting said power source and said main operating mechanism, said control lever in one of its operating positions disabling the means for preventing operation of said control element to thereby permit printing and the disabling of said detent mechanism.

3. In a printing calculating machine, the combination of a power source, main operating mechanism normally disconnected from said power source, printing mechanism including a special type carrier standing normally out of printing range, printing hammers and a control element for said hammers, means for preventing operation of said control element, means operable by said main operating mechanism for advancing said type carrier one step upon each operation of said main operating mechanism, a detent mechanism for said type carrier, means normally acting to hold said detent mechanism ineffective, means operable by said main operating mechanism for disabling the means normally holding the detent mechanism ineffective, means operable by the control element for said printing hammers for disabling said detent mechanism and restoring said detent mechanism to the control of the means normally acting to hold the same ineffective, a control lever movable to a plurality of operating positions, means operable by said control lever in each of its operating positions for connecting said power source and said main operating mechanism, said control lever in one of its operating positions for bringing said type carrier into printing range, said control lever in one of its operating positions enabling the means for preventing operation of said control element to thereby prevent printing and the disabling of said detent mechanism.

4. In a printing calculating machine, the combination of a power source, main operating mechanism normally disconnected from said power source, printing mechanism including a special type carrier standing normally out of printing range, printing hammers and a control element for said hammers, means for preventing operation of said control element, means operable by said main operating mechanism for advancing said type carrier one step upon each operation of said main operating mechanism, a detent mechanism for said type carrier, means normally acting to hold said detent mechanism ineffective, means operable by said main operating mechanism for disabling the means normally holding the detent mechanism ineffective, means operable by the control element for said printing hammers for disabling said detent mechanism and restoring said detent mechanism to the control of the means normally acting to hold the same ineffective, a control lever movable to a plurality of operating positions, means operable by said control lever in each of its operating positions for connecting said power source and said main operating mechanism, means operable by said control lever in each of its operating positions for bringing said type carrier into printing range, said control lever in one of its operating positions disabling the means for preventing operation of said control element to thereby permit printing and the disabling of said detent mechanism.

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