

July 26, 1960

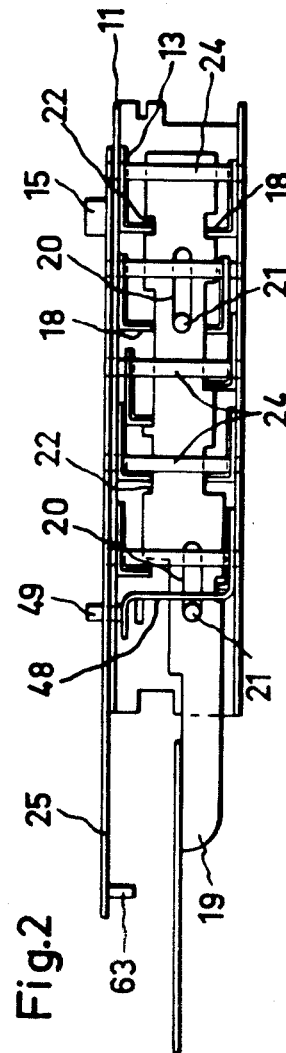
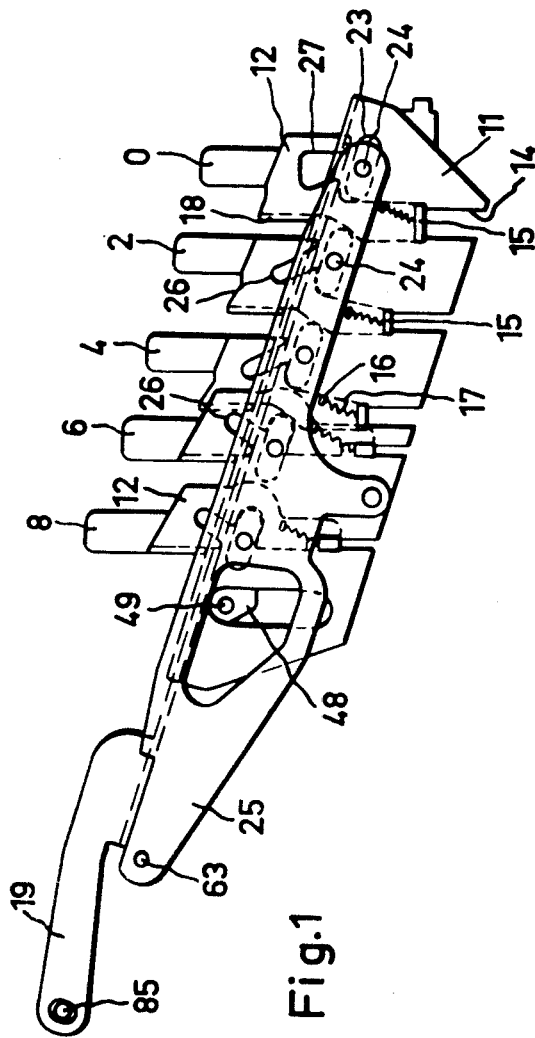
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MECHANISMS FOR SHORT CUT MULTIPLICATION IN CALCULATING MACHINES

Filed Oct. 3, 1957

6 Sheets-Sheet 1



July 26, 1960

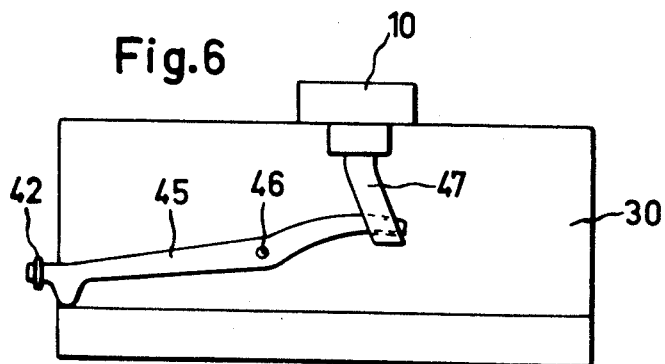
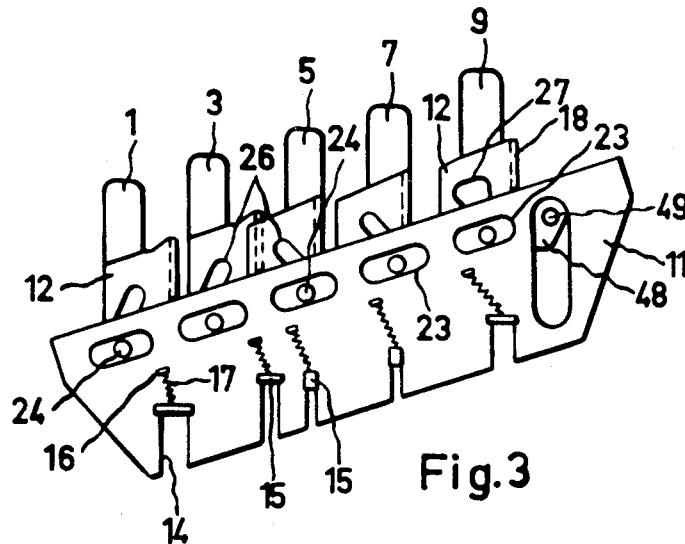
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MECHANISMS FOR SHORT CUT MULTIPLICATION IN CALCULATING MACHINES

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July 26, 1960

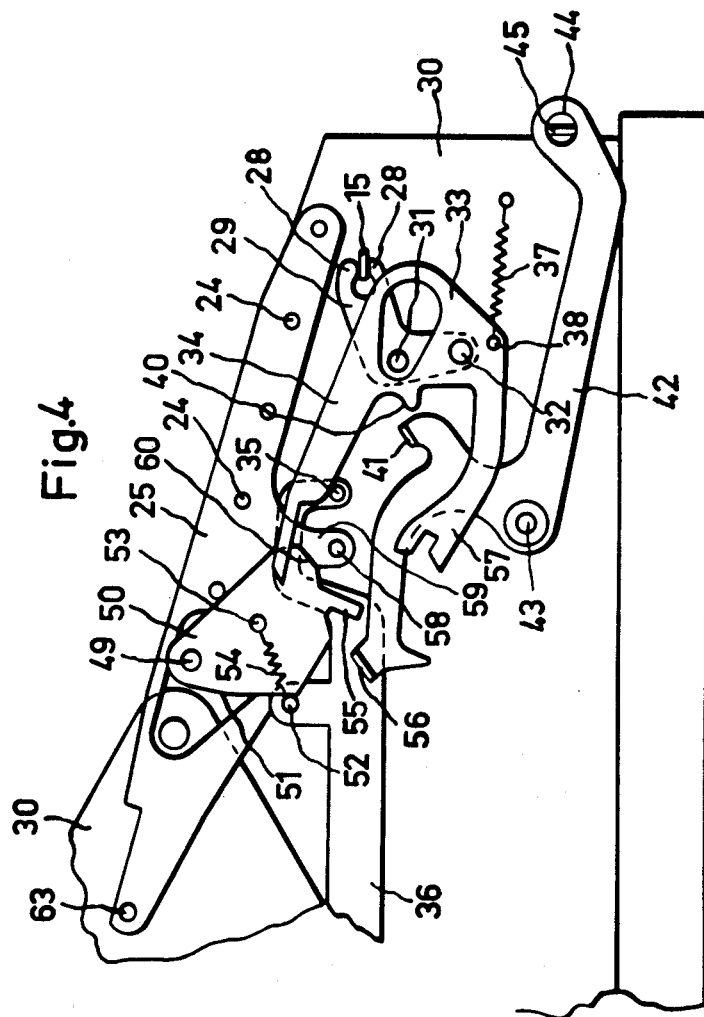
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MECHANISMS FOR SHORT CUT MULTIPLICATION IN CALCULATING MACHINES

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July 26, 1960

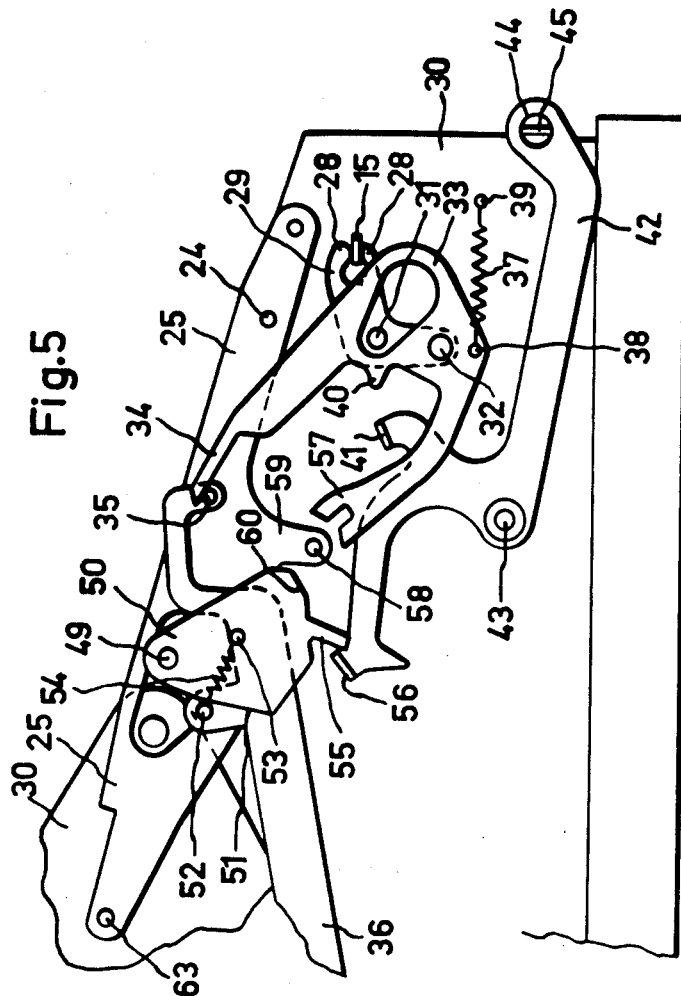
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MECHANISMS FOR SHORT CUT MULTIPLICATION IN CALCULATING MACHINES

Filed Oct. 3, 1957

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July 26, 1960

J. LYDFORS

2,946,507

MECHANISMS FOR SHORT CUT MULTIPLICATION IN CALCULATING MACHINES

Filed Oct. 3, 1957

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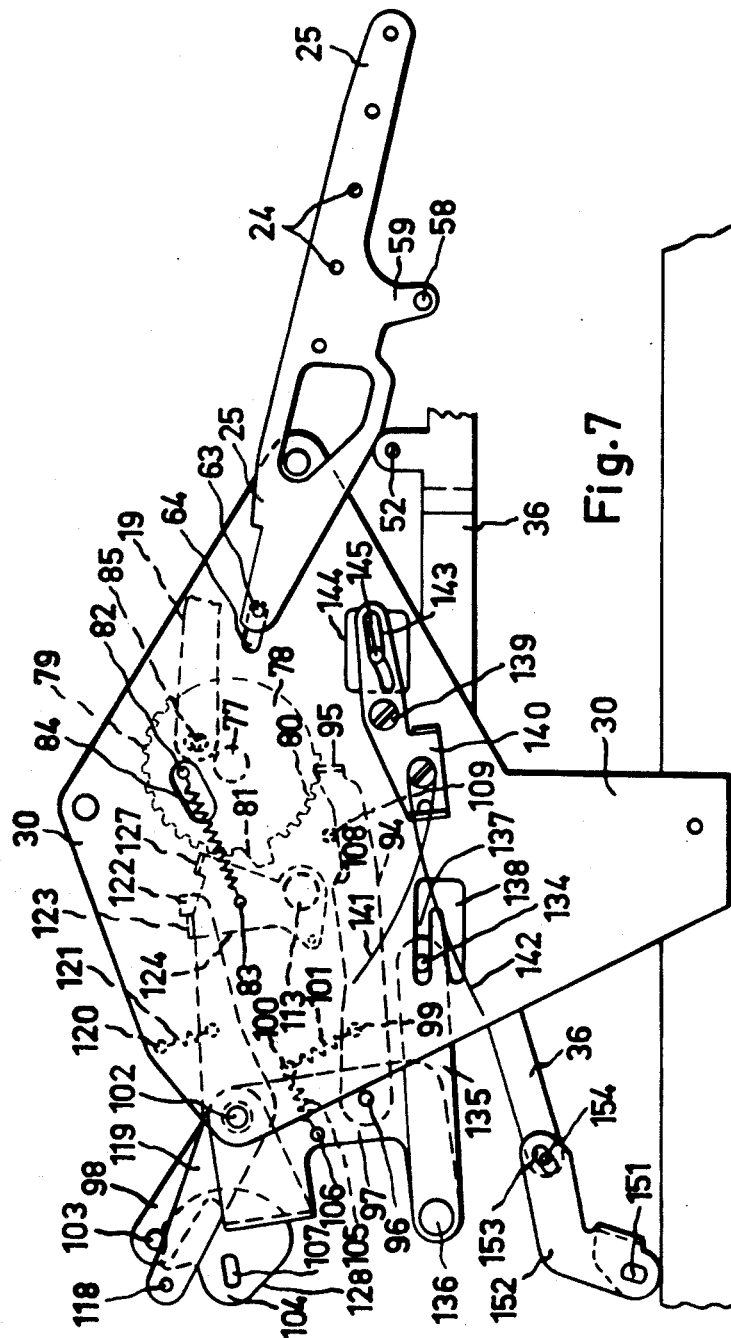


Fig. 7

July 26, 1960

J. LYDFORS

2,946,507

MECHANISMS FOR SHORT CUT MULTIPLICATION IN CALCULATING MACHINES

Filed Oct. 3, 1957

6 Sheets-Sheet 6

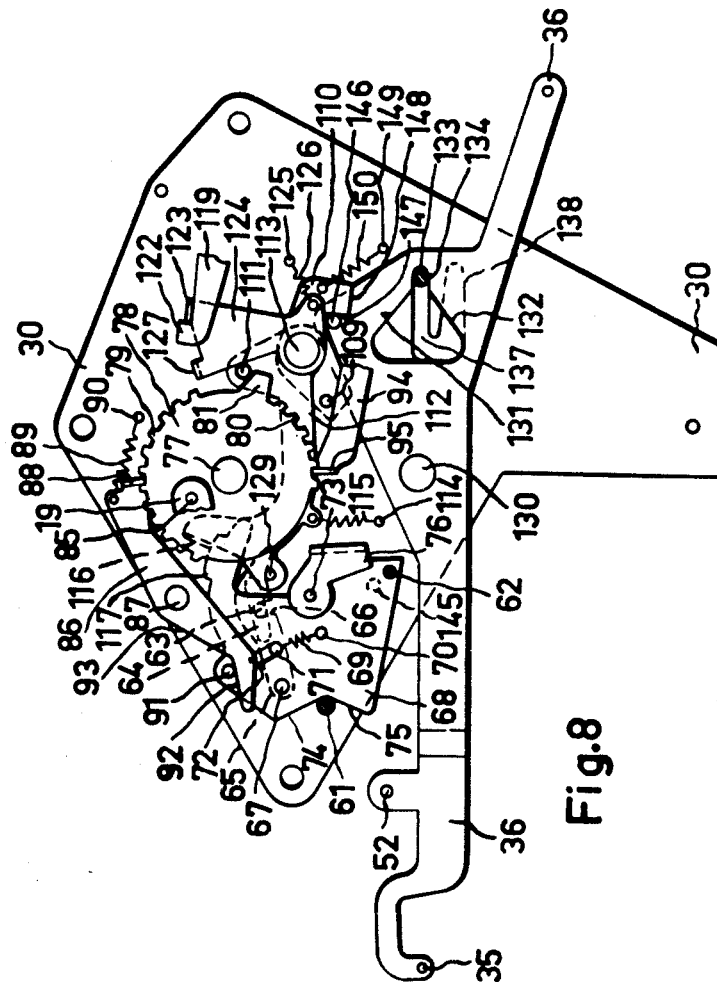


Fig. 8

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MECHANISMS FOR SHORT CUT MULTIPLICATION IN CALCULATING MACHINES

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3 Claims. (Cl. 235—63)

This invention relates to a mechanism for short cut multiplication in calculating machines having a multiplicand entering mechanism and a multiplier mechanism, in which said multiplier mechanism is adapted.

(i) during successive multiplying operations each treating one multiplier digit and each comprising one or more operating cycles during each of which the multiplicand is entered once into a result register, to adjust a multiplication control means through one or more steps from an initial position corresponding to the value of successive multiplier digits, the digits 0-9 being divided into a lower group comprising the lowest digits in connection with which group the multiplication control means is adjusted through a greater number of steps from the initial position the higher the multiplier digit in question is, and a higher group comprising the highest digits and in connection with which group the multiplication control means is adjusted through a greater number of steps from the initial position the lower the multiplier digit in question is,

(ii) to adjust the machine for such entering of the multiplicand into the result register during the multiplication by one multiplier digit that said entering is effected with opposed sign for the two groups of multiplier digits, e.g. additively for the lower group of multiplier digits and subtractively for the higher group of multiplier digits, and

(iii) to return with the aid of a step feeding means the adjusted multiplication control means through one step for each operating cycle towards its initial position.

The principal characterizing features of the invention are that the multiplier mechanism is adapted, for the lower group of digits, to adjust the multiplication control means from initial position through a number of steps which directly corresponds to the value of the respective digit, i.e. no step for digit 0, one step for digit 1 etc., and, for the higher group of digits, to adjust the multiplication control means from initial position through a number of steps which corresponds to the formula $9-S$ where S is the value of the digit in question, i.e. no step for digit 9, one step for digit 8, two steps for digit 7 etc., and that a sign storing means is adapted to cause the machine to effect an additional operation cycle to enter the multiplicand into the result register one additional time beyond those determined by the multiplication control means during each multiplication effected with a digit from one group and following immediately upon a multiplication with a digit from the other group, stop means being provided always to interrupt the multiplication going on when the control means returns to initial position or after an additional operating cycle released by the sign storing means for a multiplication by 0 or 9.

The invention provides a particularly simple and cheap mechanism which functions fully reliably and permits effecting a multiplication with the least possible number of operation cycles of the machine, even if the succes-

2

sive multiplier digits are entered on the machine with large intervals.

Further objects to the invention and the advantages gained thereby will be described more in detail in the following, reference being had to the accompanying drawings illustrating an embodiment of the mechanism according to the invention as applied to an adding machine having a ten-key board and setting pin carriage. In the drawings:

Fig. 1 shows a multiplier key board as seen from the left-hand side of the machine;

Fig. 2 shows the multiplier key board as seen from below;

Fig. 3 shows the multiplier key board as seen from the right;

Figs. 4 and 5 show some mechanisms operated by the multiplier keys and a sign storing means, as seen from the left-hand side of the machine, the parts being shown in two different positions in Figs. 4 and 5;

Fig. 6 shows from the front of the machine a connection between the mechanisms according to Figs. 4 and 5 and the ten-key board key for digit 0 actuating the setting pin carriage;

Fig. 7 shows the greater part of the multiplier mechanism as seen from the left-hand side of the machine; and

Fig. 8 corresponds to the greater part of Fig. 7 but shows the parts as seen from the right.

While the invention is not restricted thereto, the mechanism shown in the drawings is adapted to be applied to an ordinary adding machine with result register, setting pin carriage and ten-key board. Although the mechanism to be described is shown as applied to the well-known adding machine ADDO-X sold on the U.S. market by Aktiebolaget Addo, Malmo, Sweden, the same mechanism is also applicable to other adding machines of a similar type with small alterations made necessary by different locations of means to which the present mechanism must be connected in order to be driven by and to control the adding machine. When the machine is used for multiplication the ten-key board and the setting pin carriage as well as digit entering means controlled thereby serve as a multiplicand entering mechanism. These mechanisms are of the ordinary type, for instance as shown and described in Patents 2,237,881 and 2,397,745, and are therefore not shown and described in detail except for the key 10 for digit 0 of the ten-key board being illustrated in Fig. 6. Upon depression of key 10 the setting pin carriage is stepped in the ordinary manner through one denominational order in relation to the result register.

Adjacent to the ten-key board of the machine there is a multiplier key board which is illustrated in Figs. 1-3. Said key board has ten digit keys 0-9 for the multiplier digits 0-9. Keys 0-9 are arranged in two rows on a frame 11 approximately of U-shape in cross section. Each key 0-9 has a flat key stem 12 which is vertically displaceable in an L-shaped slot 13 in the frame 11 near one or the other side wall of the frame, in which there is also provided a guide slot 14 for a lug 15 at the lower end of the stem 12. Keys 1-9 are held in a raised position by a pull spring 17 expanded between lug 15 and a pin 16 on the frame 11, while key 0 is held in raised position by a spring described in the following. In the raised position a lateral lug 18 on key stem 12 is located above the lower surface of the upper wall of the frame 11 outside the path of a multiplier entering slide 19 which is movable along said lower surface. Slide 19 extends between the two key rows and is mounted for movement longitudinally thereof by means of slots 20 in the slide and pins 21 in the frame 11 engaging said slots. Provided in the lateral edges of the slide are differently

large recesses 22 in which the lugs 18 of the keys 0-9 can engage upon depression of the keys to limit the movement of the slide 19 from the position shown in the drawings, which movement will be described in the following. In addition, slots 23 are provided in the side walls of the frame 11, and five pins 24 are displaceable in said slots. Said pins 24 are secured to a sign determining means 25 displaceably carried by the pins 24 on the frame 11. Upon depression of any of the multiplier keys 1-8 an oblique slot 26 in the key stem engages one of the pins 24, whereby the sign determining means or slide 25 is displaced either to the right or to the left as seen in Figs. 1, 4, 5 and 7 for purpose described in the following. The multiplier keys 0 and 9 on the other hand cannot upon depression displace the slide 25 directly by means of an oblique slot, for instead of a slot 26 they have a large aperture 27 in the key stem 12, the edges of which aperture cannot actuate the respective pin 24, and said aperture permits the slide 25 to be displaced while the key is in depressed position.

According to the present invention a multiplication is effected in such a way that in connection with the multiplication with some of the lower digits the multiplicand is entered additively in the result register a number of times directly corresponding to the value of the multiplier digit in question, i.e. no time for digit 0, once for digit 1 etc., while on multiplying with any of the higher digits the multiplicand is entered subtractively a number of times corresponding to the formula $9-S$ where S is the value of the digit in question, i.e. no time for digit 9, once for digit 8, twice for digit 7 etc. After each multiplication by a multiplier digit the setting pin carriage of the machine is stepped through one denominational order to the next higher denominational position in relation to the result register. In case the entering of the multiplicand into the result register was effected during the preceding multiplication by a multiplier digit with a sign (e.g. subtractive) which is opposed to the sign (e.g. additive) that is required for entering the multiplicand into the result register during the next multiplication, the machine is also caused, in the manner described in the following, to enter the multiplicand into the result register during the last-mentioned multiplication an additional time beyond the number of times determined by the depressed multiplier key according to the rules given above. In case the multiplying operation has taken place with the last multiplier of a calculation by subtractive entering of the multiplicand, the machine is also caused in a known manner to enter the multiplicand an additional time in the next higher denominational position of the multiplicand entering mechanism in relation to the result register in connection with the indication of the result of the calculation.

To perform the method of multiplication which has been briefly described in the foregoing, the multiplier keys 0-9 are divided into a lower group and a higher group, and in the embodiment illustrated this division has been made in such a way that keys 0-4 belong to the lower group in which the multiplicand is to be entered additively, while keys 5-9 belong to the higher group in which the multiplicand is to be entered subtractively into the result register. The oblique slots 26 in the stems 12 of the keys 1-4 are therefore inclined in such a direction that upon depression of said keys the sign determining means 25 is moved to the left as seen in Figs. 1, 4, 5 and 7, while the slots 26 in the keys 5-8 are inclined in the opposite direction so that the slide 25 is displaced to the right upon depression of the last-mentioned keys. The marginal recesses 22 in slide 19 for the lugs 18 of the keys 1-8 are so designed that the slide can move in a manner to be described in the following to the left as seen in Figs. 1, 2 and 7 and to the right as seen in Fig. 8 to abut the lug 18 of the depressed key through a distance which amounts to one step of movement of slide 19 for keys 1 and 8, two steps of movement for keys 2 and

7, three steps of movement for keys 3 and 6, and four steps of movement for keys 4 and 5, said steps being all equally large.

The marginal recesses 22 of the slide for keys 0 and 9 are such that upon depression of said keys the slide is latched substantially in its initial position by the lugs 18 of the keys. Upon depression of key 0, after the next preceding multiplication has been effected with additive entering of the multiplicand into the result register, the depression of key 0—as mentioned above—does not result in any entering of the multiplicand into the result register but only in a step feed of the setting pin carriage into the next higher denominational position in relation to the result register. The same applies to the depression of key 9 after a multiplication which has been effected by subtractive entering of the multiplicand into the result register. On the other hand, an additional operating cycle with entering of the multiplicand into the result register takes place when the key 0 is depressed after the next preceding multiplication has taken place with subtractive entering of the multiplicand into the result register, or when the key 9 is depressed after a multiplication in which the multiplicand has been entered additively into the result register.

To provide the above mentioned step feeding of the setting pin carriage or the above mentioned additional operating cycle for entering the multiplicand into the result register with the aid of keys 0 and 9 the mechanism shown in Figs. 4-6 has been arranged. The lug 15 of the key 0 is longer than the other key lugs 15 and engages between a pair of jaws 28 on one arm of a bell-crank lever 29 which is pivoted on the machine frame 30 by a pivot 31. The other arms of the bell-crank lever 29 carries a pin 32 on which a rocking member 33 is mounted. One arm 34 of the rocking member 33 rests against a pin 35 on a sign storing means to be described more in detail in the following and occupying in a manner described in the following one of the positions shown in Figs. 4 and 5. Said sign storing means 36 occupies the position according to Fig. 4 when the next preceding multiplication has taken place with additive entering of the multiplicand into the result register, while it occupies the position according to Fig. 5 when during the next preceding multiplication the multiplicand was entered subtractively into the result register. The arm 34 of the rocking member 33 is held applied against the pin 35 by a spring 37 which is expanded between a pin 38 on the rocking member 33 and a pin 39 on the machine frame 30. The spring 37 also serves the purpose of holding key 0 in raised position. When the sign storing means 36 occupies the position according to Fig. 4 and the key 0 is depressed so that the bell-crank lever 29 is rotated clockwise about the pin 31, said bell-crank lever 29 will simultaneously swing and move the rocking member 33 in such a way that with arm 34 sliding against the pin 35 the rocking member will strike a lug 41 on a lever 42 by a projection 40 and swing said lever counterclockwise about its pivot 43 on the frame 30. The lever 42 has in one arm an opening 44 in which one end of a lever 45 engages, said lever being mounted on the machine frame 30 by means of a pin 46, while its other end engages the key stem 47 of the zero key 10 of the multiplicand entering mechanism. During the above counterclockwise swinging of lever 42 the lever 45 is thus swung clockwise as seen in Fig. 6, depressing the key 10 which in a known manner produces a step feed of the setting pin carriage of the multiplicand entering mechanism through one denominational step towards the next higher denominational position in relation to the result register.

On its stem 12 the key 9 has a lug 48 which supports a pin 49 extending through openings in the key frame 11 and the slide 25. Mounted for swinging movement on this pin 49 is a cam plate 50 which is held applied

5

with one cam portion 51 against a pin 52 on the sign storing means 36 by a pull spring 54 expanded between the pin 52 and a pin 53 on said cam plate. When the key 9 is depressed while the sign storing means occupies the position shown in Fig. 5 the cam plate 50 is moved downwards and swung through a small angle clockwise, while the cam portion 51 slides against pin 52 and a projection 55 on the cam plate 50 engages a lug 56 on the lever 42 and swings said lever counter-clockwise as seen in Fig. 5 so that the lever 45 is swung clockwise as seen in Fig. 6, depressing the key 10 for step feeding the setting pin carriage.

When on the other hand the key 0 is depressed while the sign storing means 36 occupies the position according to Fig. 5, i.e. when the last multiplication was performed with subtractive entering of the multiplicand into the result register, an additional operating cycle takes place, in which the multiplicand is entered additively once into the result register, for which purpose the sign determining slide 25 must be moved to the left as seen in Fig. 5 despite the fact that the aperture 27 in the stem 12 of the key 0 does not itself cause such a movement of the slide 25. Instead, this movement is effected as follows. Upon depression of the key 0 the lug 15 of the key stem 12 swings the bell-crank lever 29 clockwise as seen in Fig. 5, the rocking member 33 being swung and moved by the bell-crank lever 29, while the rocking arm 34 slides along the pin 35 of the sign storing means 36 simultaneously as the projection 40 passes freely above the lug 41 on the lever 42 and another rocking arm 57 strikes a pin 58 on a downwardly directed arm 59 of the slide 25, thus moving the slide 25 to the left to initiate the additional operating cycle in the manner described in the following.

When the key 9 is depressed while the sign storing means 36 occupies the position shown in Fig. 4, i.e. when the last multiplication was effected with additive entering of the multiplicand into the result register, an additional operating cycle is started in a corresponding manner, during which cycle the multiplicand is entered subtractively once into the result register. This additional operating cycle is initiated by moving the sign determining slide 25 to the right as seen in Fig. 4. This is done in the following manner. When the key 9 is depressed, while the parts occupy the position shown in Fig. 4, the pin 49 on the stem of the key 9 will push cam plate 50 downwardly, the cam portion 51 sliding against and supporting itself on the pin 52 of the sign storing means 36 and a cam portion 60 of the cam plate 50 will strike the pin 58 on the slide 25 so that the cam plate 50 is wedged down between the pins 52 and 58. Since the sign storing means 36 is swingably but nondisplacably mounted in a manner to be described in the following and cannot yield to the wedge action of the cam plate 50, the slide 25 is pressed to the right by the oblique edge 60 of the cam plate 50 to initiate the additional operating cycle. During this depression of the key 9 the projection 55 of the cam plate 50 goes free of the lug 56 on the lever 42 so that this lever is not swung.

The step feed, necessary for performing a multiplication, of the multiplicand entering mechanism in relation to the result register after each multiplying operation by a multiplier digit is thus effected as for multiplier digits 0 and 9—when these digits do not release any additional operating cycle of the machine—by depression of the zero key 10 of the multiplicand entering mechanism in the manner described above. When, however, the multiplying operation by a multiplier digit includes one or more operating cycles with additive or subtractive entering of the multiplicand into the result register, the step feed in question of the multiplicand entering mechanism is effected in a known manner in connection with the last operating cycle during the multiplying operation, for which reason it would not seem necessary to describe this step feed more in detail in this connection. Such a step

6

feeding mechanism is shown and described for instance in the above mentioned Patent 2,397,745.

The ordinary calculating machines of the type herein concerned have a starting pin 61 (corresponding for instance to pin 375 in Patent 2,397,745 or pin 68 in Patent 2,237,881) which when moved to the left from the position shown in Fig. 8 starts the machine in the ordinary manner which is not therefore described. As long as the pin 61 is held in such a position the machine proceeds to perform operating cycle after operating cycle during each of which the multiplicand is entered once into the result register. Furthermore, the prior art machines have a sign control pin 62 (corresponding to pin 104 in Patent 2,237,881 and being the same as pin 30 in my Swedish Patent 160,490) which in the initial position of the machine occupies the position shown in Fig. 8 in which during an operating cycle the multiplicand is entered additively into the result register, but rises, if not blocked at the start of an operating cycle, into another position in which the multiplicand is entered subtractively into the result register. Said pins 61 and 62 are operated by the sign determining slide 25 with the intermediary of the following mechanism. The slide 25 has a pin 63 which moves in a slot 64 in the machine frame 30 during the movements of the slide as described in the foregoing. A connection hook 65 can be releasably engaged by means of its slot 66 with the pin 63 of the slide 25. The connection hook 65 is mounted for swinging movement by a pivot 67 on a control rocking member 68 and is mostly held engaged with the pin 63 by a pull spring 69 expanded between a pin 70 on the rocking member 68 and a pin 71 on the connection hook, said last mentioned pin being movable in a slot 72 in the rocking member 68. Said rocking member is pivoted to the frame 30 by a pivot 73. When in the manner already described the slide is moved in one or the other direction by depression of a multiplier key 0-9, the pin 63 on the slide will thus swing the rocking member 68 clockwise or counterclockwise from the position shown in Fig. 8 by means of the connection hook 65, and during this swinging movement of the rocking member 68 two cam portions 74 and 75 on the rocking member move the starting pin 61 to the left as seen in Fig. 8 so that the machine is started. In the manner described in the following the rocking member 68 is locked in such swung position until the initiated multiplication has been completed so that the pin 61 is held moved into starting position during the entire multiplication even if the operator has released his finger pressure on the depressed multiplier key. During the entire time that the rocking member 68 is held locked in swung position the slide 25 is held in displaced position by means of the connection hook 65 so that the pin 24 of the slide by engaging the oblique slot 26 in the stem of the depressed multiplier key holds the key depressed even if the operator has released his finger pressure on the key before the end of the multiplication. At the same time the displaced slide 25 with its pins 24 prevents depression of any further multiplier key during the time of the multiplication going on. Upon depression of any key of the lower key group 0-4, in connection with which the multiplicand is to be entered additively into the result register, the slide 25 — as earlier described — is moved to the left as seen in Figs. 1, 4, 5 and 7 and to the right as seen in Fig. 8 so that the control rocking member 68 is swung clockwise as seen in Fig. 8, whereby the latching lug 76 is swung over the sign determining pin 62 and retains it in the position shown in Fig. 8 in which the pin 62 causes additive entering of the multiplicand into the result register. When on the other hand any multiplier key of the higher key group 5-9 is depressed the slide 25 — as earlier described — is moved to the right as seen in Figs. 1, 4, 5 and 7 and to the left as seen in Fig. 8 so that the control rocking member 68 is swung counterclockwise from the position shown in Fig. 8, whereby the latching lug 76 is swung away from the sign determining pin 62 so that at the start of the

multiplication said pin can move upwards into the position in which the multiplicand will be entered subtractively into the result register.

Mounted on the machine frame 30 is a shaft 77 supporting a rotatable ratchet wheel 78 which on its periphery has two sets of ratchet teeth 79 and 80 and a cam nose 81. A pull spring 84 expanded between a pin 82 attached to the ratchet wheel 78 and a pin 83 on the frame 30, tends to rotate the ratchet wheel 78 counterclockwise as seen in Fig. 7 and clockwise as seen in Fig. 8, but such rotation of the ratchet wheel can be prevented by means of several pawls described in the following. The ratchet wheel 78 is connected by means of a pin 85 to the earlier described multiplier entering slide 19, and when the pawls described in the following release the ratchet wheel 78 spring 84 rotates the ratchet wheel and displaces the slide 19 until a lateral edge of any of the marginal recesses 22 of the slide abuts the lug 18 of a depressed multiplier key to arrest the rotation of the ratchet wheel 78 after no, one, two, three or four of the earlier described displacement steps of the slide 19, said steps corresponding to a rotation of the ratchet wheel 78 through no, one, two, three or four ratchet tooth divisions.

In the initial position shown the ratchet wheel 78 is retained by a pawl 86 which is mounted on the frame 30 by means of a pin 87 the latching lug 88 of which is held engaged with the ratchet teeth 79 by means of a spring 89 expanded between the pawl 86 and a pin 90 on the frame 30. When upon depression of any multiplier key 0-9 the control rocking member 68 is swung clockwise or counterclockwise in the manner earlier described a pin 91 mounted on said rocking member will actuate one of two cam portions 92 and 93 on the pawl 86 thus swinging the pawl counterclockwise as seen in Fig. 8 out of engagement with the ratchet wheel 78, and the pawl 86 is held out of such engagement as long as the rocking member 68 remains in swung position, i.e. as long as a multiplication is going on.

The ratchet wheel 78 cannot however, be rotated by the spring 84 immediately after the described release of pawl 86, for the ratchet wheel 78 is retained in the initial position shown in Figs. 7 and 8 also by an indexing hook 94 the lug 95 of which engages the ratchet teeth 80. Said indexing hook is pivotally mounted by a pivot 96 on one arm 97 of a U-shaped member 97, 98, and a pull spring 101 expanded between a pin 99 on the indexing hook 94 and a pin 100 on the frame 30 tends to hold the indexing hook 94 engaged with the ratchet wheel 78. The U-shaped member 97, 98 is pivotally mounted on the frame 30 by means of a shaft 102, and the arm 98 of the U-shaped member carries a pin 103 which is held applied against a cam 104 by a spring 105 which is expanded between a pin 106 on the arm 97 of the U-shaped member and the pin 100 secured to the frame 30 and which tends to swing the U-shaped member 97, 98 counterclockwise as seen in Fig. 7. The cam 104 is secured to a shaft 107 in the machine, said shaft rotating through one revolution clockwise as seen in Fig. 7 during each operating cycle of the machine, i.e. during each entering of the multiplicand once into the result register (shaft 107 corresponds to a shaft connected with the output member 484 in Patent 2,397,745 and the output member 32 in Patent 2,237,881 or cam 104 of the present mechanism may be secured to last mentioned output member 32). The cam 104 has the shape appearing from Fig. 7 so that soon after the start of an operating cycle, after the pawl 86 has been disengaged from the ratchet wheel 78, the pin 103 slides down a steep descent of the cam 104 and swings the U-shaped member 97, 98 counterclockwise as seen in Fig. 7 by the action of spring 105, the indexing hook 94 being moved to the right in Fig. 7 and to the left in Fig. 8. At this movement the indexing hook 94 strikes with a cam edge 108 against a pin 109 on a cam latch 110 described in the following, the pin 109 moving the indexing hook

94 entirely out of engagement with the ratchet wheel 78. When the indexing hook 94 is moved out of engagement with the ratchet wheel 78 in such a manner soon after the start of an operating cycle, the ratchet wheel 78 will be entirely free and can thus rotate by the action of the spring 84 through one or more tooth divisions if any of the multiplier keys 1-8 has started the operating cycle in question. The rotation of the ratchet wheel 78 is arrested by the multiplier entering slide 19 in the manner earlier described.

At the rotation of the ratchet wheel 78 out of the initial position the cam nose 81 of the ratchet wheel moves away from a pin 111 on a latch 112 which is pivotally mounted on the shaft 113 on the frame 30 and which can swing counterclockwise by the action of a spring 115 expanded between the latch and a pin 114 on the frame 30 to engage with its lug 116 ahead of or behind a locking projection 117 on the control rocking member 68 which has been swung in a manner earlier described from initial position in Fig. 8 clockwise or counterclockwise, and said lug 116 will thereby retain the control rocking member in swung position during the multiplication started.

After the ratchet wheel 78 has been adjusted in the manner described corresponding to a depressed multiplier key the cam 104 which during an operating cycle turns one revolution clockwise as seen in Fig. 7, abuts with a rising cam portion 128 a pin 118 on a latch 119 mounted on shaft 102 and swings said latch clockwise against the action of a pull spring 121 expanded between the latch 119 and a pin 120 on the frame 30. The projection 122 of the latch 119 is now disengaged from a lug 123 on a pawl 124 mounted on shaft 113, so that by the action of a pull spring 126 expanded between the pawl 124 and a pin 125 on the frame 30 said pawl can swing clockwise as seen in Fig. 7 and counterclockwise as seen in Fig. 8 to a position in which a latching lug 127 on the pawl engages one of the ratchet teeth 79 of the ratchet wheel 78. Soon after the pawl 124 has been swung in the manner described into engagement with the ratchet wheel 78 the cam incline 128 abuts the pin 103 on the U-shaped member 97, 98 and swings it clockwise as seen in Fig. 7 so that the indexing hook 94 is pulled back to the left towards the initial position shown in Fig. 7, the cam portion 108 of the indexing hook sliding along the pin 109 so that the indexing hook is swung by means of the spring 101 into engagement with a tooth 80 of the ratchet wheel 78 which is thereby returned clockwise as seen in Fig. 7 and counterclockwise as seen in Fig. 8 through one tooth division from the position adjusted by means of the slide 19 towards the initial position shown. During this movement a tooth 79 of the ratchet wheel 78 temporarily moves the pawl 124 out of the way, which pawl snaps in ahead of the tooth 79 in question and retains the ratchet wheel 78 in the new position of adjustment while the indexing hook 94—if the multiplication comprises several operating cycles—in the manner earlier described is again moved by cam 104 to the right as seen in Fig. 7 to catch a new tooth 80 of the ratchet wheel 78 and during its return movement to move back the ratchet wheel a further step towards initial position in the manner described. During each operating cycle, i.e. during each revolution of the cam 104, the ratchet wheel 78 is thus returned through one tooth division towards initial position. Thus, as the ratchet wheel 78 stops the machine in the manner described in the following when arriving in its initial position, the multiplication will comprise as many operating cycles as the number of tooth divisions through which the ratchet wheel has been turned by depression of the multiplier key which initiated the multiplication. While the pawl 124 is swung into engagement with the ratchet wheel teeth 79 the lug 123 of the pawl is situated above the projection 122 of the latch 119 so that during the multiplication going on said latch cannot prevent the pawl 124 from retaining the ratchet wheel 78 while the

indexing hook 94 moves to the right as seen in Fig. 7 to catch a new ratchet tooth 80.

During that operating cycle of a multiplication, during which the ratchet wheel 78 is fully returned to the initial position shown in Figs. 7 and 8 by the indexing hook 94, the cam nose 81 of the ratchet wheel 78 is engaged with the pin 111 on latch 112 and swings said latch clockwise as seen in Fig. 8. The latch 112 is swung clockwise beyond the position of rest shown in Fig. 8 because the ratchet wheel 78 is indexed with a small momentary overthrow due to the shape (see Fig. 7) of the cam 104 driving the indexing hook 94. Such swinging of the latch 112 with momentary overthrow serves to release the rocking member 68 so that the starting pin 61 which tends to return to the position shown in Fig. 8 is able to move the rocking member 68 back to initial position. Thus, on swinging clockwise as seen in Fig. 8 the lug 116 of the latch 112 releases the locking projection 117 of the rocking member 68 and a pin 129 on the latch 112 lifts the connection hook 65 out of engagement with the pin 63 of the sign determining slide 25 so that the control rocking member 68 is temporarily disengaged from the slide 25. The connection hook 65 again engages the pin 63 when the latch 112 after the overthrow has reached the position of rest shown in Fig. 8 and the slide 25 is moved back into initial position by the oblique slot 26 in the depressed multiplier key which returns to initial position by the action of its spring 17. At the described return of the control rocking member 68 to initial position the spring 89 also has the opportunity of swinging pawl 86 into engagement with the teeth 79 of the ratchet wheel 78. When the projection 81 of the ratchet wheel 78 moves aside the pin 111 of latch 112 said pin will also swing pawl 124 away from ratchet wheel 78 against the action of spring 126, the projection 122 of latch 119 which rests against the underside of the lug 123 of the latch 124 being capable of snapping into engagement behind the lug 123 by the action of the spring 121 and of retaining the pawl 124 disengaged from the ratchet wheel 78 until a new multiplying operation has been started.

The control of a multiplying operation as described above is applicable to the case when no additional operating cycle is required during the multiplication beyond the normal operating cycles the number of which is determined by the number of tooth divisions through which the ratchet wheel 78 is rotated by the slide 19. In the present embodiment such an additional operating cycle is inserted as a first operating cycle during a multiplying operation before normal operating cycles, if any, are performed during which the ratchet wheel 78 is returned to initial position stepwise by the indexing hook 94, and such an additional cycle is produced by the following mechanism without any indexing of the ratchet wheel 78.

The sign storing means 36 earlier referred to is pivotally mounted on the frame 30 by a pivot 130 and has an opening with two cam portions 131 and 132 which converge to a narrow slot 133 in which a pin 134 engages. Said pin 134 is attached to one end of an arm 135 the other end of which is mounted on the arm 97 of the U-shaped member 97, 98 by means of a pin 136. The pin 134 does not only engage in the slot 133 of the sign storing means 36 but also in an approximately U-shaped slot provided in the frame 30. This U-shaped slot has an upper portion 137 and a lower portion 138. A two-armed lever 140 is furthermore mounted on the frame 30 by means of a screw 139. One arm of the lever supports a spring wire the end portions of which form diverging horns 141 and 142 which in a manner to be described in the following serve to guide the pin 134 into one or the other portion 137, 138 of the U-shaped slot in the frame 30. The other arm of the lever 140 has a cam slot 143 of weak S-shape in which a pin 145 on the control rocking member 68 engages, said pin

projecting through an opening 144 in the frame 30. In addition, the sign storing means 36 carries a pin 146 against which there is applied either of two cam portions 147 and 148 of the cam latch 110, which extend at substantially right angles to each other, by the action of a pull spring 150 which is expanded between the cam latch 110 and a pin 149 on the frame 30 and which tends to swing the cam latch 110 mounted on shaft 113 clockwise as seen in Fig. 8.

Figs. 7 and 8 show the sign storing means 36 occupying the position corresponding to its position in Fig. 4, which implies that the last multiplying operation took place with additive entering of the multiplicand into the result register. In this position of the means 36 the pin 134 of arm 135 is in engagement with the slot 133 of means 36 and the upper portion 137 of the U-shaped slot on the frame 30, while the pin 146 of the means 36 abuts the cam portion 147 on the cam latch 110. If the multiplier key 0 is now depressed no operating cycle of the machine is released, as earlier described, but the multiplicand entering mechanism is only stepped through one denominational step by depression of the multiplier key 10 by means of a mechanism already described. If any other multiplier key in the lower key group 0-4 is depressed no additional operating cycle will be released beyond the normal number of operating cycles which corresponds directly to the digit value of the depressed key. These normal operating cycles proceed in a manner already described. At the start of such a multiplying operation the control rocking member 68 is swung in a manner earlier described counterclockwise as seen in Fig. 7 and clockwise as seen in Fig. 8 so that the pin 145 occupies a position at the righthand end (Fig. 7) of the weakly S-shaped slot 143 whereby the lever 140 is retained in the position shown in Fig. 7 or swung a small distance clockwise from this position so that the spring wire horn 142 delimits the upper portion 137 from the remainder of U-shaped slot 137, 138 in the frame 30. During each of the operating cycles of the multiplying operation thus started the arm 135 is moved by the U-shaped means 97, 98 first to the right and then back to the left as seen in Fig. 7. During the movement to the right the pin 134 of the arm 135 leaves the slot 133 in the sign storing means 36 and the slot portion 137 in the frame 30 but is prevented from falling down by the spring wire horn 142 so that at its return movement to the left as seen in Fig. 7 the pin 134 again engages in the slot portion 137 and the slot of the means 36. The sign storing means 36 will thereby remain in its position shown in Figs. 4, 7 and 8, and the multiplying operation will only comprise the normal operating cycles controlled in a manner already described. If, on the other hand, any multiplier key in the higher key group 5-9 is depressed the control rocking member 68 will be swung in a manner earlier described clockwise as seen in Fig. 7 and counterclockwise as seen in Fig. 8 so that the pin 145 of the rocking member will move to the left end (Fig. 7) of the cam slot 143 in the lever 140 whereby the lever 140 is swung counterclockwise as seen in Fig. 7, pressing the spring wire horn 141 against the pin 134. Thus, when during the first operating cycle of the multiplying operation now started the U-shaped member 97, 98 is swung so that the pin 134 is moved to the right as seen in Fig. 7 out of the slot portion 137, the spring wire horn 141 will press the pin 134 downwards to the slot portion 138 in which the pin 134 engages when the arm 135 moves back to the left as seen in Fig. 7. During this return movement the pin 134 abuts the cam portion 132 of the sign storing means 36 and thereby swings said means clockwise as seen in Fig. 8 until one end of means 36 occupies the position according to Fig. 5. During this swinging movement of the means 36 the pin 146 temporarily moves the cam latch 110 counterclockwise as seen in Fig. 8, sliding from cam portion 147 to cam portion 148. During this temporary swing-

ing movement of the cam latch 110 counterclockwise the pin 109 of the cam latch urges the indexing hook away from the ratchet wheel 78 so that during the operating cycle going on the indexing hook will not be able to engage a ratchet tooth 80 to index the ratchet wheel 78 through one tooth division during this operating cycle. If the additional operating cycle thus obtained without any indexing of the ratchet wheel 78 has been started by depression of the multiplier key 9 the multiplication is completed after the additional operating cycle, as the ratchet wheel 78 never left its initial position and the control rocking member was not therefore retained in swung position. After this additional operating cycle the pin 134 of the arm 135 is retained in the lower slot portion 138 of the U-shaped slot in the frame 30 and holds the sign storing means 36 in a position swung counterclockwise in relation to Fig. 7 and swung clockwise in relation to Fig. 8, said position corresponding to that of the means 36 in Fig. 5, which indicates that the last multiplication took place with subtractive entering of the multiplicand into the result register. If, on the other hand, the multiplication described was started by any of the multiplier keys 5-8 the machine continues, after the additional operating cycle described, to perform one or more normal operating cycles during which the ratchet wheel 78 is stepwise returned to initial position in the manner earlier described. If thereafter the multiplier key 9 is depressed no operating cycle of the machine is released but merely a step feed of the multiplicand entering mechanism in the manner earlier described, as the sign storing means occupies the position according to Fig. 5. If any other key of the higher multiplier key group 5-9 is depressed, normal operating cycles only are obtained with step feed of the ratchet wheel 78, because the spring wire horn 141 prevents the pin 134 of the arm 135 from leaving the slot portion 138 and going to the slot portion 137 during this operating cycle, for which reason the sign storing means 36 remains in its adjusted position. If, on the other hand, any key of the lower key group 0-4 is depressed, the control rocking member 68 is swung counterclockwise as seen in Fig. 7 and clockwise as seen in Fig. 8 whereby the spring wire horn 142 is held pressed against the pin 134 so that during its movement to the right as seen in Fig. 7 said pin is raised and at the return movement to the left slides into the upper slot portion 137, thus adjusting the sign storing means 36 into the position shown in Figs. 7 and 8. During this adjustment of the means 36 which takes place during the first operating cycle of the multiplication now started the pin 146 of the means 36 temporarily moves the cam latch 110 counterclockwise as seen in Fig. 8, sliding from cam portion 148 to cam portion 147, and this temporary swinging of the cam latch 110 results as has been described already in that the indexing hook 94 during the first operating cycle of the multiplication is not capable of indexing the ratchet wheel 78, i.e. an additional operating cycle is obtained before the other normal operating cycles, if any, the number of which is determined by the digit value of the multiplier key depressed.

In order that the machine may indicate the correct result of the calculation after all multiplying operations produced by means of the multiplier keys there is required, as already mentioned, an additional operation cycle in the case when the last multiplying operation of the calculation has taken place with subtractive entering of the multiplicand into the result register. Such an additional multiplying operation can be initiated by depressing the mechanism disclosed in my copending patent application Ser. No. 605,391, filed Aug. 21, 1956, now abandoned. Said mechanism which is optional and does not form part of the present invention is controlled by means of a shaft which can occupy two different positions of rotation one of which corresponds to additive and the other to subtractive entering of the multiplicand

into the result register during the multiplying operation as last performed. The sign storing means 36 in the present mechanism can be used for adjusting such a shaft into the two control positions. As will appear from Fig. 7, an arm 152 is secured to said control shaft 151. At one end said arm 152 has a slot 153 in which a pin 154 on the sign storing means 36 is engaged. Fig. 7 shows the shaft 151 with the arm 152 in the control position corresponding to additive entering of the multiplicand into the result register during the next preceding multiplying operation, and when the sign storing means 36 is swung counterclockwise as seen in Fig. 7 in a manner earlier described so that the pin 134 goes from the slot portion 137 to the slot portion 138, the arm 152 and the control shaft 151 are swung clockwise as seen in Fig. 7 to the control position corresponding to subtractive entering of the multiplicand into the result register during the last multiplying operation.

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

1. In an adding machine having a starting means movable to an actuated position to initiate cyclic operation of the machine, a sign control means adjustable between two positions controlling additive and subtractive operation of the machine, respectively, and a cycling means operable through a single cycle for each operation cycle of the machine, a mechanism for controlling the number of operation cycles of the adding machine during short cut multiplication, comprising a multiplication control means, multiplier digit setting means for entering one multiplier digit at a time into the mechanism, said setting means handling the multiplier digits 0 to 9, inclusively, as a lower group comprising the consecutive lowest digits and a higher group comprising the consecutive highest digits and entering the multiplier digits by moving said multiplication control means differentially from a normal position a number of steps which, for the lower group of digits, directly corresponds to the value of the digit, i.e. no step for digit 0, one step for digit 1 etc., and which, for the higher group of digits, corresponds to the formula $9-S$ where S is the value of the digit in question, i.e. no step for digit 9, one step for digit 8, two steps for digit 7 etc., means controlled by said setting means for actuating the starting means of the machine, sign determining means operably associated with the sign control means and actuated by said setting means to control the adjustment of said sign control means to its additive position for a lower group digit and its subtractive position for a higher group digit entered by said setting means, step feeding means operated by said cycling means of the machine and feeding said multiplication control means, when moved by said setting means, towards its normal position one step for each operation cycle of the machine, sign storing means controlled by said setting means and disabling said step feeding means for one operation cycle of the machine during each multiplication effected with a digit from one group following immediately upon a multiplication with a digit from the other group, and means actuated by said multiplication control means upon movement from normal position to retain said starting means in actuated position and upon restoration to normal position to release said starting means to interrupt the multiplication going on at the end of the current operation cycle of the machine at the end of which said multiplication control means is in its normal position.

2. In an adding machine having a starting means movable to an actuated position to initiate cyclic operation of the machine, a sign control means adjustable between two positions controlling additive and subtractive operation of the machine, respectively, and a cycling means operable through a single cycle for each operation cycle of the machine, a mechanism for controlling the number of operation cycles of the adding machine during short cut multiplication, comprising a multiplication control means, multiplier digit setting means for entering

One multiplier digit at a time into the mechanism, said setting means handling the multiplier digits 0 to 9, inclusively, as a lower group comprising the consecutive lowest digits and a higher group comprising the consecutive highest digits and entering the multiplier digits by moving said multiplication control means differentially from a normal position a number of steps which, for the lower group of digits, directly corresponds to the value of the digit, i.e. no step for digit 0, one step for digit 1, etc., and which, for the higher group of digits, corresponds to the formula $9-S$ where S is the value of the digit in question, i.e. no step for digit 9, one step for digit 8, two steps for digit 7, etc., means controlled by said setting means for actuating the starting means of the machine, multiplier digit keys controlling said setting means for entering one multiplier digit at a time into the mechanism, sign determining means operably associated with the sign control means and adjustable from a normal position into two different control positions, viz. a low digit position and a high digit position, to control the adjustment of said sign control means to its additive position for a lower group digit and its subtractive position for a higher group digit, respectively, entered by said setting means, said setting means including an adjusting means operable by said keys for the multiplier digits 1-8, inclusively, for adjusting said sign determining means into its low digit position by means of those keys among said keys for the multiplier digits 1-8, belonging to the lower digit group, and for adjusting said sign determining means into its high digit position by means of the rest of said keys for the multiplier digits 1-8, step feeding means operated by said cycling means of the machine and feeding said multiplication control means, when moved by said setting means, towards its normal position one step for each operation cycle of the machine, sign storing means controlled by said setting means and disabling said step feeding means for one operation cycle of the machine during each multiplication effected with a digit from one group following immediately upon a multiplication with a digit from the other group, connecting means controlled by said sign storing means for alternately connecting said keys for digits 0 and 9 with said sign determining means so that said sign determining means is moved from its normal position into its low digit position by said key for digit 0 only when the next preceding multiplication operation was with a digit of the higher group, and said sign determining means is moved from its normal position into its high digit position by said key for digit 9 only when the next preceding multiplication operation was with a digit of the lower group, and means actuated by said multiplication control means upon movement from normal position to retain said starting means in actuated position and upon restoration to normal position to release said starting means to interrupt the multiplication going on at the end of the current operation cycle of the machine at the end of which said multiplication control means is in its normal position.

3. In an adding machine having a starting means movable to an actuated position to initiate cyclic operation of the machine, a sign control means adjustable between two positions controlling additive and subtractive operation of the machine, respectively, a register, a multiplicand pin carriage, tabulating means for shifting said pin carriage denominationally relative to said register, and a cycling means operable through a single cycle for each operation cycle of the machine, a mechanism for controlling the number of operation cycles of the adding machine during short cut multiplication, comprising a multiplication control means, multiplier digit setting means for entering one multiplier digit at a time into the mechanism, said setting means handling the multiplier digits

0 to 9, inclusively, as a lower group comprising the consecutive lowest digits and a higher group comprising the consecutive highest digits and entering the multiplier digits by moving said multiplication control means differentially from a normal position a number of steps which, for the lower group of digits, directly corresponds to the value of the digit, i.e. no step for digit 0, one step for digit 1, etc., and which, for the higher group of digits, corresponds to the formula $9-S$ where S is the value of the digit in question, i.e. no step for digit 9, one step for digit 8, two steps for digit 7, etc., means controlled by said setting means for actuating the starting means of the machine, multiplier digit keys controlling said setting means for entering one multiplier digit at a time into the mechanism, sign determining means operably associated with the sign control means and adjustable from a normal position into two different control positions, viz. a low digit position and a high digit position, to control the adjustment of said sign control means to its additive position for a lower group digit and its subtractive position for a higher group digit, respectively, entered by said setting means, adjusting means operable by said keys for the multiplier digits 1-8, inclusively, for adjusting said sign determining means into its low digit position by means of those keys among said keys for the multiplier digits 1-8, belonging to the lower digit group, and for adjusting said sign determining means into its high digit position by means of the rest of said keys for the multiplier digits 1-8, step feeding means operated by said cycling means of the machine and feeding said multiplication control means, when moved by said setting means, towards its normal position one step for each operation cycle of the machine, sign storing means controlled by said setting means and disabling said step feeding means for one operation cycle of the machine during each multiplication effected with a digit from one group following immediately upon a multiplication with a digit from the other group, connecting means controlled by said sign storing means for alternately connecting said keys for digits 0 and 9 with said sign determining means and the tabulating means of the machine, respectively, so that said key for digit 0 moves said sign determining means from its normal position into its low digit position when the next preceding multiplication operation was with a digit of the higher group, but actuates the tabulating means of the machine when the next preceding multiplication operation was with a digit of the lower group, and said key for digit 9 moves said sign determining means from its normal position into its high digit position when the next preceding multiplication operation was with a digit of the lower group, but actuates the tabulating means of the machine when the next preceding multiplication operation was with a digit of the higher group, and means actuated by said multiplication control means upon movement from normal position to retain said starting means in actuated position and upon restoration to normal position to release said starting means to interrupt the multiplication going on at the end of the current operation cycle of the machine at the end of which said multiplication control means is in its normal position.

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