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SHORT-CUT MULTIPLICATION MECHANISMS
FOR CALCULATING MACHINES
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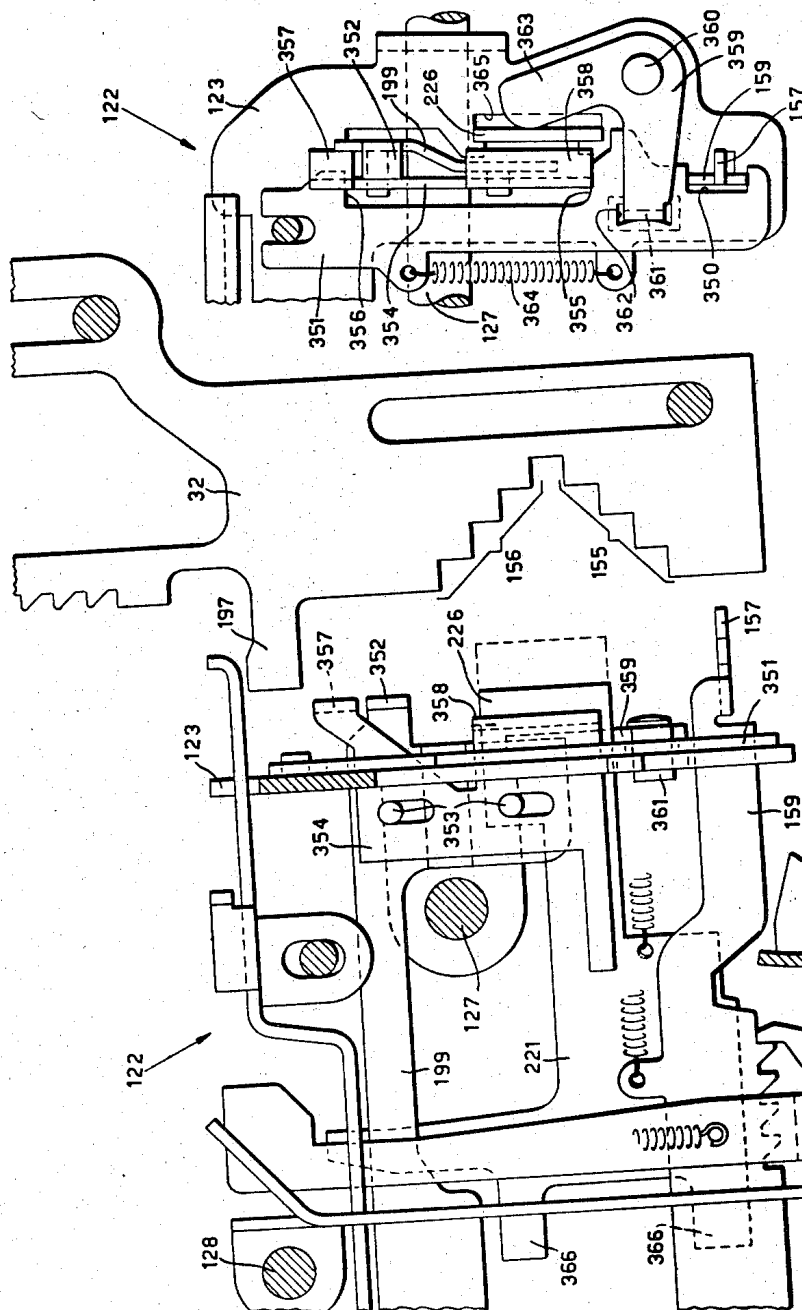


Fig. 2

Fig. 1

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**SHORT-CUT MULTIPLICATION MECHANISMS
FOR CALCULATING MACHINES**

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The present invention relates to short-cut multiplication mechanisms comprising a multiplier storage mechanism and a plurality of sensing devices cooperating therewith for sequentially sensing the denominational storing elements thereof to condition the cycling mechanism, the add-subtract controlling mechanism and other mechanisms of the machine according to the multiplier digit represented by the sensed storing element.

According to the short-cut method of multiplication, if a multiplier digit requires calculation according to the short-cut method, the next higher multiplier digit should be increased one unit.

The general object of the present invention is to provide an improved multiplication mechanism wherein the multiplier digit may be increased one unit without affecting the denominational storing element representing same.

A specific object of the invention is to provide a multiplication mechanism having a single sensing device for sensing a denominational storing element and accordingly controlling the cycling mechanism, whether or not said storing element represents a multiplier digit to be increased one unit.

Another object of the invention is to provide a multiplication mechanism of simple and inexpensive construction and of improved general operation.

According to the invention, therefore, in a short-cut multiplication mechanism comprising a multiplier storage mechanism having a storing element in each denominational order, said storing element having two stepped portions, one representing the multiplier digit requiring short-cut multiplication, the other representing the remaining multiplier digits, a cycle counting device, and a sensing device for sequentially sensing said storing elements to set said cycle counting device according to the differential travel made in sensing the portions of the individual storing element, we now provide moving means operable to move said sensing device one step substantially toward the higher digits of said stepped portions to increase the sensed digit one unit, and means on a storing element storing a multiplier digit requiring short-cut multiplication for operating said moving means, said last named storing element being one order lower than the storing element to be sensed by said sensing device.

Further objects, features and advantages of the invention will become apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a left-hand longitudinal sectional view of the multiplication mechanism according to the invention;

Fig. 2 is a partial frontal view of the mechanism of Fig. 1.

The present invention is an improvement in the multiplication mechanism embodied in a ten-key calculating machine and described in the specification of our Italian Patent No. 542,427 granted April 27, 1956, and reference may be made thereto for a complete understanding of the mechanism. In order to facilitate said understand-

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ing like numerals in the following description and in said specification refer to like parts.

According to the cited specification the multiplier is stored in a multiplier storage mechanism comprising a set of storing elements such as vertical slides 32, each one corresponding to a denominational order of the multiplier. Each vertical slide 32 is differentially movable downwards from their normal position shown in Fig. 1 to assume ten different positions corresponding to the multiplier digit values from zero to nine and is provided with two opposite stepped portions, or stairs 155 and 156, the descending stair 155 representing the digit values from zero to four, the ascending stair 156 representing the digit values from five to nine.

During an operation of multiplication the vertical slides 32 are sequentially sensed by a plurality of sensing devices mounted on a sensing carriage 122, said slides not being restored to their normal position as an incident of said operation. This carriage is made of a forward plate 123 and a rearward plate 124 rigidly connected together and is transversely movable on two stationary shafts 127 and 128 to be stepwise shifted by the traveling indexing mechanism of the machine, to which the carriage is connected during multiplication.

A first sensing device of said plurality is formed of a finger 157 of a spring actuated counting slide 159, which is adapted to be released by a pawl 161 in correspondence with each vertical slide 32 to move forwards (rightwards in Fig. 1). The sensing finger 157 thus senses the vertical slide 32 and is arrested by a step of the two stairs 155 and 156 according to the position assumed by said slide and thus to the stored multiplier digit, whereby the counting slide 159 is set according to the differential travel made by the finger 157. The slide 159 is then returned stepwise to its normal rear position by a restoring bail 164 cyclically driven by the main operating shaft of the machine, not shown in the drawings, said bail being cyclically engageable with the toothed portion of the slide 159. Normally the latter thus controls the number of cycles to be made for the sensed vertical slide 32.

According to the present invention the slide 159 is longitudinally slidable in a slot 350 of a moving means such as a transverse plate 351 (Fig. 2) which in turn is vertically slidable on the forward plate 123 of the sensing carriage 122.

The conventional add-subtract mechanism of the machine, not shown in the drawings, is controlled by a slide 199 which is conditioned by a second sensing device of said plurality, said second sensing device comprising a first sensing member, such as a longitudinal plate 354, vertically movable on two pins 353 of the slide 199 and a second sensing member, such as a fixed lug 352, which is bent from the slide 199 itself and which, therefore, is stationary with respect thereto. The longitudinal plate 354 is further guided by two edges 355 and 356 of the transverse plate 351, whereby the first sensing member 354 will be movable with the first sensing device 157. The longitudinal plate 354 is provided with a bent lug 357 located over the fixed lug 352 and aligned therewith and with a bent lug 358 located more rearward with respect to the lugs 352 and 357 (Fig. 1).

Normally the sensing carriage 122 is located in such a position as to place the finger 157 of the counting slide 159, as well as the lugs 357, 352 and 358 behind the slide 32 of the units order.

A lever 359 fulcrumed on a pivot 360 of the plate 123 is provided with a bent lug 361 engaging a slot 362 of the transverse plate 351. An arm 363 of the lever 359, by the urge of a spring 364 contacts a further or third sensing device of said plurality, said third sensing device

being formed of a spring actuated slide 221 movable in a slot 365 of the forward plate 123. The forward end 226 of this slide is normally transversely distanced toward the lower orders of the vertical slides 32 with respect to the slide 159, said distance amounting substantially to half a step of the transverse feed of the sensing carriage, i.e. half the distance between two adjacent orders.

In correspondence with each vertical slide 32 the slide 199 is adapted to be moved forwards under the control of the main operating shaft to enable the plate 354 and the lug 352 to cyclically sense the stairs 155 and 156 of the vertical slide 32 and accordingly arrest the slide 199 in order to control the add-subtract mechanism of the machine. More particularly, if the vertical slide 32 stores a digit one to four, either the fixed lug 352 or the movable lug 357 is arrested by the rearward portion or face of a projection 197 of the slide 32, thus arresting the slide 199 after a short travel adapted to condition the add-subtract mechanism for addition. In the slide 32 stores a digit five to nine, the slide 199 is arrested by the projection 197 through the movable lug 358, thus making a longer travel adapted to condition the add-subtract mechanism for subtraction according with the short-cut method of multiplication. If the slide 32 stores a zero digit (position of Fig. 1), the slide 199 is not arrested by the projection 197 and is thus moved through its maximum travel adapted to condition the machine for non-addition.

As has been mentioned above, the multiplier digits from five to nine require the multiplier digit of the next higher order to be increased one unit. To this end in correspondence with each vertical slide 32 the slide 221 is released to move forwards and thus to locate the forward end 226 in the position shown in Fig. 1 by broken lines.

The slot 365 housing the forward end 226 is so enlarged as to enable the slide 221 to be rocked around the ideal vertical axis defined by the slots of the rear plate 124 guiding the rear projections 366 of the slide 221, whereby the end 226 is transversely movable with respect to the sensing carriage 122.

If a vertical slide 32 stores a multiplier digit from five to nine, its projection 197 is located in the path of the end 226 of the slide 221. Upon terminating the sequence of machine cycles relating to such a vertical slide 32, the sensing carriage 122 is moved one step toward the higher orders to sense the next following slide 32. During this one step movement the end 226 will laterally abut against an operating means formed by the lateral right-hand portion or face of the projection 197 of the former slide 32. The end 226 thus first will be rocked with the slide 221 and after will be arrested, whereas the carriage 122 may terminate its movement. Consequently, the end 226 is moved half a step toward the lower orders (to the right in Fig. 2) with respect to the carriage 122, thus causing the lever 359 to rotate clockwise and to shift the transverse plate 351 upwards. The sensing finger 157 of the slide 159 is thus displaced one step toward the higher digits and will sense said next following slide 32 one step of the stairs 155 and 156 higher than the step representing the stored multiplier digit. With reference to the cycle counting slide 159 the stored digit is thus automatically increased one unit.

Furthermore, the transverse plate 351 will vertically shift the longitudinal plate 354 together with its bent lugs 357 and 358 one step toward the higher digits to alter the extent of travel of the slide 199 when sensing the projection 197.

More particularly, if the above mentioned next following vertical slide 32 is in zero position the slide 199 will now be arrested by the projection 197 through the movable lug 357 and will condition the add-subtract mechanism for addition instead of for non-addition.

If said vertical slide 32 is in a position from one to four,

the slide 199 will be arrested by the projection 197 through the lugs 352, 357 and will condition the add-subtract mechanism for addition, the number of cycles now conditioned by the counting slide 159 resulting increased one unit due to the vertical displacement of the finger 157. In this connection it will be remarked that the fixed lug 352 does not alter the extent of travel of the slide 199, whereby when sensing the projection 197 of a slide 32 representing the digit four the slide 199 will remain unaffected by the increase of said digit to five.

If said vertical slide 32 is in a position from five to eight the slide 199 will be arrested by the projection 197 through the lug 358 and will condition the add-subtract mechanism for subtraction, the number of cycles now conditioned by the counting slide 159 resulting decreased one unit due to the vertical displacement of the finger 157.

Finally, if said vertical slide 32 is in the nine position the projection 197 will be located lower than the lug 358. The slide 199 cannot be arrested and makes its maximum travel, conditioning the machine for non-addition instead of for subtraction, the vertical displacement of the finger 157 being now irrelevant as to the number of cycles conditioned by the counting slide 159.

It will be obvious that during the last cycle of a sequence of cycles relating to a vertical slide 32 following a slide 32 requiring the short-cut multiplication, the slide 221 will be momentarily returned rearwards by the bail 164, in order to disengage the end 226 from the projection 197 of the slide 32 against which it had abutted. The spring 364 now restores the plate 351 which through the lever 359 restores the end 226 laterally with respect to the sensing carriage 122, whereby the end 226 is moved past the projection 197. Finally, the slide 221 is restored forwardly by its spring while the carriage 122 is advanced transversely one step concurrently with the traveling indexing mechanism, whereby if the next slide 32 is in one of its "five" to "nine" positions, the end 226 will be again displaced laterally.

The operation of the mechanism in a typical multiplication problem will now be described. It will be assumed that the slides 32 have been set to store the multiplier 270,986 and that a multiplicand has been set up in the traveling indexing mechanism of the machine. Upon depression of the usual multiplication starting key the six following sequences of machine cycles will be made, beginning from the lowest order of the multiplier: four subtracting cycles, one subtracting cycle, one non-add cycle, one adding cycle, three subtracting cycles, three adding cycles.

More particularly, upon depression of the multiplication key the pawl 161 releases the counting slide 159 which thus senses the slide 32 of the units order previously set in its "six" position. The finger 157 of the counting slide 159 is thus arrested by the step "6" of the stair 156 after a forward movement of four steps, whereby the restoration of the slide 159 to its normal rear position by the ball 164 will require four machine cycles to be effected. During each machine cycle the slide 199 upon sensing the slide 32 of the units order will be arrested by the projection 197 thereof through the lug 358 of the plate 354, after having thus traveled through an extent long enough to condition the add-subtract mechanism of the machine for subtraction. Finally, upon depression of the multiplication key the slide 221 is released to its forward position.

Towards the end of the fourth cycle of this first sequence of four subtracting cycles the traveling indexing mechanism storing the multiplicand is transversely advanced a first step towards the higher orders (towards the left in Fig. 2) together with the sensing carriage 122, whose sensing devices are moved behind the slide 32 of the tens order previously set in its "eight" position. During said transverse movement the end 226 of

the slide 221 abuts against the projection 197 of the slide 32 of the units order and rocks the lever 359 clockwise (Fig. 2) to shift the plate 351 with the finger 157 and the plate 354 one step upwards.

During the next following cycle, the first of the second sequence of cycles, the finger 157 will be arrested by the step "9" of the stair 156 instead of by the step "8" and thus after a movement of a single step, whereby a single machine cycle will be effected in this sequence. During said cycle the slide 199 upon sensing the slide 32 of the tens order will be arrested after such a travel as to condition the add-subtract mechanism for subtraction. Moreover, during said cycle the slide 221 is momentarily returned rearwards to disengage the projection 197 of the slide 32 of the units order, whereupon it is restored past this projection under the tension of the spring 364. Towards the end of said cycle the sensing carriage 122 is advanced a second step, but the end 226 abuts against the projection 197 of the slide 32 of the tens order, whereby the plate 351 is shifted one step upwards.

During the next following cycle, the first of the third sequence of cycles, the finger 157 will be arrested by the upper uncut portion of the slide 32 of the third order after a movement of a single step whereby a single machine cycle will be effected in this sequence. During said cycle the slide 199 upon sensing the slide 32 of the hundreds order will not be arrested, thus conditioning the machine for non-addition. Moreover, during said cycle the slide 221 is momentarily returned rearwards to disengage the projection 197 of the slide 32 of the tens order and the sensing carriage 122 is advanced a third step, while the end 226 abuts against the projection 197 of the slide 32 of the hundreds order, whereby the plate 351 is shifted one step upwards.

During the next following cycle, the first of the fourth sequence of cycles, the finger 157 will be arrested by the step "1" of the slide 32, which is in a zero position, after a movement of a single step, whereby a single machine cycle will be effected in this sequence. During said cycle the slide 199 upon sensing the slide 32 of the thousands order will be arrested through the lug 357 by the projection 197, thus conditioning the machine for addition. Moreover, during said cycle the slide 221 is momentarily returned rearwards to disengage the projection 197 of the slide of the hundreds order and the sensing carriage 122 is advanced a fourth step.

During the next following cycle, the first of the fifth sequence of cycles, the finger 157 will be arrested by the step "7" of the slide 32 after a movement of three steps, whereby three machine cycles will be effected in this sequence. During each machine cycle the slide 199 upon sensing the slide 32 of the ten-thousands order will be arrested through the lug 358 by the projection 197 thereof to condition the machine for subtraction. Towards the end of the third cycle of this fifth sequence of subtracting cycles the sensing carriage 122 is advanced a fifth step, while the end 226 abuts against the projection 197 of the slide 32 of the thousands order, whereby the plate 351 is shifted one step upwards. During the next following cycle, the first of the sixth sequence of cycles, the finger 157 will be arrested by the step "3" of the slide 32 after a movement of three steps, whereby three machine cycles will be effected in this sequence. During each machine cycle the slide 199 upon sensing the slide 32 of the hundred-thousands order will be arrested through the lugs 352 and 357 by the projection 197 thereof to condition the machine for addition. Moreover, during the third cycle of said sequence the end 226 disengages from the projection 197 of the slide 32 of the ten-thousands order and the machine is stopped.

In the present embodiment the slides 32 storing the multiplier are vertical, whereby the first sensing device and the first sensing member are shifted vertically. It

will be apparent that in any case said device and member should be shifted in a direction according to the direction of the stairs 155 and 156 of the slides 32, which will be perpendicular to the transverse path of the sensing carriage 122.

What we claim is:

1. In a short-cut multiplication mechanism for calculating machines, comprising a multiplier storage mechanism having a storing element in each denominational order, said storing element having two stepped portions, one representing the multiplier digits requiring short-cut multiplication, the other representing the remaining multiplier digits, a cycle counting device, a sensing device for sequentially sensing said storing elements to set said cycle counting device according to the differential travel made in sensing the portions of the individual storing element; and a sensing carriage mounting said sensing device and movable in a transverse path with respect to said storage mechanism, moving means operable to move said sensing device with respect to said carriage one step substantially toward the higher digits of said stepped portions to increase the sensed digit one unit, and means on a storing element storing a multiplier digit requiring short-cut multiplication for operating said moving means, said last named storing element being one order lower than the storing element to be sensed by said sensing device.

2. In a multiplication mechanism as claimed in claim 1, a portion on each storing element adapted to indicate the character of the machine cycles to be effected for the stored multiplier digits, a second sensing device adapted to cyclically sense said portions to condition the machine according to the character of the multiplier digit sensed in the individual storing element, said second sensing device comprising a first sensing member movably mounted thereon and connected to said first sensing device to be moved in unison with the latter by said moving means to condition the machine according to the character of said increased digit, and a second sensing member stationary with respect to said second sensing device for enabling the machine to be conditioned according to the character of an unincreased digit irrespective of the movement of the first sensing member.

3. A short-cut multiplication mechanism as claimed in claim 1, wherein said storing elements are movable in a longitudinal plane, characterized in that said moving means comprise a slide shiftable to move said sensing device in a plane perpendicular to said path and a lever operable by said operating means during the movement of said carriage to shift said slide.

4. In a short-cut multiplication mechanism for calculating machines, comprising a multiplier storage mechanism having a storing element in each denominational order, said storing element having two stepped portions, one representing the multiplier digits requiring short-cut multiplication, the other representing the remaining multiplier digits, a cycle counting device, a first sensing device for sequentially sensing said storing elements to set said cycle counting device according to the differential travel made in sensing the portions of the individual storing element, and a sensing carriage mounting said first sensing device and movable in a transverse path with respect to said storage mechanism, moving means operable to move said sensing device with respect to said direction one step substantially toward the higher digits of said stepped portions to increase the sensed digit one unit, arresting means on a storing element storing a multiplier digit requiring short-cut multiplication, said last named storing element being one order lower than the storing element to be sensed by said first sensing device, and a further sensing device mounted on said carriage and movable along said path with respect to said carriage for operating said moving means, said further sensing device being adapted to laterally abut against said arresting means for being so moved.

5. In a multiplication mechanism as claimed in claim

4, a portion on each storing element adapted to indicate the character of the machine cycles to be effected for the stored multiplier digits, a second sensing device adapted to sequentially sense said portions to condition the machine according to the character of the multiplier digit sensed in the individual storing element, said second sensing device comprising a first sensing member movably mounted thereon and connected to said first sensing device to be moved in unison with the latter by said moving means to condition the machine according to the character of said increased digit, and a second sensing member stationary with respect to said second sensing device

for enabling the machine to be conditioned according to the character of an unincreased digit irrespective of the movement of the first sensing member.

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