Oct. 17, 1933. E. V. GUSTAFSSON ET AL 1,930,475

CALCULATING MACHINE

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Fig. 3

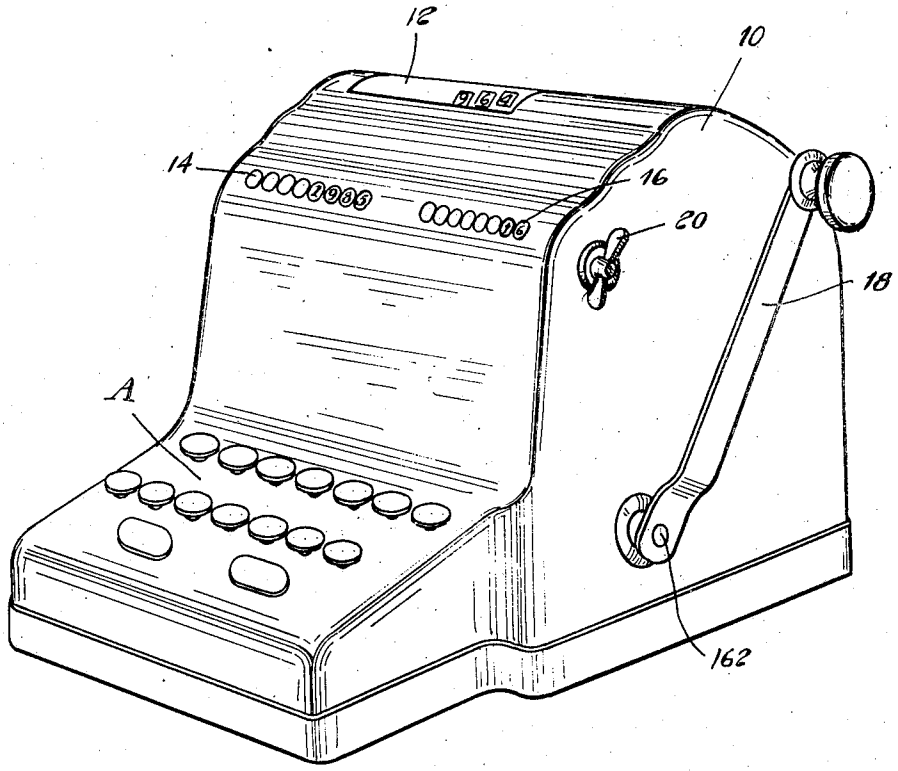


Fig. 1

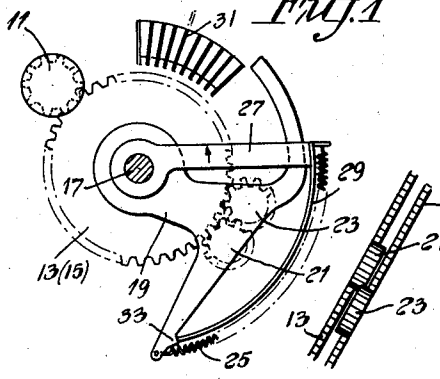


Fig. 2

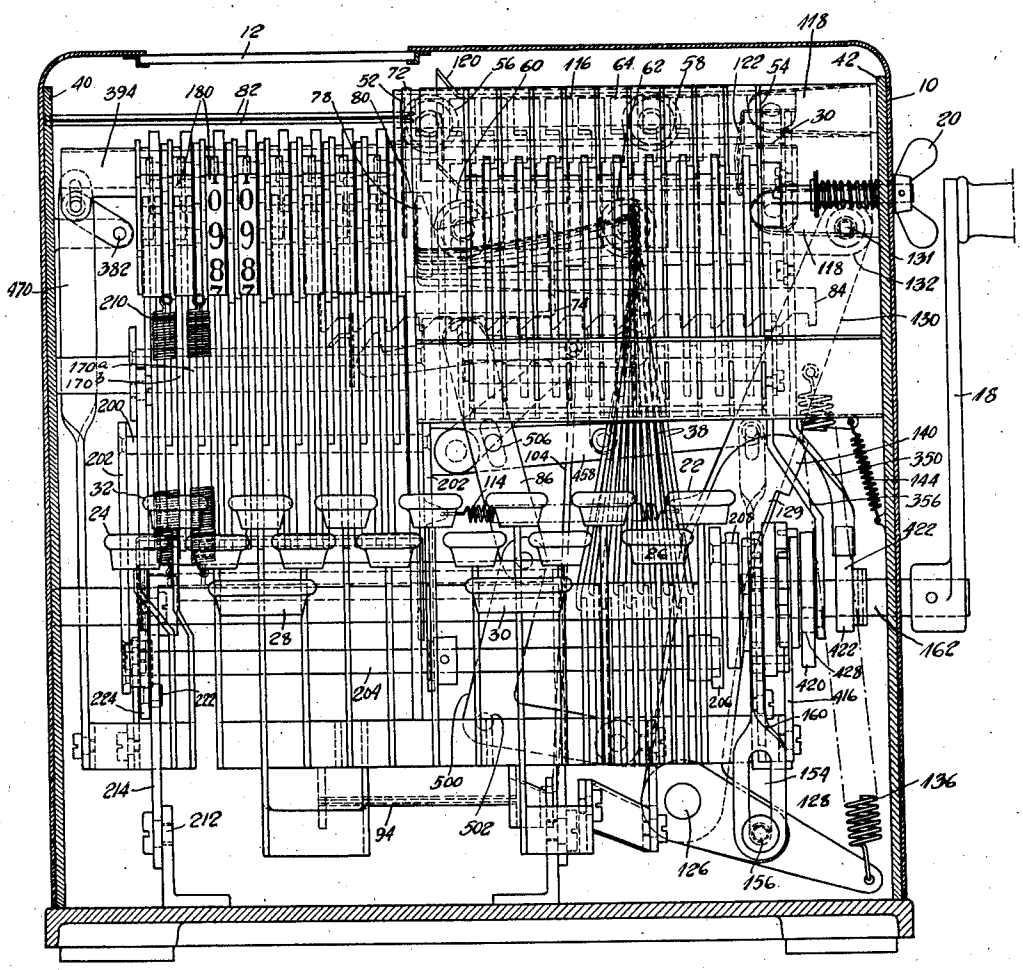
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CALCULATING MACHINE

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Fig. 4



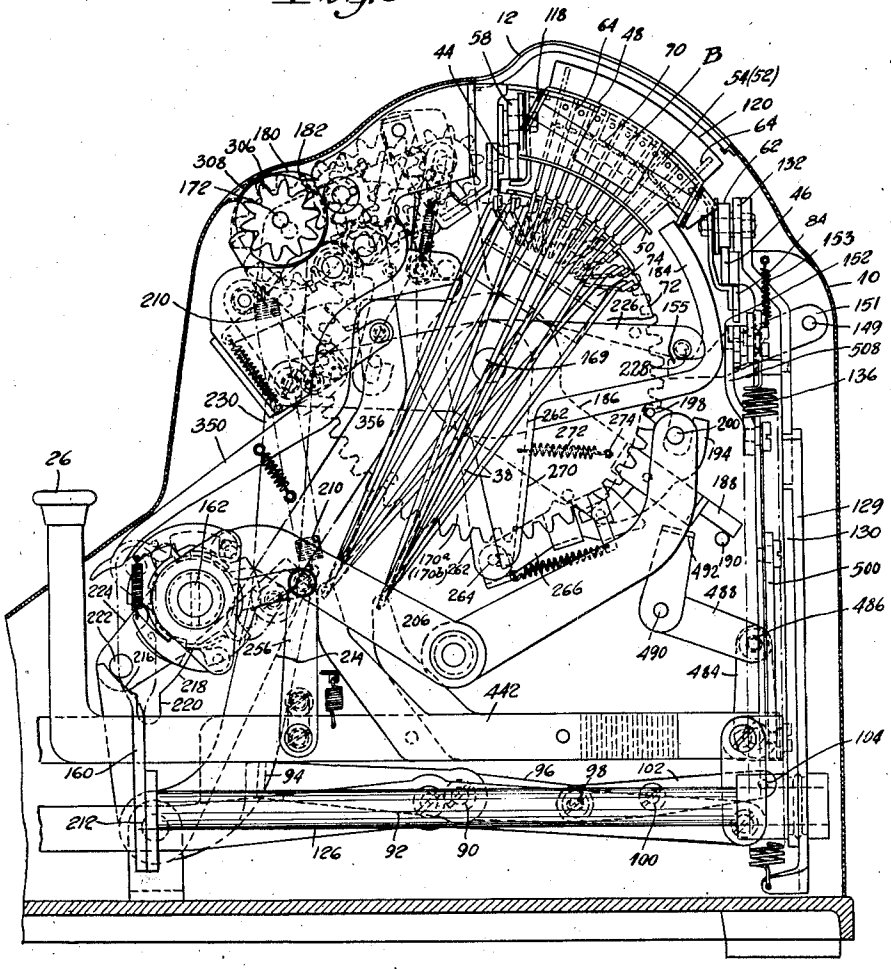
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Oct. 17, 1933. E. V. GUSTAFSSON ET AL 1,930,475

CALCULATING MACHINE

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Fig. 5



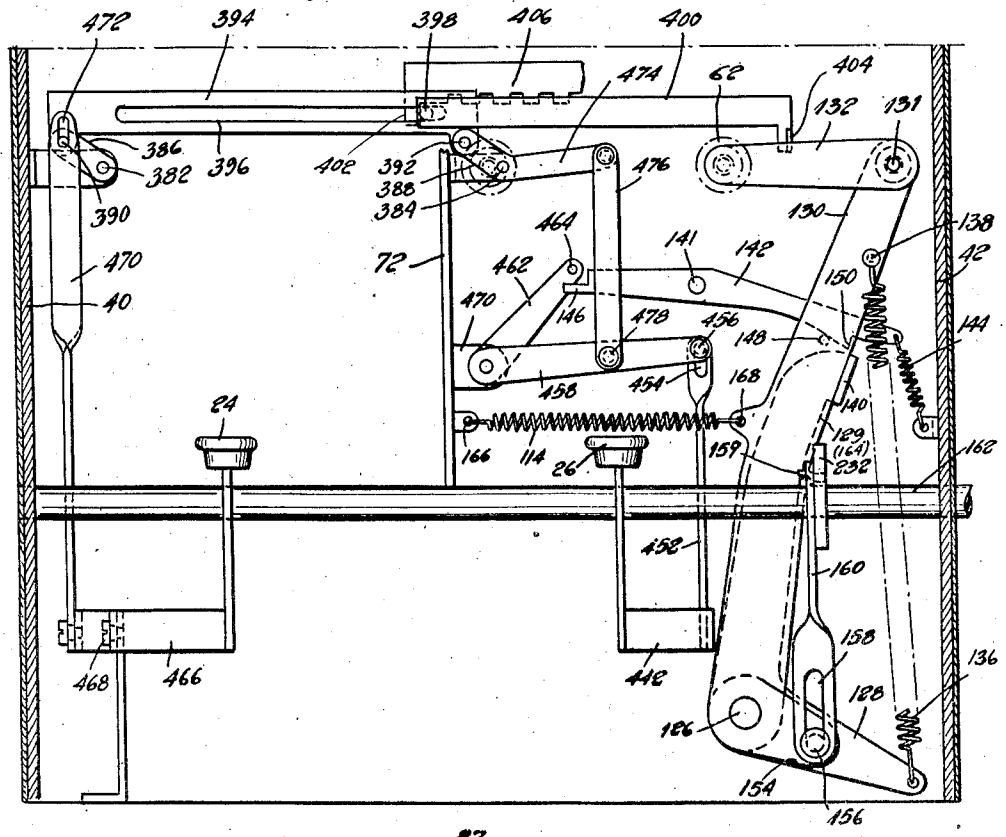
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Fig. 7



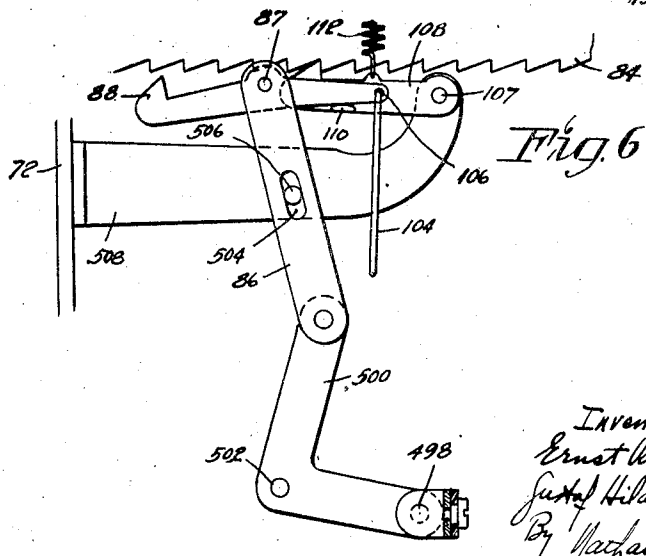


Fig. 6

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Fig. 12

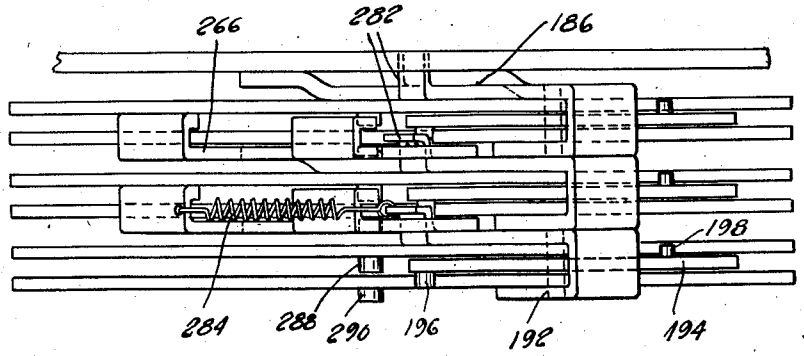


Fig. 13

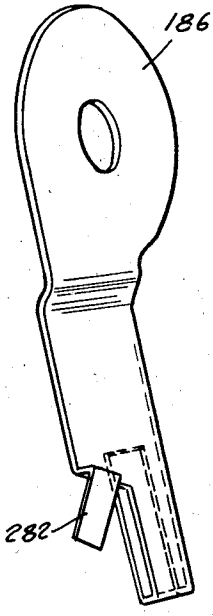


Fig. 14

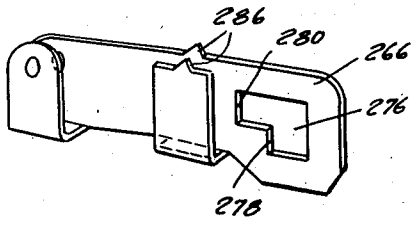
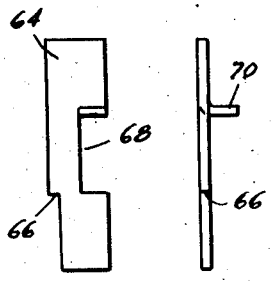


Fig. 8 Fig. 9



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Fig. 10

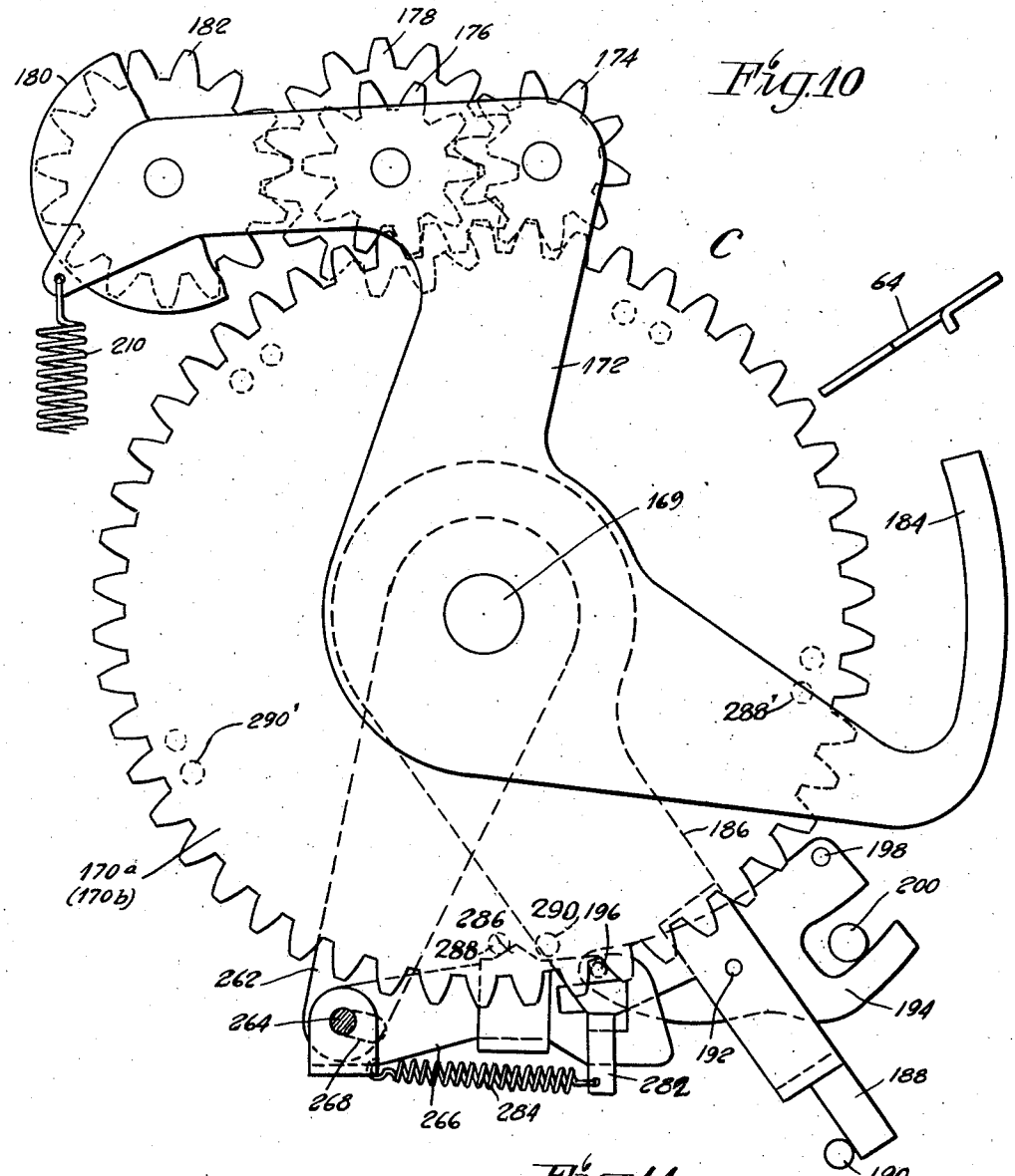
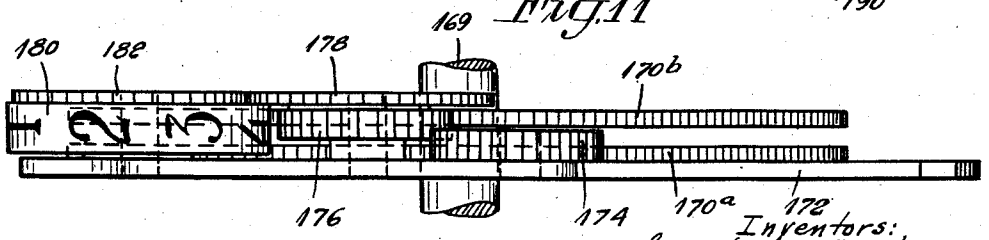


Fig. 11



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Fig. 15

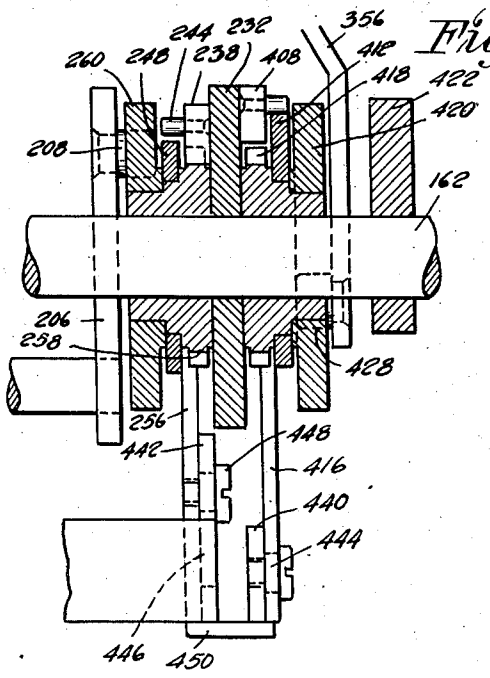


Fig. 16

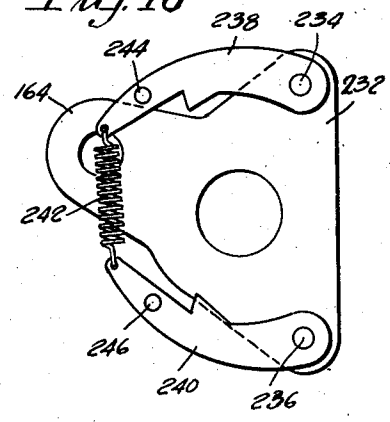


Fig. 18

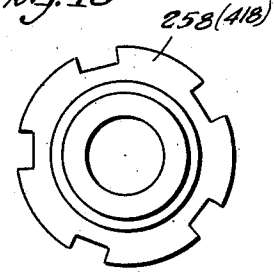


Fig. 17

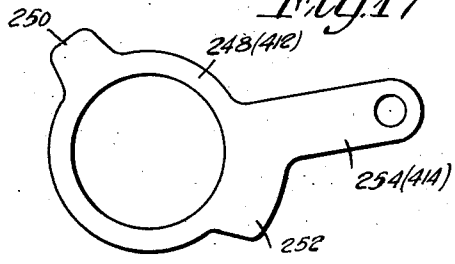


Fig. 19

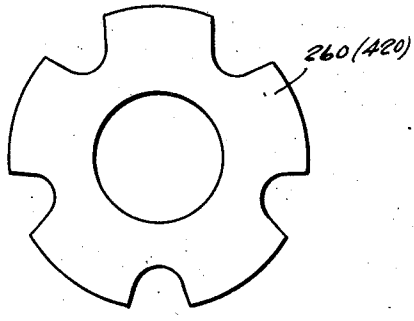
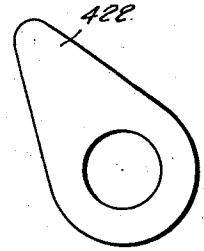


Fig. 20



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Fig. 22

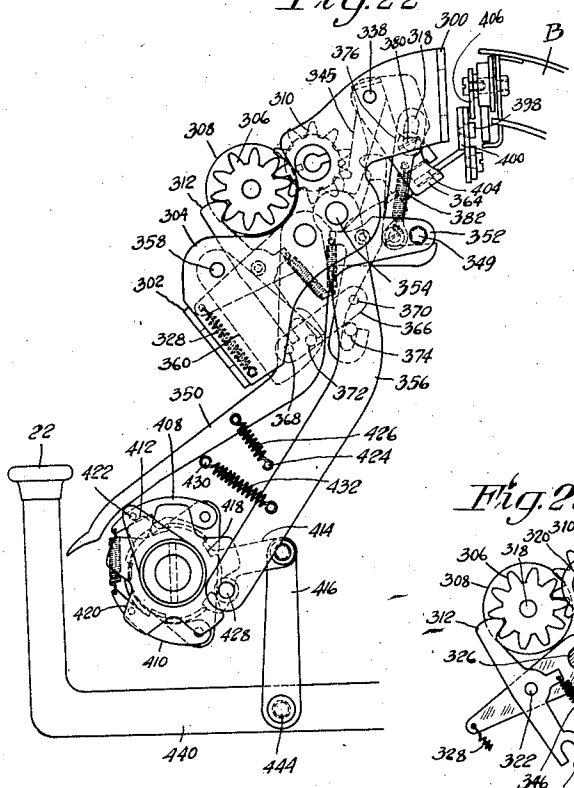


Fig. 21

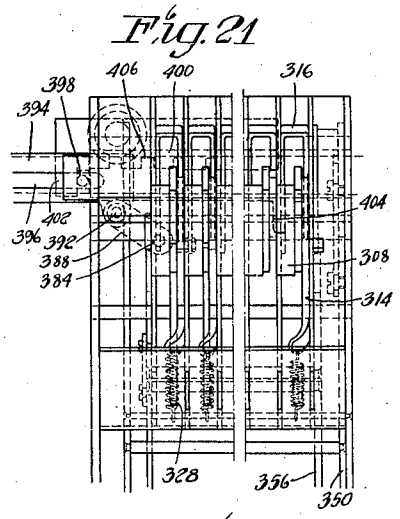


Fig. 23

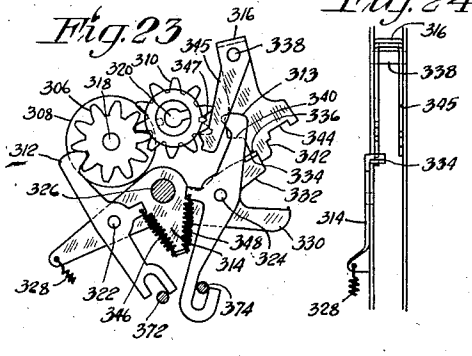


Fig. 24

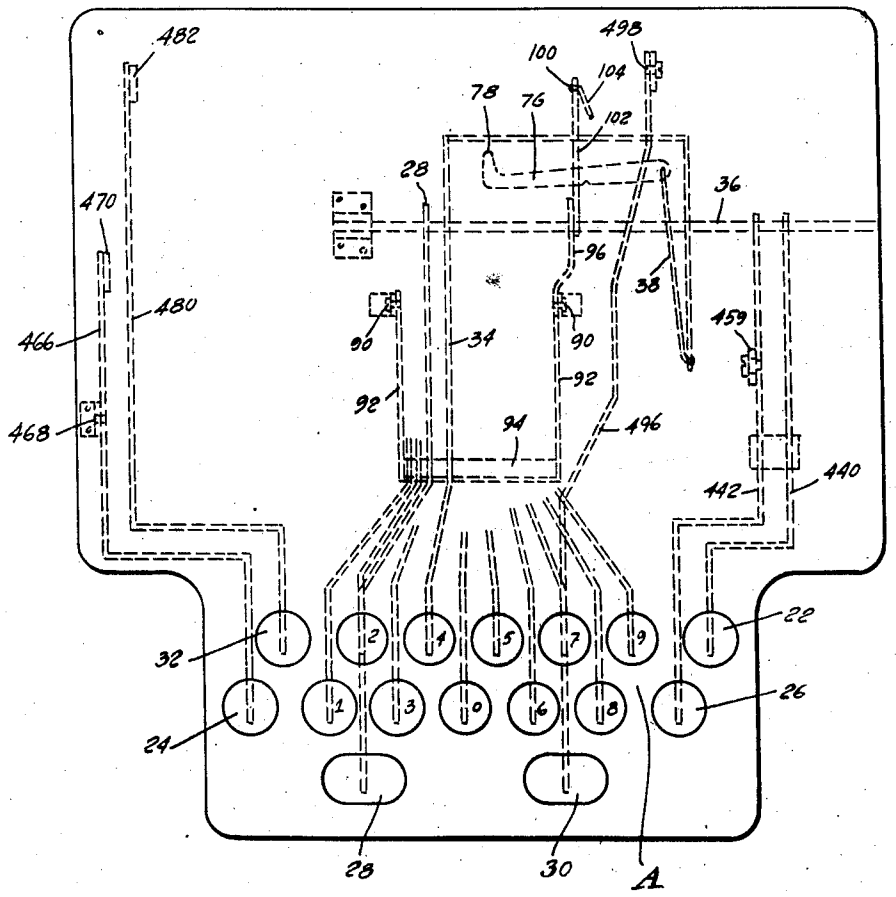
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CALCULATING MACHINE

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Fig. 25



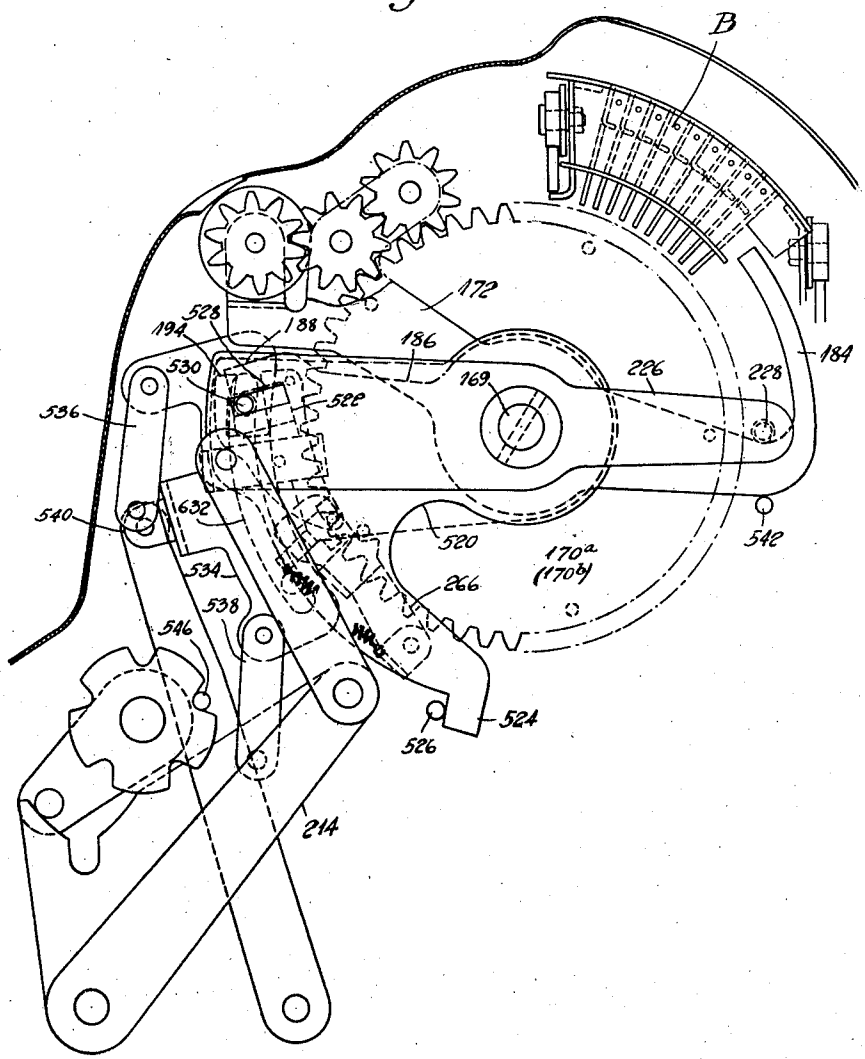
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Fig. 26



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Patented Oct. 17, 1933 1,930,475

UNITED STATES PATENT OFFICE

1,930,475

CALCULATING MACHINE

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Application December 21, 1928, Serial No. 327,587, and in Sweden December 23, 1927

48 Claims. (Cl. 235—60)

Our invention relates to calculating machines and particularly to that class known as ten-key calculating machines, that is calculating machines having only one key for each numeral.

The principal object of the invention is to provide a calculating machine of the type described which is simple in construction and operation, is durable, and is small and compact.

Our new calculating machine comprises a setting-up mechanism or selector operated by means of numeral keys, a calculating mechanism combined with a total register and operated by said setting-up mechanism or selector and several control keys and a handle stroke counter or quotient register controlled decimally by the selector and digitally by the number of pulls on the handle.

The calculating mechanism of our new calculating machine comprises a plurality of identical units each comprising two main calculating members co-operating with a result member and so formed that a relative movement between them gives a result of a size determined by the size of said movement. This relative movement may be effected by the two main calculating members alternately forming a reaction base or support. The two main members may be combined with other members so as to form what may be termed a differential gearing adapted to transfer to said result member the movement determined by the setting-up mechanism or selector, in a direction corresponding to the mode of calculation.

Our machine also comprises new and useful means operating in combination with said main calculating members to effect tens transfer, said means comprising a member adapted to be operated by the main members of one unit of the calculating mechanism and in turn to control the main members of the unit of the next higher denomination.

The handle stroke counter of our new calculating machine is adapted to record in addition and substraction the total number of items added or subtracted, respectively, and to denote in multiplication the multiplier and in division the quotient.

An important feature of our invention resides further in such an arrangement and construction of the setting-up mechanism or selector that the number set up can be read off directly in said selector, thus rendering a separate indicating register superfluous.

The invention is illustrated in the accompanying drawings, in which:—

Figs. 1 and 2 illustrate somewhat diagrammatically the principle upon which the invention is based.

Fig. 3 is a perspective view of the machine.

Fig. 4 is a front view of the machine, the casing thereof being omitted.

Fig. 5 is a right side view of the machine with the casing omitted.

Fig. 6 is a view in detail of the escapement mechanism of the selector.

Fig. 7 is a view in detail of the selector zeroizing means.

Figs. 8 and 9 show a tongue of the selector in two projections.

Fig. 10 is a detail view of one unit of the calculating mechanism.

Fig. 11 is a view seen from above of Fig. 10.

Fig. 12 is a view seen from below of Fig. 10, three consecutive units of the calculating mechanism being shown.

Fig. 13 is a detail view of an arm supporting the shifting mechanism.

Fig. 14 is a detail view of the tens transfer pawl of the calculating mechanism.

Fig. 15 is a detail sectional view of the controlling devices of the calculating mechanism and the quotient register.

Figs. 16 to 20 inclusive are detail views of different elements of said devices.

Fig. 21 is a front view of the quotient register.

Fig. 22 is a right side view of said quotient register.

Fig. 23 is a detail view of one unit of said register.

Fig. 24 is the corresponding front view.

Fig. 25 is a plan view illustrating the general arrangement of the different keys.

Fig. 26 shows a modified embodiment of the calculating mechanism.

In the following description the expressions "right", "left", "fore" and "rear" refer to the machine as seen from the key-board. The expressions "clockwise direction" and "counter-clockwise direction" refer to the machine as seen from the key-board or from the right hand side.

The principle upon which our new calculating machine is based will first be explained with reference to Figs. 1 and 2.

In these figures 11 designates the numeral member of a total register on which the numeral obtained by the calculation may be read off. This member has the form of a toothed gear having a numeral disk connected thereto. Co-operating with this gear 11 are two members 13 and 15 also in the form of toothed wheels and

each provided with a number of teeth which is equally divisible by ten, the gear 11 meshing with one of said gear wheels, for instance 13. These two gears are loosely mounted on a shaft 17 on which also other corresponding members co-operating with other numeral wheels 11 are loosely mounted. Loosely mounted on said shaft 17 is also a lever 19, one for each pair of wheels 13, 15 and carrying two gear wheels 21 and 23 in mesh with each other. As shown in Fig. 2, these gear wheels 21 and 23 have a greater width than the wheels 13 and 15 and each engage one of same, 21 engaging 13 and 23 engaging 15. The gear wheels 13, 15, 21 and 23 form together what may be termed a differential gearing. Lever 19 is by means of a spring 25 connected with a manœuvering arm 27 swingably journalled on the shaft 17, said spring 25 resting against a plate 29 connected with said arm 27 and having such an initial tension that on turning the arm 27 in the direction of the arrow shown on said arm in Fig. 1 the lever 19 together with differential gears 21 and 23 will follow this rotation, until stopped by one of selector tongues 31. A continued rotation of the manœuvering arm 27 for the setting of other groups results only in a continued tensioning of the spring 25. On the return movement of the arm 27 the plate 29 restores the lever 19 into normal position, abutting against said lever as at 33. The selector tongues 31 are controlled from the key-board of the machine in any suitable manner.

The wheels 13 and 15 are controlled by locking means (not shown in Figs. 1 and 2) in such manner that said wheels are alternately locked, one wheel on the forward stroke of the manœuvering arm 27 and the other on the return stroke of said arm.

The operation is as follows, it being assumed that wheel 15 is locked and wheel 13 freely rotatable during the forward stroke of the arm 27 whereas wheel 13 is locked and wheel 15 freely movable during the return stroke of the arm.

When arm 27 is turned in the direction of the arrow, wheel 23 in mesh with locked wheel 15 is rotated, driving in turn by means of wheel 21 the movable wheel 13 in mesh with numeral wheel 11. This latter wheel 11 will, consequently, be rotated, until lever 19 strikes the projected selector tongue 31 whereby the movement in this group is stopped. Numeral wheel 11 will then show the numeral corresponding to the projected tongue, the locked wheel 15 serving as a reaction base or support during this movement. When arm 27 which is moved further in order to set other groups in the machine reaches its upper end position, wheel 15 is released and wheel 13 stopped. On the return stroke of arm 27 wheel 21 will rotate on locked wheel 13 which latter serves as a reaction base or support for this movement, said wheel 21 driving by means of wheel 23 wheel 15 in opposite direction to that in which wheel 13 was rotated, and when the arm 27 has reached its starting position both wheels 13 and 15 have been rotated through equal angles. The rotation of wheel 15 during this second stage is not, of course, transferred to numeral wheel 11, as this wheel only engages wheel 13 which is now locked.

If at the beginning of the movement of arm 27 wheel 13 is locked, wheels 21 and 23 and, thus, wheel 15 will be rotated in opposite directions as before. The numeral wheel 11 remains then unactuated during this first stage of the movement, but when arm 27 is returned, it will be rotated in opposite direction as before through an angle corresponding to the numeral set up in the selector. Consequently, the direction of rotation of numeral wheel 11 depends upon which wheel 13 or 15 is locked at the beginning of the movement of arm 27, that is to say the desired mode of calculation, for instance addition or subtraction, can be obtained by locking one of the wheels 13 or 15 according to the order in which the numerals are arranged on the numeral wheel 11.

We will now proceed to describe a constructional form of a calculating machine built according to the principle above explained, beginning first with the embodiment shown in Figs. 3 to 25, inclusive.

A calculating machine according to the invention comprises essentially the following main parts: the key board A including ten numeral keys and a plurality of control or shift keys, the setting-up mechanism or selector B, the calculating mechanism C and the handle stroke counter or quotient register D. The general design of the machine is clearly shown in Fig. 3. As shown the machine is covered by a casing 10 in which openings are provided for the different keys and windows 12, 14 and 16 for showing the number set up in the selector, the result in the total register combined with the calculating mechanism and the number registered in the quotient register, respectively. The machine is operated in known manner by means of a handle 18, operating the main driving shaft 162, it being understood, however, that it may also be operated automatically, for instance by means of an electric motor. In this figure is also shown a wing screw 20 for clearing the quotient register, this being effected in well-known manner.

The key-board

The key-board A (see especially Fig. 25) comprises ten numeral keys corresponding to the numerals 0 to 9 inclusive, further a subtraction key 22, a multiplication key 24, a division key 26, a naught key 28 for advancing the selector one decimal step to the left, a back space key 30 for resetting the selector one decimal step to the right, and a zeroizing or blanking key 32 for clearing the total register. The numeral keys, the naught key 28, the back space key 30 and the zeroizing key 32 are in well-known manner spring-actuated so as to be automatically restored to starting position when the key tab is released from the finger pressure. The subtraction key 22, the multiplication key 24 and the division key 26 are also spring-actuated but are arranged in well known manner so as to be locked in depressed position on depression and released and restored to normal position first after a second depression.

Each of the numeral keys as well as the naught key 28 is connected with a key lever 34, said levers being at their free ends at 36 each connected with a cord 38, the other end of which engages a hammer in the selector in a manher to be described later on in connection with the description of the selector, it being stated at this point that the cord 38 of the naught key 28 engages the same hammer of the selector as that of the key "0". The arrangement and operation of the remaining keys will be described in the following.

The selector.

The setting-up mechanism or selector B consists of a slidably mounted carriage comprising an upper plate 48, a lower plate 50 and two side plates 52 and 54. Suitably journalled in this

carriage are two pairs of guiding rollers 56, 58, 60 and 62, the upper pair 56, 58 rolling on an upper guide 44 and the lower pair 60, 62 on a lower guide 46, said guides 44, 46 being secured transversely of the machine in the rear part thereof to the main side frames 40 and 42. In plates 48 and 50 are rows of openings, the openings in the one plate being in alignment with those in the other. Each longitudinal row (seen in the longitudinal direction of the machine) contains ten openings, the number of such longitudinal rows depending on the desired decimal capacity of the machine. Guided in each pair of openings thus formed in the two plates 48, 50 is a tongue 64 resting normally so as to position a notch 66 therein on the lower plate 50 of the carriage with its upper edge at the same level as the upper surface of the upper plate 48. The tongues 64 are each provided with a recess 68 limited at the top by a laterally projecting lug 70. The shape of the tongue 64 is clearly shown in Figs. 8 and 9.

Secured to a partition wall 72 disposed longitudinally of the machine is a bridge piece 74, and journalled on said bridge piece are a plurality of hammers 76 in the form of two-armed levers. In the embodiment shown there are ten such levers 76. Secured to one end of said hammers 76 is one of the cords 38 connected with the key levers 34, whereas at their other ends the hammers 76 are each provided with a head 78 guided in a suitable slot in a block 80 secured to the partition wall 72. At the front of each of the ten transverse rows of tongues 64 a rod 82 is secured to the main side frame 40 and extends into an opening in the left lateral plate 52 of the selector carriages.

The selector carriage is advanced step by step to the left by means of the following escapement mechanism, the depression of any of the numeral keys or of the naught key 28 effecting the movement of the selector one step to the left. Secured to the selector carriage in any suitable manner is a rack 84 (see especially Figs. 4 and 6). Mounted at the upper end of a link 86 of the transferring means of the back space key 30 below said rack 84 is a stud 87 on which a pawl 88 is pivotally mounted. Mounted at both sides of the machine in any suitable manner (see Fig. 25) is a stud 90 on which an arm 92 is pivoted, said arms 92 being at their free ends connected by means of a cross bar 94 against which the key levers 34 of the numeral keys and the tabulating key 28 rest. Pivotally mounted on the same stud 90 and rigidly connected with the arm 92 at the one side of the machine is an arm 96, and pivotally connected to said latter arm 96 at the free end thereof is a lever 102 pivoted on the machine frame as at 100. A cord 104 engages the other end of said lever 102 and is at its other end connected with the above-mentioned pawl 88 as at 106. Cooperating with said pawl is another pawl 108 pivotally journalled as at 107 in a bracket 508 secured to the partition wall 72, a dog 110 on the latter catching under the pawl 88. A spring 112 presses the pawl 110 normally in engagement with the rack 84, whereas the pawl 88 is normally out of engagement with said rack 84. When on depression of any of the numeral keys or of the naught key 28 a pull is exerted in cord 104 by means of lever system 92, 96, 102, pawl 88 is swung into a tooth space of rack 84 and presses simultaneously by means of dog 110 pawl 108 out of engagement with said rack 84. The selector carriage actuated in a manner to be later described by a spring 114 tending to move the carriage to the left is thereby moved in this direction through a distance corresponding to approximately half a pitch of the rack 84, until pawl 88 prevents its further movement. Upon the release by the finger of the depressed key pawl 88 is brought out of engagement with rack 84 at the same time as pawl 108 actuated by spring 112 is moved into the next tooth space of said rack 84 causing spring 114 to move the selector carriage the remaining half escapement, i. e. half a pitch to the left, until pawl 108 stops the movement. The pitch of the rack 84 is so chosen that upon the movement of the selector carriage through one step to the left the next longitudinal row of tongues 64 of the selector is moved into alignment with the heads 78 of the hammers 76.

Upon depression of any numeral key or of the naught key 28 corresponding tongue 64 is pressed out through the corresponding opening in the upper plate 48 of the selector carriage by the head 78 of the hammer 76 in question. The tongues 64 pressed out may be observed through the window 12 in the casing 10. By this arrangement very simple means is obtained to indicate the number set up in the selector which, of course, is of great importance, especially in ten-key calculating machines, as the operator can correct any mistake before the number is thrown into the total register. Upon the movement of the selector in the manner above described the tongue 64 pressed out rides up on corresponding rod 82 on which it is then hanging with its lug 70. Upon the return of the selector in the manner to be described tongue 64 is no longer supported by rod 82, so that it falls down again in its normal position resting with its notch 66 on the lower plate 50 of the selector carriage.

If for some reason or other the tongue 64 does not fall down by itself in normal position, means are provided to secure this, said means comprising a lever 116 (see especially Figs. 4 and 5) arranged above the selector tongues 64 and pivotally journalled in brackets 118 secured to the right side frame 42. At its right end lever 116 is provided with a downwardly extending tail 122 and at its left end with an inclined surface 120, said end reaching a little distance beyond the first left row of tongues 64, when the selector is in its starting position. If upon the return of the selector any tongue does not return to starting position, it will abut against inclined surface 120 causing as a rule the tongue to be pushed home. If the tongue 64 is not depressed, it will lift the lever 116 and when then at the end of the pushing home of the selector carriages the latter strikes against the tail 122 of the lever 116, said lever is pressed downwardly and depresses in turn any tongue 64 which is still projecting beyond the upper plate 48 of the selector carriage.

The selector is zeroized or cleared by the following means (see especially Figs. 4 and 7). Journalled in a rear frame 124 and a fore frame (not shown) of the machine is a shaft 126 and secured to said shaft at the rear end thereof is a bell crank lever 128, 129. Rotatably mounted on said shaft 126 is a link 130 pivotally connected at its free end at 131 with another link 132 which at its other end is pivoted on the same stud which forms the bearing for guiding roller 62. The arm 128 of lever 128, 129 is at its free end by means of a spring 136 connected with link 130 as at 138, whereas the other arm 129 terminates in a laterally projecting abutment 140 normally engaging the link 130. Journalled on a stud 141 secured to the machine frame is a dou-

ble armed lever 142, the one end of which is connected with the side frame 42 by a spring 144, whereas its other end is formed as an abutment 146 for the purpose to be described later on. The lower surface of the lever 142 is formed as a cam and co-operates with a pin 148 formed on the link 130. Further the lever 142 is at the end thereof connected with the machine frame provided with a shoulder 150 lying in the starting position of the selector carriage immediately above the surface of abutment 140 co-operating with the link 130.

Pivotally mounted on the machine frame at 149 (see especially Fig. 5) in the rear part of the machine is an arm 151 provided with a tooth 152 and actuated by a spring 153. At its free end the arm 151 is provided with an abutment 155 which by the spring 153 is pressed into engagement with a cross bar 228 to be described later on. When upon the forward stroke of the operating handle 18 said cross bar 228 is rotated in counter-clockwise direction (see Fig. 5), the arm 151 is drawn upwards under the action of the spring 153 causing the tooth 152 to engage rack 84 and lock the selector carriage in set position. When at the end of the return stroke of the operating handle 18 the cross bar 228 is again brought into engagement with the abutment 155 of the arm 151, the tooth 152 disengages the rack 84 thus releasing the selector carriage.

Secured to shaft 126 at the fore end thereof is an arm 154 carrying at its free end a pin 156 projecting through an elongated slot 158 in a link 160, the other end of which is pivoted on a stud 159 secured to the free end of a lug 164 of a part 232 fixed on the main driving shaft 162.

The operation is as follows: When a given item is set up in the selector, link 130 has been rotated in counter-clockwise direction by means of link 132 through an angle corresponding to the number of numerals in the item set up. Evidently bell crank lever 128, 129 secured to shaft 126 has also taken part in said rotation by means of spring 136 connecting said lever 128, 129 with link 130 and also arm 154 secured to said shaft 126, the pin 156 of said arm 154 sliding in slot 158 in link 160. During this rotation pin 148 is sliding on the lower cam surface of lever 142, said cam surface having such a form, that, as soon as abutment 140 has come clear of shoulder 150 of lever 142, the latter is drawn downwardly a given distance by means of spring 144. At the beginning of the forward stroke of the operating handle the selector is locked by the tooth 152 engaging the rack 84. When then the operating handle is turned forwardly, link 160 is lowered, until pin 156 on arm 154 engages the upper surface of slot 158 which, of course, will happen immediately, if the decimal capacity of the machine is entirely utilized. Then shaft 126 is turned by link 160 in clockwise direction in which rotation bell crank lever 128, 129 secured to said shaft 126 takes part against the action of spring 136 which is correspondingly tensioned. When the operating handle 18 has attained its dead center, abutment 140 of bell crank lever 128, 129 engages shoulder 150 of lever 142 which has been drawn downwardly a slight distance by spring 144, causing said lever 128, 129 to be locked. Link 130 is still in its angularly shifted position, as the selector carriage is locked by tooth 152. At the end of the return stroke the selector carriage is released by tooth 152 and returned by spring 136 into starting position, bell crank lever 128, 129 being again released from engagement with shoulder 150 by lever 142 being lifted by pin 148 against the action of spring 144. The spring 114 which as mentioned above effects the step-by-step movement to the left of the selector carriage, is at its one end fixed to the partition wall 72 at 166 and at its other end to a lug 168 of link 130, said spring 114 being weaker than spring 136 so that it is tensioned upon the return of the selector into starting position under the action of spring 136.

The calculating mechanism

The calculating mechanism C is disposed in the left part of the machine and comprises a plurality of identical units each comprising a pair of gear wheels 170^a, 170^b (see especially Figs. 5, 10 and 11) loosely mounted on a shaft 169 secured to the left side plate 40 of the machine frame and to the partition wall 72, said wheels having each a number of teeth equally divisible by ten. Loosely journalled on the same shaft 169 is a holder 172, one for each unit, and journalled in each of said holders 172 are two gear wheels 174, 176 in engagement with each other. In the machine illustrated which is adapted to be operated by an angular rotation of the operating handle 18 of ⅕ of a revolution, the gear wheels 170^a, 170^b are each provided with fifty teeth, whereas the gear wheels 176, 174 have each ten teeth. The latter have greater width than each of gear wheels 170^a, 170^b and each of them is in permanent engagement with one of the gear wheels 170^a, 170^b, 174 with 170^a and 176 with 170^b. Together with the pair of gear wheels the gear wheels 174, 176 form what may be termed a differential gear. Gear wheel 176 is rigidly connected with another gear wheel 178 engaging a numeral gear wheel 182 provided with a numeral plate 180 and also rotatably journalled in holder 172. The numeral wheels 182 form together the total register. Further holder 172 is provided with a bent arm 184 which upon rotation of holder in a manner to be described is swung, until it strikes any projecting tongue 64 in the selector. Arm 184 is so arranged in relation to tongues 64 of the selector as to pass the unactuated tongues by going through the recesses 68 in same.

Rotatably journalled on shaft 169 is an arm 186 for each unit, said arm carrying at its free end an abutment 188 normally in engagement with a cross bar 190 fixed transversely of the machine. The arm 186 is shown in detail in Fig. 13. Rotatably journalled in said arm about a stud 192 is a pawl 194 provided with two pins 196, 198 so arranged as to engage alternately a tooth space in one or other of gear wheels 170^a, 170^b, when pawl 194 is swung in a manner to be described in the following. At its one end pawl 194 is bifurcated and in the opening of the fork there is a cross bar 200 common to all pawls 194 and carried by two arms 202 (see Fig. 4), one at each side of the machine which arms are pivoted on studs 204 secured to the machine frame. Journalled on the stud 204 at one side of the machine is another arm 206 rigidly connected to arm 202, and at the free end of said latter arm 206 is a roller 208 controlled by a cam disk fixed on main driving shaft 162. The arrangement and construction of said pawl 194 is such that always one of gear wheels 170^a, 170^b is locked to arm 186 and that, when the pawl is shifted in the manner to be described the locked wheel is not released, until the other wheel has been locked, that is the pawl 194, one pin 196 of which engages a tooth space in one of the wheels, for instance 170^a, can not be swung out of engagement with this wheel, until

the other pin 198 has been brought into engagement in a tooth space in the other wheel 170^b.

The calculating mechanism is operated by following means:

Fixed in the upper part of holder 172 is a spring 210, the other end of which is fixed at the one end of an arm 214 pivoted on a stud 212 secured to the machine frame. The upper surface of said arm 214 forms a cam having a recess 220 between two cam surfaces 216, 218. Co-operating with said cam surfaces 216, 218 and said recess 220 is a roller 222 mounted at the free end of an arm 224 fixed on main driving shaft 162. The cam surface 216 has the form of a circular arc having its center coinciding with the center of shaft 162, and, consequently, on rotation of shaft 162 roller 222 will roll upon cam surface 216 without causing any turning of arm 214, until roller 222 falls into recess 220 and strikes the edge of cam surface 218 which latter is so formed that on continued rotation of shaft 162 arm 214 is swung in clockwise direction (see Fig. 5) causing the springs 210 to be further tensioned and thereby tending to rotate holders 172 in opposite direction.

Loosely journalled on shaft 169 at each side of the machine is a bridge 226, said bridges being in the rear part of the machine connected with each other by means of a cross bar 228 resting in the starting position of the machine against all holders 172. Other end of the one bridge 226 is pivotally connected with arm 214 by means of a link 230. On the forward stroke of the operating handle the bridges 226 will, consequently, be turned in counter-clockwise direction, whereby cross bar 228 will be removed from all holders 172 which, actuated by their springs 210, will also be turned in counter clockwise direction, until they are stopped by the actuated selector tongues 64. On the return stroke of the handle cross bar 228 will restore all holders 172 into starting position.

The pawl 194 is controlled by the following means (see especially Figs. 15 to 20). Fixed on main driving shaft 162 is a triangular disk 232. Swingably mounted on studs 234 and 236, respectively, in two corners of said disk 232 are saw-tooth pawls 238 and 240, respectively, said pawls being at their free end connected by a spring 242. The pawls are each provided with a pin designated 244 and 246, respectively, said pins cooperating with a cam disk 248 (see Fig. 17) rotatably journalled on the main driving shaft 162, said cam disk having for the control of the pawls two cams, 250 and 252. The latter cam 252 terminates in an arm 254, connected at its free end with a link 256 which in turn is connected with the subtraction key and the division key 22 and 26, respectively, in a manner to be described. Rotatably mounted on shaft 162 is further a ratchet disk 258 (see Fig. 18) co-operating with the saw-teeth of the pawls 238, 240, said disk being provided with five recesses as the machine is adapted to be operated by an angle of rotation of the operating handle of $\frac{1}{5}$ of a revolution. Rigidly connected with said ratchet disk 258 is a cam disk 260 (see Fig. 19) having also five recesses and co-operating with the above mentioned roller 208 on arm 206. In the position shown in Fig. 5 in which the machine is set for addition or multiplication disk 232 together with pawls 238, 240 will on the forward stroke of the handle 18 be turned in counter-clockwise direction, ratchet disk 258 and cam disk 260 not taking part in this rotation on account of saw-tooth of pawl 240 sliding on ratchet disk 258 and saw-tooth of pawl 238 also doing so, as said pawl, when in the course of the rotation it falls down on ratchet disk 258 by pin 244 leaving cam 250, is not in register with any recess in the ratchet disk 258. When operating handle is in its dead center, pawl 240 has been turned through such an angle that its saw-tooth engages the next recess in ratchet disk 258, and on the return stroke said ratchet disk 258 and, consequently, also cam disk 260 are turned in clockwise direction, the roller 208 riding up on the cam of the disk 260 lying nearest to the left, thereby causing a shifting of pawl 194, so that in Fig. 10 pin 196 is brought out of engagement with gear wheel 170^a and pin 198 into engagement with gear wheel 170^b. When at the end of the return stroke of the operating handle 18 roller 208 engages the next recess of cam disk 260, pawl 194 is again shifted and thus restored into the position which it had at the beginning of the calculating operation.

When subtraction key 22 or division key 26 is depressed, link 256 is drawn downwardly, causing rotation of cam disk 248 in clockwise direction. Then pin 244 leaves cam 250 causing the saw-tooth of pawl 238 to engage a recess in ratchet disk 258. When the operating handle then is rotated, ratchet disk 258 and cam disk 260 will both be turned during the forward stroke of the handle and, consequently, pawl 194 will be shifted. When the handle has reached its dead center pin 246 has ridden up on cam 252 so that the saw-tooth of pawl 240 is brought out of engagement with ratchet disk 258. In this position roller 208 has engaged the next recess in cam disk 260 so that pawl 194 has been restored into original position. During the return stroke of the handle the teeth of both pawls 238, 240 will slide on ratchet disk 258 which, consequently, does not partake in this rotation. As the saw-tooth of pawl 238 is still in engagement with ratchet disk 258, the parts are in their original position, when the rotation of the handle is completed.

In order to permit tens transfer in the calculating mechanism the following means are provided (see especially Figs. 10, 12, 13 and 14). Loosely journalled on shaft 169 at each side of the machine is an arm 262, which arms in their free ends are connected with each other by means of a cross shaft 264. Loosely mounted on said shaft 264 are pawls 266, so called tens transfer pawls, one for each unit of the calculating mechanism. One pawl 266 is shown in detail in Fig. 14. Shaft 264 projects through an elongated slot 268 in each of the side frames 40 and 42 and extends a little distance beyond said frames. Normally resting against the cross shaft 264 is a downwardly extending arm 270 integral with bridge 226. Arm 262 is by means of a spring 272 connected with the machine frame as at 274. Formed at the free end of tens transfer pawl 266 is an opening 276 having two bearing surfaces 278 and 280 arranged at a distance from each other in the peripheral direction of the wheels 170^a, 170^b corresponding to half a pitch. The distance between the two extreme positions of shaft 264 in slot 268 corresponds also to half a pitch. Projecting into opening 276 is a stop 282 formed at the end of the arm 186 and connected by a spring 284 with the fore part of tens transfer pawl 266. The upper edge of pawl 266 is provided with two lugs 286, and gear wheels 170^a, 170^b are each provided

with a pin 288 and 290, respectively, for every tenth tooth. In the present case where these wheels have each fifty teeth there are, consequently, five pins 288 or 290 on each wheel. The tens transfer pawl 266 is arranged in such manner that its lugs 286 normally are located in the path of both said pins 288 and 290 of the pair of gear wheels 170^a, 170^b of the next lower denomination unit, that is each tens transfer pawl 266 controls the position of the arm 186 of the next higher denomination unit. As seen in Fig. 10 in the initial position of the parts, pin 288 on wheel 170^a is located immediately to the left of lug 286 and pin 290 on wheel 170^b immediately to the right thereof.

The embodiment of the machine above described is arranged in such manner that the angular distance between two consecutive tongues 64 in the selector corresponds to one-half pitch and that in the starting position of the machine the arms 184 terminate a distance in front of the first row of tongues 64 corresponding to one-half pitch.

The calculating mechanism operates in the following manner: On rotation of the operating handle 18 in counter-clockwise direction (Figs. 3 and 5), the bridges 226 with the arm 270 and the cross bar 228 are turned, by means of link 230 and arm 214, in counter-clockwise direction and at the same time the springs 210 are further tensioned by the movement of said arm 214, so that all holders 172 will be free to turn in counter-clockwise direction, until their arms 184 are stopped by any projecting tongue 64. One gear wheel, for instance 170^a, is locked by pin 196 (see Fig. 10), whereas the other 170^b is freely movable. However at the beginning of the forward stroke of the operating handle, all differential gears 170^a, 170^b, 174, 176 are turned, through the intermediary of the springs 210 and the holders 172, as unitary bodies, on account of the friction between said gear wheels and no external friction to resist any of them separately, in counter-clockwise direction a distance corresponding to one-half pitch. This distance is determined by the movement of shaft 264 which by means of arms 262 and the spring 272 is drawn to the right one-half pitch (Fig. 10), until it occupies its extreme position to the right in slot 268, resulting in that tens transfer pawl 266, stop 282, arm 186, pawl 194 and, as above described, the differential gears as a whole are turned a corresponding angle in counter-clockwise direction, the stop 188 of arm 186 then being one-half pitch away from cross bar 190 and all arms 184 of the holders 172 being immediately in front of the first tongue 64, that is the tongue corresponding to the value "0". Starting from this position, wheel 170^a is now definitely locked and the actual calculation operation may begin. The said first one-half pitch movement of the enumerated parts is necessary on account of arms 184 standing a corresponding distance in front of the first row of selector tongues 64, and this measure has been taken to give the carriage containing the tongues ample clearance space, when it is moved step by step. As an alternative the initial one-half pitch movement, including arms 262, shaft 264 and slot 268, could be avoided and instead thereof the cross bar 190 be made movable one-half pitch in clockwise direction. This one-half pitch movement of arm 186 is necessary in any case for tens transfer operation, as will be explained later. From the above it will be clear, that said initial one-half pitch movement of all the enumerated parts or of the cross bar 190 alone has no influence on the counter wheels 178, 182, 180 as these will not change their position relatively to the differential gear. The same is the case, when during the return stroke of the handle 18 the same one-half pitch movement is effected to restore the parts to their relative initial position, inasmuch as the holders 172 and the arm 270 then are turned simultaneously in clockwise direction the final one-half pitch movement, so that there will be no relative movement between the wheels of the differential gears.

When now after said initial one-half pitch empty movement, the holders 172 are further turned by their springs 210, until they are stopped by a projecting tongue 64, differential wheel 174 in mesh with gear wheel 170^a rolls on the latter, being locked, and is thereby turned in counter-clockwise direction, said rotation being transferred to the other differential wheel 176, which, consequently, is turned in clockwise direction and in turn rotates the movable wheel 170^b in counter-clockwise direction being in permanent engagement with the latter. On account of the natural action of the differential gear, wheel 170^b will be turned twice as many pitches as the pertaining holder is turned. Considering, for instance, the holder stands still and wheel 174 is turned say two pitches, then wheel 176 and consequently wheel 170^b is also turned two pitches. As however, as in the present case in order to turn wheel 174 two pitches, holder 172 must be turned two pitches, wheel 170^b is not only turned the above stated two pitches but on account of the two pitches movement of the holder 172 two further pitches, that is in all four pitches or twice as much as the holder. The movement of wheel 176 is transferred by gear wheel 178 to numeral wheel 182, which, consequently, will be turned in counter-clockwise direction the same number of pitches as the holder 172. A further rotation of arm 214, after arm 184 having been stopped by the projecting tongue 64, will only cause further tensioning of spring 210. When the handle has reached the end of its forward stroke, numeral wheel 182 has, consequently, been rotated half the number of teeth corresponding to the numeral set up in the selector, depending on the above mentioned relation between the angular distance between the tongues of the selector and the pitch, said rotation having taken place in counter-clockwise direction. Now pawl 194 for all units is shifted in the manner above described, so that gear wheel 170^a is released and gear wheel 170^b locked. During the return stroke of the operating handle, differential wheel 176 in mesh with ear wheel 170^b, now locked, will roll on the latter and is turned in the same direction as before, thus in clockwise direction, causing numeral wheel 182 to be turned in the same direction, that is in counter-clockwise direction, and through the same angle as before, simultaneously as movable wheel 170^a will be turned in clockwise direction twice the number of pitches as holder 172 by means of differential wheel 174, that is in opposite direction to that of wheel 170^b during the forward stroke of the operating handle. At the end of the return stroke of the handle 18 arm 270 returns shaft 264 back to its original position to the left in slot 286 against the action of spring 272 causing arm 186 to be brought into engagement with cross bar 190 and the differential gears as unities to be turned through an angle in clockwise direction corresponding to one-half pitch. When the operating

handle 18 has reached its starting position, gear wheels 170[a], 170[b] have, consequently, been turned through the same angles but in opposite directions, and numeral wheel 182 has been turned through an angle corresponding to the number of teeth represented by the numeral set up in the selector.

If from the beginning for instance for effecting subtraction operations gear wheel 170[b] is locked and gear wheel 170[a] is movable the directions of movement will, of course, be reversed.

When a tens transfer is to take place, lug 286 of tens transfer pawl 266 is actuated by a pin 288 or 290 of that one of gear wheels which is not locked. On account of the working action of the differential gear the tens transfer is divided into two separate movements in a similar manner as the normal calculating operation is effected, the first half of the tens transfer operation taking place during the forward stroke of the operating handle 18 and the other half during the return stroke, as will be explained later by way of an example. By said engagement of the lug 286 by the pin 288 or 290 tens transfer pawl 266 is pressed downwardly, so that stop 282 on arm 186 which initially has been in engagement with bearing surface 278 of pawl 266 is now brought into engagement with bearing surface 280 causing movement of arm 186 through one-half pitch in clockwise direction. Thereby pawl 194 of unit of the next higher denomination is moved through a corresponding angle carrying with it the locked wheel in said unit which, consequently, is turned through the same angle, that is one-half pitch. If it is assumed that a tens transfer is to take place in the case described above in detail, in which gear wheel 170[a] was first locked, said wheel will, consequently, be turned one-half pitch in clockwise direction causing rotation of differential wheel 174 in mesh with wheel 170[a] in counter-clockwise direction also one-half pitch, said rotation being transferred to numeral wheel 182 which will be turned through one-half pitch in counter-clockwise direction, that is to say in the proper direction. The remaining one-half pitch rotation of numeral wheel 182 is effected at the end of the return stroke of the operating handle 18, when wheel 170[b] is locked and wheel 170[a] is movable and cross shaft 264 is moved by arm 270 into its extreme left position in slot 268, because arm 186 has, as above stated, been brought into engagement with cross bar 190, when it was turned one-half pitch in clockwise direction during the forward stroke of the handle, so that, when arm 270 strikes shaft 264, stop 282 will be brought back into engagement with bearing surface 278, and during the final one-half pitch rotation of holder 172, until it is locked by cross bar 228, locked wheel 170[b] is standing still, while through the intermediary of holder 172 and wheels 174, 176, the free wheel 170[a] is turned the final one-half pitch movement which is transferred to numeral wheel 182, so that this is turned the remaining one-half pitch. For those units in which a tens transfer takes place arm 186 will, consequently, after the initial one-half pitch has been transferred to numeral wheel, bear against cross bar 190, and the movement of arm 184 from the starting position to the first row of selector tongues and back from said row to the starting position will be positively transferred to numeral wheel 182, whereas for all those units in which no tens transfer takes place said movement of arm 184 is compensated by the movement of arm 186, which latter is located, at the end of the return stroke of the operating handle, still a distance in front of cross bar 190 corresponding to one-half pitch.

As seen tens transfer pawl 266 is returned into normal position first at the end of the return stroke, so that pin 288 or 290 of the gear wheel 170[a], 170[b] released during said return stroke can freely pass above lug 286.

A calculating operation will now be explained by way of an example. Starting from the initial position as illustrated in Fig. 10, the value "3" is to be entered in additive direction, and supposing that in this case during the forward stroke of the handle 18 pin 196 is in engagement with wheel 170[a], the initial one-half pitch movement brings the shaft 264 into its extreme right hand position in slot 268, all arms 186 one-half pitch distance away from cross bar 190 and all arms 184 immediately in front of the first selector tongues 64, all wheels of the differential gear not having been moved relatively to each other. On the continued rotation of holder 172 in counter-clockwise direction wheel 170[a] is stationary, while wheel 170[b] through the intermediary of the differential wheels 174 and 176 is moved three pitches in counter-clockwise direction, in which position the arm 184 is bearing against the selector tongue 64, representing the value 3. On the return stroke of holder 172 pin 198 engages wheel 170[b], so that this wheel is stationary, while wheel 170[a] is turned three pitches in clockwise direction. The pin 290 on wheel 170[b] is now standing three pitches to the right of lug 286 and the pin 288 on the wheel 170[a] is standing three pitches to the left of the lug 286. The numeral plate 180 has been rotated three steps in additive direction. Supposing now that the value 8 is to be added. During the forward stroke of holder 172 wheel 170[b] will be moved as before in counter-clockwise direction eight pitches. When the pin 290' on the wheel 170[b] reaches the lug 286, that is between the sixth and seventh step of wheel 170[b], pawl 266 is pressed down, so that stop 282 on arm 186 is drawn by spring 284 against shoulder 280 in the recess 276 of the pawl 266, which results in arm 186 moving one-half pitch in clockwise direction, the pin 196 carrying forward the wheel 170[a] of the next higher order also one-half pitch in clockwise direction, with the result that the numeral plate 180 in the corresponding unit will be moved one-half pitch in counter-clockwise direction, that is in the proper direction. During the return stroke of holder 172 pin 288' on wheel 170[a] will pass over lug 286, as pawl 266 is still in its pressed down position. At the end of the return stroke of holder 172 all parts of the differential gear excepting the locked wheel 170[b] which is prevented to move on account of the fact that arm 186 is abutting cross bar 190, will be turned one-half pitch in clockwise direction with the result that the wheel 170[a], now unlocked, moves one-half pitch in clockwise direction relatively to wheel 170[b], now locked, and therefore the numeral plate will be turned the remaining one-half pitch in counter-clockwise direction.

The quotient register

The quotient register which also may be termed the handle stroke counter denotes in addition and subtraction the number of items, while in division it develops the quotient and in multipli-

cation the multiplier, as the operations proceed. This register is disposed to the right of and transversely in line with the total register and in front of the selector. In the embodiment shown this register is constructed as follows (see Figs. 21 to 24 inclusive).

Fixed between the right side frame 42 and the partition wall 72 are two plates 300 and 302 between which the quotient register is arranged. Placed between said plates 300 and 302 are a plurality of partition plates 304 and one unit of the quotient register is arranged in each of the spaces thus formed. The quotient register units comprise each a numeral wheel 306 with a numeral disk 308 attached thereto, a gear wheel 310 meshing with said numeral wheel 306, two pawls 312 and 313, a double armed lever 314 in which said pawls are journalled and a tens transfer pawl 316. The numeral wheels 306 are loosely journalled on a shaft 318 secured to the partition wall 72 and the side frame 42, and the gear wheels 310 are mounted in similar manner on another shaft 320 also fixed to said wall and frame. Pawls 312 and 313 are each rockably mounted on a stud 322 and 324, respectively, secured to corresponding partition plate 304, said studs being placed on each side of the center of rotation of lever 314. Lever 314 is journalled on a shaft 326 secured to side frame 42 and partition wall 72, and one arm thereof is connected with corresponding partition plate 304 by a spring 328, whereas its other arm is shaped as a claw. One lip 330 of the claw forms a bearing surface for a cross bar 349 to be described in the following, whereas the other lip 332 is provided with a stop 334 normally co-operating with a bearing surface 336 on tens transfer pawl 316. The latter is rockably mounted on a shaft 338 secured to partition wall 72 and side frame 42 and has besides the bearing surface 336 another bearing surface 340 co-operating with stop 334 in another position of pawl 316, as well as a recess provided with a bearing surface 342 and a cut-out 344 for the purpose described in the following. Further tens transfer pawl 316 is rigidly connected with an arm 345 carrying a tooth adapted to co-operate with a cog 347 on the gear wheel 310 of the next lower denomination unit. Pawls 312 and 313 are each actuated by a spring 346 and 348, respectively, fixed to corresponding lever 314.

The quotient register is controlled by a bell crank lever 350, 352 journalled on shaft 326, a link 356 rockably mounted on a stud 358, a bridge 360 at each side of the register swingably mounted on a cross shaft 358 fixed in frame 42 and wall 72, said bridges 360 being connected by a cross bar 372, and another bridge 362 at each side of the register journalled on shaft 338, said latter bridges being connected with each other by means of a cross bar 364. Link 356 is pivotally connected with bridge 360 by means of a link 366 pivotally secured to bridge 360 at 368 and to link 356 at 370. Pawl 312 is adapted to co-operate with numeral wheel 306 and is bifurcated at its end. Projecting through the opening of the fork is the cross bar 372 which is common to all pawls 312. The pawl 313 is adapted to co-operate with the gear wheel 310 and is U-shaped at its lower end. Projecting through the opening of the U is a cross bar 374 common to all pawls 313 and secured to link 356. One arm 352 of lever 350, 352 is by means of a link 376 connected to bridge 362, said link being at its upper end provided with an elongated slot 378 in engagement with a pin 380 on bridge 362. Further, lever arm 352 is connected with said bridge by means of a spring 382 and at its end provided with a cross bar 349 engaging the bearing surface 332 of lever 314.

The quotient register is controlled decimally by the selector by following means:

Swingably mounted in the machine frame (see especially Figs. 7 and 21) at 382 and 384, respectively, on each side of the calculating mechanism are two links 386, 388 and pivoted to said links at 390 and 392, respectively, is a rod 394 provided with an elongated slot 396 in engagement with a pin 398 on another rod 400 extending along the quotient register and provided at its right hand end with an extension forming a die 404. Extending along the rod 400 is a toothed bar or rack 406 arranged in such manner that pin 398 engages a toothed space in said rack, when rod 394 is raised in a manner to be described in the following. Rack 406 is rigidly connected with the selector carriages in any suitable manner and provided at its left end with a downwardly projecting stop 402.

In the starting position of the selector die 404 lies in the first unit to the right of the quotient register in which it engages the cut-out 344 in tens transfer pawl 316. When the selector is advanced step by step to the left on setting up a number in same, die 404 remains in said unit of the register. When, however, in the manner described below, the rod 394 is raised by means of the parallel movement means formed by links 386 and 388, pin 398 engages a tooth space in rack 406 causing rod 400 to be locked to the selector carriage, so that, consequently, said rod 400 takes part in the step-by-step movement of said carriage, the pin 398 sliding in slot 396 in rod 394. Stop 402 of rack 406 serves to restore rod 400 into starting position, when rod 394 assumes its lowered position.

Lever arm 350 and link 356 co-operate with a controlling device on main driving shaft 162 of the same type as that of the calculating mechanism (see especially Figs. 15 to 20 inclusive). As these devices are identical it is thought to be unnecessary to describe both in detail. It should be observed, however, that in the controlling device of the calculating mechanism pawls 238 and 240 correspond here to pawls 408 and 410, cam disk 248 to cam disk 412, arm 254 to arm 414, link 256 to link 416, ratchet disk 258 to ratchet disk 418 and cam disk 260 to cam disk 420. Secured to main driving shaft 162 is further a cam disk 422 shown in Fig. 20 and having only one cam which in the starting position of the machine engages lever arm 350 which latter is pressed against the cam by means of a spring 426 fixed to the machine frame at 424. Link 356 carries a roller 428 engaging cam disk 420 against which the link is pressed by a spring 432 secured to the machine frame at 430.

The quotient register operates in the following manner, it being assumed that the die 404 lies in the unit of the register which is shown in the drawings. On the forward stroke of the operating handle arm 350 is turned in counter-clockwise direction, so that arm 352 is lifted. All levers 314 in the different units which have before been locked by cross bar 349 are thereby permitted to turn in counter-clockwise direction under the action of springs 328. All these levers are, however, also locked by stop 334 on the levers 314 abutting against bearing surface 336 of tens transfer pawl 316. In the unit of the register containing die 404 lever arm 352 can swing upwardly, as tens transfer pawl 316 is swung in

counter-clockwise direction, said pawl being by die 404 locked to cross bar 364 and, thus, to bridge 362 which takes part in this swinging movement about shaft 338, until stop 334 instead of bearing surface 336 engages bearing surface 340. This small swinging movement is permitted by the deflection of rod 400, as said rod is journalled only by pin 398 and die 404 is placed at the other end of said rod. In all other units the upward swinging of lever arm 352 only causes a swinging of bridge 362, as there is nothing that prevents cross bar 364 from swinging, pin 380 of bridge 362 thereby sliding in slot 378 of link 376 tensioning spring 382. The tens transfer pawl 316 remains unactuated and lever 314 can not move on account of the engagement of stop 334 by bearing surface 336.

On the contrary in the unit containing die 404 the swinging movement of lever 350, 352 causes a swinging of lever 314, until, as stated above, stop 334 engages bearing surface 340. Thereby pawl 312 is moved downwardly through a certain distance causing numeral wheel 306 to be turned in counter-clockwise direction, the arrangement being such that this rotation of the numeral wheel 306 corresponds to half a pitch. As described above in connection with the description of the controlling device of the calculating mechanism, cam disk 420 controlling link 356 is not actuated on the forward stroke of the operating handle, when the machine is set for addition or multiplication as is the case in the position shown in Fig. 22, such rotation, however, taking place on the return stroke of the handle, link 356 thereby swinging in counter-clockwise direction. This swinging of link 356 causes first disengagement of pawl 312 with numeral wheel 306, as by the connection of link 356 with bridge 360 by means of connecting link 366 said bridge is swung in clockwise direction, rod 372 pressing pawl 312 out of engagement with numeral wheel 306. At the same time pawl 313 is forced into engagement with gear wheel 310 on account of the engagement of said pawl with link 356 by means of cross bar 374, causing the gear wheel 310 to be moved through an angle in clockwise direction corresponding to half a pitch, said rotation being transferred to numeral wheel 306 which is, consequently, turned through a corresponding angle in the same direction as before, that is to say counter-clockwise direction. Consequently, numeral wheel 306 has been turned through one step in all. When roller 428 engages the next recess in cam disk 420 and lever arm 350 rides up on cam 422, pawls 312 and 313 are restored to normal, cross bar 349 pressing lever 314 back, returning stop 334 into engagement with bearing surface 336 of tens transfer pawl 316 which in turn is swung in corresponding direction by means of bridge 362 and spring 382. Now all parts are restored into starting position.

If cam disk 412 is shifted by means of link 416 numeral wheel 306 is on actuation of the handle rotated in opposite direction, the first half step being effected by pawl 313 engaging gear wheel 310 during the forward stroke of the operating handle and the second half step by pawl 312 engaging numeral wheel 306 during the return stroke of the handle.

It is evident that by moving die 404 into another unit of the register the registration may be executed in any denomination, this being of importance in multiplication and division.

As said above tens transfer pawl 316 is provided with an arm 345 having a tooth co-operating with a cog 347 on the gear wheel 310 of the next lower denomination unit. When a tens transfer is to take place, cog 347 on this wheel strikes arm 345, so that tens transfer pawl 316 of the next higher denomination unit is swung, disengaging lever 314 and causing a rotation of corresponding numeral wheel 306 one step in the manner described above.

The control keys

The character of operation of the calculating mechanism is determined by a plurality of control or shift keys.

In subtraction the caluculating mechanism should evidently subtract and also the quotient register. For this reason the subtraction key lever 440 must be connected with the link 256 of the controlling device of the calculating mechanism as well as with the link 416 of the corresponding device of the quotient register. In division the calculating mechanism should subtract, whereas the quotient register should add, and consequently, the division key lever 442 is only connected with the first of said levers 256. In order to prevent depression of one of the subtraction or division keys 22 and 26 on operation of the other the following means are provided. The subtraction key lever 440 is rigidly connected with the link 416 by means of a bolt 444 (see Figs. 15 and 22). At the end of the division key lever 442 is a longitudinal slot 446 in engagement with a pin 448 fixed to link 256 (see especially Fig. 5). Further said link 256 is at its lower end provided with a bent portion 450 catching under the subtraction key lever 440. Thus, on depression of the subtraction key 22 link 416 is lowered and by means of bent portion 450 also link 256, but the division key 26 maintains its raised position, pin 448 sliding in slot 446 in said key, whereas on depression of the division key 26 only link 256 is lowered.

In division and multiplication the number set up in the selector must evidently remain therein on actuation of the operating handle, and, consequently, the selector carriage must remain standing in its leftward advanced position, no matter how many times the handle 18 is actuated, in order to repeatedly introduce the same item in the calculation. To this end the following means are provided.

The division key lever 442 is rigidly connected with an ascending link 452 (see especially Fig. 7) provided at its upper end with an elongated slot 454 in which engages a pin 456 at the free end of a lever 458 pivotally journalled in a bracket 460 secured to partition wall 72. Journalled on the same shaft and rigidly connected with said lever 458 is an arm 462 carrying at its free end a pin 464 adapted to co-operate with stop 146 at the end of lever 142 of the selector zeroizing means above referred to. On depression of the division key 26 said lever 142 is swung in counter-clockwise direction in Fig. 7 against the action of spring 144 causing shoulder 150 to be permanently brought out of contact with stop 140 of bell crank lever 128, 129, independent of pin 148 on link 130. Consequently, on moving the handle, lever 128, 129 will never be locked but can swing freely to and fro so that the selector carriage remains in its advanced position and is not returned home.

In multiplication this operation is effected in the following manner. The multiplication key lever 466 (see especially Fig. 7) is journalled in any suitable manner intermediate its ends about a stud 468 and is at its rear end rigidly connected with an ascending link 470 provided at its upper

end with an elongated slot 472 in engagement with stud 390 on rod 394 of the quotient register tabulating means above referred to. Pivotally mounted on stud 384 and rigidly connected with link 388 is an arm 474 pivotally connected at its free end with a link 476 engaging at 478 lever 458 above referred to. On depression of the multiplication key 24 rod 394 is lifted causing arm 462 to be swung in counter-clockwise direction by means of arm 474, link 476 and lever 458, thereby bringing bell crank lever 128, 129 permanently out of contact with lever 142 as above described.

On account of the slots in links 452 and 470 a depression of one of the multiplication and division keys 24 and 26 has no influence on the other.

In order that in multiplication and division a shifting of the selector shall be followed by a corresponding shifting of the quotient register die 404 controlling the decimal setting of said register is locked to the selector carriage by being brought into engagement with rack 406 on raising rod 394 on depression of the multiplication key 24 or the division key 26.

When the total register is to be cleared the tens transfer means must evidently be set out of function. This is effected on depressing the zeroizing key 32 by the following means. The zeroizing key lever 480 is at its rear end at 482 pivotally connected with a link 484 (see Figure 5) which in turn is at 486 pivotally connected with a bell crank lever 488 pivoted on the machine frame as at 490. The latter is at its other end connected with a cross bar 492 extending transversely of the machine and adapted to co-operate with a bearing surface 494 on all tens transfer pawls 266. On depression of the zeroizing key 32 cross bar 492 will evidently engage tens transfer pawls 266 and lock same so that on actuation of the handle gear wheels 170^a, 170^b will be stopped by the pins 288 or 290 of said wheels striking the shoulder 286 on the pawls 266 causing numeral wheels 182 of the total register to be zeroized.

The back space key lever 496 (see Figure 6) is at 498 pivotally connected with a bell crank lever 500 rockably journalled in the machine frame at 502. At its other end said lever engages one end of link 86 carrying pawl 88 of the selector escapement mechanism above referred to. Formed in said link 86 is an elongated slot 504 in engagement with a pin 506 formed on a suitable bracket 508 secured to the partition wall 72 (see especially Fig. 6). On depression of the back space key 30, the toggle lever formed by link 86 and bell crank lever 500 is stretched out causing pawl 88 to be brought into and pawl 108 out of engagement with rack 84 which is moved to the right a distance corresponding to little more than one pitch of the rack. On the following release of the key 30 by the finger, pawl 108 engages the next tooth space of rack 84 and locks the selector carriage in a position one step further to the right.

The modified embodiment of the calculating mechanism shown in Fig. 26 differs from that shown in Figs. 3 to 25 inclusive in the following respects.

The tens transfer pawl 266 and the shifting pawl 194 are arranged in reversed position to that in the previous embodiment.

The holders 172 are not directly operated from the main driving shaft 162 but only indirectly by means of the bridge 226 and the shifting pawl 194.

The tens transfer pawl 266 is journalled in an arm 520 loosely journalled on shaft 169 and provided in its outer upper peripheral part with an opening 522 and at its lower peripheral end with a stop 524 resting normally against a cross bar 526 secured to the machine frame transversely of the machine. The bridge 226 is also provided with an opening 528 in line with the opening 522. Projecting through said openings 522 and 528 is a bar 530 slidably mounted in a curved slot 632 in a guiding member 534 on each side of the machine. The stop 188 of the arm 186 bears against the bar 530. The size of the opening 522 is so adapted that the movement of the bar 530 in this opening in the peripheral direction of the wheels 170^a, 170^b corresponds to half a pitch. The guiding members 534 are each rockably mounted on the side plate 40 and the partition wall 42, respectively, by means of two links 536 and 538 and provided with a lug 540 connected with a link 544 having a roller 546. Link 544 and roller 546 correspond to link 206 and roller 208 in the former embodiment.

Further a stop bar 542 is provided against which the holders 172 rest in normal position of the machine.

The controlling device of the mechanism is the same as in the previous embodiment.

The operation is as follows. On the forward stroke of the operating handle the bridge 226 is turned in counter-clockwise direction carrying with it by means of one of the pins 196 or 198 wheels 170^a, 170^b, arm 520 with tens transfer pawl 266, arm 186 with shifting pawl 194 as well as holder 172 with differential wheels 174, 176 and numeral wheel 182. Nothing occurs, until arm 184 of the holder strikes a projected tongue 64 in the selector. Then the first part of a calculating operation begins. The movement of holder 172 with the differential gearing ceases, whereas bridge 226 with tens transfer pawl 266 and as well as arm 186 with shifting pawl 194 continue their rotation. As one of wheels 170^a, 170^b is locked by shifting pawl 194, the differential wheel 174 or 176 in mesh with said wheel rolls on the locked wheel, causing numeral wheel 182 to be turned through an angle corresponding to half the number of teeth represented by the key depressed. During the return stroke of the machine, the other wheel 170^a or 170^b is locked by shifting pawl 194 so that the numeral wheel 182 is rotated in the same direction as before as described with reference to the previous embodiment. The rotation ceases, when bar 228 strikes arm 184, whereafter the holder 226 takes part in the rotation and, consequently, no rotation is transferred to numeral wheel 182. During the return stroke, said wheel 182 has, thus, been rotated through the second half of the number of teeth represented by the actuated tongue. All the arms 184 are returned to normal by bar 228 in which position they bear against rod stop bar 542.

The tens transfer takes place in the same manner as in the former embodiment, it being observed, however, that the opening 522 in arm 520 can be said to correspond to the elongated slot 268 in the side plates 40, 42 in the former embodiment.

It is clear from the preceding description that the principle on which the invention is based can be utilized in a plurality of ways. The differential gearing formed in the first embodiment of the wheels 13, 15, 21 and 23 and in the second and third embodiments of the wheels 170^a, 170^b, 174 and 176 may be replaced by a differential gearing in which the two main calculating members consist of two bevel gears meshing with

another bevel gear journalled in the differential holder. Further it is not necessary that the two main calculating members have the same diameter, they may also have different diameters in which case, however, transfer members must be used rendering the movements of the two members equal. One of the differential gear wheels may serve as numeral wheel.

The essential feature of the invention is the differential gearing permitting permanent engagement of all gear wheels resulting in a great simplicity and reliability.

What we claim as new and desire to secure by Letters Patent of the United States of America is:—

1. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members and a result member, said calculating members operating continuously in the same direction for the same mode of calculation, and means to transfer a relative movement between said calculating members to said result member.

2. In a calculating machine, a selector, a calculating mechanism controlled by said selector and comprising a plurality of units each comprising two movable calculating members and a result member, said calculating members operating continuously in the same direction for the same mode of calculation, and means to transfer a numeral set up in said selector to said result member by means of a relative movement between said calculating members.

3. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members and a result member, said calculating members operating continuously in the same direction for the same mode of calculation, and means to transfer a relative movement between said calculating members to said result member, said calculating members forming alternately support or reaction base for said relative movement.

4. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, said calculating members operating continuously in the same direction for the same mode of calculation, a result member and additional means cooperating with said calculating members to form a differential gearing adapted to transfer to the result member a relative movement between said calculating members.

5. In a calculating machine, a selector, a calculating mechanism controlled by said selector and comprising a plurality of units each comprising two movable calculating members, said calculating members operating continuously in the same direction for the same mode of calculation, a result member and additional means cooperating with said calculating members to form a differential gearing adapted to transfer a numeral set up in said selector to said result member by means of a relative movement between said calculating members.

6. In a calculating machine, a selector, a calculating mechanism controlled by said selector and comprising a plurality of units each comprising two movable calculating members, said calculating members operating continuously in the same direction for the same mode of calculation, a result member and additional means cooperating with said calculating members to form a differential gearing, said selector determining a relative movement between said calculating members and said differential gearing being adapted to transfer said relative movement to said result member.

7. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, a result member and means to lock said calculating members, said calculating members operating continuously in the same direction for the same mode of calculation, and means to transfer a relative movement between said calculating members to said result member, said relative movement taking place when one of the calculating members is locked by said locking means.

8. In a calculating machine, a reciprocating main driving shaft, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, a result member and means to lock said calculating members, said locking means being controlled by said main driving shaft so as to lock the one calculating member during the forward stroke of said shaft and the other during the backward stroke of same, and means to transfer to said result member a relative movement between said calculating members.

9. In a calculating machine, a reciprocating main driving shaft, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, a result member, an arm and means on said arm to lock said calculating members, said means being controlled by said driving shaft so as to fix the position of said calculating members in relation to said arm, and means to transfer a relative movement between said calculating members to said result member.

10. In a calculating machine, numeral keys, a selector controlled by said keys, a calculating mechanism controlled by said selector and comprising a plurality of units each comprising two movable calculating members and a result member, said calculating members operating continuously in the same direction for the same mode of calculation, means to transfer a numeral set up in said selector to said result member by means of a relative movement between said calculating members, a casing provided with an opening so disposed in relation to said selector that the numeral set up in same is visible for the operator.

11. In a calculating machine, numeral keys, a selector comprising elements controlled by said keys and provided with figures, a calculating mechanism controlled by said selector and comprising a plurality of units each comprising two movable calculating members and a result member, said calculating members operating continuously in the same direction for the same mode of calculation, means to transfer a relative movement between said members to said result member, a casing provided with an opening so disposed in relation to said selector that the figure of an element actuated by a key is visible for the operator.

12. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, said calculating members operating continuously in the same direction for the same mode of calculation, a result member, means to lock said calculating members and tens transfer means controlled by said calculating members and controlling in turn the locking means of the next higher denomination unit, and means to trans-

fer a relative movement between said calculating members to said result member.

13. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, said calculating members operating continuously in the same direction for the same mode of calculation, a result member, an arm, means on said arm to lock said calculating members and tens transfer means controlled by said calculating members and controlling in turn said arm of the next higher denomination unit, and means to transfer a relative movement between said calculating members to said result member.

14. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, a result member, an arm and a tens transfer element controlled by said calculating members, a spring connecting said element with said arm of the next higher denomination unit, and means to transfer a relative movement between said calculating members to said result member.

15. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members each provided with an abutment, a result member, a tens transfer element co-operating with said abutments of the calculating members, said tens transfer element controlling the calculating members of the next higher denomination unit, and means to transfer a relative movement between said calculating members to said result member.

16. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members each provided with an abutment, a result member, an arm, a tens transfer element adapted to co-operate with said abutments of the calculating members and a spring connecting said tens transfer element with said arm of the next higher denomination unit so as to displace said arm from one position to another on engagement of said element with one of said abutments, and means to transfer a relative movement between said calculating members to said result member.

17. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, said calculating members operating continuously in the same direction for the same mode of calculation, a result member and tens transfer means controlled by said calculating members and controlling in turn the calculating members of the next higher denomination unit so as to move on tens transfer the result member of said last-mentioned unit in two stages, and means to transfer a relative movement between said calculating members to the result member of the same unit.

18. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, a result member, an arm carrying means to lock said calculating members and tens transfer means controlled by said calculating members and controlling in turn the arm of the next higher denomination unit so as to displace on tens transfer said arm in two stages in opposite directions, and means to transfer a relative movement between said calculating members to said result member.

19. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two rotatable calculating gear wheels and a rotatable numeral gear wheel, and means to transfer a relative rotation between said calculating gear wheels to said numeral wheel.

20. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two rotatable calculating gear wheels, a rotatable numeral gear wheel, and an additional gear wheel, said additional gear wheel forming together with said calculating gear wheels a differential gearing adapted to transfer to said numeral wheel a relative rotation between said calculating wheels.

21. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two rotatable calculating gear wheels and a rotatable numeral gear wheel, and means to transfer a relative rotation between said calculating wheels to said numeral wheel, said calculating wheels serving alternately as support or reaction base for said relative rotation.

22. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two rotatable calculating gear wheels, a rotatable numeral gear wheel, a swingable holder and an additional gear wheel journalled in said holder and in mesh with said calculating gear wheels, and means to transfer a relative rotation between said calculating wheels to said numeral wheel.

23. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two rotatable calculating gear wheels, a swingable holder, a rotatable numeral gear and an additional gear wheel both journalled in said holder, said additional gear wheel forming with said calculating wheel a differential gearing adapted to transfer to said numeral wheel a relative rotation between said calculating wheels.

24. In a calculating machine, a calculating mechanism comprising a shaft and a plurality of units loosely journalled on said shaft and comprising each two calculating gear wheels, a numeral gear wheel and means to transfer to said numeral wheel a relative rotation between said calculating wheels.

25. In a calculating machine, a calculating mechanism comprising a shaft and a plurality of units loosely journalled on said shaft and comprising each two calculating gear wheels, a swingable holder, a numeral gear wheel and an additional gear wheel both journalled in said holder, said additional gear wheel and said calculating gear wheels forming together a differential gearing adapted to transfer to said numeral wheel a relative movement between said calculating wheels.

26. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members and a result member, a selector adapted to control said calculating mechanism and means to transfer a relative movement between said calculating members to said result member two times during each calculation.

27. A calculating machine comprising a selector, a calculating mechanism controlled by said selector and comprising a plurality of units each comprising two calculating members and a result member, said calculating members operating continuously in the same direction for the same mode of calculation, means to transfer a relative movement between said calculating members to said result member and a handle stroke counter controlled decimally by said selector

and digitally by the number of handle strokes.

28. In a calculating machine, a reciprocating main driving shaft, a handle stroke counter comprising a plurality of units each comprising a numeral gear wheel, an additional gear wheel in mesh with said numeral gear wheel, a swingable lever, two pawls journalled on said lever and each controlling one of said wheels, tens transfer means controlled by said wheels of the next lower denomination unit, and means controlled by said shaft to operate said lever so as to move said numeral wheel a half step during the forward stroke of said shaft and a half step during the return stroke of said shaft.

29. In a calculating machine, a selector, a reciprocating main driving shaft, a handle stroke counter comprising a plurality of units each comprising a numeral gear wheel, an additional gear wheel in mesh with said numeral wheel, two pawls each controlling one of said wheels and an element controlled by said selector, and means controlled by said shaft to operate said pawls, said means being controlled by said element so as to operate the pawls, only when said element is operated by said selector.

30. In a calculating machine, a selector, a reciprocating main driving shaft, a handle stroke counter comprising a plurality of units each comprising a numeral gear wheel, an additional gear wheel in mesh with said numeral gear wheel, a swingable lever, two pawls journalled on said lever and each controlling one of said wheels and an element controlled by said selector, and means including a cam disk on said shaft to operate said lever, said means being controlled by said element so as to operate said lever, when said element is operated by said selector.

31. In a calculating machine, a selector, a reciprocating main driving shaft, a handle stroke counter comprising a plurality of units each comprising a movable result member and an element controlled by said selector, and means controlled by said shaft for operating said result member, said means being controlled by said element so as to operate said result member, only when said element is locked to said means by the selector.

32. In a calculating machine, a selector, a reciprocating main driving shaft, a handle stroke counter comprising a plurality of units each comprising a movable result member and a rockable element, means including a swingable member and controlled by said shaft to operate said result member, means controlled by the selector to lock said rockable element to said swingable member, said result member operating means being capable to operate said result member, when said rockable element is locked to said swingable member.

33. In a calculating machine, a selector, a reciprocating main driving shaft, a handle stroke counter comprising a plurality of units each comprising a movable result member and a tens transfer element controlled by the result member of the next lower denomination unit, means including a swingable member and controlled by said shaft to operate said result member, means controlled by said selector to lock said tens transfer element to said swingable member, said result member operating means being capable to operate said result member, when said tens transfer element is locked to said swingable member or when said tens transfer element is actuated by the result member of the next lower denomination unit.

34. In a calculating machine, a movable selector, a reciprocating main driving shaft, a handle stroke counter comprising a plurality of units each comprising a movable result member and a rockable element, means including a swingable member and controlled by said shaft to operate said result member, a locking member for locking said rockable element to said swingable member, means to lock said locking member to said selector, said result member operating means being capable of operating said result member, when said rockable element is locked to said swingable member.

35. In a calculating machine, a control key, a movable selector, a reciprocating main driving shaft, a handle stroke counter comprising a plurality of units each comprising a movable result member and a rockable element, means including a swingable member and controlled by said shaft for operating said result member, a locking member for locking said rockable element to said swingable member, means controlled by said control key to lock said locking member to said selector, said result member operating means being capable of operating said result member, only when said rockable element is locked to said swingable member.

36. In a calculating machine, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, a result member and means to lock said calculating members, means to transfer a relative movement between said calculating members to said result member and means to shift said locking means.

37. In a calculating machine having a control key, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, a result member and means to lock the one or other of said calculating members, means to transfer a relative movement between said calculating members to said result member and means controlled by said control key to shift said locking means from the one calculating member to the other.

38. In a calculating machine having a control key, a calculating mechanism comprising a plurality of units each comprising two movable calculating members, said calculating members operating continuously in the same direction for the same mode of calculation, a result member and tens transfer means, means to transfer a relative movement between said calculating members to said result member, and means controlled by said key to lock said tens transfer means.

39. In a calculating machine, a movable selector, a calculating mechanism comprising a plurality of units each comprising two movable calculating members and a result member, means to transfer a relative movement between said calculating members to said result member, and means to lock said selector in set position to control the movement of said calculating members.

40. A calculating machine comprising a movable selector, a calculating mechanism controlled by said selector and comprising a plurality of units each comprising two movable calculating members and a result member, means to transfer to said result member a relative movement between said calculating members determined by said selector, a handle stroke counter controlled decimally by said selector and comprising a plurality of units each comprising a

movable result member, a reciprocating main driving shaft and means controlled by said shaft to move said result member a half step during the forward stroke of said shaft and a half step during the return stroke of said shaft.

41. In a calculating machine having a control key, a calculating mechanism comprising a plurality of units each comprising a numeral gear wheel, two rotatable calculating gear wheels having a number of teeth equally divisible by ten and an abutment for every tenth tooth and a tens transfer element operated by the abutments of said calculating wheels, said calculating members operating continuously in the same direction for the same mode of calculation, means to transfer a relative movement between said calculating wheels to said numeral wheel and means controlled by said key to lock said tens transfer element so that it cannot be operated by said abutments.

42. In a calculating machine, numeral keys, a movable selector comprising rows of selector elements adapted to be projected on depression of said keys, movable means to positively return said elements into starting position on the return of the selector, a calculating mechanism comprising a plurality of units each comprising two movable calculating members and a result member, said calculating members operating continuously in the same direction for the same mode of calculation, and means to transfer to said result member a relative movement between said calculating members the extent of said movement being controlled by said selector elements.

43. In a calculating machine, numeral keys, a movable selector comprising rows of selector elements, a calculating mechanism comprising a plurality of units each comprising two movable calculating gear wheels, a numeral gear wheel, a swingable holder having an arm and an additional gear wheel journalled on said holder, means controlled by said keys to move said selector elements into the path of the arm of said swingable holder, said additional gear wheel and said calculating gear wheels forming together a differential gearing adapted to transfer a numeral set up in said selector to said numeral wheel by means of a relative movement between said calculating wheels.

44. In a calculating machine, numeral keys, a movable selector comprising rows of selector elements, a calculating mechanism comprising a plurality of units each comprising two movable calculating gear wheels, said calculating members operating continuously in the same direction for the same mode of calculation, a swingable holder having an arm, a numeral gear wheel and an additional gear wheel both mounted on said holder, means to move said selector elements into the path of the arm of said swingable holder, said additional gear wheel and said calculating gear wheels forming together a differential gearing adapted to transfer a numeral set up in said selector to said numeral gear wheel by means of a relative movement between said calculating gear wheels.

45. In a calculating machine, a selector, a reciprocating main driving shaft, a handle stroke counter comprising a plurality of units each comprising a result member, a lever, means journalled on said lever to operate said result members and a rockable element controlled by said selector and normally locking said lever, means including a swingable member and controlled by said shaft to operate said lever, means to lock said rockable element to said swingable lever thereby permitting operation of said lever by said lever operating means.

46. In a calculating machine, numeral keys, a movable selector comprising rows of selector elements adapted to be actuated on depression of said keys, and means to lock the selector elements in actuated position, a calculating mechanism comprising a plurality of units each comprising two movable calculating members and a result member, and means to transfer to said result member a relative movement between said calculating members, the extent of movement being controlled by said selector elements.

47. In a calculating machine, a selector, a counter having a plurality of units each including a result member, and means controlled by said selector for actuating said result members.

48. In a calculating machine, a movable selector, a counter having a plurality of units each comprising a result member, means for shifting said result members, and means for selectively coupling said shifting means to said selector.

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