April 9, 1946. B. CARLSTRÖM ET AL 2,398,286

CALCULATING MACHINE

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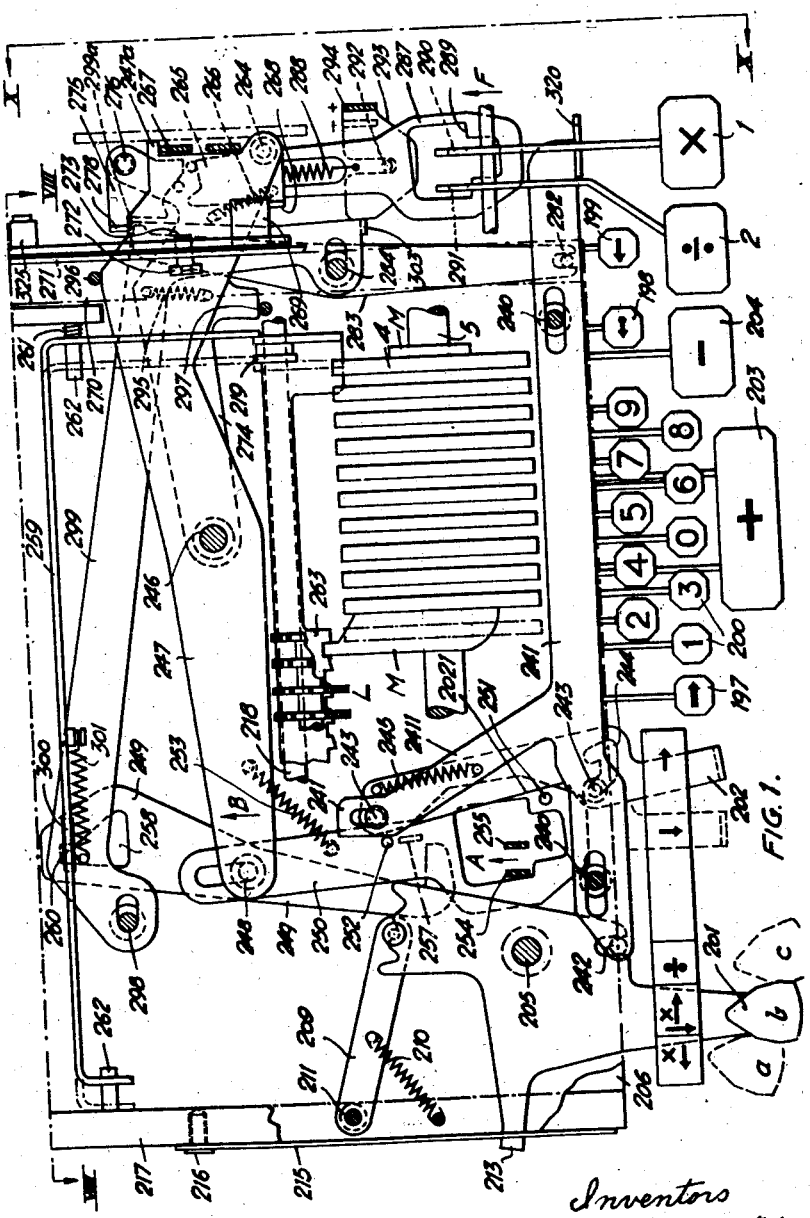

FIG. 1.

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CALCULATING MACHINE

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FIG. 2.

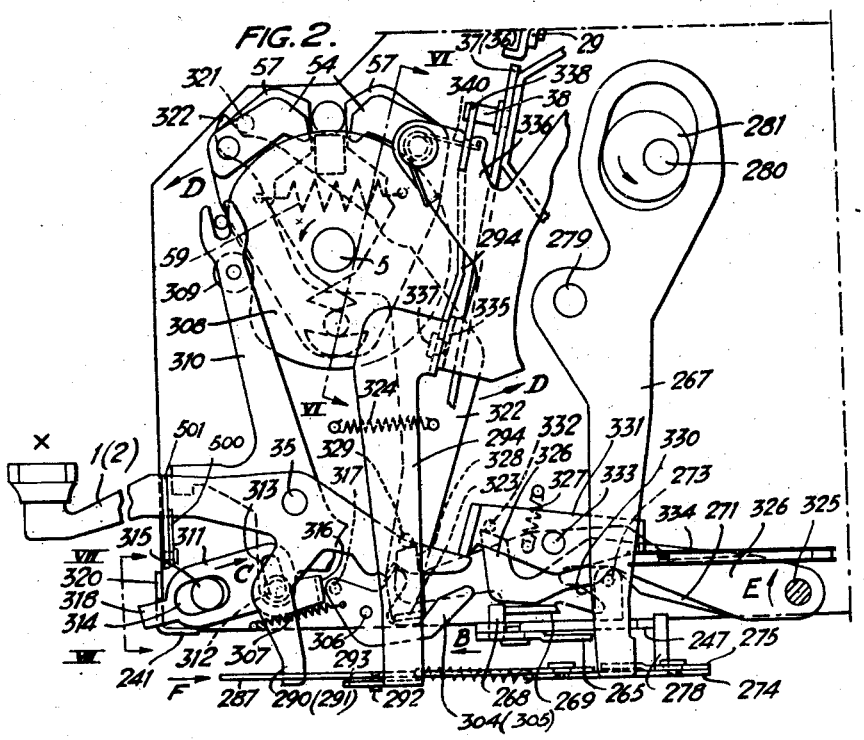


FIG. 19

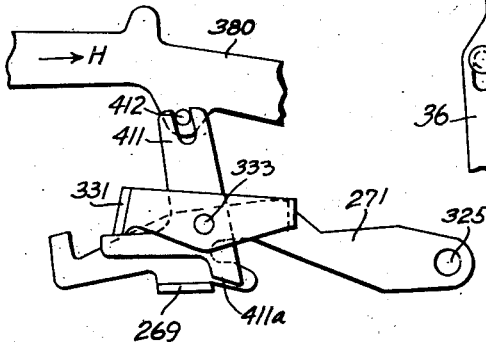
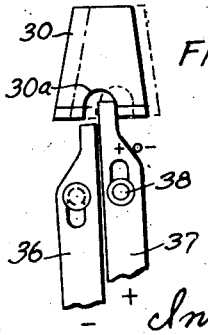


FIG. 20



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CALCULATING MACHINE

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FIG. 6.

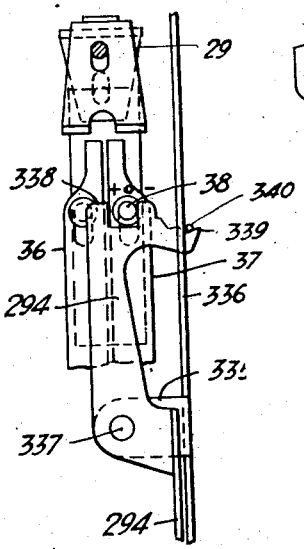


FIG. 2a.

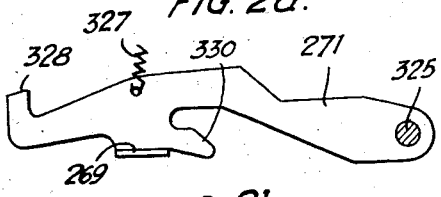


FIG. 2b.

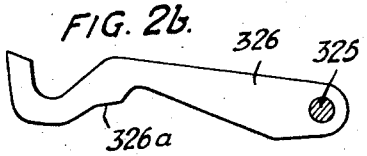


FIG. 11b.

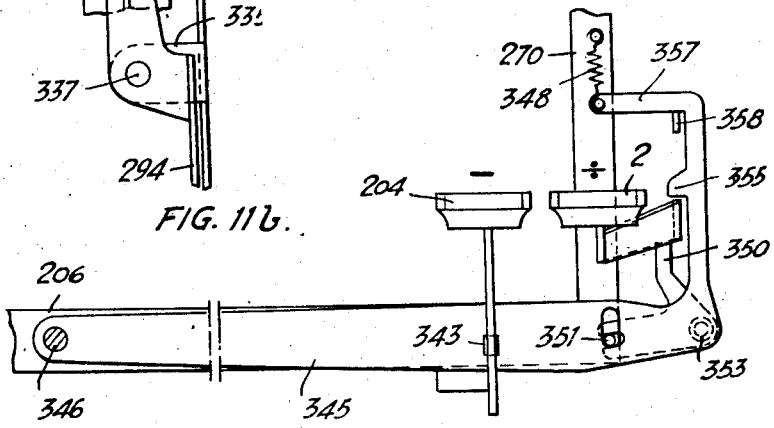
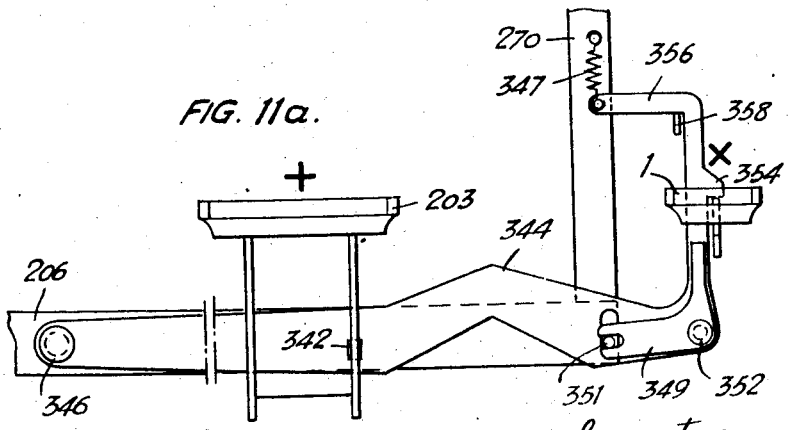


FIG. 11a.



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CALCULATING MACHINE

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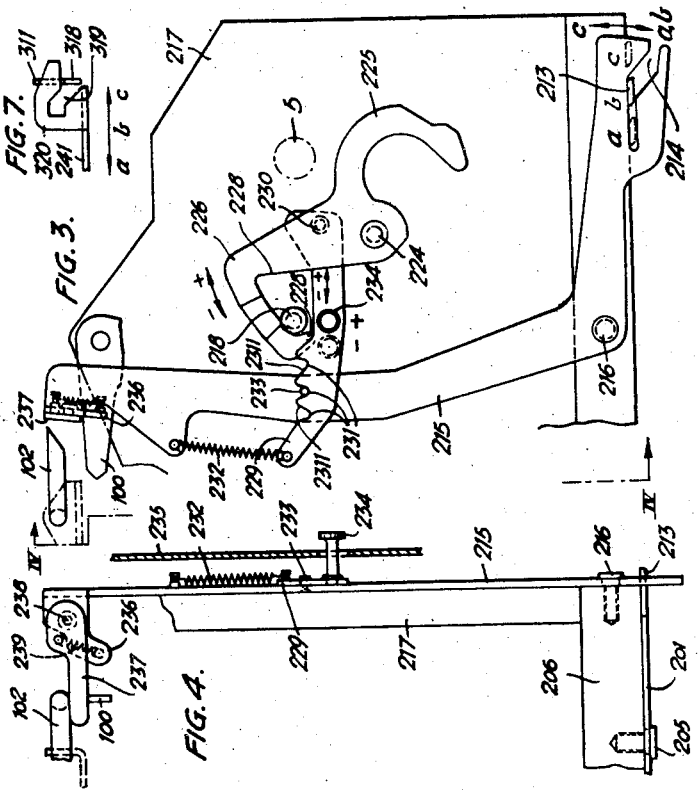

FIG. 7.

FIG. 3.

FIG. 4.

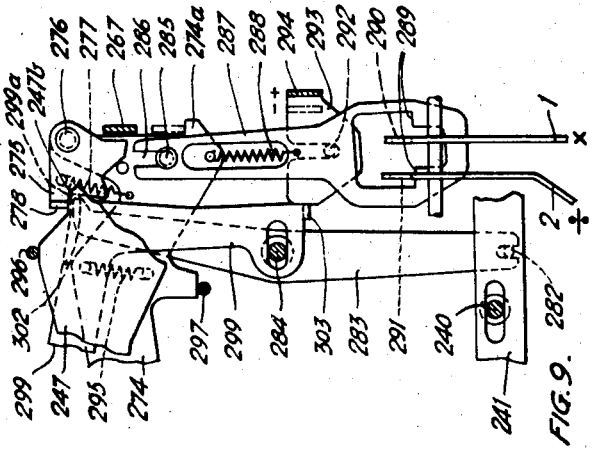

FIG. 9.

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CALCULATING MACHINE

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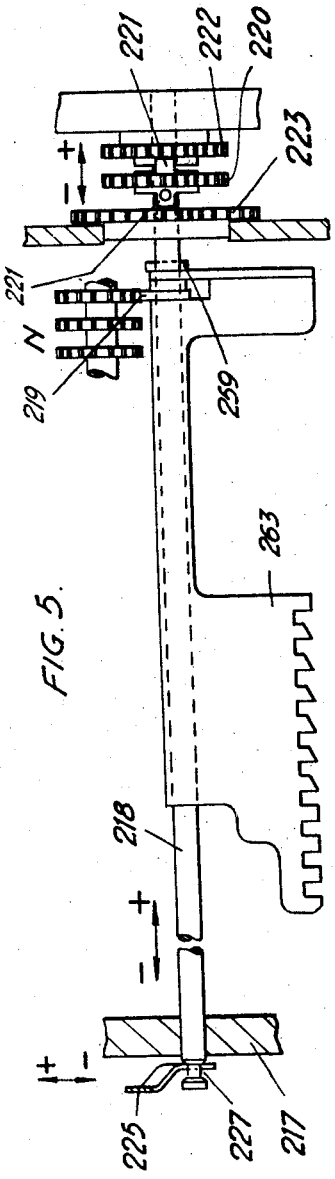

FIG. 5.

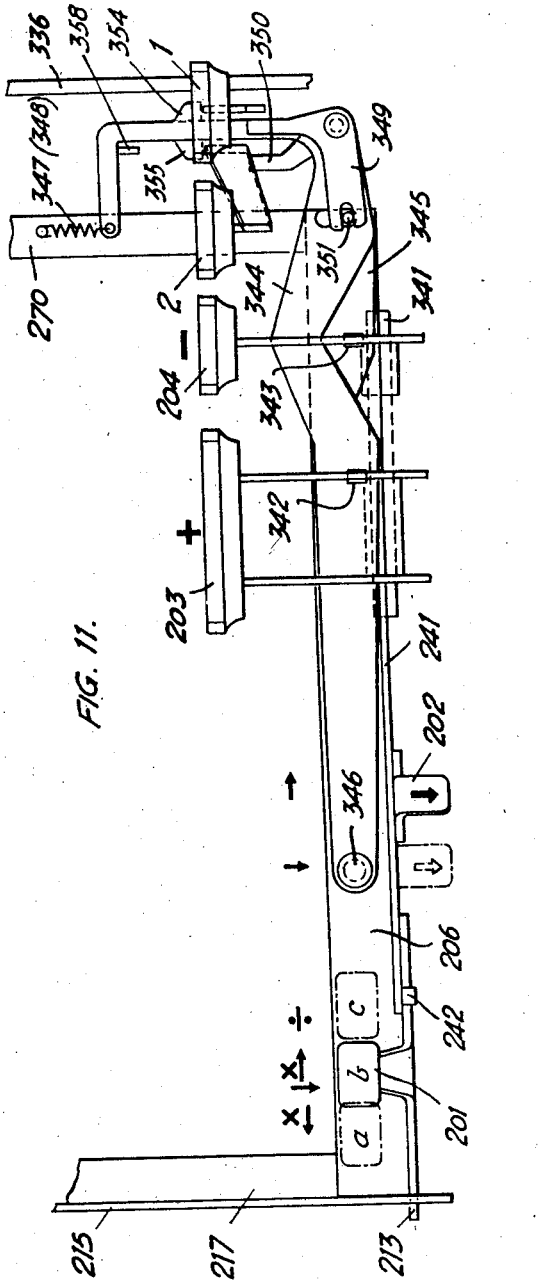

FIG. 11.

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CALCULATING MACHINE

Filed June 3, 1941 10 Sheets-Sheet 6

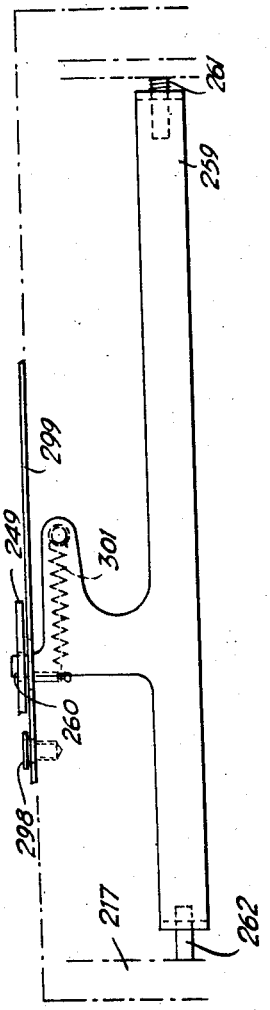

FIG. 8.

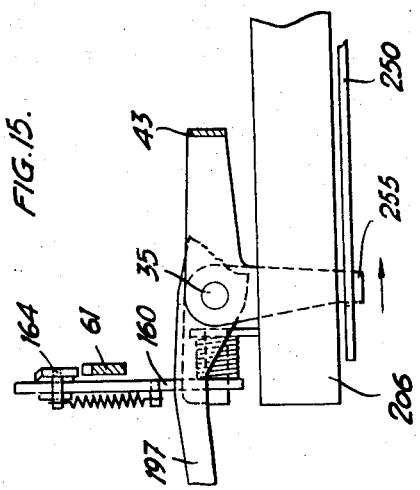

FIG. 15.

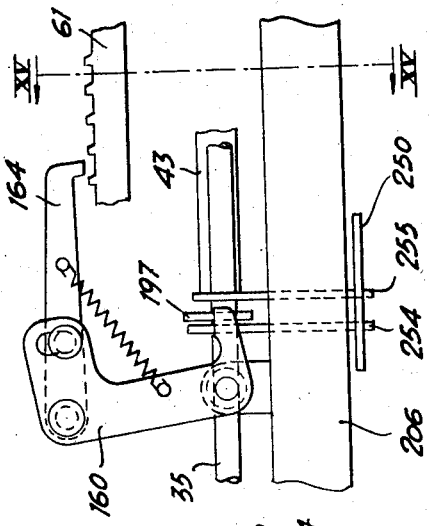

FIG. 14.

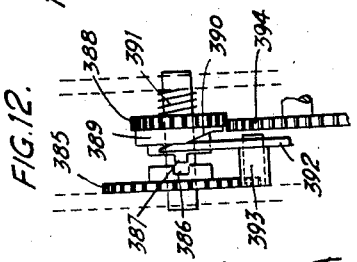

FIG. 12.

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CALCULATING MACHINE

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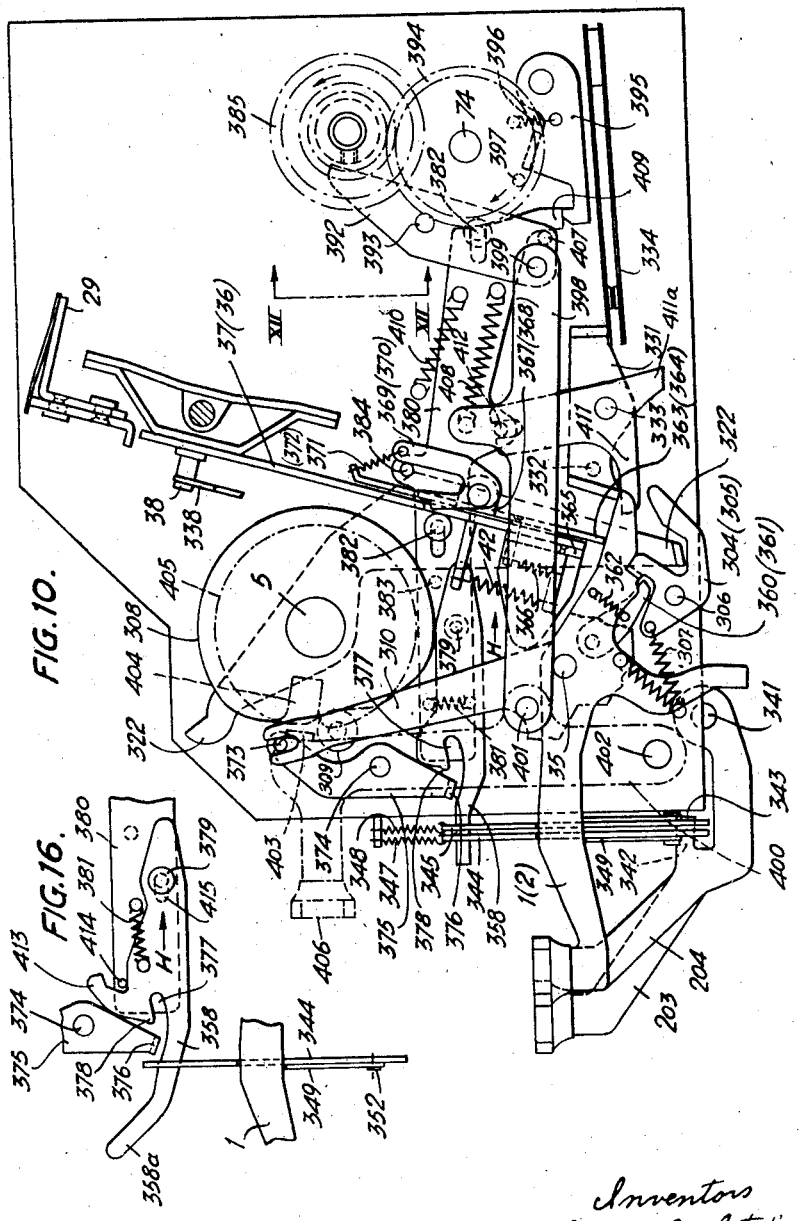

FIG. 10.

FIG. 16.

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CALCULATING MACHINE

Filed June 3, 1941 10 Sheets-Sheet 8

FIG. 18.

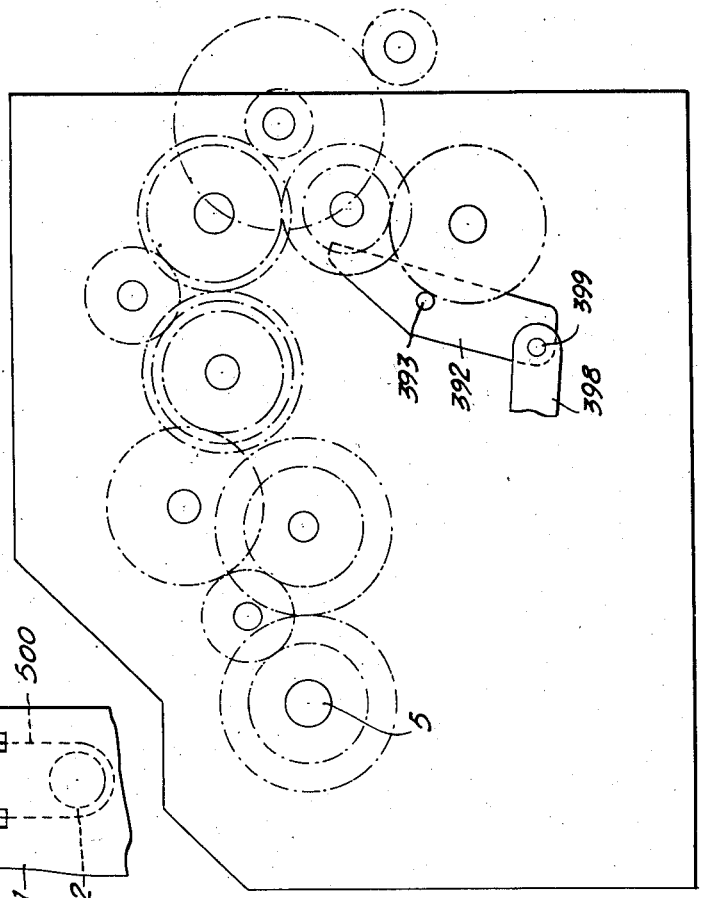


FIG. 11c.

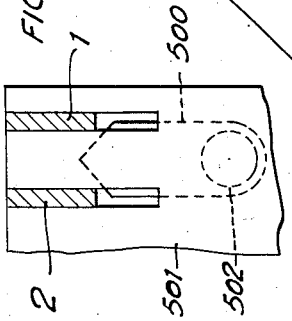
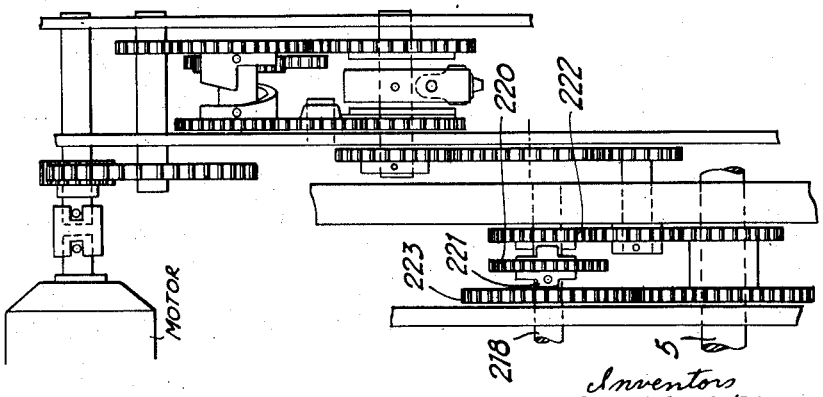


FIG. 17.



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CALCULATING MACHINE

Filed June 3, 1941 10 Sheets-Sheet 9

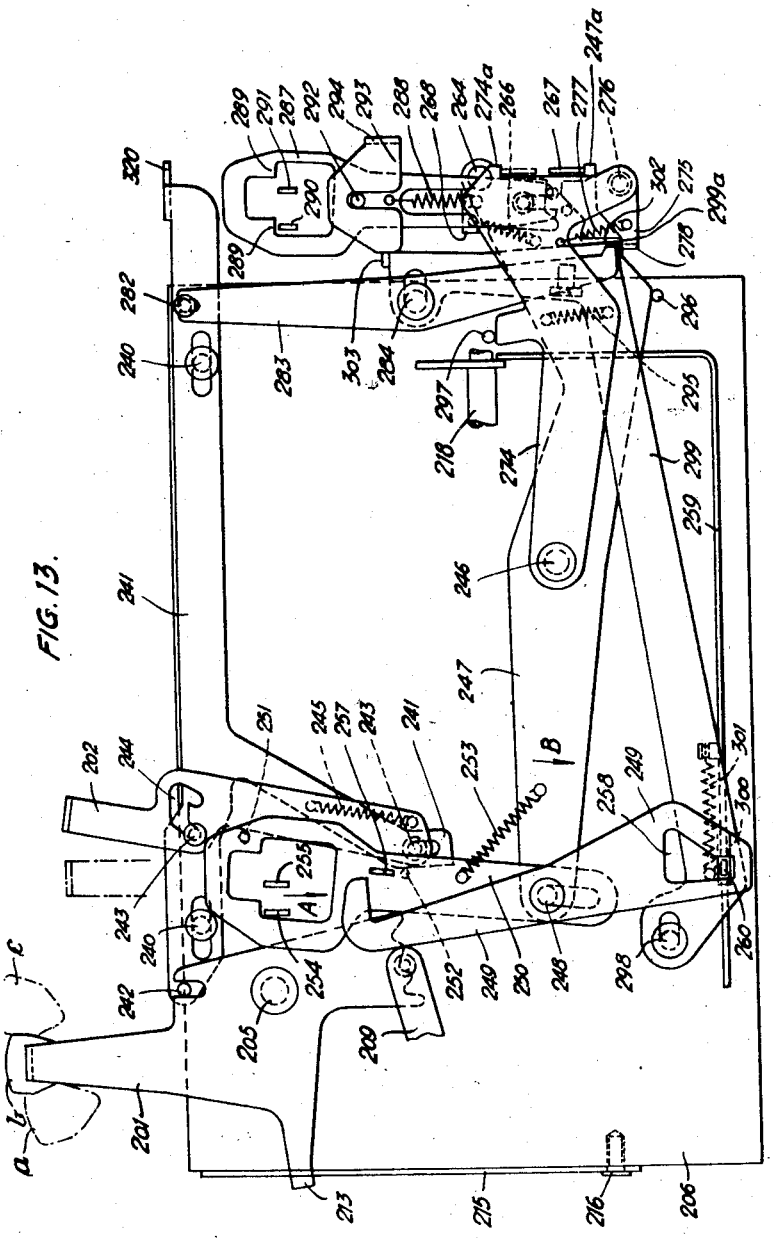

FIG. 13.

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CALCULATING MACHINE

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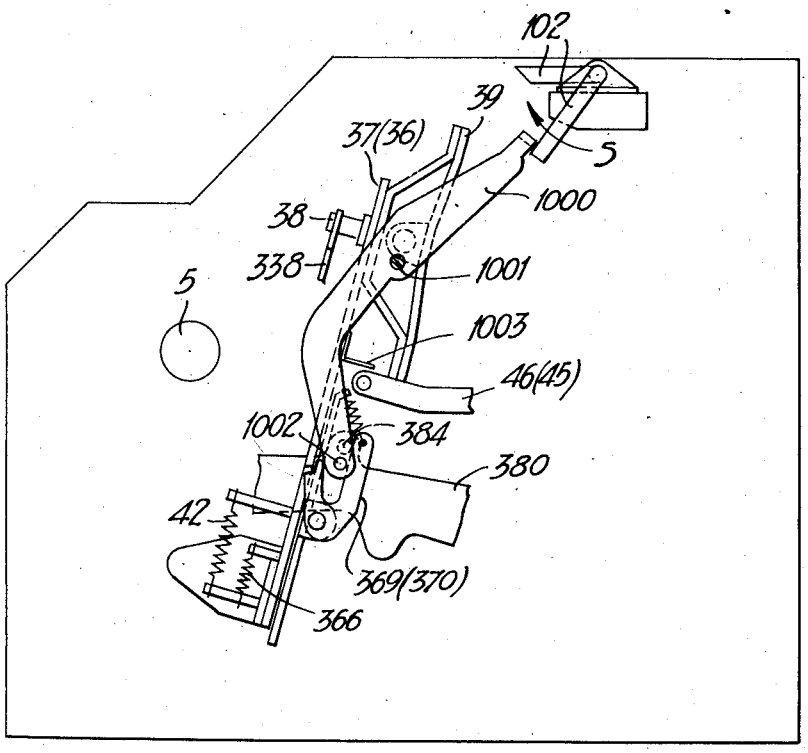
FIG. 21.



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Erik Stripe and
Sture Lovell
BY Jarvis C. Marble
their attorney

Patented Apr. 9, 1946 2,398,286

UNITED STATES PATENT OFFICE

2,398,286

CALCULATING MACHINE

Bengt Carlström, Erik Grip, and Sture Toorell, Atvidaberg, Sweden, assignors to Aktiebolaget Facit, Atvidaberg, Sweden, a corporation of Sweden

Application June 3, 1941, Serial No. 396,474
In Germany June 15, 1940

20 Claims. (Cl. 235—63)

This invention refers to power-operated calculating machines. Automatic calculating machines have been constructed, but they are rather complicated and bulky. Especially for pin wheel machines having an actuator (rotor or drum) rotable in two directions, it heretofore has not been possible to construct a simple and reliable mechanism for automatic shifting both to the right and to the left for multiplication and division. The actuator which is rotatable in either direction must be reliably stopped in its full cycle position, before the shifting may begin, and a reliable mechanism performing those functions has not heretofore been known. The chief purpose of the invention is to provide suitable automatic power-operated mechanism for shifting the carriage to the left or to the right.

Another purpose of this invention is to effect automatic shifting as soon as the multiplication or division key has been released.

Another purpose of this invention is to create a reliable mechanism for this purpose, which is controlled by a control lever which may be set in three positions.

Another purpose of this invention is to provide a calculating machine with a control lever settable in three positions, by means of which the machine is set for full-automatic division and also for multiplication with shifting of the actuator to the right or to the left.

Other purposes will be evident from the following specification.

Embodiments of the invention are illustrated in the annexed drawings, by way of example.

Fig. 1 shows a plan view of the principal parts of the machine. Only those parts are shown which are necessary for explaining this invention (chiefly the shifting means, the keyboard and the actuating means for plus and minus revolutions controlled thereby).

Fig. 2 is an end view from the right in Fig. 1 and illustrates a part of the control for the driving mechanism.

Figs. 2*a* and 2*b* show details taken from Fig. 2.

Fig. 3 shows an end view from the left in Fig. 1 and also discloses the members for reversing the revolutions counter actuator.

Fig. 4 shows the parts illustrated in Fig. 3 as viewed in the direction of the arrows IV—IV of Fig. 3. (Thus, Fig. 4 is a partial rear view.)

Fig. 5 shows the revolutions counter actuator with its controlling means.

Fig. 6 shows a detail seen in the direction of the arrows VI—VI of Fig. 2.

Fig. 7 shows a detail viewed in the direction of the arrows VII—VII in Fig. 2.

Fig. 8 is a partial rear view, that is, in the direction of the arrows VIII—VIII in Fig. 1.

Fig. 9 shows the right hand part of Fig. 1, some parts being broken away to show the parts below.

Fig. 10 is a view looking in the direction of the arrows X—X in Fig. 1.

Fig. 11 is a front view of the control keys and the adjacent parts.

Fig. 11*a* shows a front view of the addition or + key and the multiplication or × key and the adjacent parts.

Fig. 11*b* shows a front view of the subtraction or — key and the division or ÷ key and the adjacent parts.

Fig. 11*c* is a detailed view of an arrangement for preventing simultaneous depression of the multiplication and division keys.

Fig. 12 is a view of the driving coupling seen in the direction of the arrows XII—XII of Fig. 10.

Fig. 13 is a view of the machine seen from below.

Fig. 14 shows a front view of a detail of the shifting mechanism.

Fig. 15 is a cross-sectional view taken on the line XV—XV in Fig. 14.

Fig. 16 shows a modified embodiment in which an addition key only but no subtraction key is provided. Direct subtraction is then effected by depressing the ÷ key, when the operating lever is set to its lowermost position.

Fig. 17 is a plan view of a gear train for driving the actuator and other parts of the apparatus.

Fig. 18 is an end view of the gear train shown in Fig. 17.

Fig. 19 shows a detail of the mechanism for preventing shifting in adding and subtracting operations.

Fig. 20 shows a detailed view of the upper part of Fig. 6.

Fig. 21 is a view looking in the same direction as Fig. 10, and illustrates how the machine is stopped when the capacity of the accumulator is exceeded.

For the sake of clearness, only the principal parts are shown in the drawings.

The drawings will now be explained in detail. It should be mentioned that in this specification the terms "right," "left," "back," "front" are used as they apply to an operator sitting at the keyboard of the machine.

The machine as shown is in its principal features constructed in accordance with U. S. Pat-

ents Nos. 2,103,596 and 2,243,075, though the invention is not limited to that type of machines. The driving mechanism may be constructed in accordance with U. S. Patents Nos. 2,068,899 and 2,127,102. The accumulator and the revolutions counter (or quotient register) may be cleared in well-known manner, for instance by hand (see U. S. Patent No. 2,188,748), while the setting mechanism or actuator may be cleared in accordance with U. S. Patents Nos. 2,068,899 and 1,927,771.

The calculating machine shown in the drawings is of the Odhner or pin wheel type and has a setting mechanism (pin wheel rotor) or actuator 4, which is rotatably journalled in a carriage M movable along the shaft 5 which is the principal driving shaft. For effecting the calculating operations, this shaft 5 with the actuator 4 is rotated in either direction (minus revolution clockwise and plus revolution counterclockwise in Fig. 2) by means of an electric motor in well-known manner. For setting the amounts in the actuator 4 ten amount keys 200 are provided marked by the corresponding numbers. In addition, the machine has three tabulating and shifting keys 197—199. The key 197 is for shifting the actuator step by step to the right, while the key 199 is for shifting the same step by step to the left. The key 198 is for "total" tabulation, that is for tabulating the factors of division. When this key 198 is depressed, the actuator 4 moves directly to its extreme left hand position. The machine also has a positive multi-revolutions or multiplication key 1 marked × and ordinarily intended for plus revolutions without clearing the actuator, and a negative multi-revolutions or division key 2 marked ÷ and ordinarily intended for minus revolutions without clearing. There is also an addition key 203 marked + for plus revolutions with clearing of the actuator after each revolution, and a subtraction key 205 marked — for minus revolutions with clearing of the actuator after each revolution.

To the left of the key-board there are two levers, namely, the chief control lever 201 (Figs. 1 and 13) and its disconnecting lever 202. The two keys 203 and 204 are absolutely independent of these levers, that is, operations of addition and subtraction are not influenced by the position of said two levers 201 and 202. The chief lever 201 is rockable on the stationary journal 208 secured to the bottom plate 206 and can be set to three positions, namely, the two positions of multiplication "a" and "b" and the position of division "c." In these positions the lever 201 is latched by a latching arm 209 cooperating with three notches in the end of lever 201. Said latching arm is biased by a tension spring 210 and rockable on the pin 211 secured to the bottom plate 206. An arm 213 of the control lever 201 is movable in a cam slot 214 (Fig. 3) of a lever 215, which is rockable on the pin 216 secured to the left hand side wall 217 of the machine frame.

A revolutions counter actuator (or quotient tooth) 219 is displaceably splined on a shaft 218 (Figs. 1, 3 and 5) and actuates the revolutions counter N. This shaft is rotatably journalled in the side walls of the machine frame and is also movable axially, and it carries the gear 220 (Fig. 5) rigidly secured thereto. The hub of this gear carries on either side coupling projections 221. When the shaft 218 is moved axially, one or the other of these projections engages a slot in the hub of one or the other of two gears 222 or 223, respectively, depending upon the direction of motion. These gears are loosely rotatable on the shaft 218 and are permanently driven in opposite directions from the main shaft 5 by gear transmissions. The gear 220 drives the tens transfer rotor of the revolutions counter.

When the shaft 218 is moved axially in the direction of the arrow marked + in Fig. 5, the shaft is driven by the wheel 222 which rotates in the same direction as the shaft 5, that is as the actuator 4. Thus the shafts 5 and 218 rotate in the same direction and consequently the actuator 4 and the revolutions counter actuator 219 have the same direction of rotation. For multiplication this is the normal position of the shaft 218 and is herein called its plus position.

But if the shaft 218 is moved axially in the direction of the — arrow to its extreme left position, the shafts 5 and 218 are coupled to rotate in opposite directions, and hence the actuator 4 and the revolutions counter actuator 219 rotate in opposite directions. This is the normal position for division and is called its minus position. The axial motion of the shaft 218 is effected by the lever 225 (Figs. 3 and 5) which is rockable on the stationary pin 224 and carries the cam 226. This cam cooperates with an annular or peripheral slot 227 at the end of the shaft 218. When the lever 225 is rocked in the minus direction (see arrows), the shaft 218 is moved to its minus position, and vice versa. The rocking motion of the lever 225 is limited by the edges 228 striking against the shaft 218. An arm 229 is articulately connected with the lever 225 by means of the pin 230 and has three notches 231. A tension spring 232 urges the arm 229 against the pin 230 secured to the lever 215. The distance between the adjacent notches 231 is so chosen that it permits such motion of the arm 229 independently of lever 215 as is necessary for the arm 225 to move the shaft 218 from its plus position to its minus position, and vice versa. This distance is consequently equal to the distance which the pin 230 moves, when the control lever 201 is rocked from its "b"-position (multiplication) into its "c"-position (division), causing the projection 218 of control lever 201 to slide in the slanting part of the slot 210 (Fig. 3) so that the lever 215 is rocked counterclockwise in Fig. 3.

However, the lever 215 may also be moved without the aid of the control lever 201. For this purpose the knob or pin 233 (Figs. 3 and 4) is used which is secured to the arm 229 and extends through a slot in the machine casing 235 so that it can be actuated by hand from the outside. If this knob is first pressed downwards and then moved in the direction of the — arrow, the shaft 218 is moved from its + position to its — position, though the control lever 201 is still in its position "b" for multiplication. Now, it is possible to effect "minus multiplication" (negative multiplication) in the machine. Such "minus multiplication" is, for instance, used for solving problems of the form: $a \times b - c \times d$. First, the first product $a \times b$ is calculated in the accumulator in the ordinary way by positive multiplication (plus multiplication) and then the difference is directly calculated by calculating the second product $c \times d$ by use of — revolutions, that is as minus multiplication. To attain a correct indication of the multiplier in the revolutions counter in such operation, it is necessary that the shaft 218 is moved to its minus position, so that during the minus multiplication the actuator 4 rotates in the negative direction (— revolutions) but the revo-

lutions counter actuator 219 in the positive direction (+ revolutions).

If the control lever 201 is in its "c" position (for division), the knob 234 may be moved by hand in the direction of the + arrow in Fig. 3, for carrying out minus-division or "negative" division, that is, division with rotation of actuator 4 and tooth 219 in the same sense. Such operation can, for instance, be used for solving a problem of the type $a \div b - c \div d$. Then the first quotient $a \div b$ is calculated in the ordinary manner (actuator 4 rotating in one direction and revolutions counter actuator 219 in the opposite direction, this may be termed "+ division" or "positive" division), and the quotient is left in the revolutions counter N (which is not cleared). The shaft 218 is moved to its + position (position of like rotation) by manipulation of the knob 234 and the second quotient $c \div d$ is calculated; during this operation the actuator 4 and the tooth 219 both rotate in the same direction so that the second quotient $c \div d$ thus calculated is directly subtracted from the first quotient $a \div b$. The difference directly appears in the revolutions counter N.

As is shown in Fig. 3, the innermost edges 231' of the two outermost notches 231 slant towards the central notch. If the lever 225 has been moved out of its normal position by means of the knob 234, when the control lever 201 is in either of its positions "a," "b" and "c," and then the lever 201 is moved from its "b"-position to its "c"-position, or vice versa (or from its "a"-position via its "b"-position to its "c"-position, or vice versa), the pin 233 slides on the slanting edge 231' and enters the central notch 231. Thus, as soon as the lever 201 is shifted from its "b"-position to its "c"-position, or vice versa, the arm 229 always will have its central notch 231 in engagement with the pin 233.

At its top the arm 215 has a portion 236 extending at right angles to the arm (Figs. 3 and 4) on which the member 237 is rotatably journalled on the pin 238. The free end of the member 237 is pressed downwards by a tension spring 239 to engage the tens transfer lever 100 of the highest denomination of the accumulator. The lever 100 is rocked upwards, when the capacity of the accumulator is exceeded, and thus an over-draft occurs in over-addition or in over-subtraction, that is when larger value than that already registered is subtracted therefrom. If the lever 100 is thus rocked, when the lever 201 is in its position "a" or "b," the lever 100 only rocks the member 237 upwards in an idle stroke, as shown in Fig. 3, because the stop impulse lever 102 is out of the path of the member 237. But if the lever 201 is in its "c"-position, the stop impulse lever 102 is in the path of motion of the member 237, when rocked upwards by the tens transfer lever 100 as just described so that said member rocks the lever 102 upwards or counter-clockwise and stops the actuator, as described below under the heading: Ordinary division with unlike rotation of actuator and revolutions counter actuator.

Right, left and non-shift tabulation control

Into the bottom plate 206 (Figs. 1 and 13) two screws 240 are screwed, passing through slots in a slide 241 movable rectilinearly on said bottom plate. A pin 242 secured to said slide enters a slot of the lever 201 so that when said lever is shifted the slide 241 follows it. By means of the pins 243 the disconnecting lever 202 which serves for disabling the tabulation to the right in certain cases, is secured to the slide 241 in such manner that the lever 202 is both rockable and slidable in relation to said slide. The disconnecting lever 202 has a recess 244 with two notches through which one of the pins 243 passes. A tension spring 245 connects the slide 241 with the lever 202 and forces the latter to assume either of the two positions determined by the two notches of the recess 244, and shown in full lines and dotted lines, respectively, in Figs. 1 and 13. A stud 246 is secured to the bottom plate 206 and pivotally supports a lever 247. This lever carries a pin 248 on which a hook lever 249 is rockably journalled. This pin also enters a slot in the step shifting plate (left-right-shifting plate) 250, which carries two pins 251, 252 and is drawn by a tension spring 253 to the right in Fig. 1. When the control lever 201 is in its position "b" and simultaneously the disconnecting lever 202 is in its normal position indicated by a right-hand arrow (→) as shown in full lines in Fig. 1, then the shifting plate 250 is in engagement with the lower end of a step shifting lever 254 (Figs. 1, 13, 14, 15) for shifting to the right. But if the control lever 201 is moved into its position "a," the slide 241 with its arm 241' is moved to the left in Fig. 1 and strikes the pin 252 to pivot the shifting plate 250 to the left so that this plate now engages the lower end of a step shifting lever 255 (Figs. 1, 13, 14 and 15) for shifting to the left. When the lever 201 is switched over to its position "c," the shifting plate 250 is drawn by the tension of the spring 253 to engage the right step shifting lever 254 and remain in contact with it. But if the disconnecting lever 202 is in its extreme left position in Fig. 1 (operative position) indicated by a vertical arrow (↓) in Fig. 1, while the lever 201 is in its position "b," the shifting plate 250 with its pin 251 engages the edge 202' of the disconnecting lever 202 and thus is kept in its central inoperative position, not engaging either of the levers 254 or 255. If now the lever 201 is moved to its position "a," the shifting plate 250 is rocked to engage the step shifting lever 255, and when the lever 201 is moved into its position "c," the shifting plate 250 again engages the step shifting lever 254. Thus, it is evident that when the disconnecting lever assumes its said operative position, the automatic step by step shifting is inoperative only in the position "b" of the lever 201. In other words, the disconnecting lever 202 is always ineffective when the lever 201 is in its position "a" or "c."

When the step shifting lever 254 is actuated, the actuator 4 is automatically shifted one step to the right; and if the step shifting lever 255 is actuated, said actuator is shifted one step to the left. As is shown in Figs. 14 and 15, the lever 254 journalled on the shaft 35 of the keys acts directly on the step shifting pawl 160, 164 (see Figs. 30 and 33 of U. S. Patent No. 2,108,596), so that said pawl moves the rack 61 to the right. Said rack is secured to the carriage of the actuator 4 and consequently said actuator is shifted one step to the right. When depressed the key 197 for step by step shifting to the right acts directly on the pawl 160, 164. The step shifting lever 255 is directly connected with the U-shaped member 43 (Figs. 14, 15) which can also be directly actuated by depressing the key 199 for step by step shifting to the left. If the lever 255 is rocked in the direction of the arrow A, Fig. 1, the actuator 4 is shifted one step to the left, that is towards

higher denominations. The step by step shifting mechanism proper is described in detail in U. S. Patents Nos. 2,108,596 and 2,243,075.

Disabling the automatic shifting in end positions

As described in detail below, the pivoted lever 247 performs one rocking motion in the direction of the arrow B, Figs. 1 and 13, and back again, when the actuator 4 is stopped by the catching pawls 54 and catching arms 57 (Fig. 2) after one or more revolutions for a calculating operation. This rocking motion may be transferred by the hook lever 249 to a projection 257 of the shifting plate 250. The hook lever 249 rockable on the journal 248 has a recess or cam slot 258 and the cam edge thereof is engaged by a projection 260 (Figs. 1 and 3) of a U-shaped member 259 which is displaceable along the stationary studs 262. A compression spring 261 presses the member 259 to the left in Figs. 1, 5 and 3 to engage the member 263 which serves to couple the revolutions counter actuator 219 to the carriage of the actuator 4 during the calculating operations (see U. S. Patent No. 2,243,075). When the member 263 is in its position of rest (extreme right position) and the levers 201, 202 are in their position shown in full lines in Fig. 1, the member 259 by means of its projection 260 keeps the hook lever 249 in such position that the projection 257 is out of the path of motion of the lever 249 so that the swinging lever 247 does not drive the shifting plate 250, the pin 248 sliding in the slot of the shifting plate 250. But if the actuator 4 is tabulated or shifted to the left, for instance, by means of the key 199, the member 259 follows due to the pushing action of the spring 261, until said member is checked by a stop. In the drawings this stop is the left hand side wall 217. This motion of the member 259 from its full line position to its position shown in dash-and-dot-lines is equal to or shorter than the axial distance between two adjacent totalizer wheels. This motion of the member 259 causes the projection 260 to rock the hook lever 249 into engagement with the projection 257 so that at the next swinging motion of the lever 247 the shifting plate 250 follows and actuates whichever of the step shifting levers 254 or 255, that said plate is set to engage.

When the actuator 4 is shifted to the right and the member 263 (and the revolutions counter actuator 219) coupled thereto moves from the next to the lowest wheel (denomination) of the revolutions counter to the lowest wheel or denomination thereof, that is to its extreme right position, said member 263 strikes the member 259 and moves it to the right in Fig. 1, from the position shown in dash-and-dot-lines back to its full line position. Upon the automatic shifting of the actuator, this motion takes place simultaneously with the motion of the hook lever 249, and consequently the cam slot 258 is necessary to permit the relative motion of the projection 260 in relation to the hook lever 249. When the lever 247 is swung back again (in the direction opposite to the arrow B), the hook lever 249 is pivoted by the cam slot 258, out of engagement with the projection 257 and consequently the actuator 4 cannot be shifted further to the right.

The angle of rotation of the hook lever 249 is substantially equal to the angle of rotation of the shifting plate 250, when the latter is moved from its right position to its central position (Fig. 1), and consequently the hook lever 249 is always in engagement with projection 257 of the shifting plate 250, when the lever 201 is in its position "*a*." A special mechanism for preventing the shifting to the left which then takes place is not necessary, because in its extreme left position the carriage of the actuator 4 is stopped by a stationary stop and consequently cannot be moved further by the shifting and tabulating spring tending to draw the carriage to the left. Even if left step shifting lever 255 is actuated again, this has consequently no influence upon the actuator.

Setting to plus and minus revolutions

A small pawl 265 (Figs. 1, 2 and 13) is journalled on the pin 264 secured to the swinging lever 247. A tension spring 266 tends to draw said pawl into the path of a driving lever 267, swinging to and fro but normally the bent part 268 (Figs. 1 and 2) of said pawl is locked by the bent portion 269 of a lever 271 fulcrumed on the right side wall 270 of the machine frame. The lever 247 also has a bent portion 272 to which the pin 273 is riveted.

A plus minus driving lever 274 (Figs. 1, 2 and 13) is also rotatably journalled on the shaft 245. A pawl 275 (Figs. 1, 2, 9 and 13) is pivoted on lever 274 by means of a pin 276. A tension spring 277 (Fig. 9) tends to draw said pawl into the path of the swinging driving lever 267, but the pawl is normally locked and kept out of the path of said lever by means of its bent projection 278 which engages one edge of the lever 247.

The driving lever 267 actuating the pawls 265 and 275 is rockable on the journal 279 (Fig. 2) and has an oblong slot in which the eccentric 281 runs to rock the lever to and from fro. The shaft 280 of the eccentric is driven through gear transmission (not shown) by the motor of the calculating machine and rotates as long as the motor runs.

The slide 241 carries a pin 282 (Figs. 1, 9 and 13) which enters a slot in the front end of a lever 283 which is pivoted on the stud 284 secured to the bottom plate 206. The back end of said lever is hook-shaped and locks the pawl 275 against the action of its spring 277, when the lever 201 controlling the slide 241 is in its position "*a*" or "*b*." The plus-minus-driving lever 274 also carries a pin 285 (Fig. 9) which enters a slot 286 in the end of a plus-minus-control plate 287, Figs. 1, 2, 9 and 13. Between the driving lever 274 and the control plate 287 a tension spring 288 is arranged which moves the plate 287 in the direction of the arrow F (Fig. 1), when the lever 274 is rocked backwards, that is counter-clockwise in Fig. 1. Said control plate has shoulders or projections 289 which are moved into engagement with either of the arms 290, 291, accordingly as the control plate is rocked to the left or to the right, respectively, in Figs. 1 and 9. The arms 290 and 291 are integral with the keys 1 and 2, respectively. The shifting of the control plate 287 from the right to the left (that is, from minus to plus), and vice versa, is effected by the pin 292 fixed to the plate 287 which engages a slot in the bent portion 293 of the minus plus reversal lever 294 (Figs. 1, 2, 6 and 13). The reversal or shifting of this lever 294 is described in detail below. A common tension spring 295 keeps the two levers 247, 274 in their positions of rest, because the spring presses said levers against studs 296 and 297, respectively, which are secured to the bottom plate 206.

On the studs 284 and 298 secured to said bottom plate the minus locking member 299 (Figs. 1, 8, 9 and 13) is displaceable and said member

has a slot 300 through which the projection 260 of the member 259 passes. A spring 301 is tensioned between the member 259 and the locking member 299, which at its right end carries two abutments or projections 302 and 303 forming stops (Fig. 9). In the position of the minus locking member 299 shown in the drawings its projection 302 locks the pawls 275, while its projection 303 engages the bent portion 293 of the reversal lever 294. When the actuator 4 and coupling member 263 of the revolutions counter actuator 219 are shifted or tabulated to the left, that is, towards higher denominations, moving the member 259 into its position shown in dash-and-dot-lines, as described above, also the minus locking member 299 is moved to the left, because the left edge of the projection 260 strikes the left end of the slot 300. The displacement thus given to the minus locking member 299 is somewhat greater than the distance which the reversal lever 294 and its bent portion 293 are moved laterally. Due to this motion of the minus locking member 299 the pawl 275 is disengaged from the projection 302 (Fig. 9). This means that said pawl is locked by the projection 302 only when the member 263 is in its extreme right position and consequently keeps the member 259 and arm 299 in their extreme right positions, and when simultaneously the reversal lever 294 is in its plus position shown in full lines in the drawings, that is, when the control plate 287 has been rocked in position to engage the arm 291 of the key 2. When the member 263 is in any other position, the pawl 275 is free from the projection 302.

On the right side wall 270 of the machine (Figs. 2 and 10) the power-operated driving mechanism of the machine is arranged, as shown in U. S. Patents Nos. 2,068,899 and 2,127,102. This mechanism is controlled by the arms 290 and 291 of the keys 1 and 2 respectively. When one of these keys is depressed, the locking-down member 304 or 305, respectively, belonging thereto enters a corresponding notch of the key and locks it in its depressed position. These locking pawls 304 and 305 are rockable on the pin 306 and each of them is actuated by its individual tension spring 307. To the shaft 5 of the rotor 4 a cam disc 308 is secured on which the roller 309 of a releasing arm 310 runs. This arm is rockably journalled on the key shaft 35 and carries at its lower end the small slide 311, a pin 312 secured to the arm 310 passing through the slot 313 of said slide. In addition, this slide has a slot 314 through which passes the pin 315 which is secured to the side wall 270, and said slide also has a bent portion 316 which strikes the pin 317 of the locking-down pawl 304 or 305 and releases said pawl, when the slide 311 is moved in the direction of the arrow C. Then the key 1 or 2 is again restored to its position of rest by means of its usual spring. The slide 311 also has a projection 318 (Figs. 2 and 7) which slides in the curved slot 319 of the bent portion 320 of the slide 241. Figs. 2 and 7 show the position which the slide 241 assumes, when the control lever 201 is in its position "b." From the drawings it is evident that the slide 311 remains in the same position when the slide 241 is moved to the left in Fig. 7 as the control lever 201 is shifted to its position "a." But if said lever 201 is shifted to its position "c" the slide 241 is moved to the right in Fig. 7 and the projection 318 is lifted by the cam slot 319. Then the slide 311 is rocked on the pin 315 and at its slot 313 slides on the pin 312. The bent portion 316 of the slide 311 is thus lowered (clockwise in Fig. 2) and is stopped in such position that the slide 311, in its motion in the direction of the arrow C, does not act on the locking-down pawls 304 and 305.

When the actuator 4 is in its position of rest, it is held in well-known manner by the catching arms 57, the pawls 54 and the spring 59, see U. S. Patent No. 2,127,102. The left catching arm 57 has a pin 321 which may act on the shifting impulse lever 322 rockable on the shaft 5. A projection 323 (Fig. 2) bent off from the impulse lever 322 releases the pawl 304 or 305 from the key 1 or 2, respectively, when the impulse lever 322 is rocked in the direction of the arrow D. (The lever 322 is thus rocked due to the fact that when the actuator 4 is stopped by the catching pawl 54, this causes the left arm 57 to rock somewhat due to the shock.) A tension spring 324 presses the impulse lever 322 against the pin 321.

On the right side wall 270 the hooks 271 and 326 are journalled on the pin 325 (Figs. 2, 2*a* and 2*b*). The hook 271 is drawn upwards by a tension spring 327 and rests with its striking point 328 against a pin 329 on the impulse lever 322. As described above, the hook 271 has a bent portion 269 which engages the projection 268 on the pawl 265 to lock the latter, and it also includes a cam 330 to be engaged by the pin 273 of the swing lever 247. The hook 326 rests with its lower edge against the part 269 of the hook 271 and actuates the pin 332 on the contact lever 331 when the last-mentioned hook is swung in the direction of the arrow E, so that said contact lever is rocked on its stationary shaft 333 and closes the electric contact 334 for the motor, driving the machine.

On a bracket 335 (Figs. 2 and 6) secured to the external right sheet metal wall 336 of the machine (this wall is to the right of the right side wall of the frame 270; the two walls 270, 336 enclose the driving mechanism) the minus-plus-reversal lever 294 is rotatably journalled on the pin 337. As described above, at its lower end this lever has a bent portion 293 (Figs. 1 and 2) having a slot in which the pin 292 of the control plate 287 slides. At its top end the lever 294 is shaped as a fork 338 (Figs. 2, 6 and 10) to embrace one of the two pins 38. This pin 38 is extended forwards and may (as is explained in detail for the pin 38 in U. S. Patent No. 2,127,102) assume three different positions, which in the drawings (Fig. 6) are indicated by +, 0, and −. When neither of the keys 1, 2 is depressed, this pin 38 is disengaged from the oscillating arm 29. If, however, the multiplication key 1 is depressed, the arm 29 moves the pin 38 laterally into its + position when the actuating slide 30 (Fig. 20) on the oscillating arm 29 engages the slide 37 raised due to the depression of the key 1. The recess which is made in the lower edge of the slide 30 to engage that of the slides 36 or 37 which has been raised, is so dimensioned that when the slide 37 has been raised and pushed laterally to its extreme left position (+ position of pin 38), as shown in Fig. 20, its left edge is not actuated by the left edge of the recess 30*a*, when the slide 30 is in its extreme right position. In Fig. 20 the extreme lateral positions of the slide are shown in full lines and dotted lines, respectively.

When thus the pin 38 has been moved to its + position, said pin presses against the left prong of the fork 338 so that the reversal lever 294 assumes the position shown in Fig. 6; in this position it is latched by the notched arm 339 and the spring 340 (a wire wound to form a torsion spring) secured to the side wall 336. When the pin 38

returns to its position 0 (zero position), that is when the machine is stopped, the latching mechanism 339 and 340 keeps the reversal lever 294 in its plus position. But when the division key 2 is depresed, the pin 38 with the reversal lever 294 is in similar manner moved to its minus position and the lever 294 is latched there by the latching members 339, 340. Now, the reversal lever 294 is in its minus position as shown in dotted lines in Fig. 1, and keeps the control plate 287 pressed to the left in Fig. 1. If now said plate 287 is displaced in the direction of the arrow F, it also moves the multiplication key 1 so that said key is pulled down automatically into its depressed position. But if the pin 38 is moved into its + position (Fig. 6) by manual depression of the multiplication key 1, then it rocks the reversal lever 294 into its + position (shown in full lines in Fig. 1) and when now the control plate 287 is moved in the direction of the arrow F, the division key 2 is pulled down automatically. To summarize: if the pin 38 is moved to its + position, the division key 2 is automatically pulled down but the multiplication key 1 is pulled down automatically when the pin 38 is moved to its — position.

The latching mechanism 339 and 340 must be so strong that its latching action is not overcome by the pressure of the spring 301 acting through the minus locking member 299 (Fig. 1).

Addition and subtraction keys

The plus or addition key 203 and the minus or subtraction key 204 are rotatably journalled on the shaft 341 (Figs. 10 and 11). By means of its tooth 342 the addition key 203 actuates a lever 344, while by means of its tooth 343 the subtraction key 204 acts on a lever 345. The levers 344 and 345 rock on a stationary pin 346 and are pulled upwards by tension springs 347 and 348, respectively. On these levers hooks 349 and 350, respectively, are rockably journalled. A pin 351 secured to the bottom plate 206 passes through slots in said hooks so that at the motion of the levers 344 and 345 the hooks are rocked on their pins 352 and 353, respectively (see Figs. 11*a* and 11*b*). The levers 344 and 345 have elongated slots through which the pin 351 passes to permit rocking of the lever. A projection 354 of the lever 344 acts on the multiplication key 1; and the lever 345 has a projection 355 which acts on the division key 2. Also the lever 344 has a part 356 which actuates the hook 358 (Figs. 10, 11, 11*a*, 11*b*); and in similar manner the lever 345 has a part 357 which actuates the hook 358. The keys 1 and 2 are kept in their depressed position by the locking-down pawls 304, 305 which are releasable by the slide 311 of the release arm 310 (Fig. 2) or by the impulse lever 322, according to the position of the control lever 201. The keys 1—2 carry the small pawls 360 and 361, respectively (Fig. 10), which are pressed by springs 362 against pins or projections on the keys.

The keys 1—2 act on the slides 363—364, respectively (Fig. 10), which are rockably and displaceably attached to the stationary bracket 365. Tension springs 366 act on said slides, which have bent projections 367—368, respectively, and on these projections hooks 369—370, respectively, are rockably journalled. Tension springs 371—372, respectively, act on these hooks and the latter engage the slides 36 and 37, respectively (Figs. 2, 6 and 10). These slides and their mode of operation is described in detail in U. S. Patent No. 2,127,102. They are pulled downwards by tension springs 42.

The release arm 310 has a slot engaged by a pin 373 (Fig. 10). This pin is mounted on the lever 375 rockable on the stationary pin 374 and the lever 375 also has a projection 376. When the lever 375 is rocked, the projection 376 enters the slot 377 of the hook 358. When this hook is pressed down by either of the keys 203 or 204 (Figs. 10, 11, 11*a* and 11*b*), the projection 376 (Fig. 10) engages the projection 378 of the hook 358 so that the hook 358 is pushed backwards (to the right in Fig. 10; see arrow H) when the lever 375 is rocked. On a pin 379 secured to the slide 380, the hook 358 is journalled, and a spring 381 is tensioned between the hook 358 and the slide 380. Said slide is displaceable on the stationary pins 382 and carries a pin 383 which actuates the impulse lever 322 (Figs. 2 and 10) when the slide is moved in the direction of the arrow H (that is backwards) so that the hooks or locking-down pawls 304 and 305 are rocked to their release position. In addition, the slide 380 carries a pin 384 (Fig. 10) which releases the two hooks 369 and 370 as the slide moves backwards.

The gear wheel 385 (Figs. 10 and 12) is permanently connected with the motor shaft by means of a transmission and consequently is rotated, when the motor runs. The hub of the wheel 385 has a slot 386 to be engaged by the flange 387 of the gear wheel 388, when the two wheels are to be coupled to each other. Said wheel 388 has a coupling cam 389 with an oblique face 390. A compression spring 391 presses the wheel 388 with its cam 389 against a coupling arm 392, Figs. 10 and 12, which normally holds the flange 387 disconnected from the slot 386. Said arm is rockable on the stationary pin 393. The wheel 388 permanently meshes with the gear wheel 394 (Fig. 10) on the shaft 74, and on the same shaft a clearing cam is secured (see cam 77 in U. S. Patent No. 2,068,899). In its innermost or back position the slide 380 is locked by a pawl 395 having a tension spring 396. During the clearing operations this pawl is released by the pin 397 on the wheel 394 which strikes a surface or projection on the pawl.

To the coupling arm 392 (Fig. 10) one end of a link 398 is articulately connected by means of the pin 399. The other end of said link is articulately connected to the arm 400 by means of the pin 401. Said arm is rockable on the stationary pin 402 and carries a projection 403 which can enter a slot 404 of the disc 405 secured to the actuator shaft 5. The arm 400 may be rocked by manipulation of a clearing key 406. Obviously, this key can only be depressed when the actuator 4 is in its position of rest (stopping position), because only in this position can the projection 403 enter the slot 404.

The coupling arm 392 carries a pin 407 (Fig. 10) which is urged by a tension spring 408 against a projecting stop 409 formed on lever 380. This spring is tensioned between the link 398 and the slide 380.

A second tension spring 410 between a stationary pin and the slide 380 serves to restore the clearing means 406; 398; 380; and 392 to their position of rest. During the whole clearing operation the electric contact 334 of the motor is kept closed by the bell crank lever 411 fulcrumed on the shaft 333. A pin 412 secured to the slide 380 enters a slot of the lever 411; when the slide 380 is displaced backwards, that

is, to the right in Fig. 10, said slide via pin 412 rocks said lever 411 to close the contact 334.

Positions of the control lever and of the disconnecting lever

As mentioned above, the chief control lever 201 may assume three positions "*a*," "*b*" and "*c*" (Figs. 1, 11 and 13) for which the following symbolic marks are placed on the casing:

a) $\underset{\leftarrow}{\times}$ *b*) $\underset{\rightarrow}{\downarrow\times}$ and *c*) $\div$

The disconnecting lever 202 may be set to two positions, as shown in Fig. 1, namely: the right position → and the left position ↓. These levers 201, 202 control, among other operations, the automatic shifting of the actuator 4 in the following manner:

I. Lever 201 in position "*a*" and disconnecting lever 202 in its left or right position: For operations of multiplication by means of the key 1 the actuator is always shifted one step to the left, each time the operator takes his finger off the multiplication key, after the necessary number of revolutions of the actuator 4 have been made in the denomination (of the multiplier) concerned. After this automatic shifting the operator again depresses the key 1 for continuing the multiplication in the next higher denomination of the multiplier, etc.

II. Lever 201 in its position "*b*" and disconnecting lever 202 in its right hand position: When the operator takes his finger off the multiplication key after the necessary number of revolutions of the actuator 4 in the denomination (of the multiplier) concerned, the actuator is automatically shifted one step to the right. Then the operator again depresses the key 1 for continuing the multiplication in the next lower denomination of the multiplier, etc.

III. Lever 201 in its position "*b*," disconnecting lever 202 in its left position: When the operator takes his finger off the multiplication key, the actuator is not shifted automatically (but it may be shifted manually by means of the keys 197, 199).

IV. Lever 201 in its position "*c*" and lever 202 in its left or right position: The operator depresses the division key, then immediately releases it, and the actuator carries out automatic revolutions in the minus direction (that is clockwise in Fig. 2), followed by revolutions in the plus direction (counter-clockwise in Fig. 2) etc.; and after the correct number of revolutions in the direction concerned in one denomination of the divisor the actuator is automatically shifted one step to the right.

These operations are described in detail below.

When the plus key 203 or minus key 204 is depressed, no automatic shifting of the actuator is effected. The mechanism for preventing automatic shifting is shown in Fig. 19. When in an adding (or subtracting) operation the slide 380 is pressed backwards (in the direction of the arrow H), as mentioned above, it rocks the lever 411 clockwise and the projection 411*a* of said lever then engages the bent portion 269 of the lever 271 from above. This causes the lever 271 to be depressed somewhat and to be locked in its depressed position. When the actuator 4 is arrested in full-cycle position, the impulse lever 322 receives an impulse and the pin 329 releases the lever 271. But said lever is locked, as just mentioned, and no shifting is effected. Because said lever 271 is locked in a somewhat depressed position, the impulse lever 322 can swing back to its position of rest. After each revolution the actuator 4 is cleared automatically, that is, the machine works as an adding machine with direct subtraction, independent of the positions of the levers 201, 202.

MODE OF OPERATION

For the different calculations the machine is operated as follows:

Addition

After an item has been set in the actuator by means of the amount or item keys 200, the addition key 203 is depressed, and its motion is transferred to the multiplication key 1 through the link 344 (Fig. 11*a*) so that this key is also pressed down and becomes locked by its locking-down pawl 304 (Fig. 10). The pawl 360 is below the bent portion of the pawl 304 and is rocked so that its spring is tensioned. When the link 344 is rocked downwards by the key 203, the small hook 349 pivots in a clockwise direction by virtue of its engagement with stationary pin 351 so that the vertical arm of hook 349 is below the multiplication key 1. Thus, the key 203 cannot be restored, as long as the multiplication key 1 remains depressed, because this key locks the link 344 by means of the hook 349. When the key 203 is depressed, it also depresses the hook 358 which then can be engaged by the projection 376. When said key is depressed, it also lifts the slide 37 and the machine begins in well-known manner (U. S. Patent No. 2,127,102) a revolution in the plus direction, that is counter-clockwise in Fig. 10 so that the amount set in the actuator is entered into the accumulator or results register.

During this revolution the release arm 310 is rocked by the cam disc 308 acting on the roller 309 and through the pin 373 rocks the lever 375, whose projection 376 pushes the hook 358 and the slide 380 backwards, that is in the direction of the arrow H in Fig. 10. In its back position this slide is locked by the hook 395. When the arm 310 is rocked it moves the slide 311 in the direction of the arrow C to release the locking-down pawl 304 to release the key 203 which is restored to its position of rest by its spring. Even if the operator keeps this key pressed down, the pawl 304 cannot again lock the key, when the arm 310 is restored, because when the pawl 304 is released by the arm 310, the pawl 360 simultaneously is released and swings upwards, that is counter-clockwise in Fig. 10, and thus prevents the pawl 304 from locking the keys 1 and 203. The mechanism works as described only if control lever 201 is in its position "*a*" or "*b*." But if the lever 201 is in its position "*c*" for division so that the slide 311 is disabled, the pawl 304 is released through the impulse lever 322 which is actuated through the pin 383 on the slide 380, when the latter is moved due to the depression of the key 203. The motion of the slide 380 also releases the hooks 369 and 370 so that the slide 37 is pulled downwards by the spring 42. This slide now stops the machine after one single rotation of the actuator. The slides 36, 37 each carry one projection 1003 (Fig. 21) which releases the latches 45, 46 from the guide member 39, when the slide 36 or 37 is moved downwards by its spring 42. Consequently, the guide member 39 is restored to its central position and the machine stops, as described in detail in U. S. Patent No. 2,127,102. (See details 39, 45, 46 in that patent.) When the actuator has been arrested in its full-cycle position and the arms 310

and 375 swing back, the hook 358 is released and is pulled upwards into its position of rest by the spring 381. When displaced backwards the slide 380 tensions the spring 408, but the coupling arm 392 is kept locked by the disc 405 through the members 403; 400 and 398 and thus cannot be moved by said spring. When the rotation of the actuator has been stopped, the projection 403 enters the slot 404 of the disc 405 and the spring 408 pulls the link 398 backwards, that is, in the direction of the arrow H of Fig. 10. This motion of the link rocks the coupling arm 392 counterclockwise to release the coupling gear 388. The spring 391 now couples this gear with the power-driven gear 385 and due to this the actuator is now cleared in well-known manner (see U. S. Patent No. 2,068,899). Shortly before the end of the clearing operation, that is when the wheel 394 has rotated almost 360°, the pawl 395 is released by the pin 397 and the initiating members 380; 398; 392 for the clearing are now restored by the spring 410 to their position of rest. Thus the lever 392 is moved into the path of the oblique surface 390 of the cam 389 and during its continued rotation the gear 388 disconnects itself from the gear 385, and the clearing action is now finished.

During the whole clearing action the slide 380 keeps the motor contact 334 closed by means of the pin 412 and the levers 411 and 331.

Subtraction

When the subtraction key 204 is depressed, after an item has been set in the actuator, an operation of subtraction is effected in a manner quite analogous to that described above under the heading "Addition"; the only difference is that the actuator 4 rotates in the minus direction, as a result of the slide 36 being raised by the key 204 (whereas the addition key 203 raises the slide 37).

As was mentioned above, the operations of addition and subtraction are quite independent of the setting of the levers 201, 202.

Multiplication

For multiplication an item (multiplicand) is entered into the actuator 4 and the chief lever 201 is set to its position "*a*" or "*b*," while the disconnecting lever 202 may be set in its left or right position. The setting of the lever 202 determines the position of the shifting plate 250, when lever 201 is in its position "*b*."

If the knob 234 (Figs. 3 and 4) was not separately set by hand, the revolutions counter actuator 219 (Fig. 5) is set to rotate in the same direction as the actuator 4. In other words, for multiplication the revolutions counter actuator 219 always rotates in the same direction as the actuator 4, even though said actuator 4 can be caused to rotate in the negative direction by depression of the key 2. Also the stop impulse lever 102 for division (Figs. 3, 4) is disabled, because it is out of the path of the arm 237, when the latter is actuated by the tens transfer lever 100 of the highest denomination. The pawl 275 is locked by the arm 283 (Figs. 1, 9) and the small slide 311 is in its operative position shown in Fig. 2. Either of the keys 1 or 2 is now depressed to initiate positive or negative operation, respectively and the actuator begins to rotate correspondingly. The slide 311 moves the locking down pawls 304 and 305 to their inoperative position so that the depressed key 1 or 2 is restored to its position of rest, as soon as the operator releases it. When the key is restored, the motor contact 334 is opened and the actuator 4 is stopped in well-known manner, for instance, as described in U. S. Patent No. 2,127,102; either of the catching pawls 54 then stops the actuator (see also description under the heading "Addition" above). At a minus revolution (clockwise in Fig. 2), the actuator is caught by the right catching arm 54 and 57, but bounces back against the left catching arm 54 and 57 which is rocked thereby. This causes the pin 321 to rock the shifting impulse lever 322 so that this arm receives a shifting impulse. If the actuator 4 rotates in the plus direction, that is, counter-clockwise in Fig. 2, the actuator 4 is caught directly by the left catching arm 54 and 57 so that also in this case the lever 322 receives a shifting impulse through the pin 321. Said lever 322 moves the pin 329 away from the tip 328 of the hook 271 which is then pulled upwards by its spring 327 and releases the pawl 265 which is mounted on the end of lever 247. The spring 266 now rocks this pawl into the path of the swinging driving lever 267. The right end (Figs. 1 and 9) of the lever 247 is then rocked forwards, that is clockwise. If member 249 has not been set to its inoperative position (by the U-shaped member 259 at the last shifting step to the right), this motion is transmitted through the member 249 to the member 250 which will act upon either or none of the step shifting levers 254 and 255, according to the position to which the shifting plate 250 was set. According to the setting of said plate the actuator 4 is shifted one step to the left or to the right or is not shifted at all.

As mentioned above, the shifting plate 250 is set to engage the right step shifting lever 254, when the lever 201 is in its position "*b*" and simultaneously the disconnecting lever 202 is in its right position (→), as shown in Fig. 1 in full lines. On the contrary, the actuator 4 is shifted to the left, when the shifting plate 250 has been set to engage the left shifting lever 255 due to the fact that the lever 201 is in its position "*a*." (To what position the lever 202 is set is of no importance in this last-mentioned case.) If the chief lever 201 is in its position "*b*" and simultaneously its disconnecting lever is set in its left position (↓), the shifting plate 250 cannot actuate either of the step tabulating levers 254 or 255, and in such case the actuator is not automatically shifted.

It is to be observed that the hook 326 follows the hook 271, when the latter is drawn upwards by the spring 327, after the lever 322 has received a shifting impulse. Then the hook 326 closes the contacts 334 so that the latter remain closed during the whole step shifting action. When the lever 247 is moved forwards, that is clockwise in Fig. 1, the pin 273 acts on the cam 330 (Fig. 2) of the hook 271 and presses it down to release the impulse lever 322. Thus, the hook 271 returns to its position of rest and is locked again.

When the actuator is shifted to the left to its end position as described above, further shifting to the left is checked by a stationary stop, say, by the wall 217 after the last shifting step. When the actuator is shifted to its end position at the right, the revolutions counter actuator 219 acts on the U-shaped member 259 at the last shifting step, so that the hook lever 249 is disabled and further shifting to the right is prevented.

Because the revolutions counter actuator 219 rotates in the same direction as the actuator 4 (on the condition that the knob 234 has not been set by hand) and the impulse lever 237 (Figs. 3 and 4) is inoperative. short-cut multiplication may always be used, that is, the multiplication

may be carried out by a minimum of revolutions. Thus, the numbers "9" may appear in the highest denominations of the revolutions counter when the machine is manipulated by means of the key 2, and the machine is not stopped automatically when the capacity of the product (in the accumulator L) is exceeded.

Ordinary division with unlike rotation of actuator and revolutions counter actuator

For automatic division the control lever 201 is set to its position "c." This sets the elements as follows:

1. The stop impulse lever 237 is set to operative position (Fig. 3).

2. The shaft 218 (Fig. 5) is moved into its position of division or minus position, so that it will rotate in the opposite direction to the actuator.

3. The shifting plate 250 (Fig. 1) is rocked to the right by spring 253, independently of the position of the disconnecting lever 202. The plate 250 is consequently set to engage the right step shifting lever 254.

4. The lever 283 (Fig. 9) is rocked counterclockwise and no longer locks the pawl 275 on the lever 274.

5. The slide 311 (Fig. 2) is shifted so that it no longer acts on the pawls 304 and 305 (Fig. 10).

Now the dividend is set in the actuator 4 by means of the amount keys 200 and the key 198 is depressed so that the actuator is tabulated to its extreme left position (see U. S. Patent 2,243,075). The plus key 203 is now depressed by hand and this causes the dividend to be introduced into the accumulator and the actuator is automatically cleared, as described above. The revolutions counter is cleared by hand (see, for instance, U. S. Patent 2,188,748). Now the operator sets the divisor in the actuator by means of the keys 200, depresses the division tabulating key 198 to move the actuator to its extreme left position and initiates the automatic division by depressing the division key 2.

The tabulation of the actuator 4 to the left due to the manipulation of the key 198 moves the U-shaped member 259 (Figs. 1, 8 and 13) and the minus locking member 299 to the left, and the hook lever 249 is set to engage the projection 257. As mentioned above, the pawl 275 is now locked exclusively by the lever 247.

The manipulation of the division key 2 starts the motor and the pin 38 is moved to its — position (Fig. 6) and it moves the lever 294 so that the control plate 287 engages the multiplication key 1 (Figs. 1 and 2). When the motor runs, the driving lever 267 receives a swinging motion to and fro. Because the key 2 was depressed, the machine subtracts the divisor from the dividend, until over-draft occurs, that is, the capacity of the accumulator is exceeded; this rocks the tens transfer hook 100 (Figs. 3 and 4) of the highest denomination upwards and this motion is transferred as a stopping impulse through the members 237 and 102 and causes the actuator to stop in the following manner: When the lever 102 is thus swung in the direction of the arrow S (Fig. 21) it rocks counter-clockwise a stopping lever 1000 which is journalled on a stationary pin 1001. The pin 1002 on this stopping lever then releases the hook 369 or 370 so that the slide 36 or 37 is drawn downwards by its spring 42. Then the projection 1003 of the slide releases the latch 45 or 46 from the guide member 39, which is then restored to its central position (position of rest), so that the actuator is stopped, as described in detail in U. S. Patent No. 2,127,102. In minus operations the actuator 4 rotates clockwise in Fig. 2 and is consequently stopped by the right catching pawl 54 and the right catching arm 57. However it bounces back and strikes the left catching pawl 54 and the left catching arm 57 which is thus rocked. This causes the pin 321 to move the impulse lever 322 so that said lever receives a shifting impulse and its projection 323 releases the pawl 305; thus the division key 2 is released, returns to its position of rest and would open the motor contacts 334. But when the lever 322 is rocked, the pin 329 slides off from the projection 328 of the hook 271, which is thus liberated and drawn upwards by its spring 327. The hook 326 follows the hook 271 and would close the contacts 334 again. As a matter of fact the contacts are never opened, because the closing action is effected simultaneously with the opening action effected by the release of the key 2. When the hook 271 swings upwards, the pawl 265 is released and rocked by the spring 266 into the path of the swinging driving lever 267. The right end (Fig. 1) of the lever 247 to which the pawl 265 is pivoted is then rocked forwards, that is, clockwise, and this motion is transferred through the members 249 and 250 to the right step shifting lever 254 so that the actuator 4 is shifted one step to the right to the next lower denomination. When the lever 247 moves forwards, that is, clockwise, the pin 273 acts on the curve 330 of the hook 271 and presses it down to release the impulse lever 322. Thus, the hook 271 returns to its position of rest and is locked there again. The contacts 334 remain closed during the whole motion of the lever 247, due to the cam 326*a* (Figs. 2, 2*b*) of the hook 326, which rests upon the pin 273. During said clockwise motion of the lever 247 the pawl 275 is free to pivot in a counterclockwise direction and is hence drawn by the spring 277 into the path of the driving lever 267. At the backward or counter-clockwise motion of this lever 267 the arm 274 is rocked backwards in Fig. 1 and pulls down the key 1 by means of the control plate 287 (Figs. 1 and 9). When the driving lever 267 is moved backwards, as just mentioned, it moves the lever 247 into its position of rest by means of the projection 247*a* thereof. The pawl 265 is then rendered inoperative due to the fact that the projection 269 of the hook 271 now in its position of rest acts on the projection 268 (Fig. 1). When later the driving lever 267 again is moved forwards, it rocks the lever 274 (Figs. 9 and 13) back again through its projection 274*a*. The projection 278 of the pawl 275 strikes the lever 247 and said pawl is released from the lever 267. The tabulating mechanism is now again in its position of rest, but the multiplication key 1 has been pulled down.

Thus, the forward motion of the driving lever 267 effects a shifting of the actuator, while the backward motion of said lever pulls down the key 1. Because the operations are thus distributed, the load on the driving mechanism is reduced.

As was mentioned above the multiplication key 1 is now pulled down and thus the machine starts for plus revolutions, that is counter-clockwise in Fig. 2. The pin 38 (Fig. 6) is moved to its plus position and via the lever 294 it sets the control plate 287 to engage the key 2. The plus revolutions of the actuator 4 are continued, until the number "9" in the highest denomination of the accumulator is changed to "0," that is, the overdraft is cancelled (over-addition). This rocks the tens transfer hook 100 upwards and causes the machine to stop (just as described above for

the minus revolution). The actuator 4 is now checked by the left catching pawl 54 and the left catching arm 57, the shifting impulse lever 322 is rocked and the operation of actuator shifting is repeated again, as described above for the minus revolution. Thereupon also the division key 2 is pulled down. Thus, the division is continued with alternate minus revolutions and plus revolutions and the actuator is shifted one step when the direction of rotation is changed, until the revolutions counter actuator 219 reached the lowest but one denomination of the revolutions counter N. If the calculation began at an even denomination of the revolutions counter, say in the eighth denomination (which may be its highest denomination) the calculating operation is effected in accordance with the following scheme:

Denomination of revolutions counter	8	7	6	5	4	3	2	1
Direction of rotation of actuator 4	−	+	−	+	−	+	−	+

When the actuator 4 and the revolutions counter actuator 219 are shifted to the lowest denomination, the revolutions counter actuator 219 and its carrier 263 move the U-shaped member 259 to the right in Fig. 1, so that the hook lever 249 is disconnected from the projection 257 and consequently no further shifting to the right can be effected. The spring 301 tends to draw the minus locking member 299 to the right in Fig. 1, but the latter is locked by the part 293 which is in its minus position, shown in dotted lines in Fig. 1. The key 1 is automatically pulled down and the calculation begins in the lowermost denomination of the revolutions counter, the arm 294 and 293 being set to the plus position, when the key 1 is pulled down. This releases the member 299 which is drawn to the right in Fig. 1 by the spring 301 and stops in its position shown in Fig. 1. When after the necessary number of revolutions of the actuator 4 the lever 322 receives a stopping impulse, which is transferred as a shifting impulse to the lever 247, in the manner described above, said lever 247 makes a stroke (is rocked). But now the hook 249 is disconnected from the projection 257 so that the actuator 4 is not shifted, and, in addition, minus locking member 299 locks the pawl 275 and consequently the key 2 is not pulled down. The machine has now been stopped and the revolutions counter shows the quotient. The division has been completely carried out also in the extreme right or lowest denomination of the revolutions counter, and a positive remainder (or possibly no remainder) appears in the accumulator.

However, the division may also begin at an odd denomination of the revolutions counter, say in accordance with the following scheme:

Denomination of revolutions counter	8	7	6	5	4	3	2	1
Direction of rotation of actuator 4	−	+	−	+	−	+	−	+

The calculating operation is effected as described above until the moment in which the revolutions counter actuator 219 arrives at the lowest but one denomination of the revolutions counter. As is evident from the scheme above, in this denomination the actuator 4 makes one or more + revolutions and the arm 294 is in its position shown in Fig. 6. When thereafter the revolutions counter actuator 219 and the actuator 4 are shifted to the lowest denomination, the U-shaped member 259 is moved to the right in Fig. 1, and also moves the member 299 in the same direction through the spring 301. However, the mechanism is so constructed that at the motion of the lever 247 the pawl 275 snaps in, before the member 299 has reached its locking extreme right position. Thus, said member engages the projection 278 of the pawl 275 and consequently the key 2 is pulled down by the lever 267 by means of the control plate 287. This causes the projection 278 to slide off the edge 299*a* of the member 299, which then moves into its locking position. Immediately at the start of the machine (for the minus revolution initiated by the key 2 pulled down) the arm 294 is pressed into its minus position shown in dotted lines in Fig. 1 and presses the member 299 back again by means of the projection 303 against the tension of the spring 301 so that said member no longer locks the pawl 275. The control plate 287 is rocked to engage the multiplication key 1.

When so many revolutions have been made in the minus direction that the capacity of the accumulator is exceeded and an overdraft occurs, the highest denomination of the accumulator moves from "0" to "9," the machine is stopped as described above, and a step shifting impulse is initiated. This causes the lever 247 to be rocked again, but the hook lever 249 is inoperative and consequently the actuator 4 is not shifted. But the key 1 is pulled down by the control plate 287, because the pawl 275 is free. Thus, the actuator 4 is started in the plus direction, the reversal lever 294 is reversed (to its plus position) and the member 299 is allowed to enter its locking position. The actuator makes one plus revolution so that the numbers "9" in the highest denominations of the accumulator are moved to "0" and thus the over-draft is cancelled. Now the machine is stopped and thus a step shifting impulse is initiated, but it has no effect and the keys 1 and 2 are not further pulled down automatically. The division is completed; the quotient has been calculated down to the lowermost denomination of the revolutions counter and the remainder is positive (or zero).

In Fig. 11c there is shown a pawl 500 which in ordinary manner prevents more than one key from being pressed down simultaneously. This pawl is journalled on a pin 502 secured to a part 501 of the machine frame.

The division may also be stopped by depressing the lever 358 (Fig. 10) by hand. For this purpose said lever should be extended outwards through a slot in the machine casing. When said lever 358 is pressed down, the actuator 4 is cleared and this stops the machine in the manner described in U. S. Patent 2,068,899.

Positive division with like rotation of actuator and revolutions counter actuator

The control lever 201 is moved into its position "*c*" for division. Then the knob 234 is moved downwards and forwards by hand in the direction of the + arrow in Fig. 3 and this sets the revolutions counter actuator 219 to rotate in the same direction as the actuator 4. By means of the amount keys 200, the dividend is now entered in

the actuator 4, which is tabulated to its extreme left position by the manipulation of the key 198. Now the subtraction key 204 is depressed by the operator. Because this operation is effected by means of a minus revolution, it is not the dividend itself but its complementary value that appears in accumulator. (In other words, the dividend is subtracted from an item consisting of a one (unit) of a denomination just to left of (just higher than) the highest denomination of the accumulator, followed by zeros in all denominations of the accumulator; if the results register has, say, thirteen denominations, said item is 10,000,000,000,000 from which the dividend is subtracted. The unit in the fourteenth denomination which does not exist in the machine but is only imagined is called the "external imagined one"). Now in one or more denominations of the revolutions counter the number "9" appears, which is cleared by hand. Then the divisor is entered in the actuator 4, the key 198 is depressed to tabulate the actuator to its extreme left position, whereupon the automatic division is initiated, when the operator depresses the multiplication key 1. This automatic division is now effected as described above under the heading "Division" and the machine is finally stopped, but it is to be observed that the division is so to speak reversed and begins in the plus direction (scheme $+ - + - +$, etc.). Thus, when the operator depresses the multiplication key 1, as just mentioned, the division first begins with a number of plus revolutions until the "external imagined one" (that is, the item 10,000,000,000,000) is reached or exceeded, whereupon the stopping impulse thus released causes the actuator to be shifted one step to the right, and in this denomination the calculation continues due to the fact that the key 2 for division is pulled down to cancel the "overmultiplication" or positive overdraft, as said exceeding of the external imagined one may also be called, and the calculation is similarly continued in the various denominations of the revolutions counter.

The positive or plus-division is especially useful for automatically calculating problems of fractional equations or of calculating proportions or ratios that is problems in accordance with the formula

$$\frac{a}{b}\times c=y$$

such as interest problems, multiplication by vulgar fractions, etc. After the item "a" has been entered into the highest denominations of the accumulator as complementary value by means of the subtraction key 204, the item "b" is entered in the highest denominations of the actuator 4 (to the extreme left of it) and a number of zeros are then entered and finally the item "c" is entered as multiplicand into the lowest denominations of the actuator 4. Thus, in the actuator 4 now appears the item "b," after it a number of zeros and then the multiplicand "c" to the extreme right. Now the key 198 is depressed to move the actuator 4 directly to its extreme left position and the calculation is automatically started by depressing the multiplication key 1. The calculating operations are carried out automatically, until the lowest (extreme right) denomination of the revolutions counter has been reached. Now the revolutions counter shows the multiplier calculated by means of the positive or plus division, while the accumulator to the right shows the item "y," that is the result of the calculation, and to the left above the divisor "b" the remainder, if any, appears in the accumulator.

Full-automatic multiplication may be effected in accordance with the formula

$$\frac{a}{1}\times b=y$$

Control lever 201 is in its "c"-position while knob 234 is in its + position. The multiplier "a" is entered into the actuator 4 by means of the keys 200, the key 198 is depressed to tabulate the actuator 4 to its extreme left position and the subtraction key 204 is depressed to enter the complementary value of the multiplier in the accumulator. In the actuator 4 now the item "1" (unit denominator) is entered in the highest denomination thereof (extreme left pin wheel of the actuator) and thereafter a number of zeros are entered in the actuator and then the multiplicand "b" is entered in the lowest denominations thereof (that is at the right end of the actuator). Now the actuator is tabulated to its extreme left position by means of the key 198 and the multiplication key 1 is depressed. The machine now effects a full-automatic multiplication due to the fact that first so many plus-revolutions are effected in the highest denomination that the "external imagined one" is reached or exceeded that is, the plus-revolutions are continued until over-addition (positive overdraft) occurs. This causes a shifting impulse as described above and the actuator is shifted one step to the right and the calculating operations are continued, because the division key has been pulled down. When so many minus revolutions have been carried out that the item in the accumulator falls below the imagined external one (that is, over-subtraction or negative overdraft occurs) and consequently a complementary item appears in the accumulator, a shifting impulse is caused, etc., etc., until the multiplier "a" set from the beginning has been worked off to zero. Finally the product "y" appears in the accumulator and the revolutions counter shows the multiplier "a." In the actuator 4 stands to the right the multiplicand "b" and to the left the unit denominator, as before.

For calculating the reciprocal value of an item "a," heretofore division was effected in accordance with the formula

$$y=\frac{1}{a}$$

the unit item "1" being entered as dividend to the extreme left of the accumulator (highest denomination) while the divisor "a" is then entered into the actuator 4 and division is carried out in the ordinary manner. But if the machine is set to plus division as mentioned above, the reciprocal value "y" of the item "a" may be calculated automatically in accordance with the formulae $a\times y=1$. For this purpose, the item "a" is set as divisor in the actuator, the key 198 is depressed to tabulate the actuator to its extreme left position and the automatic calculation is initiated, when the operator depresses the multiplication key 1. Then first plus revolutions are effected as described above, until over-draft occurs and the imagined external one is exceeded, then the actuator is automatically shifted one step to the right and in the next denomination minus revolutions are effected to cancel the over-draft, as described above. Then the next shifting impulse is caused, etc., etc., until the machine is stopped, when the revolutions in the lowest denomination

of the revolutions counter have been completed. The accumulator then shows zero, if the divisor is an aliquot part of the dividend (that is, if dividend is divisible by divisor without any remainder), because evidently the accumulator cannot show the imagined external one. But if the reciprocal is not an aliquot part, the lowest denominations of the accumulator show the remainder. In the revolutions counter appears the reciprocal value "*y*" of the divisor "*a*."

It may be mentioned here that the machine can also calculate reciprocals by automatic division in another manner, viz., without the necessity of first entering the dividend "1" into the highest denomination of the accumulator; and this is effected as follows:

The control lever 201 is set to its position "*c*" for ordinary division, the divisor "*a*" is set in the actuator 4 by means of the keys 200 and the tabulating key 198 is depressed by the operator to tabulate the actuator 4 to its extreme left position. Now the operator depresses the division key 2 and keeps it depressed by his finger until after the machine is stopped, after the actuator 4 has made one minus revolution and has been automatically shifted one step to the right as described above. The operator now releases the key 2 and cancels the shifting step by depressing the left step shifting key 198, whereupon he again starts the machine by depressing the division key 2 again. Now the division is completed automatically and after the calculating operation in the lowest denomination of the results counter has been completed, the machine stops.

Fig. 16 shows a modified embodiment having no separate subtraction key. In this embodiment operations of addition are effected in the same manner as in that described above in connection with Figs. 1–15. For effecting a direct subtraction, the division key 2 is depressed, after the operator has set the hook 358 to its lowermost position. For rendering it possible to set this hook by hand, it has an extension 358*a* projecting through a slot in the casing of the machine. In addition, the hook also has a locking tooth 413 cooperating with a pin 414 on the slide 380. When the operator presses the hook 358 downwards into its lowermost position, its locking tooth 413 engages the pin 414 and the hook 358 is displaced to the left in the direction opposite to that of the arrow H, while the pin 379 of the hook 358 slides in the slot 415 of the slide 380. The spring 381 tends to draw the hook 358 in the direction of the arrow H and also upwards to engage the pin 414. The mechanism is so constructed that the hook 358 when it is depressed by the lever 344 (as described above in connection with Figs. 1–15), only moves so far downwards that the tooth 413 is still above the pin 414. In the same manner as in the embodiment shown in Figs. 1–15, the hook 358 in Fig. 16 is restored by the spring 381 to its position of rest in clearing operations.

But if operator presses the hook 358 manually so far downwards that it is locked in its depressed position by the tooth 413 and the pin 414, it remains in engagement with the projection 376 of the lever 375 so that now the machine effects a direct subtraction upon depression of the division key. Now the hook 358 is not restored automatically but must be restored by hand to its uppermost position.

We claim:

1. In a calculating machine having an actuator rotatable in two directions, in combination, an electric motor for driving said actuator, a manually operable multiplication key, a manually operable division key, means actuated by said keys for starting the motor and controlling the connection of said actuator to said motor for revolutions in opposite directions of rotation, an accumulator to be operated by said actuator, in either direction, a control lever settable to three positions, two positions being for multiplication and the third position for division, a shifting mechanism for said actuator, a setting mechanism under the control of said control lever to set said shifting mechanism to automatic shifting to the right and on the left respectively in dependence on the depression of said multiplication key in the two respective positions of multiplication of said control lever and to automatic shifting to the right in the position of division of said control lever, and a revolutions control device settable by said control lever for automatically operating said multiplication key and said division key, after one of said keys has been depressed manually to start said motor, said revolutions control device and said shifting mechanism being under the control of said accumulator to effect automatic revolutions control and automatic shifting in the position of division of said control lever.

2. In a calculating machine having an actuator rotatable in two directions, in combination, an electric motor for driving said actuator, a manually operable multiplication key, a manually operable division key, means actuated by said keys for starting the motor and controlling the connection of said actuator to said motor for revolutions in opposite directions of rotation, an accumulator to be operated by said actuator in either direction, a control lever settable to three positions, two positions being for multiplication and the third position for division, a shifting mechanism for said actuator, a setting mechanism under the control of said control lever to set said shifting mechanism to automatic shifting to the right and to the left respectively in dependence on the depression of said multiplication key in the two respective positions of multiplication of said control lever and to automatic shifting to the right in the position of division of said control lever, and a revolutions control device settable by said control lever for automatically operating said multiplication key and said division key, after one of said keys has been depressed manually to start said motor, said revolutions control device and said shifting mechanism being under the control of said accumulator to effect automatic shifting and automatic reversing of the direction of rotation of said actuator, each time when the capacity of said accumulator is exceeded.

3. In a calculating machine having an actuator rotatable in two directions, in combination, an electric motor for driving said actuator, a manually operable multiplication key, a manually operable division key, means actuated by said keys for starting the motor and controlling the connection of said actuator to said motor for revolutions in opposite directions of rotation, an accumulator to be operated by said actuator in either direction, a control lever settable to three positions, two positions being for multiplication and the third position for division, a shifting mechanism for said actuator, a setting mechanism under the control of said control lever to set said shifting mechanism to automatic shifting to the right and to the left respectively in dependence

on the depression of said multiplication key in the two respective positions of multiplication of said control lever and to automatic shifting to the right in the position of division of said control lever, a secondary lever for selectively disconnecting said shifting mechanism in one of said two positions of multiplication of said control lever, and a revolutions control device settable by said control lever for automatically operating said multiplication key and said division key, after one of said keys has been depressed manually to start said motor, said revolutions control device and said shifting mechanism being under the control of said accumulator to effect automatic revolution control, and automatic shifting in the position of division of said control lever.

4. In a calculating machine having an actuator rotatable in two directions, in combination, an electric motor for driving said actuator, a manually operable multiplication key, a manually operable division key, means actuated by said keys for starting the motor and controlling the connection of said actuator to said motor for revolutions in opposite directions of rotation, an accumulator operable by said actuator in either direction, a control lever settable to three positions, two positions being for multiplication and the third position for division, a shifting mechanism for said actuator, a setting mechanism under the control of said control lever to set said shifting mechanism to automatic shifting to the right and to the left respectively in dependence on the depression of said multiplication key in the two respective positions of multiplication of said control lever and to automatic shifting to the right in the position of divison of said control lever, an addition key, a uni-directional connecting member from said addition key to said multiplication key for depressing the latter when said addition key is depressed manually, a subtraction control member, a clearing mechanism under the control of said addition key for clearing said actuator after one single revolution and a revolutions control device for automatically operating said multiplication key and said division key, after one of said keys has been depressed manually to start said motor, said revolutions control device being under the control of said accumulator to effect automatic revolutions control and automatic shifting in the position of division of said control lever.

5. In a calculating machine having an actuator rotatable in two directions, in combination, an electric motor for driving said actuator, a manually operable multiplication key, a manually operable division key, means actuated by said keys for starting the motor and controlling the connection of said actuator to said motor for revolutions in opposite direction of rotation, an accumulator operable in either direction by said actuator, a control lever settable to three positions, two positions being for multiplication and the third position for division, a shifting mechanism for said actuator, a setting mechanism under the control of said control lever to set said shifting mechanism to automatic shifting to the right and to the left respectively in dependence on the depression of said multiplication key in the two respective positions of multiplication of said control lever and to automatic shifting to the right in the position of division of said control lever, an addition key, a uni-directional connecting member from said addition key to said multiplication key for depressing the latter when said addition key is depressed manually, a subtraction control member, a clearing mechanism under the control of said addition key and said subtraction control member for stopping and clearing said actuator after one single revolution, said subtraction control member being settable to be actuated by said division key, when depressed, and a revolutions control device for automatically operating said multiplication key and said division key, after one of said keys has been depressed manually to start said motor, said revolutions control device and said shifting mechanism being under the control of said accumulator to effect the automatic revolutions control and the automatic shifting for automatic division, when said control lever is set to division.

6. In a calculating machine having an actuator rotatable in two directions, in combination, an electric motor for driving said actuator, a manually operable multiplication key, a manually operable division key, means actuated by said keys for starting the motor and controlling the connection of said actuator to said motor for revolutions in opposite directions of rotation, an accumulator operable in either direction by said actuator, a control lever settable to three positions, two positions being for multiplication and the third position for division, a shifting mechanism for said actuator, a setting mechanism under the control of said control lever to set said shifting mechanism to automatic shifting to the right and to the left respectively in dependence on the depression of said multiplication key in the two positions of multiplication of said control lever, respectively, and to automatic shifting to the right in the position of division of said control lever, a pawl preventing the depression of more than one of said keys simultaneously, and a key depressing mechanism for automatically operating said multiplication key, and said division key alternately in division operations, when one of said keys has been depressed manually to start said motor, and disabling means for said key depressing mechanism under the control of said control lever to be released thereby for rendering said key depressing mechanism operative, when said control lever is in its position of division, said key depressing mechanism and said shifting mechanism being under the control of said accumulator to effect automatic revolutions control and automatic shifting of said actuator, when said control lever is in its position of division.

7. In a calculating machine having a power-operated actuator rotatable in two directions under the control of a multiplication key and a division key, in combination, an accumulator operable by said actuator in either direction, a control lever settable to three positions, namely one position for division, one position for multiplication with shifting to the right and one position for multiplication with shifting to the left, a shifting mechanism for said actuator, a setting mechanism under the control of said control lever to set said shifting mechanism to automatic shifting in accordance with the position of said control lever, a revolutions control device for automatically operating said multiplication key and said division key, after one of said keys has been depressed manually to start said motor, said revolutions control device being under the control of said accumulator to effect automatic revolutions control and automatic shifting for automatic division, when said control lever is in the position of division, and means for making the last rotation of said actuator a plus revolution in division.

after said actuator has been shifted to its extreme right position in division.

8. In a calculating machine having an actuator rotatable in two directions, in combination, an electric motor for driving said actuator, a manually operable multiplication key, a manually operable division key, means actuated by said keys for starting the motor and controlling the connection of said actuator to said motor for revolutions in opposite directions of rotation, an accumulator operable by said actuator in either direction, a control lever settable to three positions, two positions for multiplication and the third position for division, a shifting mechanism for said actuator, a setting mechanism under the control of said control lever to set said shifting mechanism to automatic shifting to the right and to the left respectively in dependence on the depression of said multiplication key in the two respective positions of multiplication of said control lever and to automatic shifting to the right in the position of division of said control lever, a revolutions control device for automatically operating said multiplication key and said division key, after one of said keys has been depressed manually to start said motor, said revolutions control device being under the control of said accumulator to effect automatic revolutions control and automatic shifting for automatic division, when said control lever is in its position of division, a revolutions counter actuator, and means under the control of said control lever for setting the direction of rotation of said revolutions counter actuator in dependence on the position of said control lever.

9. In a calculating machine having an actuator rotatable in two directions, in combination, an electric motor for driving said actuator, a manually operable multiplication key, a manually operable division key, means actuated by said keys for starting the motor and controlling the connection of said actuator to said motor for revolutions in opposite directions of rotation, an accumulator operable by said actuator in either direction, a control lever settable to three positions, two positions being for multiplication and the third position for division, a shifting mechanism for said actuator, a setting mechanism under the control of said control lever to set said shifting mechanism to automatic shifting to the right and to the left respectively in dependence on the depression of said multiplication key in the two respective positions of multiplication of said control lever and to automatic shifting to the right in the position of division of said control lever, a revolutions control device for automatically operating said multiplication key and said division key, after one of said keys has been depressed manually to start said motor, said revolutions control device and said shifting mechanism being under the control of said accumulator to effect automatic revolutions control and automatic shifting of said actuator for automatic division, when said control lever is set to division, a revolutions counter actuator, means under the control of said control lever for setting the direction of rotation of said revolutions counter actuator in dependence on the position of said control lever, and an additional manually operable member for setting the direction of rotation of said revolutions counter actuator independently of said control lever.

10. In a calculating machine having a motor-operated actuator rotatable in two directions of rotation under the control of a multiplication key and a division key, respectively, an accumulator operated by said actuator, a tens transfer mechanism for said accumulator, means for stopping the rotation of said actuator when a tens transfer is effected in the highest denomination of said accumulator, characterized by a setting member under the control of said stopping means to alternately depress and release said multiplication key and said division key automaticaly in automatic division, one of said keys being depressed, when the other is released, and vice versa.

11. In a calculating machine having a power-operated actuator rotatable in two directions under the control of a multiplication key and a division key, respectively, in combination, an accumulator operated by said actuator, a tens transfer mechanism for said accumulator, means for stopping the rotation of said actuator when a tens transfer is effected in the highest denomination of said accumulator, a control lever settable to three positions, namely one position for full-automatic division, one position for multiplication with shifting to the right and one position for multiplication with shifting to the left, a shifting plate settable by said control lever to three positions corresponding to said three positions of said control lever, a right and left shifting mechanism for said actuator selectively operable by said shifting plate in accordance with the setting thereof, and a driving device directly controlled by said actuator stopping means for reciprocating said shifting plate to actuate said right and left shifting mechanism each time said actuator is stopped.

12. In a calculating machine having a motor-operated actuator rotatable in two directions under the control of a multiplication key and a division key, respectively, in combination, an accumulator operable in either direction by said actuator, a chief control lever settable to three positions, namely, for automatic division, and for multiplication with automatic shifting to the right and to the left, respectively, a shifting plate settable by said lever, a right and left shifting mechanism for said actuator selectively operable by said shifting plate in accordance with the setting thereof, a stop mechanism for said actuator under the control of said accumulator, a driving device for said shifting plate under the control of said stop mechanism for effecting a shifting motion of said plate each time said actuator is stopped, a control plate settable under the control of said keys, said control plate when reciprocated, serving to move either of said keys to its operative position in accordance with the setting thereof, a disabling mechanism under control of said control lever to disable said control plate only when said control lever is in either of its positions for multiplication, and means under the control of said driving device for reciprocating said control plate, when not disabled.

13. In a calculating machine having a motor-operated actuator rotatably in two directions under the control of a multiplication key and a division key, respectively, in combination, an accumulator operable in either direction by said actuator, a chief control lever settable to three positions, namely, for automatic division and for multiplication with automatic tabulation to the right and to the the left, respectively, a shifting plate settable by said control lever, a right and left shifting mechanism for said actuator selectively operable by said shifting plate in accordance with the setting thereof, a stop mechanism for said actuator under the control of said accumulator, a driving lever driven by said motor, a swinging lever, a pawl on said swinging lever nor-

mally disabled but releasable by said stop mechanism to engage said driving lever for causing the latter to rock said swinging lever, and a hook lever journalled on said swinging lever to engage said shifting plate and to reciprocate it for effecting the shifting.

14. In a calculating machine having a motor-operated actuator rotatable in two directions under the control of a multiplication key and a division key, respectively, in combination, an accumulator operable in either direction by said actuator, a chief control lever settable to three positions, namely, for automatic division and for multiplication with automatic shifting to the right and to the left, respectively, a shifting plate settable by said control lever, a right and left shifting mechanism for said actuator selectively operable by said shifting plate in accordance with the setting thereof, a stop mechanism for said actuator under the control of said accumulator, a driving lever driven by said motor, a swinging lever, a pawl on said swinging lever normally disabled but releasable by said stop mechanism to engage said driving lever for causing the latter to rock said swinging lever, a hook lever journalled on said swinging lever to move said shifting plate for effecting the shifting, and means for disabling said hook lever in the extreme right end position of said actuator.

15. In a calculating machine, in combination, an actuator, two keys, a motor for rotating said actuator in opposite directions under the control of said keys, an accumulator operable by said actuator, a chief control lever settable manually to three positions, namely, for multiplication with automatic shifting of the actuator to the left or to the right and for automatic division, respectively, a disconnecting lever manually settable to a disconnecting position and a normal ineffective position, a shifting plate settable under the control of said chief control lever, a mechanism for shifting said actuator to the right and to the left operable by said shifting plate in accordance with the setting thereof, said disconnecting lever in its disconnecting position being in the path of the setting motion of said shifting plate to disconnect it from said shifting mechanism when said chief control lever is in its position for multiplication with shifting to the right, a stop mechanism for said actuator under the control of said accumulator in automatic division, and a driving device for said shifting plate under the control of said stop mechanism to effect a shifting motion of said plate when said actuator is stopped.

16. In a calculating machine having a motor-operated actuator rotatable in two directions under the control of a multiplication key and a division key, respectively, in combination, an accumulator operable by said actuator, a chief control lever settable to three positions, namely, for automatic division and for multiplication with automatic shifting of said actuator to the right and to the left, respectively, a shifting plate settable by said control lever, a right and left shifting mechanism for said actuator selectively operable by said shifting plate in accordance with the setting thereof, a stop mechanism for said actuator under the control of said accumulator in automatic division, a driving device for said shifting plate controlled by said stop mechanism to effect a shifting motion of said shifting plate when said actuator is stopped, means for clearing said actuator, an addition key controlling said clearing means, shift suppression means controlled by said addition key, and means between said addition key and said multiplication key to depress said multiplication key when said addition key is depressed manually.

17. In a calculating machine, in combination, a motor, a multiplication key, a division key, said keys serving to start said motor, an actuator rotatable in two directions under the control of said keys, an accumulator operable by said actuator, interlocking means for said keys preventing them from being depressed simultaneously, a chief control lever settable manually to three positions for automatic division and for multiplication with automatic shifting of said actuator to the right and to the left respectively, a shifting plate settable by said lever, a right-and-left shifting mechanism for said actuator selectively operable by said shifting plate, a stop mechanism for said actuator under the control of said accumulator in automatic division, a driving device for said shifting plate under the control of said stop mechanism to effect a shifting motion of said shifting plate when said actuator is stopped, a control plate movable under the control of said keys to engage the other key when one of said keys is depressed, said control plate, when reciprocated, serving to depress either of said keys to its operative position, except when the other key is kept depressed manually until after said actuator has been stopped, means for disabling said control plate under the control of said control lever to disable said control plate only when said control lever is in either of its two positions for multiplication, and means under the control of said driving device when a shifting motion is effected, for reciprocating said control plate, when not disabled.

18. In a calculating machine, in combination, a motor, a multiplication key, a division key, said keys serving to start said motor, an actuator rotatable by said motor in two direction under the control of said keys, an accumulator actuated by said actuator in either direction, interlocking means for said keys preventing them from being depressed simultaneously, a chief control lever settable manually to three positions for automatic division and for multiplication with automatic shifting of said actuator to the right and to the left respectively, a shifting plate settable by said lever, a right-and-left shifting mechanism for said actuator selectively operable by said shifting plate in accordance with the setting thereof, a stop mechanism for said actuator under the control of said accumulator in automatic division, a driving device for said shifting plate under the control of said stop mechanism to effect a shifting motion of said shifting plate, when said actuator is stopped, a control plate settable under the control of said keys to engage the other key than that depressed, said control plate, when reciprocated, serving to depress to its operative position the key engaged, except when the other key is kept depressed manually until after said actuator has been stopped, means for disabling said control plate under the control of said control lever to disable said control plate only when said control lever is in either of its two positions for multiplication, means under the control of said driving device for reciprocating said control plate when not disabled, and a minus locking member for disabling said reciprocating means for said control plate when said actuator is shifted to its extreme right position.

19. In a calculating machine, in combination, an actuator, two multi-revolution keys, a motor for driving said actuator in opposite directions of

rotations under the control of said keys, an accumulator operated by said actuator, a chief control lever manually settable to three positions, namely, for automatic division and for multiplication with shifting in opposite directions, a shifting plate settable under the control of said control lever, a mechanism for shifting said actuator to the right and to the left operable by said shifting plate selectively in accordance with the setting thereof when reciprocated, stopping pawls for said actuator, said stopping pawls being controlled by said accumulator in automatic division, a stop impulse lever receiving a stop impulse from said stopping pawls when said actuator is being stopped, a swing lever, a swing pawl on said lever normally disabled by said stop impulse lever but adapted to be released when said stop impulse lever receives a stop impulse, a driving lever driven by said motor and driving said swing lever when said swing pawl is released, a hook lever journalled on said swing lever, and a projection on said shifting plate normally in the path of said hook lever to be engaged thereby for reciprocation.

20. In a calculating machine, in combination, an actuator, two multi-revolution keys, a motor for driving said actuator for rotation in opposite directions under the control of said keys, an accumulator actuated by said actuator, a chief control lever manually settable to three positions, namely, for automatic division and for multiplication with shifting in opposite directions, a shifting plate settable by said lever, a right-and-left shifting mechanism for said actuator selectively operable by said shifting plate in accordance with the setting thereof, a stop mechanism for arresting said actuator in full-cycle position when it is being stopped, said stop mechanism being under the control of said accumulator in automatic division, a driving mechanism for said shifting plate under the control of said stop mechanism operable to cause a shifting motion of said shifting plate each time when said actuator is stopped except when said actuator is in its extreme right shifting position, a reversal lever rockable under the control of said keys, a control plate rockable by said reversal lever, to that one of two positions in which the other key is engaged when one of said keys is depressed, said control plate when reciprocated serving to depress said keys alternately, a control pawl normally disabled both by said chief control lever and by said driving mechanism and released when said chief control lever is in its position for automatic division and simultaneously said driving mechanism is rendered operable by said stop mechanism, a driving lever carrying said control pawl and connected with said control plate, and a driving lever driven by said motor and engaging said control pawl in its released position to reciprocate said control plate.

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