Dec. 19, 1944. P. H. ALLEN 2,365,507

CALCULATING MACHINE

Filed Jan. 27, 1940 8 Sheets-Sheet 1

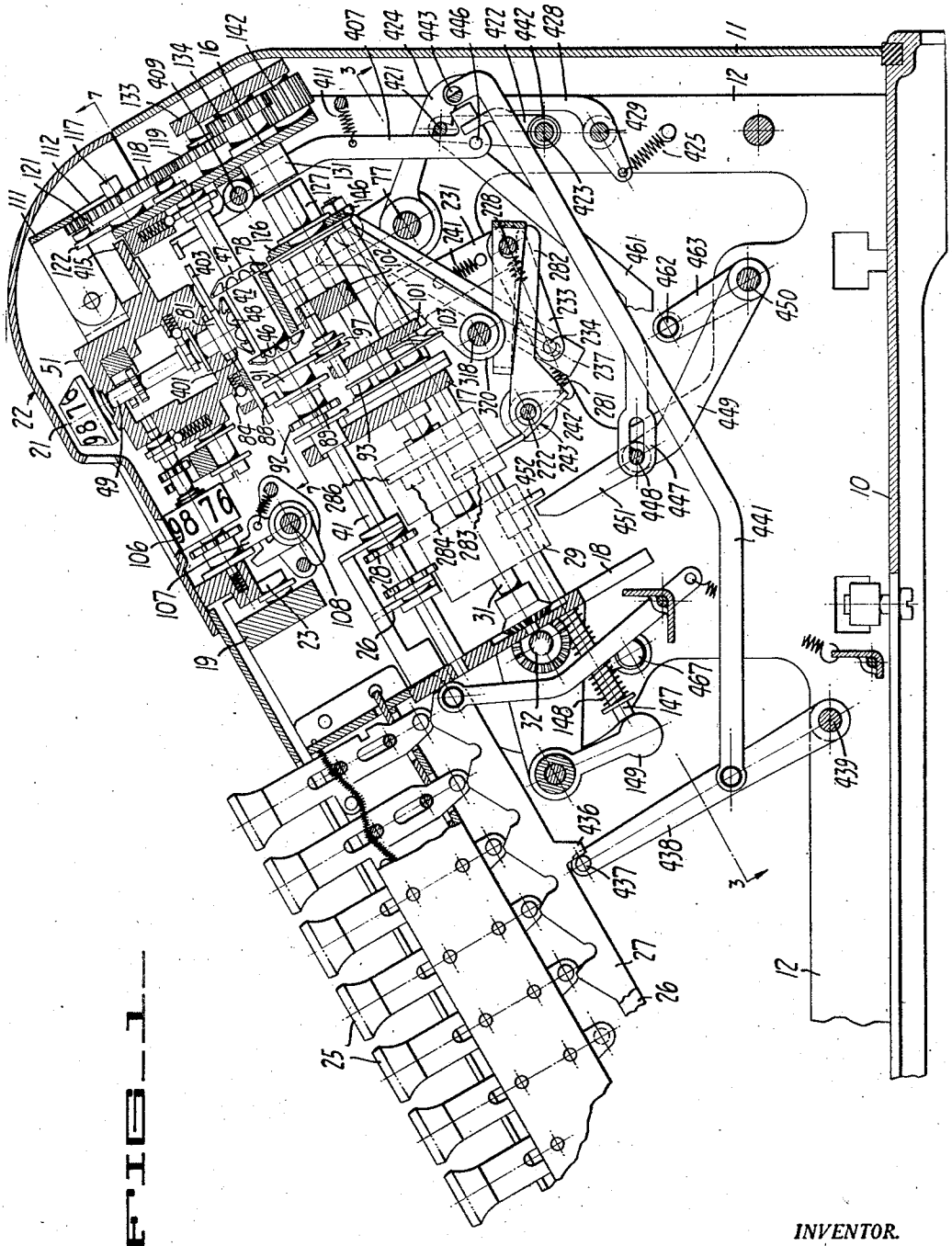


FIG. 1

INVENTOR.

Philip H. Allen

Dec. 19, 1944. P. H. ALLEN 2,365,507

CALCULATING MACHINE

Filed Jan. 27, 1940 8 Sheets-Sheet 2

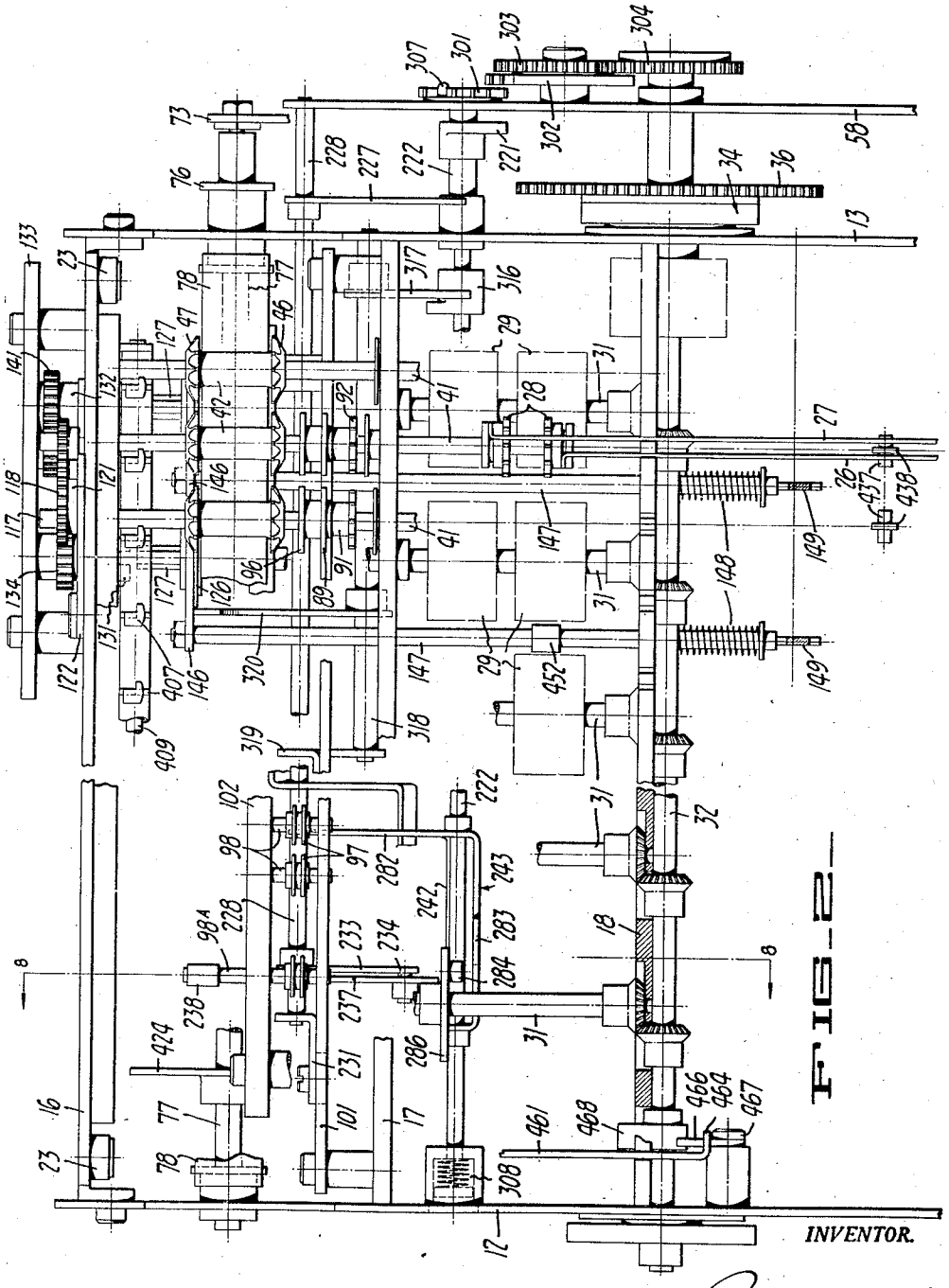


FIG. 2.

INVENTOR.

Philip H. Allen

Dec. 19, 1944. P. H. ALLEN 2,365,507

CALCULATING MACHINE

Filed Jan. 27, 1940 8 Sheets-Sheet 3

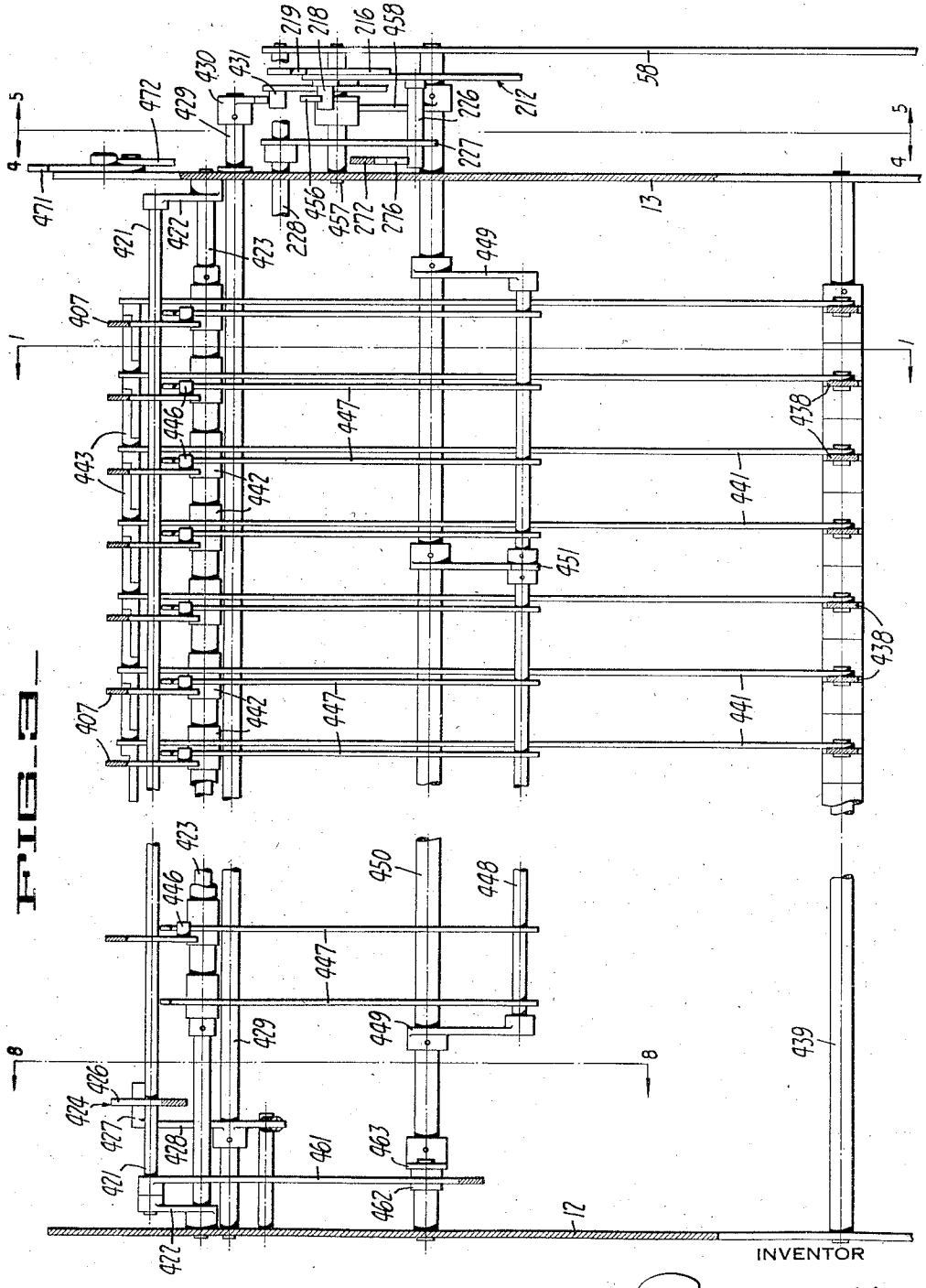


FIG-3

Dec. 19, 1944. P. H. ALLEN 2,365,507

CALCULATING MACHINE

Filed Jan. 27, 1940 8 Sheets-Sheet 4

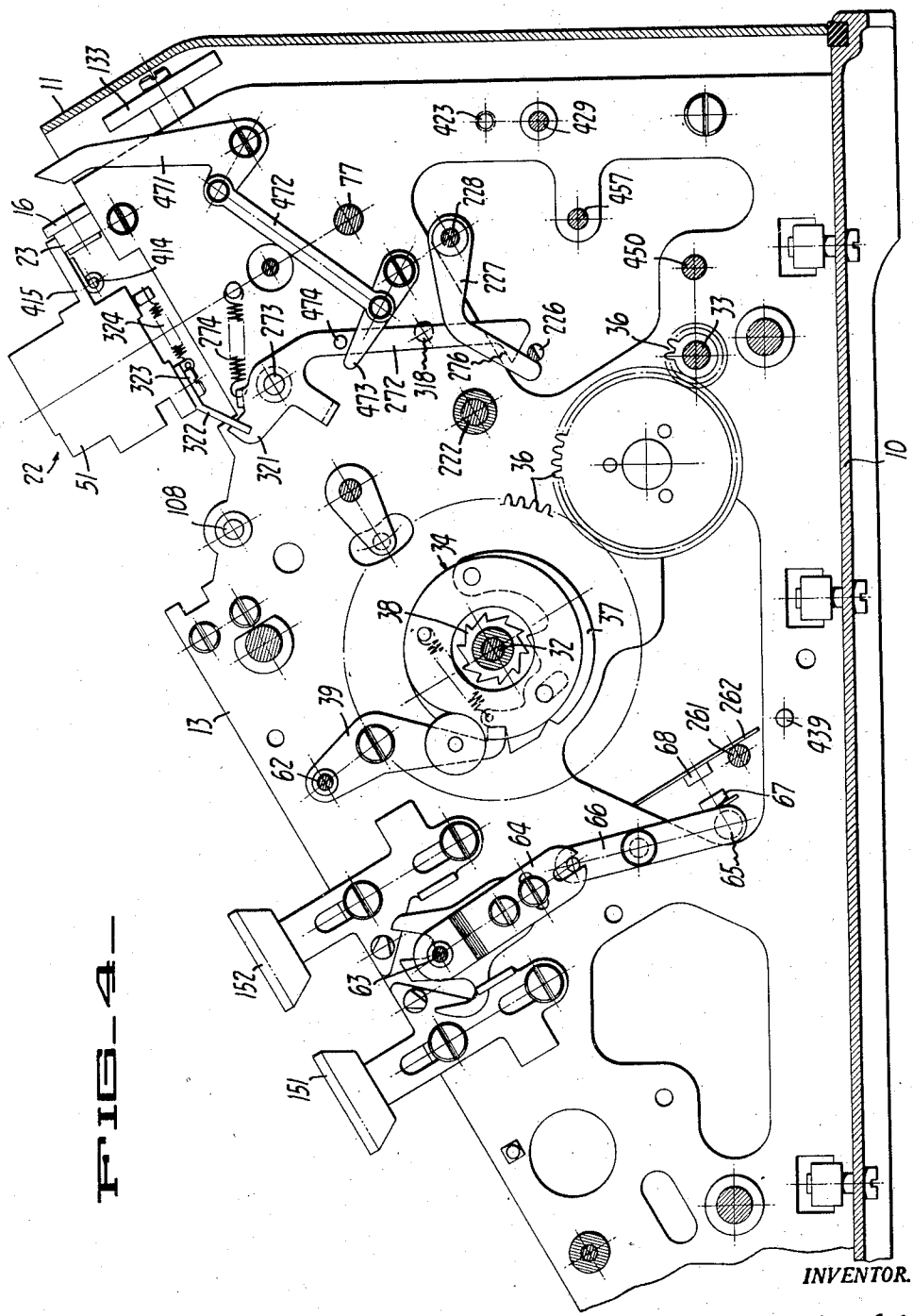


FIG. 4.

INVENTOR.

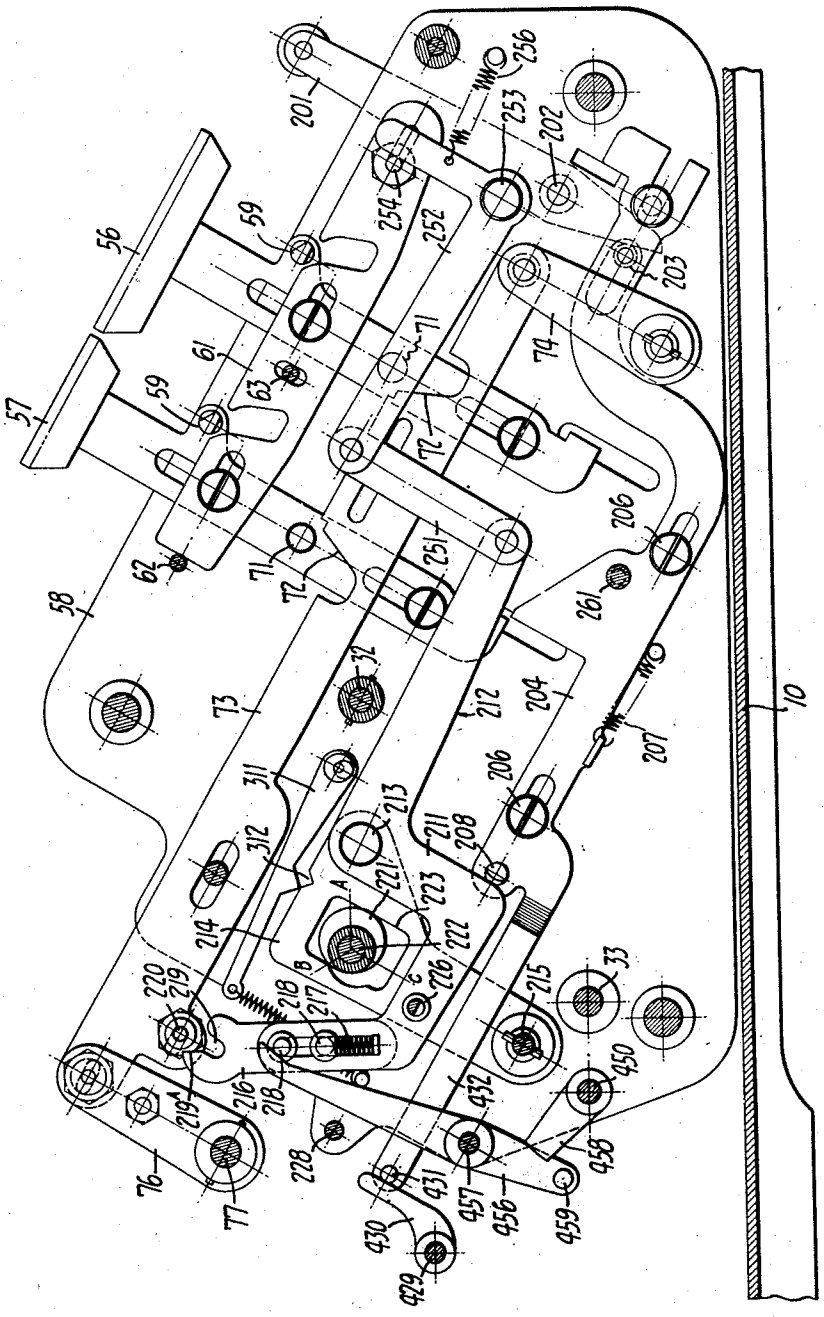
Philip H. Allen

Dec. 19, 1944. P. H. ALLEN 2,365,507

CALCULATING MACHINE

Filed Jan. 27, 1940 8 Sheets-Sheet 5

FIG. 5



INVENTOR.

Philip H. Allen

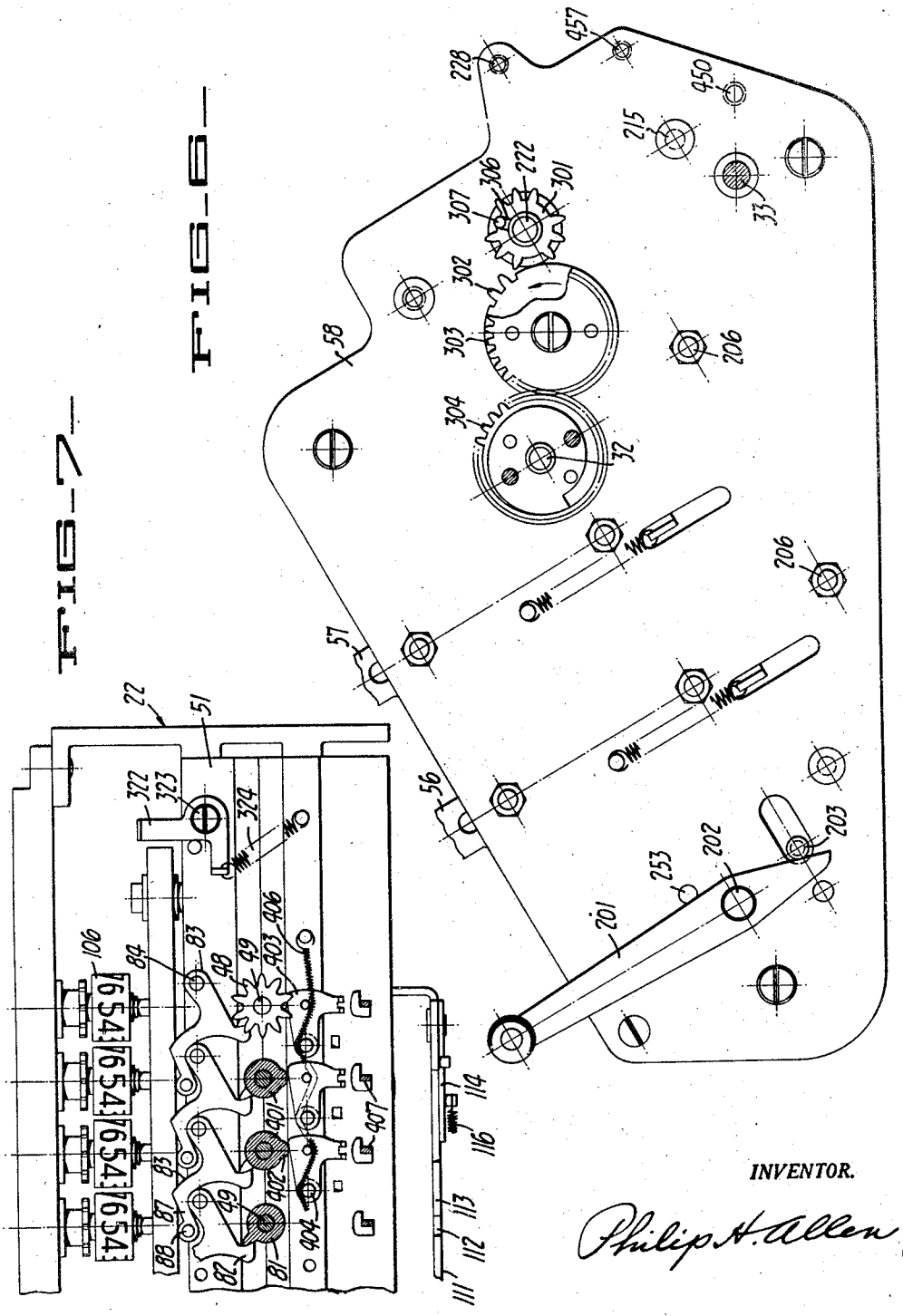
Dec. 19, 1944. P. H. ALLEN 2,365,507

CALCULATING MACHINE

Filed Jan. 27, 1940 8 Sheets-Sheet 6

FIG-6-

FIG-7-



INVENTOR.

Philip H. Allen

Dec. 19, 1944. P. H. ALLEN 2,365,507

CALCULATING MACHINE

Filed Jan. 27, 1940 8 Sheets-Sheet 7

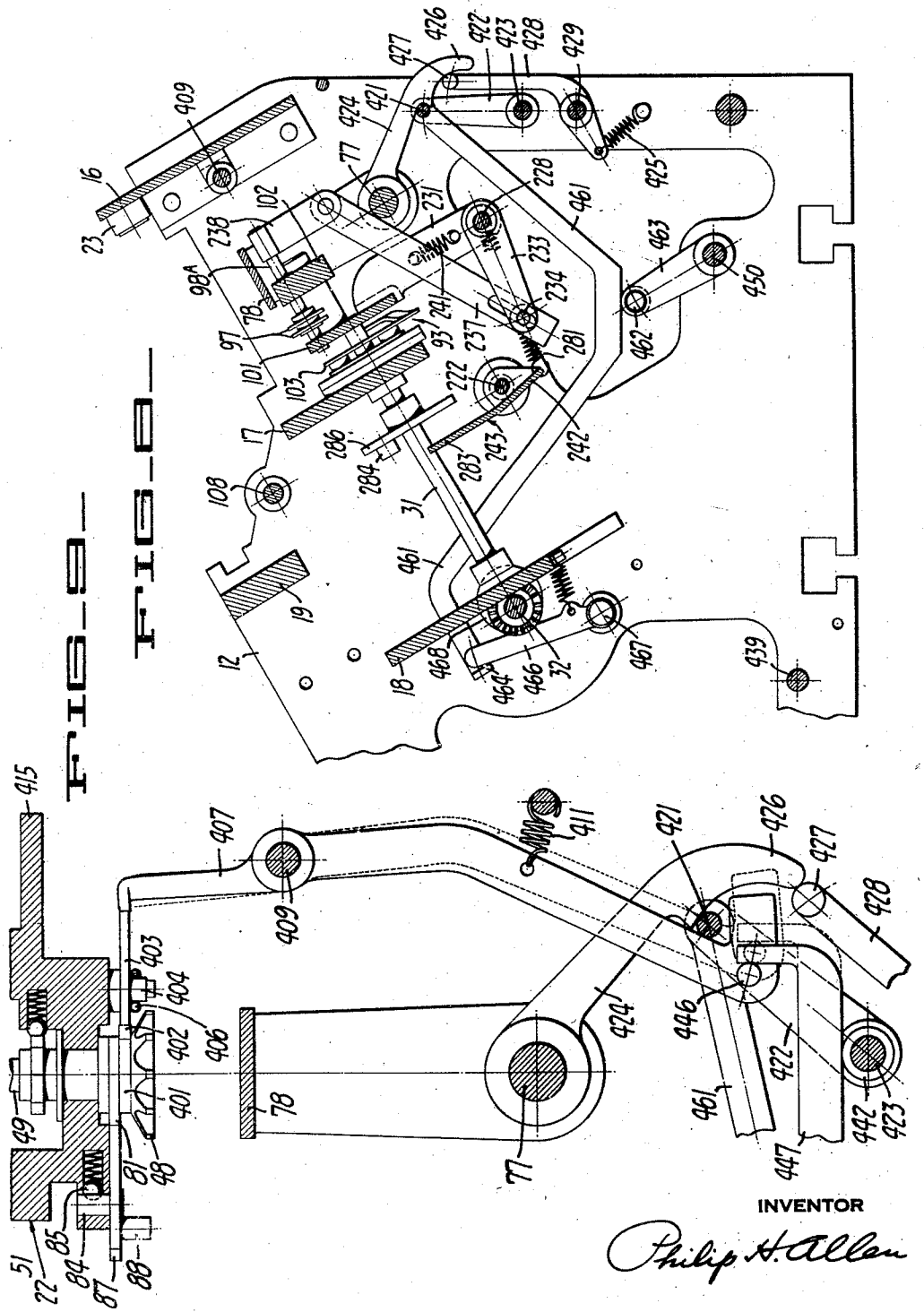


FIG. 9.

INVENTOR

Philip H. Allen

Dec. 19, 1944. P. H. ALLEN 2,365,507

CALCULATING MACHINE

Filed Jan. 27, 1940 8 Sheets-Sheet 8

FIG. 10

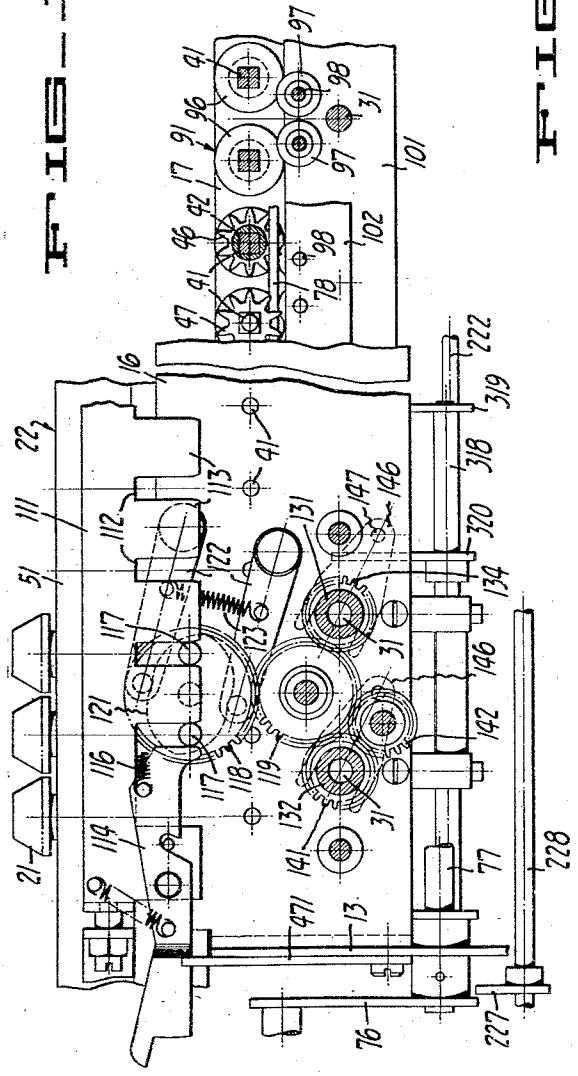
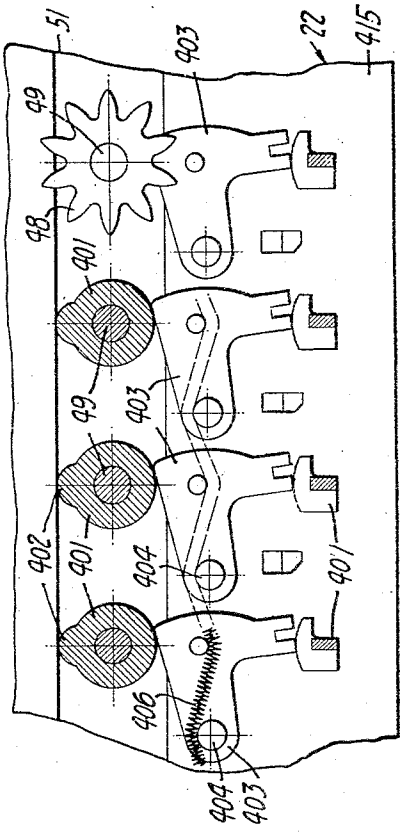


FIG. 11



INVENTOR

Philip H. Allen

Patented Dec. 19, 1944 2,365,507

UNITED STATES PATENT OFFICE

2,365,507

CALCULATING MACHINE

Philip H. Allen, Richmond, Calif., assignor to Friden Calculating Machine Co. Inc., San Leandro, Calif., a corporation of California

Application January 27, 1940, Serial No. 315,981

7 Claims. (Cl. 235—63)

This invention relates to calculating machines and is concerned more particularly with the provision of improved means for performing division operations.

It is a general object of the invention to provide improved means for performing division whereby alignment of the dividend and divisor can be effected automatically.

Other objects and advantages will be apparent from the following description of a preferred embodiment as illustrated in the accompanying drawings, in which:

Fig. 1 is a longitudinal sectional view through a calculating machine embodying my invention, with certain parts shown in section. The plane of the view is indicated by the line 1—1 in Fig. 3.

Fig. 2 is a sectional plan view with certain parts such as the carriage, key-sections and sensing mechanism omitted to clarify the view.

Fig. 3 is another sectional plan view illustrating the arrangement of the sensing and control mechanism, the plane of the view being indicated generally by the line 3—3 in Fig. 1.

Fig. 4 is a section showing the right side plate of the frame and certain of the control mechanism of the machine thereon, the plane of the section being indicated by the line 4—4 in Fig. 3.

Fig. 5 is a section showing other portions of the control mechanism including the plus-minus keys and the division control mechanism, the plane of the section being indicated by the line 5—5 in Fig. 3.

Fig. 6 is an elevational view showing a portion of the division controlling drive means.

Fig. 7 is a bottom plan view of the right-hand end of the carriage, the view being taken as indicated by the line 7—7 in Fig. 1.

Fig. 8 is a fragmentary sectional view taken as indicated by the lines 8—8 in Figs. 2 and 3.

Fig. 9 is an enlarged view similar to a portion of Fig. 1, but illustrating operated positions of the alignment sensing control.

Fig. 10 is a fragmentary rear elevational view of the machine with certain parts omitted and others shown in section.

Fig. 11 is an enlarged fragmentary view similar to Fig. 7 but showing an operated position of the alignment sensing control means.

My invention is illustrated in connection with the type of calculating machine having a unidirectionally operable actuator and reversible or bidirectionally operable numeral wheels, as disclosed in the patent of Carl M. Friden, Number 2,327,981, issued August 31, 1943. While certain features of my invention are adapted particularly for use in this type of machine, certain of such features and other features of my invention can be used in other types of calculating machines.

Selecting, actuating and accumulating mechanisms

The machine includes base 10 (Fig. 1) which supports casing 11 and has side frame plates 12, 13 (Figs. 1 and 2), mounted thereon. Side plates 12, 13 are connected by various cross frame brackets 16, 17, 18 and 19 which serve to mount various mechanisms referred to hereinafter.

The accumulator comprises a series of reversible numeral wheels 21 (Fig. 1) in register carriage 22 which is mounted on brackets 16 and 19 by rollers 23 for endwise shifting movement laterally of the machine in either direction to various ordinal positions. The values to be introduced into numeral wheels 21 are selected by means of a plurality of banks or orders of settable value keys 25, one of which banks is illustrated in part in Fig. 1. Each bank of keys 25 cooperates with selecting mechanism including a pair of spring-urged slides 26, 27 (Figs. 1 and 2) mounted for endwise movement to position the associated pair of gears 28 selectively with respect to the stepped teeth of the associated actuating cylinder 29 in accordance with the value of the depressed key. Cylinders 29 are mounted on actuating shafts 31 having suitable bevel gear connections with transverse shaft 32 which is suitably journalled in side plates 12, 13. Each shaft 31 serves for two orders of the machine and has a pair of cylinders 29 mounted thereon.

Shaft 32 and shafts 31 are driven cyclically from a suitable electric motor (not shown) through clutch 34 (Fig. 4) which is driven by suitable gearing 36 from motor shaft 33. As explained in said patent, clutch 34 is engaged or disengaged by oscillation of spring-urged clutch pawl or dog 37 mounted for rotation with shaft 32 with respect to ratchet 38 journalled on shaft 32 and driven by gearing 36. Clutch control lever 39 pivoted on side plate 13 determines engagement or disengagement of the clutch by releasing or engaging clutch dog 37 in the full cycle position thereof.

From the above description, it is seen that the values set in the machine by depression of keys 25 will be introduced into numeral wheels 21 by the cooperation of gears 28 with cylinders 29 during cyclic operation of the clutch. Each pair of gears 28 is slidably mounted on a sectional square shaft 41 (Figs. 1 and 2) supported in cross brackets 17, 18 and extending rearwardly of the ma-

chine through bracket 17 and having its rear end journalled in bracket 18. Intermediate brackets 16, 17, a spool 42 is slidably and non-rotatably mounted on each shaft 41 and has opposite bevel gears 46, 47 at its ends positioned for cooperation with numeral wheel gear 48 mounted at the lower end of numeral wheel shaft 49 journalled in frame 51 of carriage 22. Therefore, when one set of gears 46, 47 is engaged with gears 48, numeral wheels 21 will be rotated forwardly or reversely to register a number of increments equal to the value of the depressed keys 25 in the aligned banks of keys.

Plus and minus keys

Means are provided for selectively determining positive or negative registration on the numeral wheels in the form of plus key 56 (Fig. 5) and minus key 57 which are slidably mounted on auxiliary frame plate 58. Depression of either of keys 56, 57 serves to engage the clutch, close the motor circuit and select the sign character of the registration. To enable the drive, keys 56, 57 have respective pins 59 in operative relation with suitable cam surfaces on clutch actuating slide 61 mounted for endwise movement on plate 58. To effect control of the clutch by such movement, pin 62 on the upper arm of clutch control lever 39 (Figs. 4 and 5) abuts the rear end of slide 61, so that rearward movement of slide 61 oscillates lever 39 in a clockwise direction as viewed in Fig. 4 to release clutch dog 37 for engagement with ratchet 38 on shaft 32.

To close the motor circuit, slide 61 is connected by pin 63 (Figs. 4 and 5) with lever 64 (Fig. 4) pivoted on side plate 13 and pivotally connected at its lower end with lever 66 also pivoted on plate 13. Lever 66 has a suitable insulated pin 65 in overlapping relation with spring mounted contact 67 normally spaced from similar contact 68. Thus, movement of slide 61 operates through levers 64 and 66 to move contact 67 into engagement with contact 68.

To determine the sign character of the registration, plus and minus keys 56, 57 (Fig. 5) have respective rollers 71, disposed in operative relation with opposed cam surfaces 72 on plus-minus slide 73. Slide 73 is mounted for endwise movement at its front end by link 74 and at its rear end by arm 76 on shaft 77 (Fig. 5) which is suitably journalled in side plates 12, 13. Shaft 77 carries transversely extending strap 78 (Figs. 1 and 2) which is positioned between gears 46, 47 so that rocking movement of shaft 77 under control of plus-minus slide 73, serves to determine engagement of gears 46 or 47 with numeral wheel gears 48 (Fig. 1) or to determine the disengagement thereof as in the position shown. Thus, depression of the plus key 56 by meshing gears 46, 48 and enabling the drive determines one or more positive registrations of the value set in the keyboard on numeral wheels 21. Similarly, depression of key 57 determines one or more negative registrations of such values by meshing gears 47, 48.

Accumulator transfer mechanism

Means are provided for carrying from order to order in the accumulator register when the registration of a numeral wheel changes from zero to nine or vice versa. For this purpose, each numeral wheel shaft 49 (Figs. 1 and 7) carries single tooth gear 81 immediately beneath frame 51 in operative relation with nose 82 of transfer lever 83 pivoted at 84 on frame 51. Lever 83 is mounted in frame 51 (Fig. 1) by spring-pressed ball 85 engaging a suitable notch in pivot 84. Each lever 83 has an arm 87 (Figs. 1 and 2) extending into the next higher order of the machine and carrying pin 88 extending downwardly in operative relation with flange 89 (Figs. 1 and 2) on collar 91. Gear 92 on collar 91 is normally disposed out of the path of single tooth actuator 93 on shaft 31. When numeral wheel 21 of one order passes from nine to zero or vice versa, single tooth gear 81 rocks lever 83, which through pin 88, moves collar 91 to position gear 92 of the next higher order in the path of the associated transfer actuator 93. Thus, the transferred increment is introduced through either gear 46 or 47 of next higher order depending upon setting of the machine for addition or subtraction. Transfer gear 92 is maintained resiliently in either adjusted position thereof by the engagement of flange 96 of collar 91 between spaced flanges 97 on stub shaft 98 slidably mounted in cross brackets 101, 102 and engaged by a suitable spring-pressed ball (not shown). A suitable restoring cam 103 is provided for the shiftable transfer mechanism in association with transfer actuator 93.

Revolutions counter

A revolutions counter is also provided to register positively or negatively the number of actuations of accumulator numeral wheels 21. Revolutions counter numeral wheels 106 (Fig. 1) are suitably journalled in carriage 22 and are actuated by actuator 107 on shaft 108 to register the number of positive and negative registrations on numeral wheels 21 as fully disclosed in said patent.

Carriage shift mechanism

Means are provided for shifting the carriage in either direction from one ordinal position to another by power driven means controlled by manually operable keys. The power driven means comprises elements of the actuating means for entering values into the accumulator. Carriage 22 (Figs. 1 and 10) has plate 111 suitably mounted along the rear side thereof and provided with vertical slots 112. End slots 112 are formed in part by similar yieldable pawls 114, only one of which is shown, and which are connected by spring 116. Slots 112 are adapted for engagement by opposite shift pins 117 on shift gear 118 suitably journalled on bracket 16. Shift gear 118 is rotated selectively in either direction through idler gear 119 to shift the carriage through any desired number of ordinal spaces by the cooperation of pins 117 and teeth 113. Shift gear 118 (Figs. 1 and 10) is centralized by means of cam 121 and spring-urged centralizing arms 122.

In order to rotate shift gear 118 selectively in either direction the two right hand actuating shafts 31 (Figs. 1 and 2) are extended and are provided with similar controllable drive connections with gear 118. Each connection includes a collar 126 slidably and non-rotately mounted on the associated shaft 31. Collar 126 has teeth 127 in operative relation with corresponding slots in gear sleeve 131. Gear sleeve 131 is suitably journalled in bracket 18 and plate 133 and carries gear 134 (Figs. 1 and 10) meshing with idler gear 119. Similar gear sleeve 132 has gear 141 which meshes with wide gear 142 (Figs. 2 and 10) also in operative relation with idler gear 119. Thus, by selective shifting of collars 126 to establish a drive connection, rotation of actuating

shafts 31 determines rotation of shift gear 118 in either direction and correspondingly shifting of the carriage 22 in either direction.

Similar mechanisms are provided to control shifting of collars 126. Each mechanism includes a fork 146 (Figs. 2 and 10) at the rear end of rod 147 and engaging the associated collar 126. Rod 147 is slidably mounted in cross members 17, 18 and is spring-urged to the position shown by spring 148. Rods 147 (Figs. 1 and 2) have associated therewith respective arms 149 which are oscillated to shift rods 147 by means including shift keys 151, 152 (Fig. 4) mounted for endwise movement on side plate 13 and also suitably connected to engage clutch 34 and close the motor circuit. Thus, carriage 22 carrying numeral wheels 21 can be shifted selectively in either direction by depression of keys 151, 152.

Division mechanism

The division operation itself is performed in a conventional manner and the mechanism for effecting this operation will be described first.

Division control lever 201 (Fig. 5) is pivoted at 202 on plate 58 and has its lower end in operative relation with roller 203 on division setting slide 204. Slide 204 is mounted for endwise movement by slots formed therein and engaged by studs 206 on plate 58. Spring 207 tensioned between slide 204 and plate 58 urges slide 204 to its forward position illustrated in Fig. 5. Adjacent rear stud 206, slide 204 carries roller 208 in abutting relation with a depending part of rearward arm 211 of connecting lever 212. Lever 212 is pivoted at 213 on arm 214 which is supported pivotally at 215 on plate 58. Arm 214, as later described, forms a part of the program control device and is oscillated in controlling machine operation.

From the foregoing description, it is seen that rearward movement of division setting slide 204 serves through roller 208 to rock lever 212 in clockwise direction about its pivot 213. Such clockwise movement serves to connect the program control device with plus-minus slide 73 if the dividend and divisor are properly aligned or if the dividend is too far to the right with respect to the divisor. For this purpose the rearward arm 211 of lever 212 carries a slidable extension 216 which is normally spring-urged to extended position by spring 217 compressed between the lower one of a pair of studs 218 on extension 216 and engaging a slot in arm 211. In effect, extension 216 forms a compressible end for connecting lever 212 so that the connecting function can be temporarily disabled for a purpose later described.

At its upper end, extension 216 is provided with notch 219 adapted to engage pin 220 which is mounted on plus-minus slide 73. The movement of lever 212 to engage notch 219 with pin 220 serves to move slide 73 forwardly by virtue of cam surface 219A adjacent notch 219, thereby rocking shaft 77 and meshing gears 47, 48 so that the machine is set for subtraction. This action occurs because of the position of pivot 213 for connecting lever 212 as determined by control cam 221 on shaft 222 of the program control device. Cam 221 engages aperture 223 in arm 214 and is rotated in a manner described later to adjust the machine for addition or subtraction.

The clockwise oscillation of connecting lever 212 also serves to enable the overdraft mechanism with respect to the program control device. Pin 226 (Fig. 5) on rear arm 211 of lever 212 is disposed beneath arm 227 (Figs. 2 and 4) on the right hand end of shaft 228 journalled in auxiliary plate 58, side plate 13 and bracket 231 on cross bracket 101. Adjacent bracket 231 (Figs. 1 and 2), shaft 228 has arm 233 secured thereon having pin 234 disposed in a suitable slot in link 237. Link 237 (Figs. 2 and 8) is pivotally connected at its upper end to depending bracket 238 secured on the extended end of transfer stub shaft 98A of next to highest order of the machine. Link 237 is urged to the inoperative position thereof shown in Fig. 1 by spring 241 which normally maintains the free end of link 237 below depending plate portion 242 of lever member 243 rotatably and non-slidably mounted on shaft 222 of the program control device. Upon clockwise oscillation of lever 212, pin 226 rocks arm 227, shaft 228 and arm 233 to lift link 237 into operative position with respect to plate portion 242 of lever member 243.

The clockwise movement of lever 212 also serves to condition the clutch for engaging and the motor circuit for closing. At its front end lever 212 (Fig. 5) is pivotally connected with link 251 having its upper end pivotally connected to the rearward horizontal arm of bellcrank 252 which is pivotally mounted at 253 on plate 58. The vertical arm of bellcrank 252 is in abutting relation with pin 254 adjustably mounted on clutch actuating slide 61. Spring 256 tensioned between bellcrank 252 and plate 58 maintains bellcrank 252, link 251 and connecting lever 212 in the positions shown when division setting slide 204 is also in its idle position. Thus, clutch actuating slide 61 is free to be moved under the influence of the other operating controls.

From the described linkage it is seen that clockwise motion of lever 212 serves through link 251 and bellcrank 252 to move clutch actuating slide 61 rearwardly to rock control lever 39 (Fig. 4) to clutch engaging position as previously described.

It will be recalled also that the rearward movement of slide 61 serves through levers 64, 66 (Fig. 4) to move contact 67 to circuit closing position. However, the circuit is not closed but merely conditioned for closing by virtue of insulated pin 261 (Figs. 4 and 5) mounted on division setting slide 204 and engaging extended end 262 of contact 68. When slide 204 moves rearwardly pin 261 moves contact 68 out of circuit closing position and the circuit is merely conditioned for energization. Subsequent restoration of control lever 201 and division setting slide 204 allows contact 68 to return to normal position and engage contact 67 to start the division operation.

However, before the division operation begins, i. e., before return of lever 201 to its normal position, latch means becomes effective to latch the settable parts in their above described adjusted positions for the division. Preferably the latch means is associated with connecting lever 212 to maintain said lever in its adjusted active position until the end of the division operation, or until such operation is interrupted by the operator.

Flat bottomed pin 226 on lever 212 (Figs. 4 and 5) projects into operative relation with latch lever or member 272 (Fig. 4) pivoted at 273 on side plate 13 and urged in a clockwise direction as viewed in Fig. 4 by spring 274. When lever 212 is moved by setting slide 204, pin 226 moves upwardly rocking latch member 272 until pin 226 rises above latching face 276 on member 272.

Spring 274 then becomes effective to move face 276 beneath pin 226 whereby lever 212 and the parts adjusted thereby are maintained in operative relation. Thus, arm 214 of the program control device, connecting lever 212, plus-minus slide 73 and latch member 272 are latched together for movement as a unit, slide 73 having been adjusted to its minus or subtracting position. Also overdraft control link 237 (Fig. 1) has been moved into operative relation with member 243 of the program control device.

The above described conditioning is effected entirely during rearward movement of setting slide 204. Thereafter, when the operator releases lever 201, slide 204 and lever 201 are returned to normal position under the influence of spring 207 so that the circuit is closed as described above to start the division operation, if the dividend and divisor are in proper alignment or if the dividend is too far to the right with respect to the divisor or keyboard factor, as previously described.

When the machine starts operation, the divisor is subtracted repeatedly from the dividend to obtain the highest order digit of the quotient, when the divisor is subtracted once too often the resulting overdraft causing forward movement of stubshaft 98A (Figs. 2 and 8) to condition the overdraft control means for operation by the actuating means. When shaft 98A and link 237 move forwardly (Fig. 2) link 237 engages and actuates plate portion 242 of member 243 so that member 243 is rocked in a clockwise direction as viewed in Fig. 8. This movement occurs against the influence of spring 281 (Fig. 1) which normally maintains tail 282 of member 243 against shaft 228. Such clockwise movement of member 243 moves upwardly extending cam arm 283 thereof into the path of pin 284 on disc 286 secured on actuating shaft 31 of highest order.

Immediately after cam arm 283 is moved into the path of roller 284 it is engaged thereby to shift member 243 and shaft 222 to the right as viewed in Fig. 2 to start operation of the program control device. Thereafter the program control device determines a predetermined sequence of operations including correction of the overdraft, shifting of the register carriage to the next lower order, and resetting of the machine for subtraction.

The program control device, which in the typical example shown may comprise the shaft 222 and cams 221 and 316 thereon exercises its control by virtue of intermittent rotation of certain parts thereof including shaft 222 during the overdraft cycle of the machine and the two succeeding cycles after which the device is automatically disabled. To produce the intermittent movement of shaft 222, gear 301 (Figs. 2 and 6) is mounted on the end of shaft 222 which projects beyond the right hand side of auxiliary plate 58. Gear 301 is normally in the inoperative position shown in Fig. 2 out of the path of cooperating mutilated gear 302 which is driven cyclically through gear 303 carried by gear 302 and meshing with gear 304 on shaft 32. Such inoperative position is determined by notch 306 in gear 301 engaging over pin 307 on plate 58 under the urgency of spring 308 (Fig. 2) at the left end of shaft 222.

As seen in Fig. 6, gear 301 has three equally spaced sets of three teeth each for cooperation with a single set of two teeth provided on gear 302. Also as gear 302 rotates in a counter-clockwise direction as seen in Fig. 6, its teeth are positioned to engage a set of teeth of gear 301 immediately before the end of the cycle. The arrangement is such, therefore, that when gear 301 is projected into the path of gear 302 during a cycle of operation, gear 301 is rotated ⅓ revolution at the end of that cycle and ⅓ revolution at the end of each of the next two succeeding cycles, being maintained in projective position by the engagement of pin 307 on plate 58 with the inner face of gear 301.

It will be recalled that, upon overdraft, cam arm 283 (Fig. 1) is moved into the path of roller 284 so that shaft 222 is moved to the right and gear 301 is placed in operative relation with gear 302. Thus, the first ⅓ rotation of shaft 222 occurs just before the end of the overdraft cycle. This first ⅓ rotation of shaft 222 is utilized to change the setting of the machine from subtraction to addition so that the next cycle of the actuating means will cause a correction of the overdraft.

As described previously, eccentric cam 221 (Fig. 5) is now in position to set the machine for subtraction by moving plus-minus slide 73 forwardly of the machine when the machine is set for division by operation of lever 201, setting slide 204 and connecting lever 212. This position of cam 221 is indicated at A in Fig. 5. The ⅓ rotation of shaft 222 at the end of the overdraft cycle moves cam 221 from position A in a counterclockwise direction to position B and such movement results in rearward movement of arm 214, connecting lever 212 and plus-minus slide 73 to set the machine for addition by meshing gears 46, 48 (Fig. 1). The machine drive is maintained during such movement of arm 214 (Fig. 5) by connecting lever 212 as link 251 merely oscillates about its pivotal connection with bellcrank 252 without changing the adjustment of bellcrank 252.

Thus the operation cycle after an overdraft cycle serves to correct the overdraft and at the end of the corrective cycle the second ⅓ rotation of cam 221 and shaft 222 occurs to determine a carriage shift cycle of the machine. This is effected by setting plus-minus slide 73 to its neutral position where both gears 46, 47 are out of mesh with gear 48 as illustrated in Fig. 1 and by engaging the drive connection to determine a one-step shift of the carriage to the left. The second ⅓ rotation of shaft 222 (Fig. 5) moves cam 221 counter-clockwise from position B to position C where a slight clearance is provided so that arm 214, lever 212, plus-minus slide 73, and gears 46, 47 can be centralized quickly in neutral position by the engagement of spring-urged latching pawl 311 with notch 312 in arm 214.

Means are provided for engaging left hand shift collar 126 (Fig. 2) with gear sleeve 131, during such second ⅓ rotation of shaft 222. Cam 316 mounted on shaft 222 adjacent right side plate 13 is positioned normally out of alignment with arm 317 on shaft 318. Shaft 318 is pivoted in side plate 13 and bracket 319 of cross-bracket 101 and carries arm 320 which extends upwardly and rearwardly so that its end abuts left hand shift fork 146. When the program control device is enabled by shifting of shaft 222, cam 316 is moved into alignment with arm 317. Cam 316 is so positioned angularly on shaft 222 that it is effective to rock arm 317, shaft 318, and arm 320, to engage collar 126 with gear sleeve 131 during said second ⅓ rotation of shaft 222. Such engagement is maintained for one cycle of operation in the machine and effects one ordinal spacing of the carriage.

At the end of the shift cycle, shaft 222 receives

its third ⅓ rotation to restore the program control device to its original position, cam 221 (Fig. 5) being restored from position C to position A to reset the machine for subtraction, and shaft 222 (Fig. 2) being moved to the left by spring 308, notch 306 in gear 301 engaging over pin 307. As a result, the subtraction operation is begun in the new position of the carriage until an overdraft when the program control device is again placed in operation as described.

The described sequence of operation continues till the carriage is shifted into its lowest order position when division stop means becomes effective to terminate the operation automatically after the completion of the quotient figure of lowest order.

To effect this control the second ⅓ rotation of shaft 222 of the program control device after overdraft in the lowest order is utilized. Latch lever 272 (Fig. 4) is provided with an upwardly extending arm 321 which lies in the path of live pawl 322 (Figs. 4 and 7) pivoted at 323 on the bottom side of carriage frame 51 and held against a suitable stop pin by spring 324. As the carriage is shifted into the lowest order position, pawl 322 engages arm 321 and is turned about its pivot during the subtracting operation which ensues. After the overdraft cycle, the machine is set for addition which causes counter-clockwise movement of latch lever 272 and forward movement of arm 321 thereof a sufficient amount to allow pawl 322 to move into longitudinal blocking alignment with arm 321 so that further movement of latch lever 272 is prevented while the carriage is in its lowest order position. Therefore when the second ⅓ rotation of shaft 222 and cam 221 occurs at the end of the additive cycle plus-minus slide 73 and lever 212 are moved forwardly by cam 221, pin 226 moves off latching surface 276 of lever 272 to disable the division control mechanism. However this action is not completed until the clutch has begun the shift cycle. This cycle is ineffective to shift the carriage because of yielding of pawl 114 (Fig. 10) but operates to restore the program control device to its normal condition by moving cam 221 to its position A.

Division alignment control

As previously stated means are provided for shifting the carriage to the right when the dividend in the accumulator is out of alignment with the divisor in the keyboard by being too far to the left. For this purpose, sensing mechanism is provided for sensing when the numeral wheels of the accumulator which are in an inboard position are standing at a value other than zero and this sensing means is only brought into play with respect to the orders of the accumulator which are to the left of the keyboard set-up. The sensing mechanism is normally disabled and is only brought into play by the operation of the division lever.

Each numeral wheel shaft 49 (Figs. 1 and 7) carries a cam disc 401 having a rounded nose or cam extension 402 which, with the numeral wheel at zero, stands toward the rear of the machine. Associated with each cam disc 401 is a cam follower arm 403 pivoted at 404 on the bottom of the carriage frame and providing an interponent between the associated cam disc 401 and the aligned sensing lever. Interponents 403 are spring-urged towards the cam discs 401 by suitable strong spring 406.

From the foregoing description it will be seen that when interponents 403 are swung rearwardly to the position shown in Figs. 1 and 7, the associated numeral wheel is standing at zero. When the associated numeral wheel is standing at a value other than zero, the interponent 403 associated therewith will be positioned as shown, for example, in Fig. 11. The means for sensing the positions of the interponents and thereby the registration of the numeral wheels may comprise a series of sensing levers 407 for the inboard orders of the accumulator. Sensing lever 407 is mounted on transverse shaft 409 and each lever is urged in a counter-clockwise direction by an associated spring 411 whereby the upper end of each lever is urged toward the aligned interponent. The various sensing levers 407 are spaced in ordinal relation as shown in Figs. 2 and 7.

As seen in Fig. 2, the sensing levers 407 have their upper ends formed with cam surfaces at either end to insure shifting from order to order without jamming.

Sensing levers 407 (Fig. 1) are normally restrained against active movement by bail or rod 421 carried by arms 422 pivoted on transverse shaft 423. The restraining bail 421 is normally retained in the position shown in Fig. 1 by a latch 424. Latch 424 is pivoted on transverse shaft 77 and has a depending nose 426 overlying a pin 427 on an arm 428 secured on transverse shaft 429. At its right hand end shaft 429 carries an arm 430 (Figs. 3 and 5) lying in the path of pin 431 on an extension 432 of division setting slide 204. Thus upon movement of slide 204 to set the machine for division, arm 430 is rocked and operates through shaft 429 and latch 424 to release the sensing levers 407 before operation of the machine can start in division.

Means are provided for restraining all sensing levers of lower order than the highest order of the keyboard set up. For this purpose each pair of selecting slides 26 and 27 of the keyboard (Figs. 1 and 2) is provided with a depending ear 436 operatively engaged in the zero position of the selecting slide with pin 437 extending to either side of an upstanding lever 438 pivoted on transverse shaft 439. Each lever 438 therefore will be rocked in a counter-clockwise movement upon setting movement of either of slides 26, 27 associated therewith. Each arm 438 is pivotally connected to a link 441 which is supported at its rearward end by spacers 442 on transverse shaft 423. At its upstanding rearward end, each link 441 is provided with a transversely extending pin 443. The respective ends of each pin 443 are cut away at opposite sides so that the respective series of pins 443 are in overlapping relation whereby forward movement of link 441 will correspondingly move all of the lower order links. The link 441 from one order of the keyboard extends to sensing lever 407 of the same order so that upon setting a value in an order of the keyboard the corresponding order sensing lever 407 and all lower orders will be restrained against movement to active position upon release of bail 421.

The sensing levers when released control shifting of the carriage to the right in accordance with whether or not one of the inboard numeral wheels of higher order than the keyboard set-up is standing at a value other than zero. As seen in Fig. 1 any numeral wheel having its cam 401 set at zero has its interponent 403 rocked rearwardly to block operative movement of the asso-

ciated sensing lever 407. However, if a sensing lever is allowed to move forward at its upper end to the position shown in Fig. 9, the lower end through pin 446 moves an aligned link 447 rearwardly. Links 447 are also supported on transverse shaft 423 and extend forwardly, each link having a slot at its forward end engaging a transversely extending rod 448 supported by arms 449 on shaft 450.

Rod 448, arms 449 and shaft 450 form part of a bail assembly including an upstanding arm 451 (Fig. 1) having its upper end disposed immediately forward of a depending arm 452 on shift rod 147 associated with the shift mechanism for shifting the carriage to the right. Therefore if any sensing lever operates through its spring 411 (which is made strong enough to overcome the spring 148) and the link 447 to move the arm 451 rearwardly, the shift drive determining shifting of the carriage to the right will be engaged and will continue to be engaged so long as the numeral wheel standing at a value other than zero is in a position higher than the highest order position of the keyboard set-up.

During such shifting operation the division mechanism is maintained inoperative by virtue of the collapsible nature of the rearward end of connecting lever 212 (Fig. 5). As seen in Fig. 5, the upper pin 218 mounted on extension 216 has associated therewith a blocking arm 456 pivoted on transverse shaft 457 and normally disposed to block upward movement of extension 216 with the movement of connecting lever 212. If the shift is determined and shaft 450 is rocked in a clockwise direction as viewed in Fig. 1 then arm 458 (Fig. 5) on shaft 450 is moved into blocking relation with pin 459 at the lower end of lever 456. Thus, when division lever 201 is operated and a shift for alignment of the dividend and divisor is determined, the arm 456 is blocked against movement and thereby prevents upward movement of extension 216. In this way the program control device is not connected to the plu-minus slide and the gears remain in neutral position so that no registration can occur.

When all of the sensing levers 407 are restrained because the interponents 403 are positioned rearwardly by the zero projections 402 of the cam discs 401, then the spring on shift-rod 147 becomes effective to return arm 449 to the position shown in Fig. 1 and thereby disables the shift. This also removes the block from lever 456 so that the connecting lever 216 can move upwardly and perform its normal function in positioning the plus-minus slide for effective operation so that the division operation can start.

When the shift to the right is concluded or if no shift is determined, power operated means becomes effective to move the sensing levers to inactive position. As seen in Figs. 3 and 8, link 461 is pivotally connected to bail 421 at one end and rests on pin 462 carried by arm 463 on shaft 450 so that when shaft 450 is positioned as shown with the shift-rod 147 associated therewith in inactive position, link 461 is lowered and when shaft 450 is rocked to engage the shift for alignment of the dividend and divisor link 461 is raised. At its forward end, link 461 is provided with bent ear 464 for cooperation with arm 466 pivotally mounted at 467 and spring-urged toward cam 468 on transverse drive shaft 32.

During an aligning shift, ear 464 is maintained above arm 466 but at the end of such shift is lowered so that link 461 is moved by arm 466 and cam 468 to restore bail 421 to its active position where it is latched by latch 424 to maintain the sensing levers disabled.

If the wrong set-up is made for division so that the dividend cannot be shifted far enough to the right for alignment with the divisor, then a pawl at the left of the carriage similar to pawl 114 operates through a means (not shown) bell-crank 471 (Fig. 4), link 472 and arm 473, to engage arm 473 with pin 474 on latch lever 272 to release the connecting lever 212 and thereby disable the division mechanism and stop the operation of the machine.

Operation

The operation of the mechanism for aligning the dividend and the divisor may be briefly summarized as follows:

With the divisor and dividend set in the machine, the operator moves division lever 201 forwardly so that division setting slide 204 is moved rearwardly as viewed in Fig. 5, and the first operation is to rock arm 430 and shaft 429 which operates through arm 428 (Fig. 8) to move latch 424 to inactive position and thereby release the bail 421. This action serves to release the sensing levers 407 so that all unrestrained levers can rock counter-clockwise from the positions shown in Fig. 1 under the influence of their springs. It will be recalled that in setting the divisor in the keyboard, depression of a key 25 (Fig. 1) in the highest order of the divisor resulted in forward movement of associated link 441 to place pin 443 in blocking position behind the foot of the associated lever 407, and on account of the overlapping relationship of the pins 443 (Fig. 3) all levers 407 to the right of the highest order of the divisor are also rendered inoperative. In other words, all sensing levers to the left of the highest keyboard order in which a value other than zero has been set will be able to move forward as shown in Fig. 9, where if the numeral wheel is in zero position as shown in that figure, the sensing lever will be stopped in the full line position before being moved far enough to initiate the shift.

However, if an inboard numeral wheel is at a value other than zero, the upper end of the associated sensing lever 407 can continue its movement to the dotted line position shown in Fig. 9 when the lower end will have operated through the link 447 (Figs. 1 and 9) to rock arm 451 and thereby engage the shift drive connection which determines shifting to the right. This movement of shaft 450 to initiate a shift also rocks arm 463 which lifts link 461 above cam driven arm 466 so that the bail 421 can remain in inactive position until the shifting operation is completed.

At the time that arm 451 and shaft 450 are rocked to engage the shift, arm 458 (Fig. 5) on shaft 450 moves in front of pin 459 to block rocking movement of lever 456 and thereby block upward movement of spring-urged extension 216 of connecting lever 212. This action occurs before pin 208 becomes operative to start rocking movement of the connecting lever 212. As the rocking movement of connecting lever 212 begins the extension 216 is collapsed.

The rocking movement of lever 212 operates through link 251 and bell crank 252 to engage the clutch and to condition the contacts for closing. Upon release of the division lever the circuit is closed as described, and the shifting operation to the right begins. This shifting will continue until the highest order value of the dividend

is aligned with the highest order value of the divisor.

Whenever the displaced interponent 403 is moved out of alignment with an active sensing lever, the lever is moved back to the full line position shown in Fig. 9 so that the shift controlling connection 147 can be returned to normal position under the influence of spring 148, whereby link 461 (Fig. 8) is lowered into cooperation with cam driven lever 466. Then lever 466 rocks bail 421 to restore all the levers to inactive position where they are held by latch 424. Toward the end of the same cycle block 458 (Fig. 5) is moved from in front of lever 456 so that the extension 216 can snap into place and set the plus-minus slide 73 for subtractive operation.

It will be understood that the timing of the above operations is such that as the carriage concludes the last shifting step to cause alignment of the highest order values of the dividend and divisor, the shift control is disabled by reason of the fact that all the sensing levers 407 are restrained either by the pins 443 or the interponents 403 and consequently the block 458 is not disposed in blocking relation to the pin 459 at the beginning of the next cycle and the connecting lever extension 216 becomes operative, so that the next cycle will be the initial cycle of subtractive operation in the regular division procedure which is effected in a conventional manner.

As previously explained, if the dividend is too far to the right with respect to the divisor, the alignment is effected under control of the conventional division control mechanism.

I claim:

1. In a calculating machine having a shiftable carriage, a dividend register in said carriage, actuating means for said register, means including a keyboard for entering a divisor, and means for shifting said carriage, means for dividing an amount registered in said dividend register by an amount set in said keyboard by a subtractive operation, including manually operable control means for initiating a division operation, said control means having one movement for setting the machine for division and a subsequent movement for initiating the division operation, sensing means enabled by said manually operable control means upon said initial movement thereof for sensing values other than zero in numeral wheels ordinarily aligned with said actuating means and of higher order than the keyboard set-up, and means responsive to the sensing of a value other than zero by said sensing means to prevent subtractive operation upon said subsequent movement of said manually operable control means and to initiate a shifting operation to bring the values of the dividend and divisor into alignment for said subtractive operation.

2. In a calculating machine having a shiftable carriage, a dividend register in said carriage, actuating means for said register, means including a keyboard for entering a divisor, and means for shifting said carriage, means for dividing an amount registered in said dividend register by an amount set in said keyboard by a subtractive operation, including manually operable control means for initiating a division operation, sensing means enabled by said manually operable control means when the machine is set for division for sensing values other than zero in numeral wheels ordinally aligned with said actuating means of higher order than the keyboard set-up, and means responsive to the sensing of a value other than zero by said sensing means to prevent subtractive operation and to initiate a shifting operation to bring the values of the dividend and divisor into alignment for said subtractive operation.

3. In a calculating machine having a shiftable carriage, a dividend register in said carriage, actuating means for said register, means including a keyboard for entering a divisor, and means for shifting said carriage, means for dividing an amount registered in said dividend register by an amount set in said keyboard by a subtractive operation, including manually operable control means for initiating a division operation, sensing means enabled by said manually operable control means when the machine is set for division for sensing values other than zero in numeral wheels ordinally aligned with said actuating means and of higher order than the keyboard set-up, and means responsive to the sensing of a value other than zero by said sensing means to prevent subtractive operation and to initiate a shifting operation to bring the values of the dividend and divisor into alignment for said subtractive operation, and means responsive to alignment of the dividend and divisor values to disable the control of said sensing means and to initiate said subtractive operation.

4. In a calculating machine adapted to perform division by the successive subtraction method, a plurality of orders of means in which the figures of a divisor can be set, an ordinally shiftable register having a plurality of orders of means in which the figures of a dividend can be set, means for shifting said register in the direction of decreasing orders, a control therefor operable to cause a shift operation, a plurality of orders of actuators for said control, one for each order of said divisor setting means, means tending to cause said actuators to actuate said shift control, a pair of ordinally aligned sensing means for each of said actuators, one of said pair of sensing means being movable in response to the setting of a figure other than zero in said divisor setting means to restrain the actuator associated therewith, means for moving all the divisor sensing means in orders below that of the first significant figure of the divisor, the other one of said pair of sensing means being movable in response to a figure other than zero in the associated order of said dividend setting means to permit operation of the actuator provided the divisor sensing means has not been moved.

5. In a calculating machine adapted to perform division by the successive subtraction method, plural order selecting mechanism, an ordinally shiftable carriage having numeral wheels therein, means for shifting said carriage in the direction of decreasing orders, an operation control for said shifting means, a series of selecting mechanism sensing means, a corresponding series of numeral wheel sensing means, the sensing means in the two series being arranged in ordinally-aligned pairs for cooperation, each selecting mechanism sensing means being movable in response to the setting of a divisor figure other than zero to restrain the associated numeral wheel sensing means, means for moving all the selecting mechanism sensing means in orders below that of the first significant figure of the divisor, each numeral wheel sensing means being movable unless restrained by the associated selecting mechanism sensing means in response to a dividend figure setting other than

zero in the numeral wheel aligned therewith, and means responsive to movement of any one of said numeral wheel sensing means for moving said carriage shift control to operative position.

6. In a calculating machine adapted to perform division by the successive subtraction method, a frame, an ordinally shiftable carriage on said frame, means for shifting said carriage from one ordinal position to the next, numeral wheels in said carriage for registering a dividend, a series of sensing members mounted in ordinal arrangement on said frame along the path of said carriage, means on said carriage including a zero-position index for each numeral wheel adapted to cooperate with the sensing members ordinally aligned therewith to determine movement of said sensing members, a plural order keyboard for entering a divisor, means controlled by said keyboard for restraining the sensing members in alignment with the order in which the first significant figure of the divisor is entered and all lower orders, a control means for said carriage shifting means rendered operative upon movement of any one of the unrestrained sensing members to sense the zero-position index opposite thereto when the associated numeral wheel is out of zero position.

7. In a calculating machine adapted to perform division by the successive subtraction method, a frame, an ordinally shiftable carriage having numeral wheels therein, means to shift said carriage on said frame in the direction of decreasing orders, a control for said shifting means, ordinally arranged means on said frame for operating said control, a plural order keyboard for entering the divisor, means controlled by said keyboard for preventing operation of the shift control operating means in the order in which the first significant figure of the divisor is entered and in all lower orders, and means including a zero-position index for each numeral wheel for preventing operation of the shift control operating means in inboard orders higher than the order of the first significant figure of the divisor when the numeral wheels in said higher orders are in zero position.

PHILIP H. ALLEN.