May 22, 1956 E. E. REYNOLDS 2,746,678

FUGITIVE ONE MECHANISM

Filed April 13, 1951 3 Sheets-Sheet 1

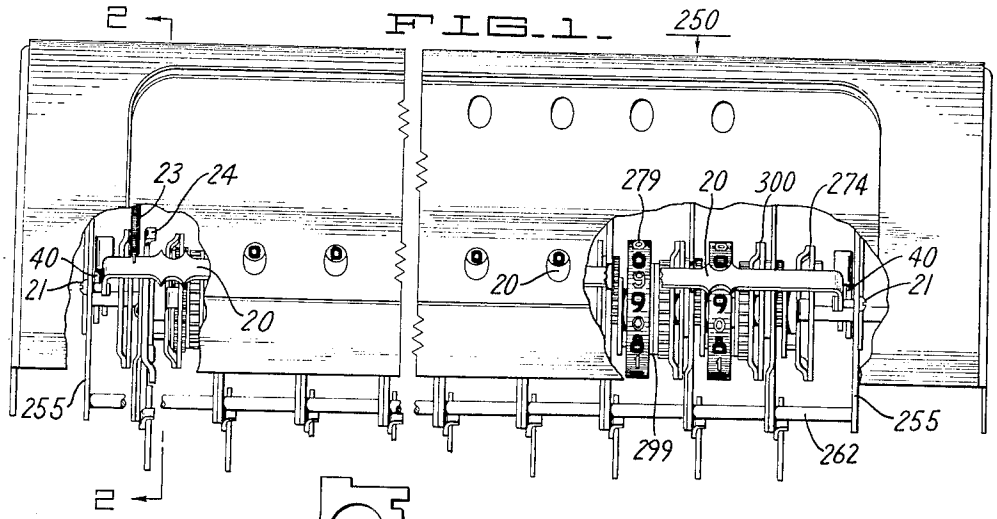


FIG. 1.

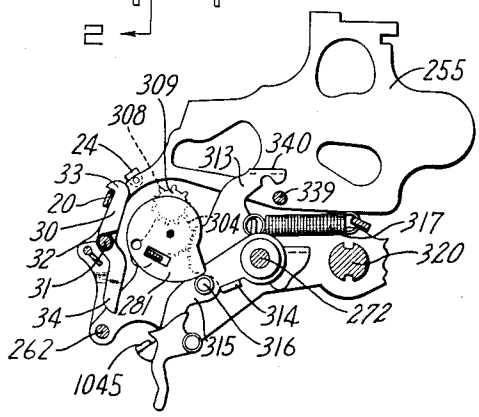


FIG. 2.

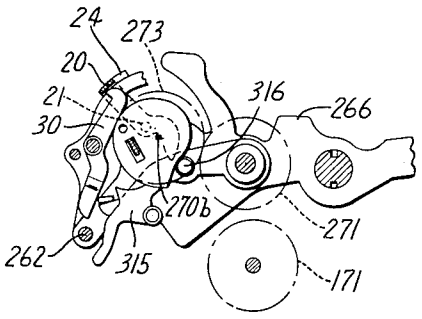


FIG. 3.

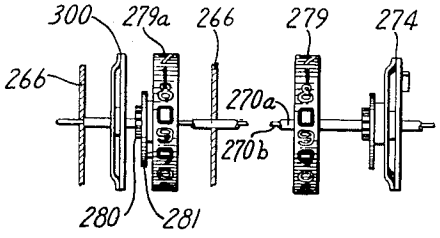


FIG. 4.

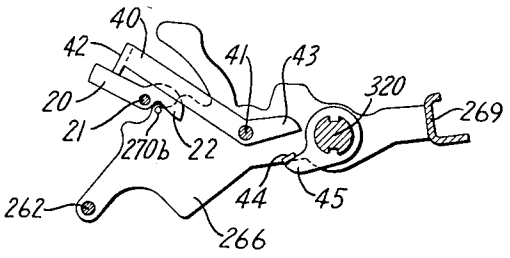


FIG. 5.

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FUGITIVE ONE MECHANISM

Filed April 13, 1951 3 Sheets-Sheet 2

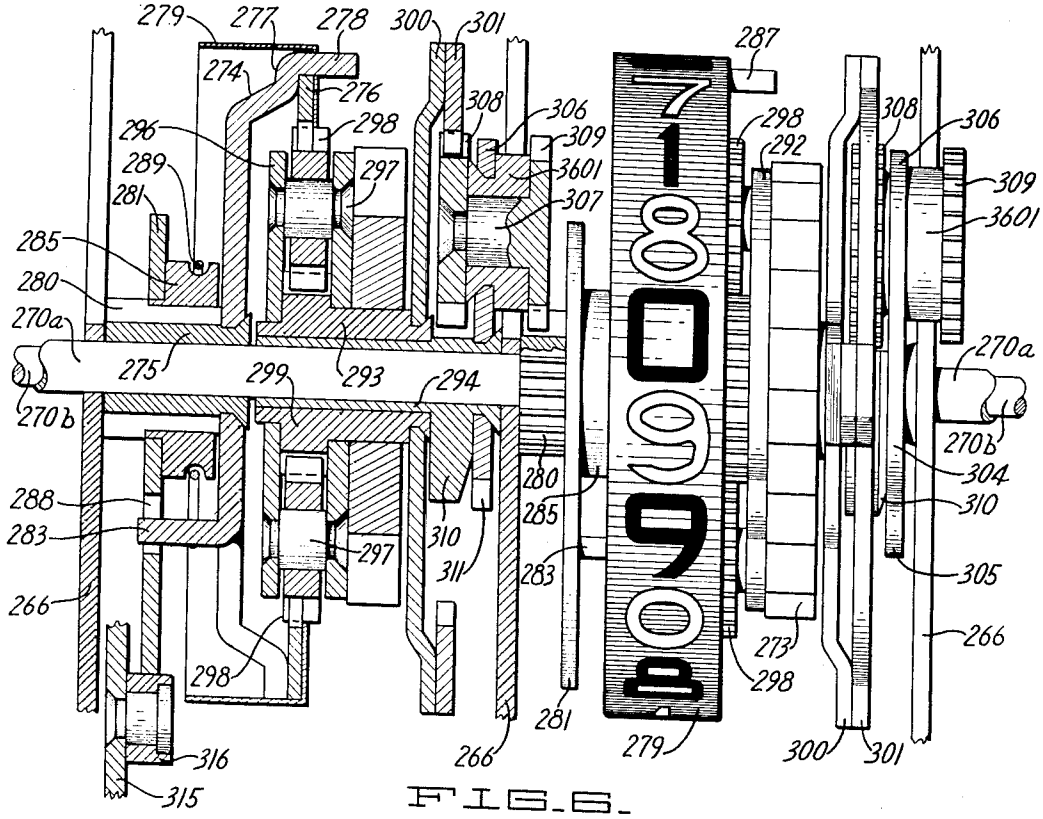


FIG-6-

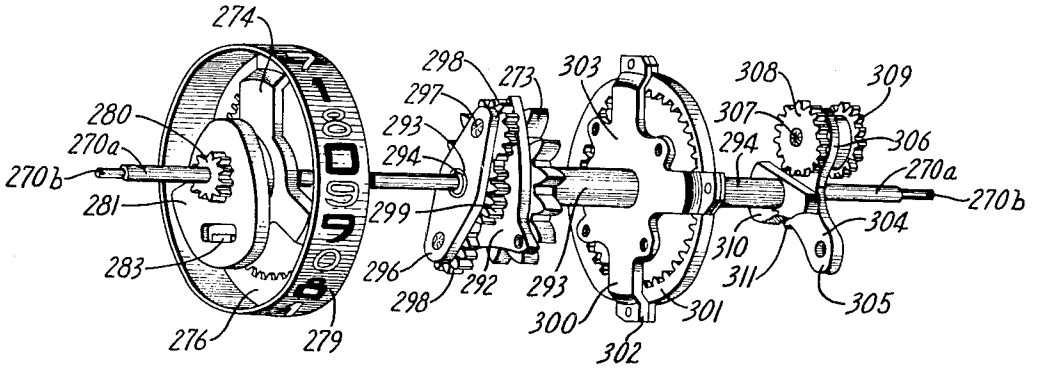


FIG-7-

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FUGITIVE ONE MECHANISM

Filed April 13, 1951 3 Sheets-Sheet 3

FIG. 8.

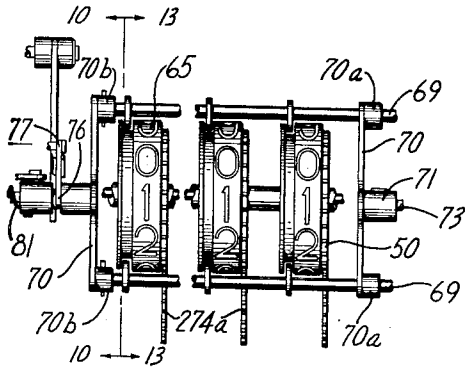


FIG. 9.

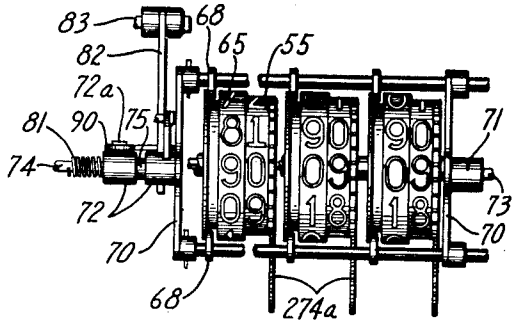


FIG. 10.

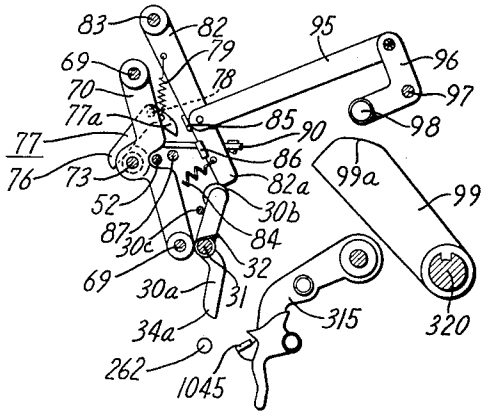
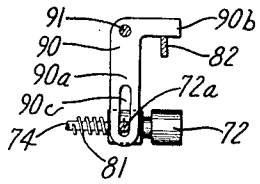


FIG. 11.



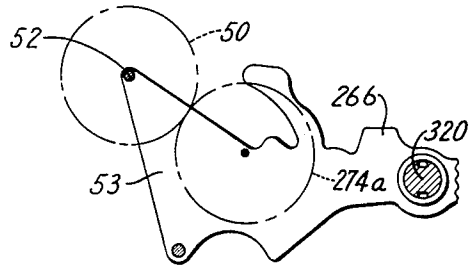


FIG. 12.

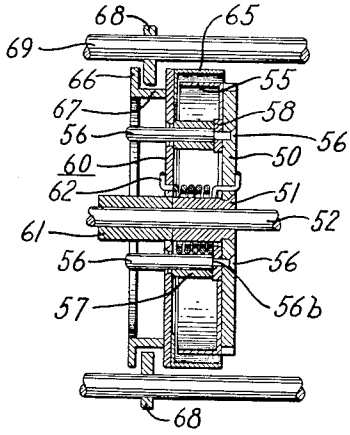


FIG. 13.

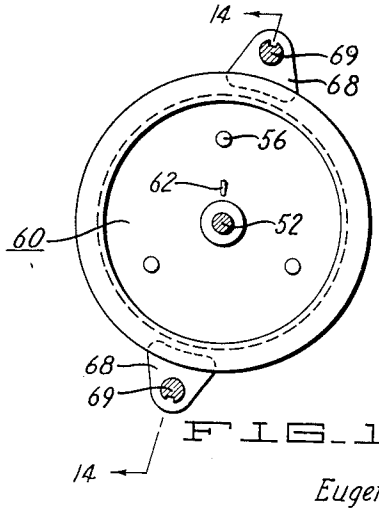


FIG. 14.

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United States Patent Office 2,746,678
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2,746,678

FUGITIVE ONE MECHANISM

Eugene E. Reynolds, Richmond, Calif., assignor to Marchant Calculators, Inc., a corporation of California

Application April 13, 1951, Serial No. 220,760

6 Claims. (Cl. 235—61)

The present invention relates to calculating machines or the like and particularly concerns registers that are capable of indicating the absolute numerical values of either positive or negative results.

The true registration of both positive and negative results in a calculating machine has long been recognized as desirable and has been accomplished in a variety of ways. In all machines which display true positive and true negative results in a single register, it is a mathematical necessity that a "fugitive digit" be entered in some manner into the lowest denominational order of the register when the sign character of the accumulated value changes from positive to negative or vice versa. Any tens carry or chain carry resulting from the entry of the fugitive digit must then be performed. Several methods have been provided for entry of the fugitive digit and performance of the consequent carries, but the additional computation and subsequent display of the absolute result have always required one or more extra-cyclic operations.

In adding machines which print both true positive and true negative results, any operations necessary for entry of the fugitive digit are not disadvantageous since they may be performed concomitantly with the printing operation which itself is extra-cyclic. On the other hand, calculating machines which display results on the numeral wheels of a single register, such as the machine disclosed in Carlin Patent Number 1,312,018, issued August 5, 1919, require an extra-cyclic operation to achieve true registration of positive and negative results in many problems. In the Carlin machine, only one order is actuated at a time, and if the denominational orders to the right of the actuated order all stand in "0" positions when the fugitive digit is entered, an extra-cyclic operation is required to complete the carry from the extreme right-hand order to the actuated order. Likewise, in the machine disclosed in Crumpton Patent Number 1,349,049, issued August 10, 1920, true registration of both positive and negative results is achieved through entry of the fugitive digit in an extra-cyclic operation.

The present invention, on the other hand, provides a mechanism whereby a numeral wheel register of a calculating machine is capable of true registration of either the positive or negative results by means of an intra-cyclic operation, i. e., an operation occurring during the calculation and display of the results in a machine similar to the present machine but not including the feature of the present invention.

This invention is disclosed as embodied in a machine of the type shown in the Avery Patent Number 2,271,240, issued January 27, 1942. It is to be understood, however, that although the invention is shown as applied to a crawl carry register, it is likewise applicable to machines

having other types of carry mechanisms which carry the tens in all denominational orders simultaneously.

The numeral wheel aligning mechanism of the present invention is employed to sense whether the result is positive or negative, and is operable in accordance with such sensing, to effect the corresponding true registration of the result regardless of whether such result is positive or negative in character. This sensing occurs during the period in which the carriage is raised from its actuating position to its rest position, and if a negative result is sensed, the numeral wheel aligning mechanism causes the fugitive digit to be entered and the consequent carries to be performed while the carriage is being raised.

Each numeral wheel of the present register is provided with two series of numerals arranged in complementary relation to each other in such a way that a numeral and its nines complement are both framed by each ordinal numeral window. While the carriage is being raised, a shutter is also positioned under the control of the above-mentioned numeral wheel aligning mechanism to conceal the appropriate one of each set of two numerals in accordance with the sensed character of the result.

It is therefore a primary object of this invention to effect true registration of both positive and negative results in a calculating machine having a single accumulator register regardless of the values entered into any denominational order.

It is a further object of this invention to effect true registration of both positive and negative results in a calculating machine having a single carry mechanism, by means operable independently of the actuating mechanism.

It is a further object to provide a device which is capable of intra-cyclic true registration of the appropriate positive or negative result of a calculation.

It is a further object to indicate the appropriate true positive or negative result of a calculation through a single window opening for each denominational order of the carriage.

It is a further object to provide true registration of both positive and negative results by means of two concentric numeral wheels in each denominational order, one of which is transversely shiftable to expose or conceal the other.

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

Fig. 1 is a front view of the carriage with a portion of the cover plate removed to show the accumulator mechanism and the shutter.

Fig. 2 is a sectional view of the carriage taken along the sectional line 2—2 of Fig. 1 showing the position of the mechanism when a positive result has been registered.

Fig. 3 is a view similar to Fig. 2 showing the position of the mechanism when a negative result has been registered.

Fig. 4 is a portion of the mechanism shown in Fig. 1 indicating the method of mounting the numeral wheels.

Fig. 5 is a right side view of a portion of the mechanism operable during clearance of the accumulator.

Fig. 6 is an enlarged front view, partly in section, of two adjacent numeral wheel assemblies, illustrating the manner of their construction.

Fig. 7 is an exploded perspective view of a numeral wheel assembly.

Fig. 8 is a front view of a portion of the carriage

mechanism indicating an alternate arrangement employing two concentric numeral wheels in each denominational order.

Fig. 9 is a front view similar to Fig. 8 showing the mechanism arranged to expose a negative result.

Fig. 10 is a side view taken along the sectional line 10—10 of Fig. 8.

Fig. 11 is a plan view of a portion of the mechanism shown in Fig. 10.

Fig. 12 is a side view of the carriage illustrating the driving connection to the numeral wheels.

Fig. 13 is a side view of one denominational order of the mechanism shown in Fig. 8.

Fig. 14 is a front sectional view of the mechanism shown in Fig. 13 taken along the lines 14—14.

The accumulator register carriage **250** (Fig. 1) includes a series of ordinally spaced numeral wheels **279**, each of which bears two alternated series of numerals 0–9 evenly spaced upon its periphery and arranged in complementary relationship as indicated. One series, shown in dark numerals, is for the purpose of indicating positive values and the other, shown in light numerals, is for indicating negative values.

Values set up on the keyboard of the machine are registered on the appropriate numeral wheels in the manner described in the previously mentioned Avery patent. Briefly, a differential gear mechanism is actuated to advance each numeral wheel by an increment of rotation corresponding to the value set up on its associated order of the keyboard; simultaneously, the differential gear mechanism transmits a proportional carry drive from each lower order numeral wheel to its adjacent higher order numeral wheel. This type of carry mechanism is known in the art as a "crawl carry mechanism" and the registers in which such mechanisms are employed are commonly referred to as "crawl carry registers." As previously noted, a register of this type is disclosed in the Avery patent. Identical parts appearing both in the present disclosure and in the Avery patent bear the same reference numerals, and where parts are herein shown and numbered, but not described, reference is made to the Avery patent for a complete description of their operation.

At the beginning of a calculation, initiated by an operation control key, a setting, or program, clutch (not shown) causes a "dipping" of the carriage clockwise about a shaft **262** (Fig. 3) to engage an idler gear **271** in each order with a corresponding digital drive gear **171** of the actuator, and such engagement between the actuator and the register is maintained throughout the actuating operation. Gear **271** meshes with a numeral wheel gear **273** (Figs. 3, 6 and 7) which is the digital entry gear of the differential. Gear **273** is freely mounted on a hub **293** of a sun gear **299**, and hub **293** is freely mounted on a sleeve **294**, which, in turn, is freely mounted on a hollowed shaft **270***a*. A plate **292** is fixed to gear **273** and to a second plate **296** by a pair of pins **297** and is also freely rotatable on hub **293**. A respective planet gear **298** is rotatably mounted on each pin **297** between plates **292** and **296**. The planet gears mesh with the sun gear **299** and also with an internal ring gear **276** integral with a spider **274** upon which is fixed the numeral wheel dial shell **279**. With the sun gear **299** held fixed, as is the case in the lowest order of the register, clockwise rotation of gear **273** (Fig. 7) in response to a positive digital actuation, and the consequent clockwise rotation of supporting pins **297** for planet gears **298**, revolves the planet gears in a clockwise direction around sun gear **299** and therefore advances ring gear **276** and the numeral wheel a proportionate amount in a clockwise direction.

Carry increments of drive are introduced simultaneously with the digital drive through the differential gearing. A ring gear **301** is securely mounted on the hub **293** of sun gear **299** and meshes with an idler gear **308** which is securely mounted on a shaft **307**. A second idler gear **309** is likewise securely mounted on shaft **307** and meshes with a gear **280** which is integral with the numeral wheel of the next lower order. Shaft **307** is rotatably mounted on an arm **306** of a carrier piece **304** which is freely mounted on the shaft **270***a*. Rotation of a numeral wheel causes rotation of the gear **280** integral therewith, rotating idler gears **309** and **308** of the next higher order. Gear **308** rotates ring gear **301** and therefore rotates sun gear **299**. The sun gear **299** rotates planet gears **298** which rotate ring gear **276** and the numeral wheel **279**, thereby imparting a carry drive from one order to the next. The gear ratios are such that the one-tenth of a digital increment of carry drive is imparted to a numeral wheel for each full digital increment of rotation of the next lower order numeral wheel.

At the end of the actuating operation, the numeral wheels which have been advanced by partial carry increments do not stand aligned at positions of full digital display. An aligning mechanism of the type shown in the aforementioned Avery patent is therefore provided, and is effective, when the carriage is raised to its rest position at the end of each ordinal actuating operation, to back out the partial carry increments of drive transmitted between adjacent numeral wheels, thereby rotating the numeral wheels to respective positions of full digital display. Briefly, this aligning mechanism includes a snail cam **281** (Figs. 2, 3, 6 and 7) which is carried by each numeral wheel **279**. An associated sensing lever **315** (Fig. 2) carries a freely mounted roller **316** which is caused to contact the periphery of the snail cam when the carriage is brought from its "dipped" to its initial raised position at the conclusion of each ordinal actuation. The snail cam is graduated from its largest to its smallest radius to correspond to the values "0" to "9"; therefore, the amount of movement required to cause roller **316** of the sensing lever to contact the snail cam when the the carriage is raised, is indicative of the value standing in the associated numeral wheel. The movement of the sensing lever is transmitted by mechanism described in the Avery patent to the carrier **304** (Fig. 7) of the next higher order and rocks the carrier a proportionate amount in a clockwise direction to cause clockwise movement of ring gear **301** and sun gear **299**. This causes the higher order numeral wheel to be rotated in a counterclockwise, or subtractive, direction by the correct amount required to bring the same to a position of full digital display.

The snail cam arrangement is such that, when the carriage is raised after a negative actuation, if a numeral wheel has rotated from a "0" to a "9" position, the sensing lever **315** of the same order drops to the lowest radius of its associated snail cam. This rocks the carrying plate **304** of the next higher order sufficiently about shaft **270***a* to rotate the higher order numeral wheel nine-tenths of a digital increment in the negative direction. Simultaneously with the above action, the rotation of the gear **280** of the lower order through one digital increment (from "0" to "9") introduces a further carry drive into the higher order which rotates the higher order numeral wheel an additional one-tenth of a digital increment in the negative direction. Thus, the two simultaneous drives imparted to the higher order together rotate the higher order numeral wheel one full digital increment, negatively, when the lower order numeral wheel is rotated from a registration of "0" to a registration of "9." If the higher order numeral wheel stands at a registration of "0" when it receives the full negative increment of carry, its associated sensing lever **315** drops from the highest to the lowest radius of the corresponding snail cam, so that the next higher order receives a full negative increment of drive. In the same manner, all numeral wheels to the left thereof which stand at a "0" position are rotated, by the aligning mechanism, to respective "9" positions. The highest, or "overflow" order is identical to the other orders ex-

cept that it has no dial shell **279***a*, and is not associated with an ordinal machine frame window. The purpose of the overflow order will be fully described hereinafter.

By the foregoing description of the register mechanism it is seen that the numeral wheels are advanced by both digital and carry increments of drive during the actuating operation and that the differential gearing between the numeral wheels is effective to advance each higher order numeral wheel by one-tenth of the total advance of its adjacent lower order numeral wheel. It is further seen that at the end of each ordinal calculation the numeral wheels are brought to respective positions of full digital display by the aligning mechanism.

Means for selectively displaying positive and negative values

Since both a positive numeral and its complementary negative numeral are displayed through each ordinal accumulator window, as previously mentioned, a mechanism is provided for displaying one numeral in each order and concealing the other in accordance with the sign of the result. A shutter **20** (Figs. 1 and 5), in the form of a U-shaped bail, is pivotally mounted at its ends upon two stationary end plates **255** of the carriage by means of a pair of studs **21**. A spring **23** is secured between the shutter and the machine frame and urges the shutter upward as seen in Fig. 1 (clockwise in Fig. 5). A lug **24** (Figs. 2 and 3) is secured to an end frame **255** and acts as a stop for the shutter in its rocked (upper) position. A latch **30** pivotally mounted on a machine frame stud **31** is urged counterclockwise by a torsion spring **32** and has a nose **33** which normally overlies the shutter to latch the same in its lower position, thereby concealing the negative result numerals and exposing the positive result numerals. If the mechanism of the overflow order stands in a "9" position (Fig. 3) when the carriage is raised to rest position, a lower arm **34**, of latch **30**, is engaged by an ear **1045** of the overflow order snail cam sensing lever **315**, rotating latch **30** clockwise to unlatch the shutter **20** which is then raised to its upper position by spring **23** (Fig. 1), exposing the negative result numerals.

The ends of the shutter bail are shaped in the form of a camming surface **22** (Figs. 3 and 5) adapted to be contacted, during the carriage dip, by the left end (as seen in Fig. 1) of a shaft **270***b* which is journaled within the hollowed shaft **270***a*. If the shutter is not already latched in its lower position when the carriage is dipped, the surface **22** is contacted by shaft **270***b* early in the dip, and the shutter is rocked counterclockwise (in Fig. 3) to its lower position, where it is latched down by lever **30**. If the mechanism of the overflow order stands at "9" when the carriage is subsequently raised, the ear **1045** on lever **315** rotates latch **30** to its clockwise position, releasing the shutter which is returned to its upper position under the urging of spring **23**, exposing the negative result numerals. On the other hand, if the mechanism of the overflow order stands at any position other than "9" when the carriage is raised, ear **1045** on lever **315** does not contact latch **30**, which therefore remains in its counterclockwise position and retains the shutter in its lower position, exposing the positive result numerals.

Entry of a fugitive digit

In the event that a calculation causes the sign character of the accumulated value to change from positive to negative, sometimes known as a "negative overdraft," it is apparent that a fugitive digit must be entered into the lowest accumulator order if the true negative result, and not the complement of the result, is to be registered. The fugitive digit is driven into the lowest order from the overflow order by means of the following mechanism.

The carriage **250** includes a "dummy" accumulator order to the right of the units order. The dummy order, like the other orders, includes a snail cam **281** and a gear **280** (Fig. 7). Gear **280** meshes with the idler gear **309** of the units order and is fixed to the right end of the previously described shaft **270***b*. Similarly, the gear **280** which is integral with the overflow order spider **274** is fixed to shaft **270***b* near its left end. Therefore, the dummy order is integral with the overflow order, and functions as a unit therewith. The arrangement is such that neither of these two orders is ever driven by the actuator, and no digital actuating drive is ever imparted to the dummy order, so that the only rotation occurring in the overflow order, and consequently in the dummy order, is due to the carry drive imparted to the overflow order. Therefore, during negative actuation, when the mechanism of the overflow order is rotated from "0" to "9" position, signifying a negative overdraft, the dummy order is likewise rotated from "0" to "9." Consequently, the sensing lever **315** cooperating with the dummy order snail cam falls to the lowest radius of the snail cam when the carriage is raised, and a digital increment, the desired fugitive digit, is thereby subtracted from the units order in the manner previously described. If the units order and any adjacent consecutive higher orders stand at a registration of "0" when the fugitive digit is subtracted from the units order, a negative carry wave will proceed through all such orders to change the "0's" to "9's" and also to subtract a fugitive digit from the lowest order numeral wheel standing at any value other than "0."

Backing out fugitive digit

The fugitive digit which is entered in response to a negative overdraft must be "backed out," i. e. a fugitive digit of opposite sign must be entered, if a subsequent actuation changes the sign character of the accumulated value from negative to positive, the latter being designated a "positive overdraft." It is recalled that the accumulator is arranged so that any numeral wheel which stands at a "9" position when the carriage is dipped, imparts nine-tenths of a digital increment of carry drive to the numeral wheel of the next higher order. If the lower order numeral wheel remains at a "9" position when the carriage is raised, the nine-tenths of an increment is backed out of the higher order by the aligning mechanism; but if the lower order numeral wheel is advanced from "9" to "0" during a positive actuation, an additional one-tenth of a digital increment is imparted to the higher order, and no part of the resulting whole digit of carry drive is backed out by the aligning mechanism when the carriage is raised. Therefore, when a numeral wheel is advanced from "9" to "0," all consecutive orders to the left thereof which stood at "9" before the carriage was dipped, also register "0" when the carriage is raised. And since the dummy order is integral with the overflow order, when the above described action proceeds through the overflow order, signifying a positive overdraft, the same action proceeds through the dummy order and all consecutive orders to the left thereof which stood at "9" before the carriage was dipped. Thus, a fugitive digit is entered in a direction opposite to that entered in response to a negative overdraft.

It is to be understood that the means for entering and backing out a fugitive digit are not limited to the particular mechanism described above, which is merely illustrative. The fugitive digit may be entered by several other mechanisms cooperating with the present accumulator register. For example, the dummy order spider **274** (Fig. 1) may be linked to the shutter **20**. The normal travel of the shutter from its higher to its lower position, or vice versa, then enters or backs out a fugitive digit in the correct direction for true registration of either positive or negative results.

Clearance

When the register is cleared, the shutter **20** must be rocked to its lower position in order for the numeral wheels to indicate "0's" after clearance. During clearance, which is described in the previously mentioned Avery patent, the carriage does not dip; therefore, sepa-

rate means are provided for lowering the shutter during this operation.

A pair of levers **45** (Fig. 5) are keyed to the clearance shaft **320** disclosed in the Avery patent, and cooperate with a second pair of levers **40** pivotally mounted on respective studs **41** extending from two of the inter-ordinal spacer plates **266**. Each lever **40** has an ear **42** overlying the upper edge of shutter **20** and also has an arm **43** overlying an ear **44** on the corresponding lever **45**. During clearance, shaft **320** is rocked clockwise through a predetermined angle rotating levers **45** clockwise to rotate levers **40** counterclockwise, thereby forcing the shutter **20** to its lower position where it is maintained by latch **30** (Fig. 2).

Sequence of operation

The following example of a subtraction problem will serve to illustrate the sequence of operations in registering a true negative result.

Assume that the value 100 has been entered into the three lowest orders of a ten order accumulator and that the actuator mechanism has been positioned for a subtractive entry of 200. When the carriage dips into actuating position, wherein gear **271** (Fig. 3) meshes with gear **171**, actuation causes the third order numeral wheel to rotate two digital increments in a negative direction, from "1" to "9." When the actuation is completed, the carriage rises and returns to its normal position, and during this return movement an incremental digit of carry drive is imparted to the fourth order, as previously described, so that the fourth and higher order numeral wheels, which all stand at "0," are rotated to their respective "9" positions by a chain carry. Since the dummy order is integral with the overflow order, the mechanism of the dummy order is also rotated to its "9" position, continuing the chain carry movement through the first, second and third orders, so that the numeral wheels of these orders are rotated to positions of "9," "9" and "8" respectively. The carry terminates at the third order because the snail cam of that order is not rotated from a "0" to a "9" position, and therefore does not impart a full incremental digit of drive to the fourth order. The accumulator dials are therefore positioned at a registration of 99,999,899. When the overflow order sensing lever **315** (Figs. 2 and 3) is rocked clockwise to the low radius of its associated snail cam, as the carriage is raised, the ear **1045** of lever **315** cams the arm **34** of lever **30** to the left, rocking lever **30** clockwise so that its nose **33** is removed from latching engagement with shutter **20**. The shutter is rocked to its upper position by spring **23** concealing the registration of 99,999,899 and exposing the complementary registration of 00,000,100, which is the true negative result.

Alternate embodiment

An alternate mechanism for true registration of both positive and negative results is shown in Figs. 8 to 14. Each denomination order includes a pair of numeral wheels, one of which, designated the "positive result wheel" bearing the numerals 0–9 on its periphery for indicating positive results, and the other, designated the "negative result wheel," also bearing the numerals 0–9, but in reversed order for indicating negative results. The arrangement is such that each numeral on a numeral wheel is aligned with its nines complement on the associated numeral wheel. The numeral wheels in the present embodiment are mounted on a shaft which is separate from the numeral wheel shaft **270** of the first embodiment, and the present numeral wheels are driven by gears mounted on shaft **270**. The crawl carry mechanism and the aligning cams remain mounted on shaft **270** as in the first embodiment. Each positive wheel forms a cup which is of larger diameter than its associated negative wheel and normally overlies and conceals the latter in a position adjacent the associated ordinal numeral window, so that positive results are normally exposed. To display negative results, each positive wheel is shifted transversely along its axis, thereby uncovering its associated negative wheel which remains adjacent a numeral window. The mechanism for this type of registration is based upon the mechanism disclosed in relation to the first embodiment but differs therefrom as follows.

The dial shells **279***a* are removed from the numeral wheel spiders **274**, and the periphery of each of these spiders is toothed to form a respective ordinal gear **274***a* (Figs. 8 and 12). Each gear **274***a* meshes in a ratio of unity with an ordinal gear **50**, the hub **51** (Fig. 14) of which is freely mounted on a shaft **52** supported by extensions **53** (Fig. 12) of the interordinal plates **266**. A negative result wheel **55** is secured to each gear **50** by means of a plurality of studs **56** (Figs. 13 and 14) while a positive result wheel **65** is secured to a disc **60** freely mounted on a bushing **61** which is rotatably mounted on the above-mentioned shaft **52**. Bushing **61** extends leftwardly, as viewed in Fig. 14, to abut the face of gear **50** of the next higher order, and therefore forms an interordinal spacing member. Disc **60** and gear **50** are urged together transversely to the position shown in Fig. 14 by a light torsion spring **62**, normally maintaining the negative result wheel concealed within the positive result wheel.

The positive result wheels are adapted to be moved leftward, for displaying negative results, by the following mechanism. Each of the studs **56**, described above, has an extension **56***a* having a diameter greater than that of the stud and having a shoulder **56***b*. The stud extensions are sleeved in bushings **57** securely mounted in disc **60** so that the disc and the positive result wheel **65** are slidable transversely relative to the negative result wheel. A spacer **58** is mounted on each stud **56** between the shoulder **56***b* and the negative result wheel **55**. The righthand face of each bushing **57** (Fig. 14) abuts its associated spacer **58**, limiting the rightward transverse movement of the positive result wheel **65**.

A rim **66** is secured to each disc **60** so that a channel **67** is formed between the rim and the disc. A pair of fingers **68** extend into each channel **67** and are secured to respective shafts **69**. The righthand ends of shafts **69** are slidably mounted in a pair of bushings **70***a* (Fig. 8) which are connected by a yoke **70**; on the other hand, the lefthand ends of shafts **69** are pinned to a pair of bushings **70***b* which are connected by a second yoke **70**. A bushing **71** is secured to the righthand yoke **70** and is fixed to a stub shaft **73** secured to an end plate of the dipping carriage. Similarly, a bushing **72** having an annular notch **75** (Fig. 9) is secured to the lefthand yoke **70** and is slidably mounted on a stub shaft **74** which is also secured to an end plate of the dipping carriage.

A spring **81** is connected between the carriage frame and bushing **72**, urging the latter leftward. A bell crank **77** (Fig. 10) is pivotally mounted on a stud **78** of the machine frame and has an arm **76** (Figs. 8 and 10) which normally rests in the annular notch **75** of bushing **72**, maintaining this bushing in the position shown in Fig. 8 against the tension of spring **81**. When the arm **76** of bell crank **77** is lifted from engagement with notch **75**, as described hereinafter, the bushing **72** is slid to the left on shaft **74** by spring **81**, thereby moving to the left its associated yoke **70**, shafts **69**, and fingers **68**. The fingers **68** engage rims **66**, moving them to the left along with discs **60** and the posiitve result wheels **65**, thereby exposing the negative result wheels **55**.

In the present embodiment, as in the first, the negative result numerals are caused to be displayed when the mechanism of the overflow order stands at "9" position. In response to this condition, the following means are provided for lifting the arm **76** of bellcrank **77** from notch **75** of bushing **72**, thereby causing the negative result wheels **55** to be exposed in the manner described above.

A lever **30***a*, similar in function to the previously de-

scribed lever **30**, is freely mounted on the machine frame stud **31** and urged counterclockwise by the torsion spring **32** to a normal position against a limit stud **30***c* fixed to the machine frame. A lower arm **34***a* of lever **30***a* cooperates with the ear **1045** on the sensing lever **315** of the overflow order. Therefore, when the overflow order stands at "9" position, indicating that the sign character of the result is negative, the sensing lever **315** of the overflow order rotates to its extreme clockwise position and ear **1045** cams arm **34***a* leftward, rotating lever **30***a* clockwise about its axis. A lever **82** is pivotally mounted on a stud **83** of the machine frame, and is urged clockwise about its pivot by a spring **84**. A lower tip **82***a* of lever **82** cooperates with a roller **30***b* on the upper arm of lever **30***a*, normally maintaining lever **82** in its counterclockwise position as shown in Fig. 10.

When lever **30***a* is rocked, clockwise, as described above, roller **30***b* is rotated out of engagement with the tip **82***a* of lever **82**, permitting the latter to rotate clockwise. An ear **85** on lever **82** engages an arm **77***a* of the previously described bellcrank **77** rocking the bellcrank clockwise, thereby lifting arm **76** from engagement with notch **75** of bushing **72** to cause registration of the negative numerals in the manner described hereinbefore. A stop pin **87** secured to a dipping carriage frame plate cooperates with an ear **86** on lever **82**, limiting the clockwise rotation of the latter. The fugitive digit is entered in the manner described in connection with the first embodiment, so that a true negative result is displayed.

The display mechanism is reconditioned for positive registration each time the carriage dips, preparing the accumulator for a subsequent calculation. As the carriage is dipped about its pivot **262**, stop pin **87** dips with the carriage and forces lever **82** (which does not dip) to its extreme counterclockwise position. The sensing lever **315** also dips with the carriage and disengages its ear **1045** from lever **30***a* (which does not dip), permitting the latter to rock to its extreme counterclockwise position against stop pin **30***c*, so that roller **30***b* is in position to engage tip **82***a* of lever **82**. The mechanism for restoring the positive result wheels to their rightmost positions include a bellcrank **90** (Figs. 9, 10 and 11), pivotally mounted on a machine frame stud **91**. One arm **90***a* of bellcrank **90** has a slot **90***c* adapted to receive a stud **72***a* on bushing **72**, and another arm **90***b* cooperates with lever **82**. The arrangement is such that when lever **82** is restored to its counterclockwise position (Fig. 10) by stop pin **87**, it forces arm **90***b* of bellcrank **90** upward as seen in Fig. 11, rocking the bellcrank counterclockwise. At the same time, stud **72***a* on bushing **72**, which dips with the carriage, moves upward (as seen in Fig. 11) and is cammed to the right by the slot **90***c*. Therefore, during the dip the bushing **72** is forced to the right (Figs. 8, 9 and 11) against the tension of spring **81**, moving fingers **68** rightward to permit the positive result wheels to be restored to their initial positions by springs **62**. A spring **79** (Fig. 10) tensioned between lever **82** and arm **77***a* of bellcrank **77** rocks the latter counterclockwise during the carriage dip, maintaining the arm **76** in contact with bushing **72**, so that when bushing **72** has been forced a proper distance to the right by bellcrank **90**, the arm **76** is urged into notch **75** to maintain bushing **72** in its rightmost position.

Means are also provided for returning the display mechanism to normal position during clearance of the accumulator register. A link **95** (Fig. 10) is pivotally connected at its two ends to lever **82** and to one arm of a bellcrank **96** pivotally mounted on a machine frame stud **97**. The other end of bellcrank **96** is provided with a roller **98** adapted to contact a camming surface **99***a* of a lever **99** which is keyed to the clearance shaft **320** disclosed in the aforementioned Avery patent. Shaft **320** is rocked clockwise during clearance so that surface **99***a* of cam **99** contacts roller **98**, rocking bellcrank **96** clockwise to force link **95** to the right, thereby restoring lever **82** to normal position. Lever **82** cooperates with bellcrank **90**, in the manner previously described, to return the bushing **72** and the numeral wheels **65** to their normal positions, so that the register is readied for a subsequent calculation.

I claim:

1. In a calculating machine having a register comprising a plurality of ordinally arranged numeral wheels and digital actuators therefor, crawl carry differential gearing between adjacent numeral wheels each differential gearing comprising a digital entry gear for receiving increments of drive from a respective digital actuator, a tens carry entry gear for receiving partial increments of drive from an adjacent lower order numeral wheel, and an output gear driven by an amount corresponding to the sum of said digital and partial increments of drive, means for engaging and disengaging the digital input gears from their respective actuators, ordinally arranged aligning devices, means for moving the aligning devices from an enabled to a disabled position and vice versa, said aligning devices when enabled being operable under the control of the value representative positions of the numeral wheels to back out the partial increments of drive from their respective adjacent higher order numeral wheels, a drive connection between the output gear of the highest order numeral wheel and a differential input gear of the lowest order numeral wheel, and means controlled jointly by the crawl differential gearing and by the aligning devices and operable in response to an overdraft movement of the highest order numeral wheel for causing said drive connection to move the lowest order numeral wheel one digital increment in a subtractive direction.

2. A calculating machine according to claim 1 in which the means for engaging the numeral wheels with their respective actuators moves the aligning means to non-aligning position and enters a positive fugitive digit in the lowest order numeral wheel.

3. A calculating machine according to claim 1 in which the movement of the lowest order numeral wheel from a value representative position of "0" to a position of "9" causes movement of the adjacent higher order numeral wheel one digital increment in a subtractive direction.

4. A calculating machine according to claim 1 in which each numeral wheel carries two series of numeral indicia, a shutter normally lying in a first position where it conceals one of said series of indicia, and means operable by the aligning device of the highest order numeral wheel for moving the shutter to a second position in which it conceals the second one of said series of indicia and reveals the first one of said series of indicia.

5. A calculating machine according to claim 1 in which each numeral wheel carries two series of numeral indicia, a shutter normally lying in a first position where it conceals one of said series of indicia, means operable by the aligning device for the highest order numeral wheel for moving the shutter to a second position in which it conceals the second one of said series of indicia and reveals the first one of said series of indicia, and mechanism operable by the gear engaging means for returning the shutter to its first position.

6. In a calculating machine having a register comprising a plurality of ordinally arranged numeral wheels and digital actuators therefor, crawl carry differential gearing between adjacent numeral wheels, each differential gearing comprising a digital entry gear for receiving increments of drive from a respective digital actuator, a tens carry entry gear for receiving partial increments of drive from an adjacent lower order numeral wheel, and an output gear driven by an amount corresponding to the sum of said digital and partial increments of drive, an overflow differential gear unit driven by the highest order numeral wheel output gear, an aligning mechanism for the overflow output gear, a dummy order output gear for driving the tens carry gearing of the units

order differential gearing, and a fugitive digit entry mechanism comprising a permanent connection between the overflow order output gear and the dummy order output gear, and aligning means for the units order numeral wheel controlled by the overflow order output gear.

References Cited in the file of this patent

UNITED STATES PATENTS

1,033,303	Carlin	July 23, 1912
1,312,018	Carlin	Aug. 5, 1919
1,349,049	Crumpton	Aug. 10, 1920
1,649,408	Jacob	Nov. 15, 1927
2,271,240	Avery	Jan. 27, 1942
2,278,863	Chase	Apr. 7, 1942
2,602,585	Ellerbeck	July 8, 1952