Dec. 23, 1952 H. T. AVERY 2,622,805

CALCULATING MACHINE

Filed Feb. 19, 1949 4 Sheets-Sheet 1

FIG. 1.

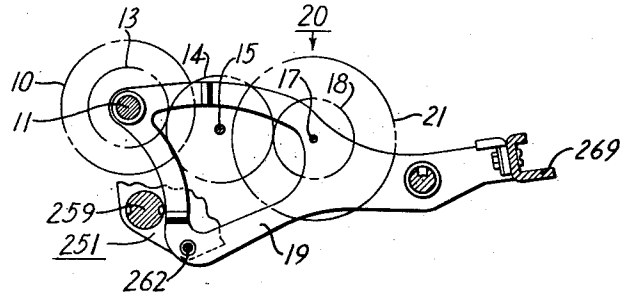


FIG. 2.

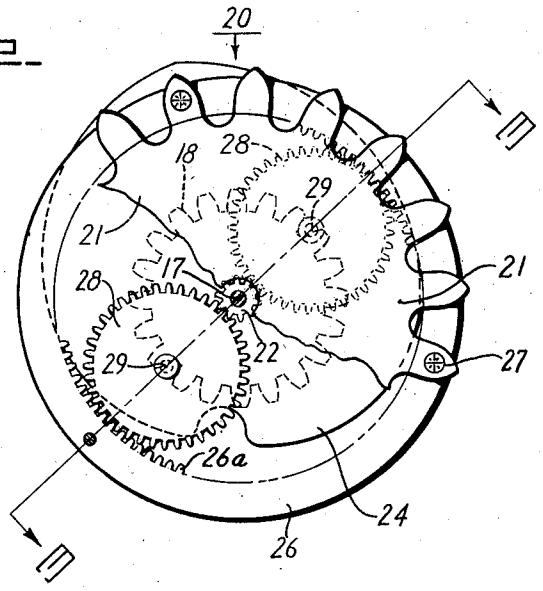
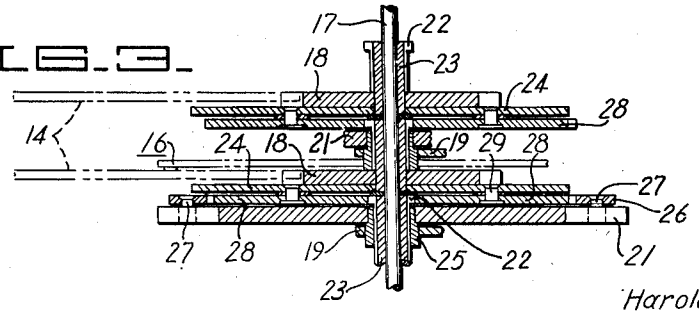


FIG. 3.



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CALCULATING MACHINE

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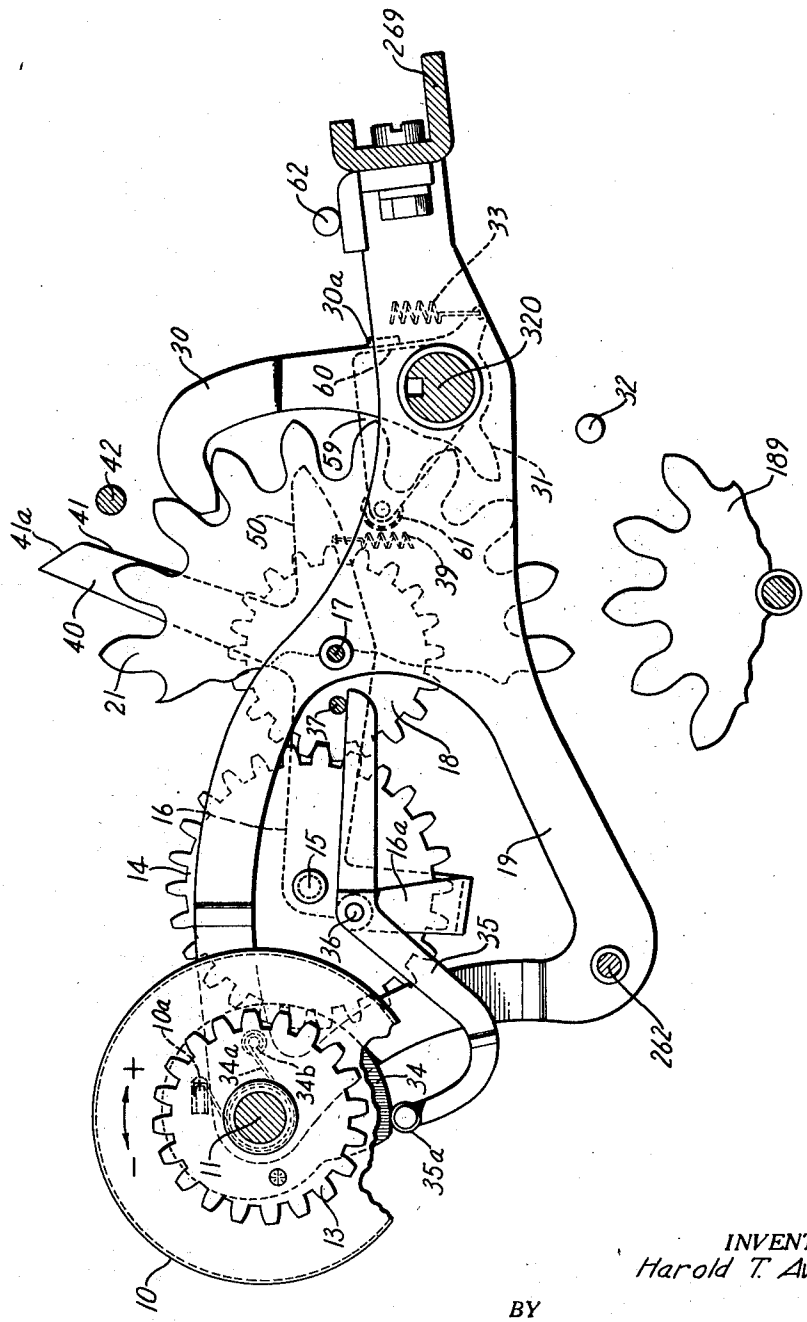


FIG-4-

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CALCULATING MACHINE

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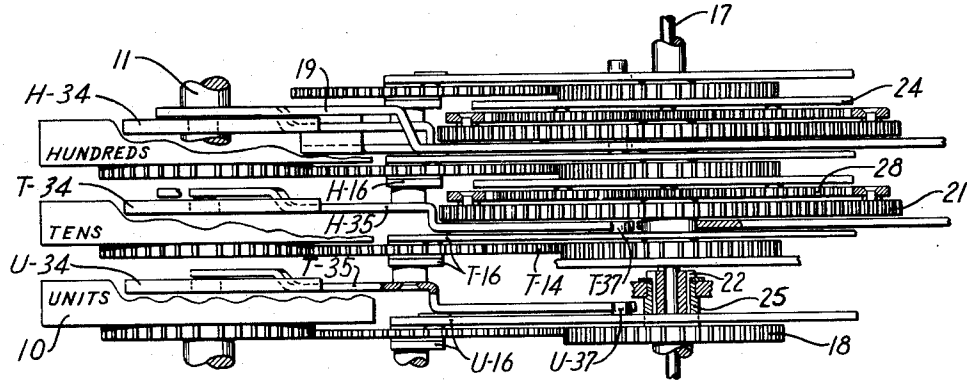


FIG. 5.

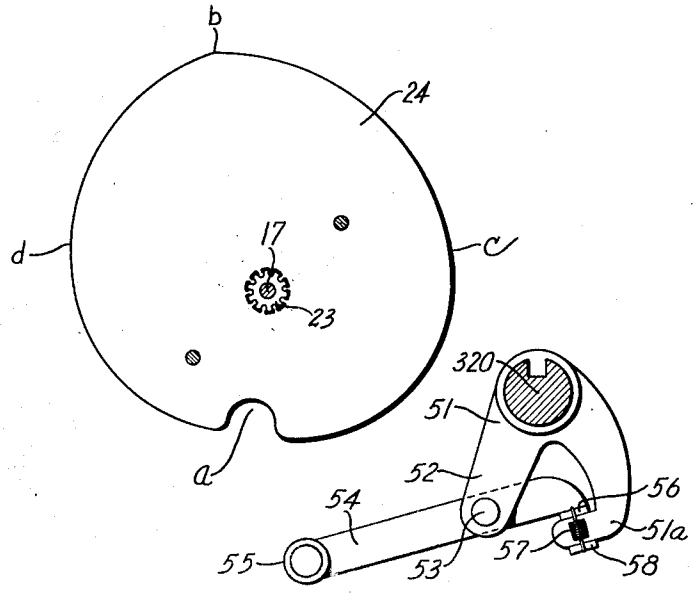


FIG. 6.

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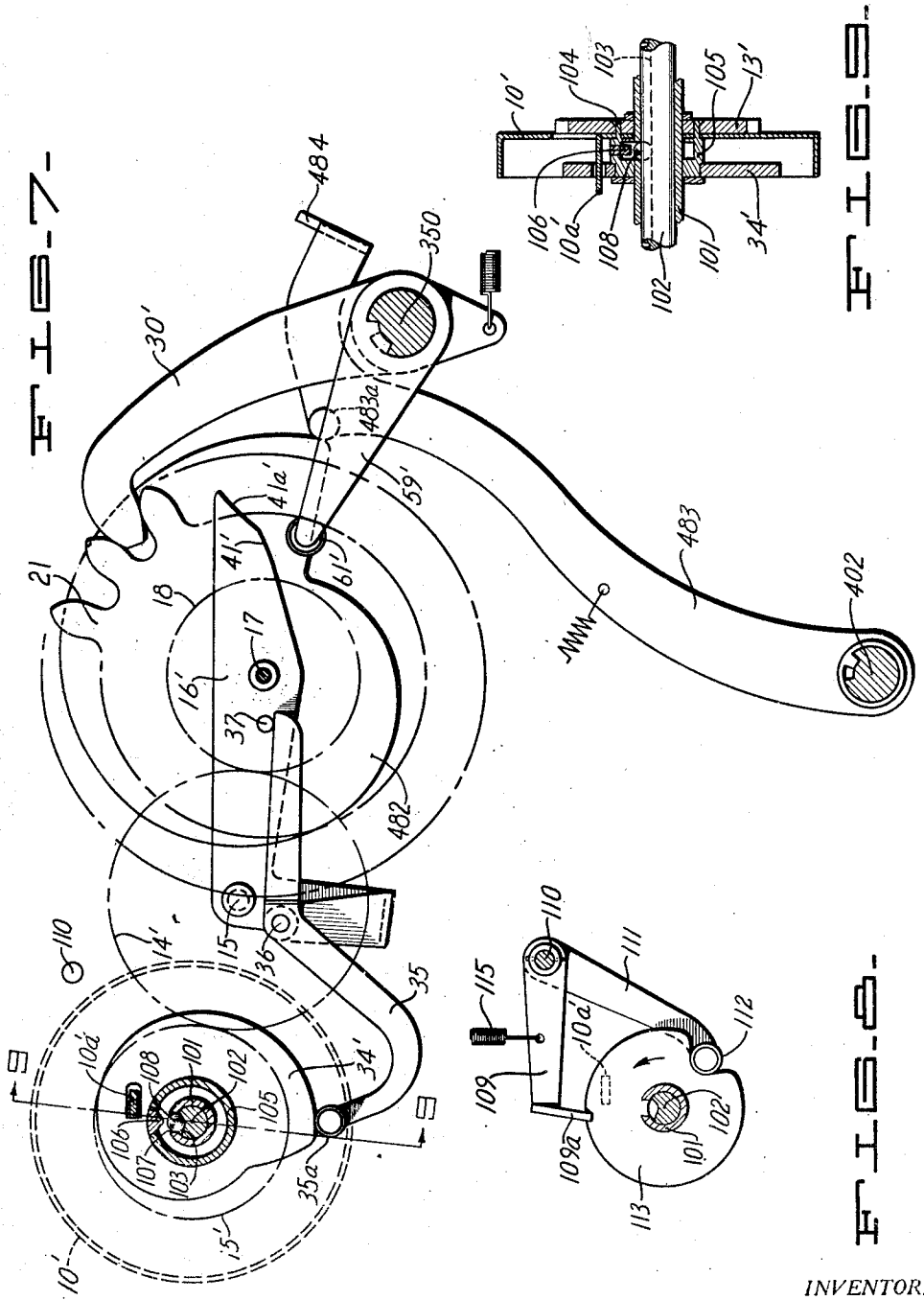
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CALCULATING MACHINE

Filed Feb. 19, 1949 4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,622,805

CALCULATING MACHINE

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Application February 19, 1949, Serial No. 77,350

7 Claims. (Cl. 235—136)

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The present invention relates to crawl carry registers and more particularly concerns means for aligning the numeral wheels thereof.

The numeral wheels of a crawl carry register are each driven through a respective differential transmission, by means of which the digital and tens carry increments of drive are simultaneously transmitted to the numeral wheel.

Since partial carry increments are transmitted to each numeral wheel in proportion to the value displayed in the respective next lower order of the register, the numeral wheels are displaced from positions of full digital display during the operation of the register.

Aligning mechanisms, well known in the art, are generally brought into play at the conclusion of an operation to back out the partial carry increments and thus align the numeral wheels in positions of full digital display.

In all prior aligning mechanisms, however, it has been necessary either to displace the differential transmission of an order each time the numeral wheels are changed from crawl carry to aligned condition and vice versa or in those cases where the differential transmission is not displaced by the change between aligned and crawl carry condition, it has heretofore been necessary to use auxiliary mechanisms with the aligning mechanism to obtain the proper aligning movement. In either case the aligning operation generally is accomplished by spring power which is stored during part of the motor driven operation of the machine, and the greater the number of gears or auxiliary mechanisms that must be moved the greater will be the spring power necessary to effect such alignment, all of which tend to increase the operating load of the machine. Furthermore, the greater the number of gears that must be moved, the greater will be the backlash between the respective gears which may cause misalignment of the numeral wheel.

One form of aligning mechanism which examplifies the prior art is disclosed in the Patent No. 2,222,164, issued November 14, 1940. The crawl carry register disclosed in this patent includes a planetary differential gear assembly which, like all such differentials has three legs or gear trains. One such leg or train is used to receive the drive from the digital actuators, while the second leg receives the tens carry drive from the next lower order numeral wheel. These two driving movements are combined in a resultant or summation gear comprising the third leg of the differential, and the sum of the two drives is transmitted from this third leg to the related numeral wheel.

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The above mentioned patent provides a rocking idler gear which is situated in each respective tens carry leg or gear train between adjacent orders. The arrangement is such that when the idler gear is rocked at the end of a calculation, it adjusts the tens carry train and backs up the numeral wheel. In order to determine the amount by which the above-mentioned idler gears should be rocked to back up the numeral wheels to positions of full digital display, each numeral wheel has attached thereto a graduated member in the form of a snail cam. At the end of a calculation, a member which carries the rocking idler gear is rocked to sense the rotated position of the snail cam of the next lower order numeral wheel and during such sensing, the member rocks the idler gear by the proportionate amount necessary to back up its respective numeral wheel to full digital display position.

A second aligning mechanism shown in the United States Patent No. 2,089,682, issued August 10, 1937, is similar in principle of operation to that of the first mentioned patent except that the idler gear which is rocked to effect the aligning movement is located in the digitation entry train instead of the tens carry train.

The present invention provides an improved aligning mechanism comprising a rocking idler gear in the output train between the differential transmission and its respective numeral wheel and which idler may be rocked to cause numeral wheel alignment without changing the differential transmissions from "crawl carry" to "aligned" condition.

This arrangement provides for aligning the numeral wheels by moving a minimum number of gears and permits the use of a relatively light spring to operate the aligning mechanism. Also, with this mechanism, backlash is reduced to a minimum by reducing the number of gears that must be moved to effect the aligning operation. Furthermore, the spacing between the numeral wheels has been reduced to a minimum in the present arrangement by mounting the numeral wheels and the differential transmissions on different respective shafts instead of side by side on the same shaft.

The numeral wheel snail cams, mentioned above, may also be used for purposes other than numeral wheel alignment. During the division operations disclosed in Patent No. 2,211,736, issued August 13, 1940, the numeral wheel snail cams are sensed to determine the value of the dividend. This dividend value is compared with the value of the divisor for controlling the num-

ber of cycles of operation of the digital actuators.

When the machine disclosed in the last mentioned patent is in normal condition of rest or is in normal condition between actuator operations during division, the numeral wheels and the associated differential transmissions are brought to aligned condition. The dividend sensing operations preparatory to the start of each ordinal division operation, and also for sensing for an overdraft, must all be delayed while the register is changed from "aligned" to "carry" condition.

Mechanism shown in the modified embodiment of the invention, disclosed herein, eliminates the necessity of the above delays. For this purpose, a snail cam for dividend sensing is provided in each order in addition to the snail cam for aligning its respective numeral wheel. This second snail cam is integral with the summation gear of each differential transmission. Each summation gear constantly stands in a position corresponding to the sum of the digital and tens carry increments registered regardless of numeral wheel alignment; therefore, the snail cam integral with the highest significant order summation gear may be sensed for determination of the approximate value of the entire dividend without waiting for the numeral wheels to be changed from aligned to crawl carry position.

One manner of obtaining numeral wheel alignment through adjustment of the output gear train is shown in the Patent No. 2,344,627, issued March 21, 1944, to H. P. Mixer. In this patent, the amount of adjustment in any order is determined by sensing a snail cam which is carried by the adjacent lower order summation gear; however, under certain conditions set forth in the last mentioned patent, the adjustment obtained by the snail cams is incorrect and therefore auxiliary means must be provided to supersede the control exerted by the snail cams to thereby obtain the correct amount of adjustment necessary for numeral wheel alignment. The present invention on the other hand, departs from the Mixer principle by providing mechanism that is capable of correctly adjusting the output gear train under any and all conditions and eliminates the need for the auxiliary aligning mechanism required by Mixer.

The present invention is therefore based upon the principle of separating the numeral wheel aligning mechanism of a crawl carry register from the tens carry train, the digital entry train and the summation gear of said two trains, so that each numeral wheel may be aligned in any one of its full digital display positions without effecting the position of said summation gear or said two trains.

It is a general object of the invention to improve the numeral wheel aligning means for crawl carry registers in accordance with the above principle.

It is a further object to align a numeral wheel by adjustment of the gear train between the numeral wheel and the summation gear of the differential transmission.

It is a further object to align a numeral wheel of a crawl carry register without imparting any change to the crawl carry mechanism.

It is a further object to minimize the resistance to the alignment of the numeral wheels.

It is a further object to align a numeral wheel with a minimum movement of a minimum number of parts.

It is a further object to cause a numeral wheel

snail cam or the like to stand at a position representative of the digital and partial tens carry values entered into its respective order of the register regardless of the alignment of its numeral wheel.

Other objects and advantages of the present invention will appear from the following description of a preferred form of the invention, reference being had to the accompanying drawings forming part of this specification, in which:

Fig. 1 is a right side view of the register schematically illustrating, in part, the components of a single order thereof.

Fig. 2 is an enlarged right side detail view of the differential transmission shown schematically in Fig. 1.

Fig. 3 is a sectional view taken on line 3—3 of Fig. 2.

Fig. 4 is an enlarged right side view of the mechanism shown schematically in Fig. 1, showing a numeral wheel, the crawl carry mechanism, and the aligning mechanism.

Fig. 5 is a plan view of three orders of the mechanism shown in Fig. 4.

Fig. 6 is an enlarged right side view of the mechanism for returning a numeral wheel to zero.

Fig. 7 is an enlarged right side view of a register comprising a modified embodiment of the invention.

Fig. 8 is a detailed right side view of part of the zeroizing mechanism for the register of the modified embodiment.

Fig. 9 is a sectional view taken on the line 9—9 of Fig. 7.

The present invention is shown applied to a register having what is known as epicyclic differential gearing but is applicable as well to the entocyclic type of differential or any other type in which one leg of the differential is driven in accordance with the sum of the drive imparted to the other two legs thereof.

Accumulator register

The register disclosed herein is composed of a plurality of orders, each including a numeral wheel 10 (Fig. 1), a gear 13 integral with the numeral wheel, an idler gear 14, and a differential transmission generally indicated at 20. The numeral wheels 10 and the differential transmissions 20 are mounted for free rotational movement on transverse shafts 11 and 17, respectively, carried by the ordinal frame members 19. Each idler gear 14 is freely mounted on a stud 15 fixed to a rocking carrier 16 (Fig. 4) freely pivoted on shaft 17.

The frame members 19 (Fig. 1) are mounted on a shaft 262 which corresponds to the shaft of the same number in said Patent No. 2,222,164. The shaft 262 is supported at its ends, as shown in that patent, by a pair of carriage end plates 251, a portion of the left end plate being shown in Fig. 1. The shaft 262 is also supported by ordinal carriage frame extensions (not shown). The end plates 251 are secured to a shaft 259 which is slidably mounted in the main framework of the calculating machine as disclosed in the last mentioned patent.

A common "dipping" bail 269 (Figs. 1 and 4) is attached to the right-most ends of the ordinal frame members 19 in the manner described in said patent and is automatically dipped clockwise about shaft 262 prior to each calculating operation to cause engagement between the digitation input gears 21 and respective actuator gears 189 (Fig. 4) of the ordinal actuator drive

trains. At the end of an actuation the dipping bail 269 is returned to its initial raised position against a limit stop 62, in which position the gears 21 are disengaged from the actuator gears 189. This dipping movement of the register is utilized in the present invention to adjust the output leg of the differential, to thereby change the numeral wheels from aligned to crawl carry condition and to use the raising of the register to similarly change the numeral wheels from crawl to aligned position, as is more fully explained hereinafter.

Differential transmission

The differential transmission 20 (Figs. 2 and 3) includes the previously mentioned digitation entry gear 21; a ring gear 26 attached to the gear 21 by means of rivets 27; a tens carry entry gear 22, by means of which the crawl carry drive is transmitted from the next lower order; a heart-shaped cam 24 having two studs 29 (upon which a pair of planet gears 28 are freely mounted for meshing with both the ring gear 26 and the sun gear 22); and a summation gear 18 integral with both the planet carrier 24 and the sun gear 22 for the next higher order, and which summation gear is driven in accordance with the sum of the digital and tens carry increments introduced into its associated order.

The differential 20 (Fig. 3) of each order is assembled in the following manner: A bearing 25 is suitably fixed in each ordinal frame member 19, and the digitation input gear 21 is freely mounted on the outside diameter of the left-most end of the bearing. The left-most end of the bearing is at the top as viewed in Fig. 3. Next, the reduced diameter of a tubular spline shaft 23, is passed through the left side of bearing 25. The unreduced portion of the spline shaft forms the sun gear 22. Gear 18 and the planet carrier 24 are then mounted on and have spline connection with the right end of the reduced shaft 23 to form an integral unit composed of gear 18, carrier 24 and the sun gear 22. The latter meshes with planet gears 28 of the next higher order when that unit is assembled. As the differential gears are assembled order by order, shaft 17 is passed through the spline shafts 23.

Suitable washers are provided between the sun gear 22 and the next higher order spline shaft 23 to prevent end thrust. Washers are also provided on either side of gear 21 to prevent bind between that gear, the frame member 19, and sun gear 22.

Clockwise movement of digitation input gear 21 (Fig. 2) causes the ring gear 26 integral therewith to revolve the planet gears 28 clockwise about the sun gear (assuming the sun gear to be held stationary, which is always the case in the lowest order wherein the sun gear is secured to member 19). Such movement of the planet gears causes the planet gear carrier 24 to be rotated a proportionate amount and in the same direction as the digitation entry gear 21. The summation gear 18 which is integral with the carrier 24, drives the numeral wheel gear 13 (Fig. 1) through idler 14; therefore, any clockwise movement imparted to the carrier 24 by clockwise movement of gear 21 causes an equal amount of clockwise movement of both the summation gear 18 and the numeral wheel. Similarly, any counter-clockwise movement imparted to digital gear 21 causes a corresponding counter-clockwise movement of the numeral wheel and gear 18.

With the ring gear 26 held stationary, which occurs when no movement is imparted from the digital actuator to gear 21, clockwise rotation of the next lower order gear 18 causes the sun gear 22 integral therewith to advance the planet gears 28 and rotate the planet gear carrier 24 clockwise. When the gear 21 is driven by the actuator, the ring gear 26 is driven clockwise to introduce digitation, and it will also rotate the planet carrier clockwise by the amount of such digitation in addition to the amount said carrier was rotated by the above tens carry train from the lower order summation gear 18. The movement of the planetary carrier 24, and its integral summation gear 18 and also the associated numeral wheel 10, is therefore the resultant of the digital entry into the respective order plus the tens carry movement transmited thereto from the next lower order.

The various gears of the differentials are so proportioned that each digital increment of advance of a summation gear 18 and its related numeral wheel 10 will cause the next higher order summation gear to be advanced by $\frac{1}{10}$ that amount. The gear combination which will give such results may be determined by well known formulae and therefore the gear ratios given below are for purposes of illustration only.

The digitation input gear 21 is provided with 18 teeth, the ring gear 26 with 90 teeth, the planet gears 28 with 40 teeth, the sun gear 22 with 10 teeth, the summation gear 18 with 20 teeth and the numeral wheel gear 13 with 20 teeth. Each full rotation of the digition entry gear 21 and its integral ring gear 26 rotates the planet carrier 24, the summation gear 18 and the numeral wheel gear 13 only nine-tenths of a revolution, providing the sun gear driven by the next lower order remains stationary. Therefore, a complete rotation of the numeral wheel requires $1\frac{1}{9}$ revolutions of the ring gear 26 which is the equivalent of a 20 tooth advance of the 18 tooth digitation entry gear 21 integral therewith. A two tooth advance of gear 21, therefore causes a single digit of advance of the numeral wheel.

If, on the other hand, the digitation entry gear 21 in an order remains stationary and the lower order numeral wheel makes a full revolution, the sun gear 22 is then rotated a full revolution of 10 teeth. The planet gear meshed with the sun gear "walks" around the 90 tooth ring gear a distance of 9 teeth or one-tenth of a revolution. This rotates the planet carrier and the summation gear 18 integral therewith an equal amount and advances the associated numeral wheel by one-tenth of a revolution. Each numeral wheel therefore advances the amount received by its respective digitation entry train plus one-tenth of the amount which the next lower order numeral wheel is advanced.

If the valve 375, for example, is entered into the register by the digital actuators of the machine disclosed in the above mentioned Patent No. 2,222,164, then before alignment of the numeral wheels, the lowest order of three numeral wheels receiving this value stands at 5, the second stands at 7.5 or half way between 7 and 8, while the third stands at 3.75 or three quarters of the way between 3 and 4. In order to bring the numeral wheels to their full digital display positions, the partial increments transmitted to them by the tens carry trains must be backed out and this is accomplished by the numeral wheel aligning mechanism.

Numeral wheel aligning mechanism

The upward movement or "rise" of the carriage out of mesh with the actuator gears 189 (Fig. 4) described hereinbefore is utilized to cause operation of the aligning mechanism. The first part of the carriage rise moves all of a plurality of arms 31 away from a stationary cross shaft 32 and thus permits springs 33 to rock pawls 30 to the position shown and lock the digital entry gears 21 in the full digital positions to which they were driven by the actuators. The gears 21 are so locked to prevent their movement out of position during operation of the aligning mechanism.

Idler gear 14 (Fig. 4) is freely mounted on a stud 15 fixed to a rocking carrier 16 which is part of the aligning mechanism. The carrier is bent to form a web beneath the gear 14 and is then bent upwardly to form the extension 16*a* on the other side of the gear. Extension 16*a* carries a stud 36 upon which a lever 35 is freely mounted. A roller 35*a* on the left end of lever 35 is limited in its upward movement by contact with a cam 34 (Figs. 4 and 5) of the next lower order numeral wheel. The right end of the lever 35 is limited in its upward movement by contact with a pin 37 mounted on the next lower order carrier 16.

Each snail cam 34 is yieldably attached to its respective numeral wheel and the rotated position of the snail cam is indicative of the value standing in its numeral wheel. The contour of snail cam 34 (Fig. 4) is proportioned in such a manner that the point of greatest radius represents the digit "0," and, as the numeral wheel is advanced clockwise to display successive digits up to "9," the radius of the cam becomes successively smaller until the smallest radius on the cam represents the digit "9."

A spring 39, tensioned between the right arm 50 of the carrier 16 and a suitable frame stud (not shown), urges carrier 16 clockwise until further movement thereof is blocked by contact of the roller 35*a* with snail cam 34 and by contact of the right end of lever 35 with stud 37.

When the register is in its normal raised position as shown in Fig. 4 the numeral wheels are aligned, but when the register is "dipped" to engage the digitation input gears 21 with their aligned actuator gears 189, the numeral wheels are moved to crawl carry position.

A stationary cross shaft 42 contacts the camming surface 41 of bail extension 40 during "dipping" of the register and rocks the carrier 16 counterclockwise. The time at which the cross shaft 42 contacts the camming surface 41 during the dipping movement depends on the position at which carrier 16 stands when the dipping operation occurs. If the carrier 16 stands at the "zero" position as shown in Fig. 4, then the cross shaft 42 contacts the camming surface 41 during the latter portion of the dipping movement and moves the carrier and the lever 35 only by an amount sufficient to permit clearance between roller 35*a* and the snail cam 34. On the other hand, if a snail cam 34 and/or the pin 37 stand at values of other than zero before the dipping movement, then the carrier stands in a more clockwise position than shown in Fig. 4 and the camming surface 41 will contact the cross shaft 42 earlier in the dipping movement of the carriage and move the carrier an amount in proportion to the values sensed at the snail cam 34 and pin 37. Such movement of the carrier 16 rocks the gear 14 counter-clockwise about shaft 17. At this time gear 18 is locked through the planetary gear train by the locking of gear 21 and therefore the revolving of gear 14 about shaft 17 rotates the numeral wheel gear 13 clockwise by the amount necessary to move the numeral wheel to the crawl carry position mentioned hereinbefore. The latter part of the dipping movement also moves the roller 35*a* slightly beyond the maximum radius of cam 34 to permit free rotation of the latter during actuation.

During the "dipping" movement of the carriage, the camming surface 41 of extension 40 moves downwardly, past shaft 42 and surface 41*a* wipes along shaft 42 without further rocking of extension 40 and carrier 16. During the idle movement of surface 41*a* relative to shaft 42 the cross shaft 32 contacts the extension 31 and rocks pawl 30 out of engagement with gear 21. The arrangement is such, therefore, that carrier 16 completes its rocking movement and the gear 14 moves the numeral wheel 10 to crawl carry position before pawl 30 is moved out of engagement with gear 21 thus insuring that the movement of the numeral wheels to crawl carry position will not rotate any gear of the differential 20. Conversely, during the rise of the register to aligned position, the pawl 30 is rocked to its locking position before the carrier 16 moves to aligning position, thus insuring that the gears of the differential 20 are not changed by the aligning movement of the numeral wheels.

Since the alignment of the numeral wheels does not change the condition of the differential, the summation gear 18 always remains in crawl carry position; therefore, a second cam such as cam 482 shown and described hereinafter in connection with the modified embodiment or, the numeral wheel snail cam of the previously mentioned Patent 2,211,736, could be fixed to gear 18 and be used for dividend sensing in a machine such as shown in that patent.

Since no tens transfer increments are transmitted to the lowest order numeral wheel, no aligning movement need be transmitted to the lowest order idler gear 14. Therefore, a fixed snail cam 34 and a fixed pin 37 are provided to the right of the lowest order numeral wheel for cooperation with the lever 35, thus holding the lowest order carrier 16 in its "0" position when the carriage is in either its dipped or in its raised positions. It should be noted that this fixed position of carrier 16 also fixes the position of the pin 37 carried thereby, and which pin cooperates with the second order lever 35.

A numerical example will clearly illustrate the action of lever 35 and carrier 16 and the control of cam 34 and pin 37 over the same to produce numeral wheel alignment. Assume, therefore, that the value 375 discussed generally hereinbefore, is entered into the units, tens and hundreds order numeral wheels so identified in Fig. 5. The entry of this value by the digital actuators rotates the units order numeral wheel to 5. The actuators together with the concurrent operation of the crawl mechanism rotate the tens order numeral wheel to 7.5 and the hundreds order wheel to 3.75. Aligning mechanisms are usually provided and are brought into play after the operation of the actuators to bring the numeral wheels to full digital display positions. This alignment is brought about in the present invention by means which is distinctly different from the prior art.

Considering primarily the alignment of the

hundreds order of the three numeral wheels, the prior art structure exemplified by the U. S. Patent No. 2,222,164 mentioned hereinbefore, backs out the .7 from the hundreds order through control exercised in the tens order snail cam over a rocking idler in the carry train between the tens and hundreds orders, while the aligning mechanism shown in the previously mentioned Patent No. 2,039,682, backs out the .7 from the hundreds order by a similar control over a rocking idler located in the digital entry train of the hundreds order. In both cases, however, the .05 transmitted to the hundreds order by the tens carry gear train during actuation is backed out of the hundreds order by the reverse movement of this same tens carry train during the alignment of the tens order numeral wheel from 7.5 to its full digital position 7. In this manner the aligning movement of a numeral wheel is obtained from two separate means: (1) from sensing the snail cam of the next lower order, and (2) through the tens carry gear train between the respective orders.

The aligning mechanism shown in the previously mentioned Patent No. 2,344,627 also obtains the aligning movement from two separate means. Normally, a numeral wheel is aligned by sensing the snail cam carried by the next lower order summation gear, but under certain conditions described in the specification of that patent, the sensing mechanism may falsely sense a registration of "0" instead of "9.9," for example, and therefore auxiliary means are provided which, under such a condition, supersedes the snail cam sensing mechanism and causes a correct aligning operation. From the foregoing then, it is seen that regardless of whether the aligning movement is obtained from adjustment of the tens carry leg, the digital entry leg, or the summation leg of the differential gearing between the orders, the aligning movement has in each case actually depended upon two separate means.

In the present invention, on the other hand, the partial tens carry increments from the units and tens orders, for example, are compounded in a single device which alone and without the use of auxiliary corrective means, exercises a unitary control over the alignment of the hundreds order numeral wheel without disturbing the condition of the tens carry train or the summation gears of the differentials in any of the orders. This device includes the lever **35** (Fig. 4) and its carrier **16**, the construction of which was described hereinbefore.

The snail cam **34** (Fig. 4) is so proportioned that movement of roller **35***a* from the zero position shown to the position on the cam corresponding to a 7 in the tens order, for example, will back up the hundreds order numeral wheel .7 of a digital increment. The backing up by the amount of the additional .05 of a digital increment in order to bring this numeral wheel from a registration of 3.75 to 3.00 is caused by the movement of pin **37** and by compounding this movement in lever **35** with the movement imparted thereto by or under control of cam **34**.

The relationship between the units, tens and hundreds order may be seen in Fig. 5. The units order snail cam identified as U–**34** in this figure controls the movement of the tens order lever T–**35** which in turn controls the rocking movement of the carrier T–**16** and the idler T–**14** carried thereby. Since the units order numeral wheel stands at 5 in the present example, the carrier T–**16** and all the parts that it carries, move an amount representative of .5 and back up the tens order numeral wheel from 7.5 to 7.

The pin T–**37**, mounted on the carrier T–**16** lies in the plane of the lever H–**35** which controls the backing up of the hundreds order numeral wheel to aligned position. The forward or left end of lever H–**35** is controlled by snail cam T–**34** which is indicative of a 7 standing in the tens order numeral wheel, while the right end of the same lever H–**35** is controlled by the pin T–**37**. The .5 movement of the carrier T–**16** mentioned above is reduced to $\frac{1}{10}$ that amount and transmitted to the hundreds order numeral wheel by the following mechanism so that .05 is backed out of the numeral wheel.

Pin **37**, shown in Fig. 4, is located one-fifth of the distance between shaft **17** and stud **36** and therefore the movement of pin **37** is $\frac{1}{5}$ that of stud **36**. Pin **37** extends across the plane of the lever **35** in the next higher order and the stud **36** is located midway between pin **37** and roller **35***a*. With roller **35***a* and cam **34** serving as a fulcrum for lever **35**, the above $\frac{1}{5}$ movement of pin **37** moves stud **36** one-half that amount or $\frac{1}{10}$ the amount of movement of stud **36** in the next lower order. In the case of the present example, therefore, the .5 movement of the tens order carrier **16** causes a .05 movement in the hundreds order. This amount is compounded with the .7 movement controlled by snail cam T–**34**, mentioned above and the two movements back up the hundreds order numeral wheel from 3.75 to 3.00.

In the event some value such as 9900 stands in the register before the carriage is dipped, then during dipping of the carriage, the higher order 9 is moved from 9 to substantially 0 by the disabling of the above described aligning mechanism. At the beginning of such movement the rollers **35***a* in the orders displaying 9's, are each in contact with the low points of their respective cams **34** (Fig. 4), but as the higher order numeral wheel is changed from 9 to substantially 0, the steep rise of the higher order cam **34** moves against the roller before the roller is moved clear of the cam. Allowance is made for such conflict, as is fully shown and described in said Patent No. 2,222,164, by yieldably attaching each snail cam **34** to its numeral wheel **10** by means of a spring **34***a* connected at one end to a stud **34***b* carried by said cam and connected at its other end to a lug **10***a* formed on the side of the numeral wheel and which lug passes through a slot in the cam. The resistance of roller **35***a* to the movement of the cam **34** tensions the spring **34***a* and when roller **35***a* is moved to its lowermost dipped position just beyond the periphery of the cam, the spring rotates the cam to its 9.9 or substantially 0 position.

Clearance

The mechanism for returning the numeral wheels to zero is of the general type shown in the Schaller Patent No. 1,400,004 which includes a well known heart-shaped cam and a camming clearance lever adapted to engage either side of the heart and through its camming action, to drive the heart cam and the related numeral wheel in one direction or the other to zero.

The numeral wheels in connection with which heart cam clearance mechanisms have heretofore been used, are always in one of a plurality of digital positions and therefore the apex of the heart has been located mid-way between two

digital positions, such as between the 4 and 5 or between the 5 and 6 positions, so that the camming lever will always engage the heart cam on one side or the other of its apex for starting its camming action.

Since a numeral wheel of the register of the present invention may be in any intermediate location between the full digital positions, the camming lever may, under one specific condition of the numeral wheel, engage the heart cam directly at its apex and be in a position to have no camming action thereon. The camming lever is therefore arranged so that it will yield under its power driving action and such yielding, in effect, extends the lever and moves the same off of the apex and into the camming surface of the cam.

The clearance mechanism of the present invention includes a plurality of bell cranks **51** (Fig. 6) each of which is keyed to a transverse shaft **320** and is located in operative relation to each respective heart cam and its numeral wheel. Shaft **320** is rocked clockwise during a clearance operation by a clearance drive mechanism such as that shown and described in the U. S. Patent No. 2,291,135. A camming lever **54** is pivotally mounted to an arm **52** of bell crank **51** by means of a stud **53**. Lever **54** is provided with an ear **56** overlying an arm **51***a* of bell crank **51**, which ear is spring urged against said arm by means of a tension spring **57** connected to ear **56** and an ear **58** of arm **51***a*. A roller **55**, mounted on lever **54**, is adapted upon rocking of shaft **320** to contact the periphery of the heart-shaped cam **24** and through its camming action to rotate said cam until the roller seats into the notch "*a*" which is the "0" position of the cam. If the roller contacts the cam surface "*c*," the cam will be rotated in a counter-clockwise direction, while if the roller contacts the surface "*d*," the cam will be rotated clockwise to its "0" position. in the event the roller contacts the cam exactly at point "*b*," spring **57** will yield and stud **53** will move upwardly toward the straight line between the axis of shaft **320** and roller **55**. This, in effect, extends lever **54** relative to point "*b*" so that roller **55** moves off of the apex at point *b* and onto the camming surface *c*, to thereby rotate the cam to "0" position. Cam **24** (Fig. 3) is integral with the summation gear **18** which is geared to the numeral wheel by means of gears **14** and **13** (Fig. 4). Return of the cam to zero position consequently returns the numeral wheel to zero.

It is desirable that roller **35***a* of lever **35** be removed from engagement with numeral wheel cam **34** during resetting of the numeral wheel to "0" and for this purpose a lever **59** (Fig. 4) having a roller **61** is keyed to the clearance shaft **320**. During rocking of shaft **320**, the roller contacts the lower surface of arm **50** on carrier **16** and rocks the carrier counter-clockwise to crawl carry position thus moving roller **35***a* out of the path of cam **34**.

One leg of the planetary differential **20** must be free to rotate when the other two legs are driven or when one of the two legs is driven and the other is locked. In the case of clearance, the output leg is driven by the clear cam and the tens carry leg is driven by the clearance mechanism of the next lower order numeral wheel; therefore, the digital input leg which includes gear **21** must be freed from restraint during the clearance operations. For this purpose lever **59** is provided with a surface **60** which lies adjacent an ear **30***a* of pawl **30**, and as the lever **59** is rocked clockwise, this surface contacts the ear and causes the pawl to be rocked clear of gear **21**.

At the completion of the clearance operation, shaft **320** is returned counter-clockwise to normal position and the pawl **30** re-engages gear **21** to centralize the differential assembly and the numeral wheel. Carrier **16** is released from roller **61** and is free to rock clockwise under urge of spring **39** to aligned position at which time lever **35** almost immediately re-engages its respective pin **37** and cam **34** in their zero positions. The resetting lever **54** (Fig. 6) is also rocked out of the path of cam **24** to thus permit the numeral wheel to be driven during the next operation.

Modified embodiment

A modified embodiment of the present invention is shown in Figs. 7, 8, and 9. The register and the aligning mechanism shown in Fig. 7 are designed to be incorporated in a machine of the type shown in U. S. Patent No. 2,567,120, issued September 4, 1951. In the machine disclosed in the latter application, an ordinal actuator is provided for each order of the accumulator register and an actuator drive gear is permanently enmeshed with each digitation input gear **21**. In such a machine there is no need to "dip" the register to cause engagement between the actuators and the digitation entry gears. Therefore, means other than the "dipping" means disclosed in the first embodiment of the present invention is provided in the mechanism of the modified embodiment to move the numeral wheels to crawl carry and then back to aligned positions.

The pawl **30'** (Fig. 7) is loosely keyed to a shaft **350** for limited movement relative thereto while arm **59'** is tightly keyed to the same shaft. When shaft **350** is rocked clockwise, the roller **61'** on arm **59'** contacts surface **41'** and then "wipes" along surface **41***a'*. This rocks carrier **16'** and then holds it in rocked position in the same manner as the stationary cross shaft **42** (Fig. 4) contacts the surfaces **41** and **41***a* of the extension **40** on carrier **16** to hold the latter in rocked position. The latter part of the rocking movement of shaft **350** causes the pawl **30'** to be rocked clockwise out of engagement with gear **21** to permit the actuators to drive the same.

Pawl **30'** and carrier **16'** must be moved and held in their disengaged and crawl carry positions, respectively, during both actuating and clearing operations. A mechanism is disclosed in the above mentioned U. S. Patent No. 2,567,120 whereby a shaft which controls the rocking movement of a plurality of numeral wheel centralizer pawls may be selectively rocked and locked in pawl-disengaging position under the control of either a clear clutch or of a setting clutch, the latter operating previous to each actuating operation. The control shaft of said application is released from locked position when the clear clutch or the main actuator clutch becomes disengaged, depending on the operation being performed. A similar mechanism may be used to control the rocking of shaft **350** shown in Fig. 7.

In those machines where the main actuator clutch operates to drive the numeral wheels without a preliminary setting clutch operation, the rocking of shaft **350** may be directly controlled by the main clutch or related mechanisms which will rock the shaft and hold it in clockwise position for the duration of operation of the clutch.

A snail cam 482 (Fig. 7), a sensing arm 483 and a shaft 402 correspond to the parts of the same number in the last mentioned patent. The arm 483 is loosely keyed for limited rotation on the shaft 402. Each arm carries a roller 483a for contacting the snail cam 482. The latter also serves as a planetary gear carrier and therefore constantly stands in the crawl carry position regardless of whether the respective numeral wheel is aligned in full digital display position or not. The amount of counter-clockwise rocking of arm 483 necessary to contact the snail cam 482 is an indication of the value standing in that order and all lower orders to the right thereof.

During each actuating operation the shaft 402 for the arms 483 is rocked clockwise to move the rollers 483a clear of the snail cams 482 and permit free rotation of the cams, all as is fully described in the last mentioned patent.

A clearance mechanism for the modified embodiment of the invention is illustrated in Figs. 7 and 8 and, which mechanism corresponds in principle of operation to a clearance mechanism disclosed in Patent No. 1,928,125, issued September 26, 1933. Briefly, the numeral wheels are returned to zero by the rotation of a clearance drive shaft and are prevented from over-running zero positions by respective zero detent pawls.

Numeral wheels 10' are mounted for free rotation upon a common sleeve 101 (Fig. 9). This sleeve is stationary during actuation of the numeral wheels but is driven by the clearance driving mechanism to return the wheels to zero. Sleeve 101 is journalled upon a stationary inner shaft 102 which is provided with a longitudinal groove 103. Extensions 104 (Fig. 9) of a hub 105 are passed through aligned openings provided in the numeral wheel 10' and its associated gear 13'. The extensions are riveted over to secure the hub, numeral wheel and gear as one integral unit in each order. A tooth 106 (Fig. 7) is disposed within each hub and when the numeral wheel is in its "0" position, the tooth is in radial alignment with a respective hole 107 in the sleeve 101 and the groove 103 in the shaft 102. A ball 108 is disposed in each hole 107 and upon counter-clockwise rotation of the sleeve 101 around the shaft 102, the balls are forced out of the groove and project beyond the periphery of the sleeve. During such rotation of the sleeve, the projected balls engage the teeth 106 of the respective numeral wheels which are out of "0" position and carry those numeral wheels back to "0" position. At such time the balls recede into the groove 103 and move out of engagement with the teeth 106.

Means are provided to prevent overdriving or overthrow of the numeral wheels so as to stop the wheels precisely at zero at the time the above driving action terminates. A cam 113 (Fig. 8) is fixed to either end of sleeve 101. Each cam 113 has a follower arm 111 with a roller 112 which rides on the periphery of the cam. The arms 111 are fixed to a transverse shaft 110 and to which shaft is fixed a series of ordinally arranged zero stop pawls 109. Springs 115, fixed to the respective right and left end pawls 109 hold the rollers 112 in contact with the cams 113. Upon counter-clockwise rotation of the sleeve 101, for operation of the ball type clearance mechanism described above, the cam 113 rocks the follower arms 111 and the pawls 109 counter-clockwise. The cam is so designed as to move the pawl noses 109a into the path of the numeral wheel lugs 10a' and to hold the pawls in this position until near the end of the clearance cycle. The timing of the retraction of the pawl noses 109a is such that the pawls 30' (Fig. 7) are moved into engagement with the gears 21 during the retraction of the noses 109a, thus centralizing the numeral wheels in zero position.

I claim:

1. A crawl carry register having a plurality of orders of registering mechanism, each order thereof including a differential transmission comprising the combination of a resultant member, means for positioning said member at a crawl carry position corresponding to the digital value of an amount registered in its respective order plus a partial carry increment equal to one tenth of the amount registered in the next lower order registering mechanism, a higher order numeral wheel, a graduated member connected to said numeral wheel and adapted to rotate therewith, and a gear connection between said higher order numeral wheel and said resultant member, with aligning means controlled jointly by the lower order graduated member and the gear connection in said lower order for adjusting the higher order gear connection to thereby compensate for said partial carry increment registered by the respective higher order registering mechanism, and means to maintain the resultant member in crawl carry position throughout the operation of the aligning means to enable the latter to rotate the higher order numeral wheel to full digital display position.

2. A crawl carry register having a plurality of orders of registering mechanism, each order thereof including a differential transmission comprising a resultant member, means for positioning said member at a crawl carry position corresponding to the digital value of an amount registered in its respective order plus a partial carry increment equal to one-tenth of the amount registered in the next lower order registering mechanism, a lower order numeral wheel and a higher order numeral wheel associated with their respective lower and higher order registering mechanisms, and a gear connection between said higher order numeral wheel and its related higher order resultant member for transmitting motion from the member to the numeral wheel equal to the amount registered in its respective order plus said partial carry increment received from the next lower order, with aligning means associated with each ordinal registering mechanism, said aligning means including a graduated member connected to said lower order numeral wheel and operable to represent the position of said numeral wheel, a carrier for said higher order gear connection and adjustable to a position representative of the crawl carry value registered in a plurality of lower order numeral wheels, and means controlled jointly by the lower order graduated member and the carrier of the lower order gear connection to adjust the higher order carrier and cause the gear connection of the latter to back out of said higher order numeral wheel an amount equal to said partial carry increment.

3. In a calculating machine having digital actuators, the combination of a crawl carry register including numeral wheels and a differential transmission for each numeral wheel, said transmission including a digitation leg for receiving digital values from said actuators, a tens carry leg for receiving the tens values from the lower order differential, and a resultant leg driven by

said digitation and tens carry legs to a crawl carry position representative of the numerical sum of said digital and tens carry values, with aligning means operable to change each numeral wheel from crawl carry position to full digital display position, said aligning means including, an adjustable gear connection between said resultant leg and the respective numeral wheel, a graduated member on each numeral wheel, and a device controlled jointly by the graduated member and gear connection of the next lower order to adjust the first mentioned gear connection.

4. In a calculating machine having digital actuators, the combination of a crawl carry register including a plurality of differential transmissions mounted upon a transverse shaft, each differential transmission including a digitation leg for receiving digital values from said actuators, a tens carry leg for receiving the tens value from the lower order differential, and a resultant leg for combining the digital and tens values, with a plurality of numeral wheels mounted on a second shaft parallel to said transverse shaft, a gear connection between the resultant leg of each differential transmission and the respective numeral wheel, numeral wheel aligning means for bringing each numeral wheel to a full digital display position including, an adjustable carrier for said gear connection effective upon adjustment thereof to cause the gear connection to back out of its respective numeral wheel an amount proportional to such adjustment, a graduated member on each numeral wheel, and an element controlled jointly by the graduated member of the next lower order numeral wheel and the carrier for the lower order gear connection to adjust the carrier for the gear connection in the higher order by an amount proportional to said tens value.

5. In a calculating machine, the combination of a plural order crawl carry register, each order thereof including a numeral wheel, and a differential transmission having a resultant member continuously positioned in the crawl carry position corresponding to the digital value of the amount registered therein plus a partial carry increment equal to one-tenth of the amount registered in the next lower order member, and a gear connection between each resultant member and its respective numeral wheel to transmit to the latter a movement corresponding to the sum of the digital and tens carry values received by the resultant member, with numeral wheel aligning means operable at the conclusion of a machine operation to bring each numeral wheel to full digital display position, said aligning means including a graduated member on each numeral wheel and operable to represent the position of said wheel, an adjustable carrier for said gear connection of each order and adjustable to a position representative of the crawl carry value registered in a plurality of lower order numeral wheels, and a device jointly positioned under control of the graduated member of the next lower order and under control separately exercised by the carrier in said next lower order to adjust the carrier of the higher order to compensate for the partial carry increments transmitted from the resultant member to its numeral wheel.

6. In a calculating machine having a plural order crawl carry register including a unit order, a tens order and a hundreds order, each order including a numeral wheel, a differential transmission, and a gear connection between each differential and its respective numeral wheel to transmit to the latter a movement corresponding to the sum of the digital and tens carry values received by the differential; the combination of, numeral wheel aligning means operable at the conclusion of a machine operation to bring each numeral wheel to full digital display position, said aligning means including a graduated member on each numeral wheel, an adjustable carrier for said gear connection of each order, and an element on each carrier, with means operable under control of the graduated member in the unit order to adjust the carrier of the tens order to a position corresponding to one-tenth of the value in the units order numeral wheel, a device controlled jointly by the graduated member in the tens order and the element of the tens order carrier for adjusting the carrier in the hundreds order in accordance with the sum of one-hundredth of the value in the units order and one-tenth of the value in the tens order.

7. In a calculating machine having digital actuators, and a crawl carrying register including a plurality of differential transmissions mounted upon a transverse shaft, each differential transmission including a digitation leg for receiving digital values from said actuators, a tens carry leg for receiving the tens values from the lower order numeral wheel, and a resultant leg for combining the digital and tens values; the combination of, a plurality of numeral wheels mounted upon a second shaft parallel to said transverse shaft, and a gear connection between the resultant leg of each differential transmission and the respective numeral wheel and operable to rotate said numeral wheel to a crawl carry position indicative of the sum of said digital and tens values, with numeral wheel aligning means for bringing each numeral wheel to a full digital display position including, a graduated member on each numeral wheel, means to lock each differential and its resultant leg in crawl carry position, a carrier for each of said gear connections adjustable to back out of said numeral wheel the partial tens carry value entered therein, means for controlling such adjustment including a lever pivotally mounted intermediate its ends on said carrier with one end adapted to contact the graduated member of the next lower order and the other end adapted to contact a projection on the carrier of the gear connection for said next lower order, a second graduated member positioned by said resultant leg in accordance with the digital and tens values while the numeral wheel in the same order is brought to full digital display position by said aligning means, and a division control element for sensing said second graduated member to determine the value of a multi-digit dividend.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,148,516	Irion et al.	Aug. 3, 1915
1,356,607	Dixon	Oct. 26, 1920
1,781,320	Crosman	Nov. 11, 1930
2,089,682	Chase	Aug. 10, 1937
2,211,736	Avery	Aug. 13, 1940
2,222,164	Avery	Nov. 19, 1940
2,344,627	Mixer	Mar. 21, 1944