July 2, 1940. S. HILDER 2,206,724

CALCULATING MACHINE

Original Filed Jan. 23, 1935 5 Sheets-Sheet 1

Fig. 1

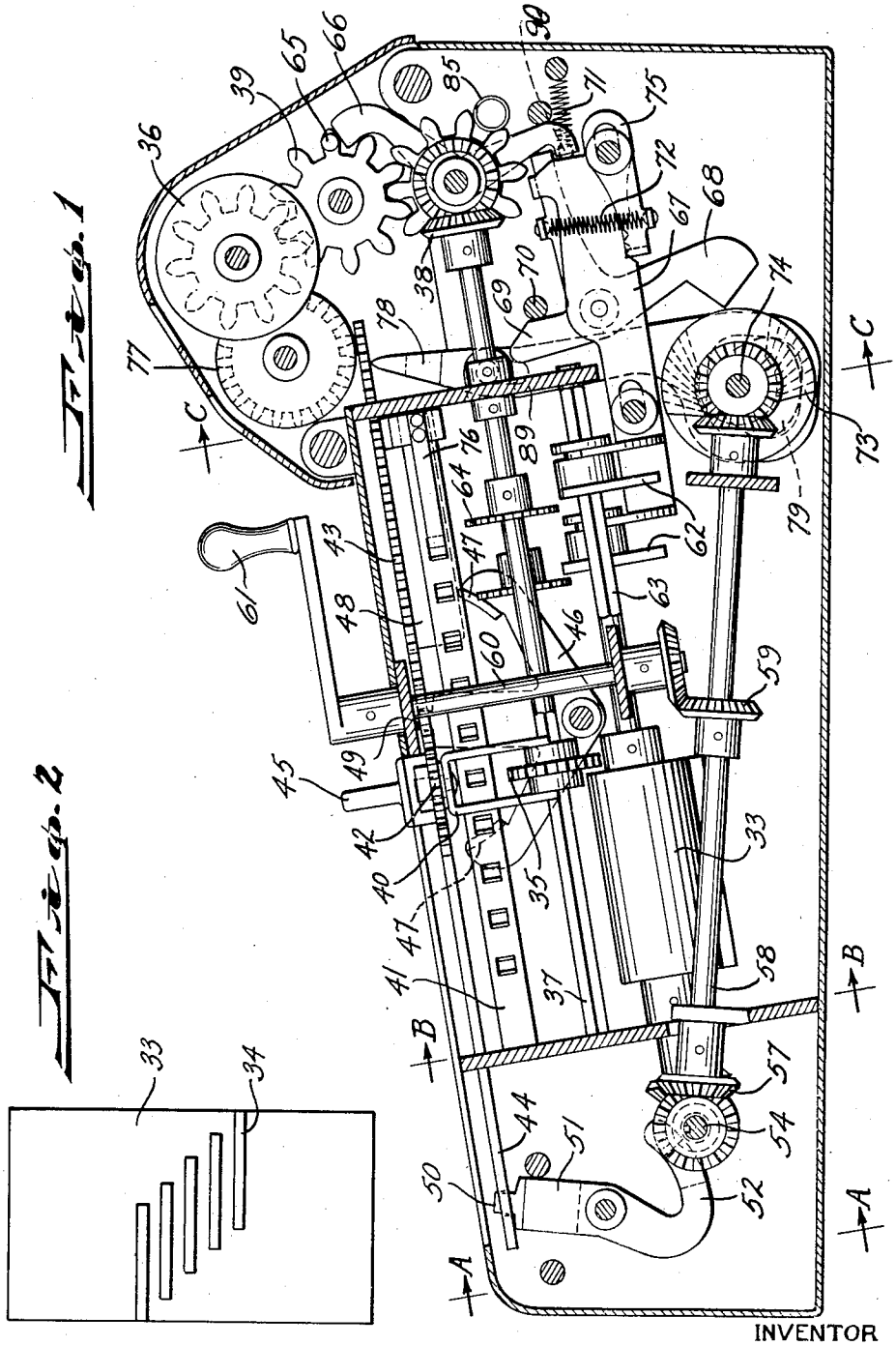

Fig. 2

INVENTOR

Stuart Hilder

July 2, 1940. S. HILDER 2,206,724

CALCULATING MACHINE

Original Filed Jan. 23, 1935 5 Sheets-Sheet 2

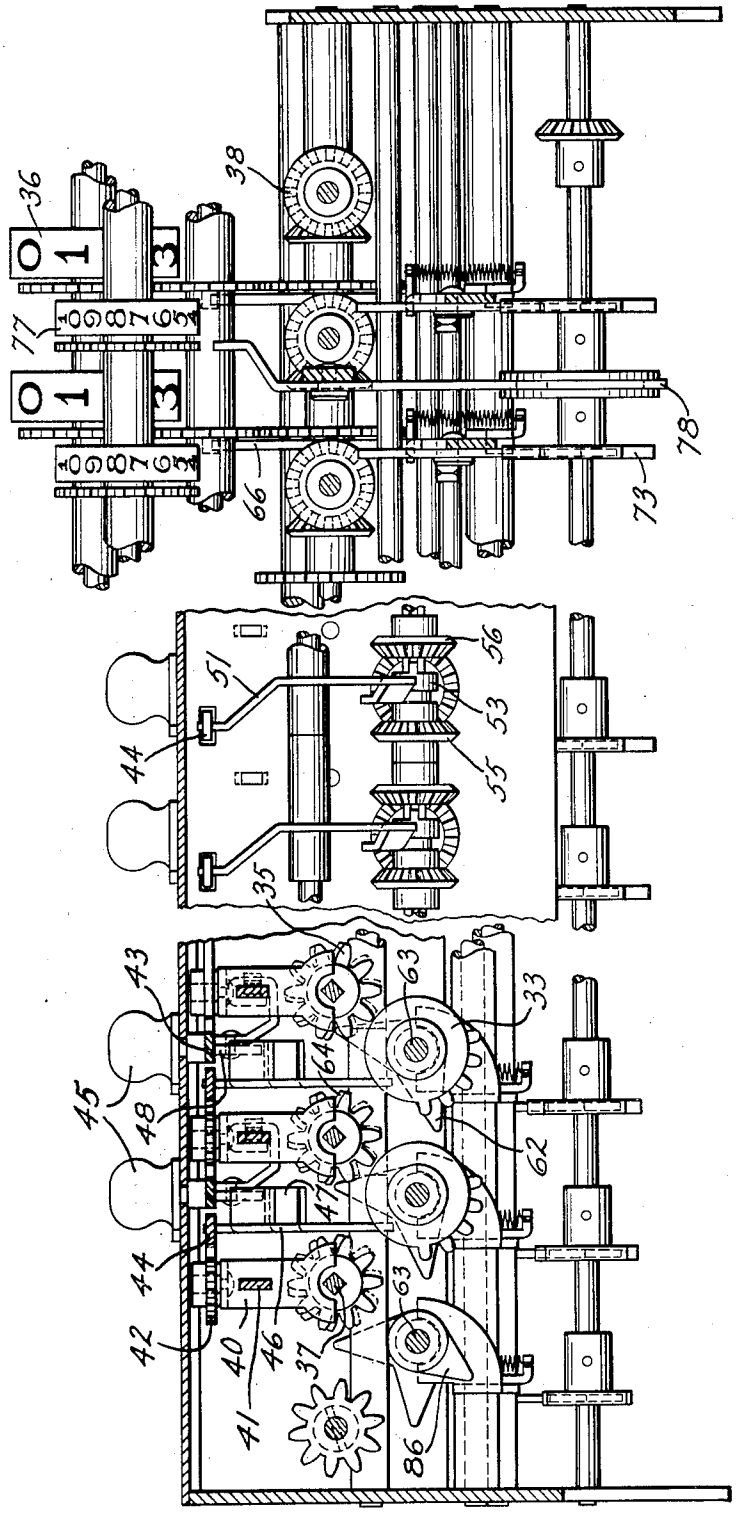

Fig. 3C

Fig. 3A

Fig. 3B

INVENTOR

Stuart Hilder.

July 2, 1940. S. HILDER 2,206,724

CALCULATING MACHINE

Original Filed Jan. 23, 1935 5 Sheets-Sheet 3

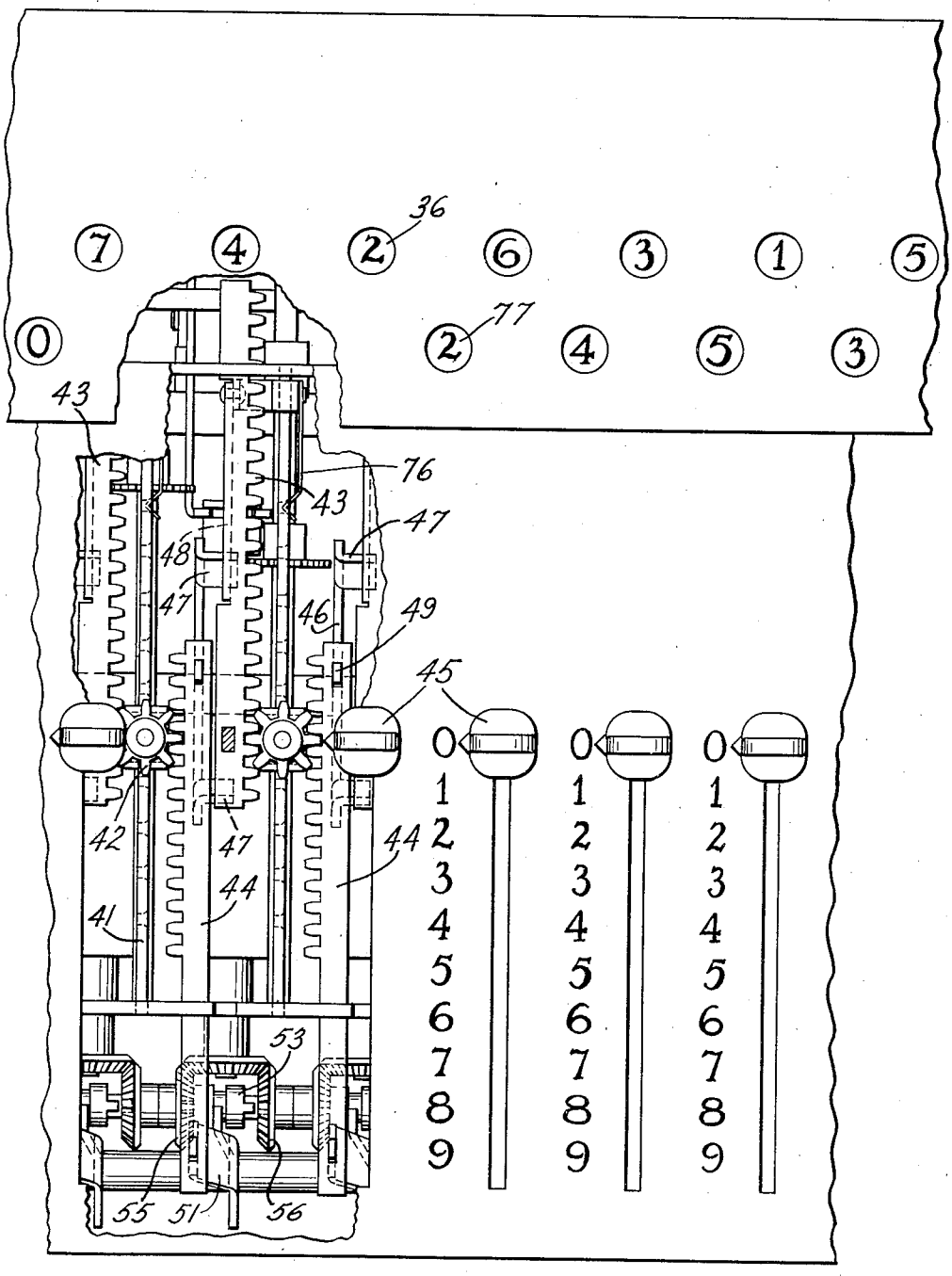

Fig. 4

INVENTOR

Stuart Hilder

July 2, 1940. S. HILDER 2,206,724

CALCULATING MACHINE

Original Filed Jan. 23, 1935 5 Sheets-Sheet 4

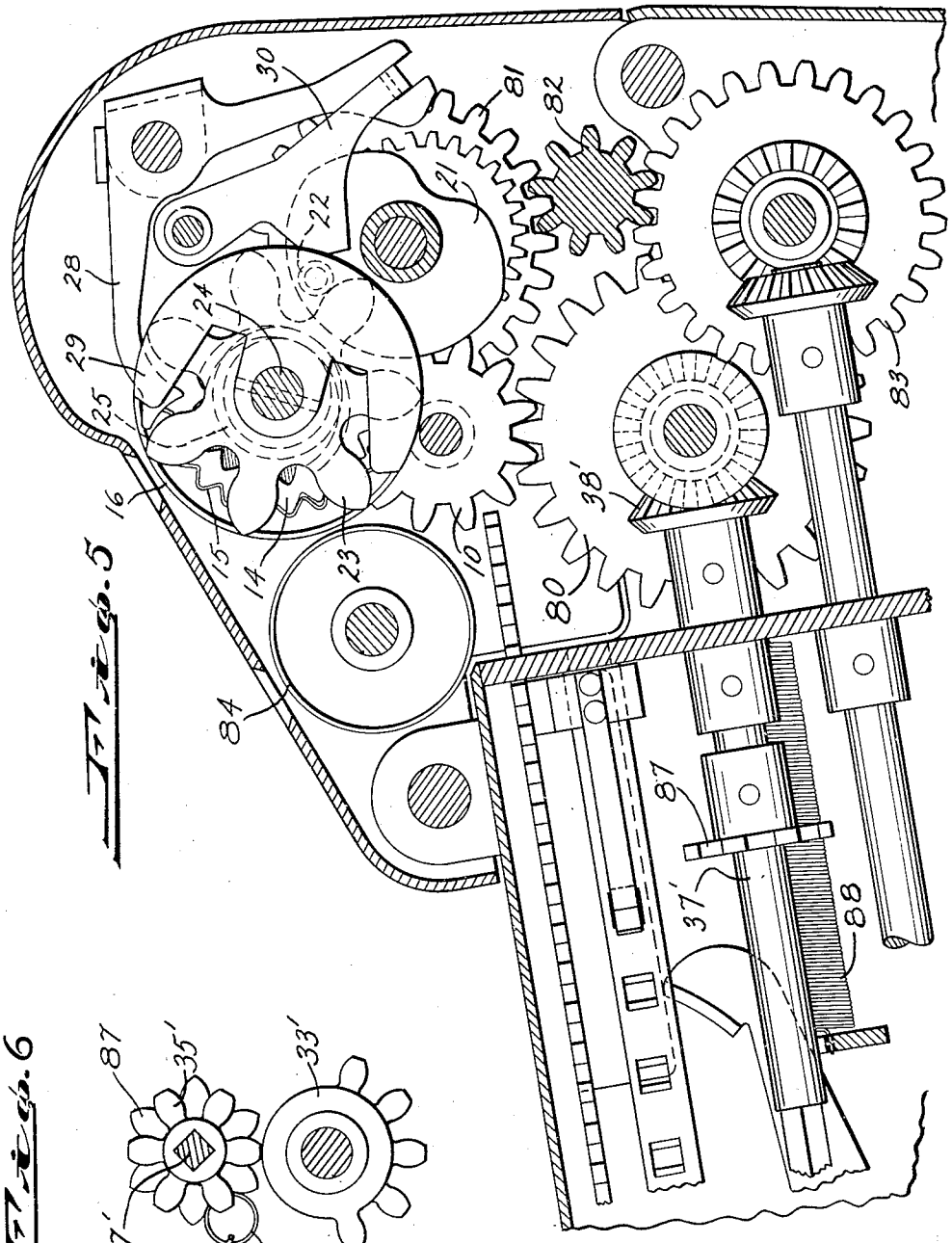

Fig. 5

Fig. 6

INVENTOR

Stuart Hilder

July 2, 1940. S. HILDER 2,206,724

CALCULATING MACHINE

Original Filed Jan. 23, 1935 5 Sheets-Sheet 5

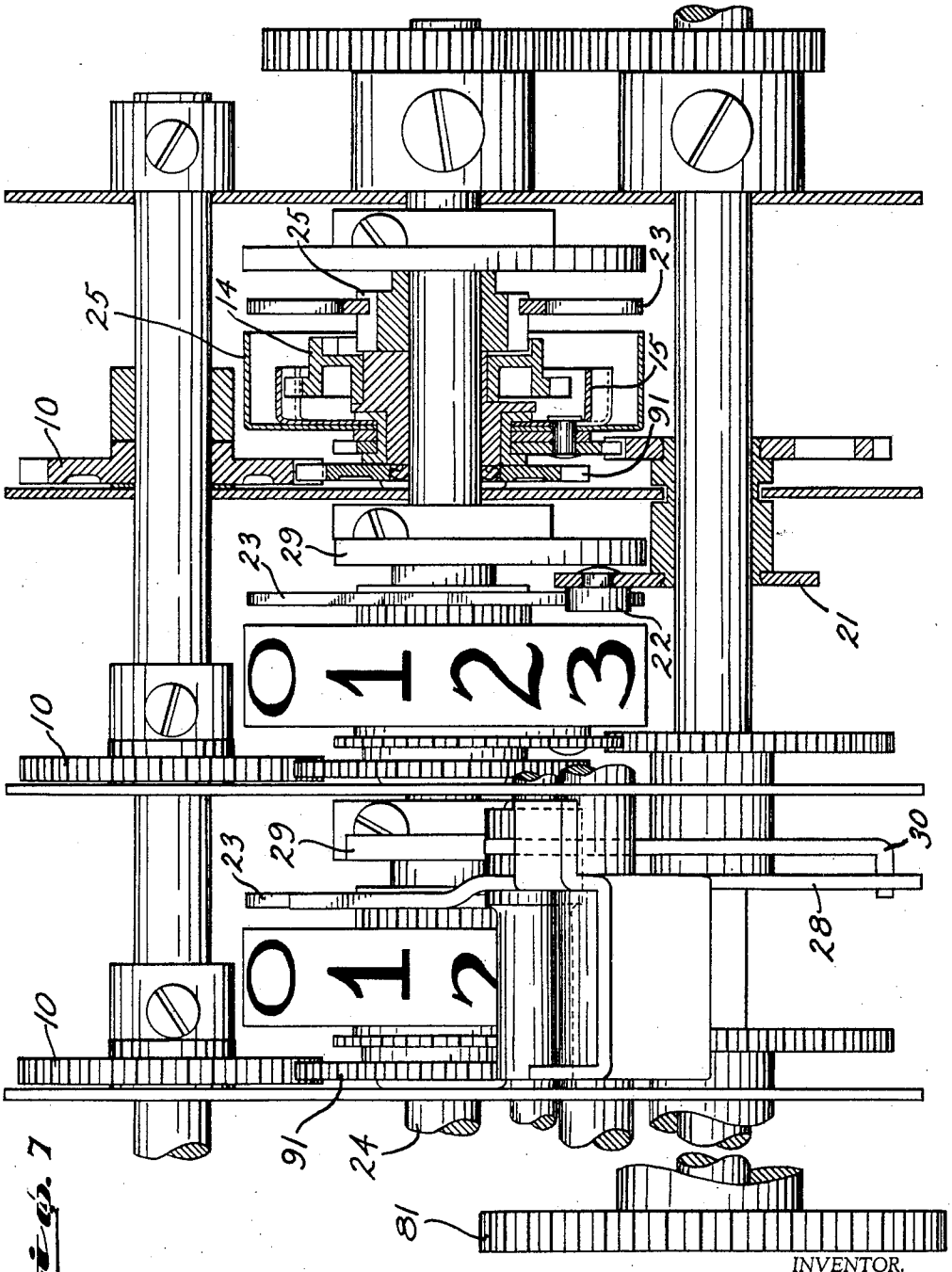

Fig. 7

INVENTOR.

Stuart Hilder

Patented July 2, 1940 2,206,724

UNITED STATES PATENT OFFICE

2,206,724

CALCULATING MACHINE

Stuart Hilder, Arlington, Va., assignor to Monroe Calculating Machine Company, Orange, N. J., a corporation of Delaware

Continuation of application Serial No. 3,088, January 23, 1935. This application November 12, 1938, Serial No. 240,157

7 Claims. (Cl. 235—79)

This application is a continuation of application Serial No. 3,088 filed January 23, 1935. The invention has relation to calculating machines and provides means whereby the semi-complemental system of registration described in the U. S. patent to Enberg No. 1,341,049, issued May 25, 1920, is used to reduce the extent of movement of the parts of the machine involved in a cycle of operation.

This semi-complemental system combines the registration of any of the digits from 1 to 4, set up in a given column of the machine by the direct method (rotating the related numeral wheel forwardly in addition or reversely in subtraction), with a registration of the digits 5 to 9 by subtracting the complements of such digits from 10 during addition or by adding the complement to —10 in subtraction. The method of registration in any given column will thus depend upon the amount set up in such column, and during the registering operation the machine may operate according to one method in certain columns and according to the other method in other columns.

The Enberg disclosure relates to a direct multiplying machine, wherein partial product members are employed, settable in accordance with a multiplier and a multiplicand to register the units of the product in one cycle of operation and the tens of the product in a second cycle. The saving in operative movements effected by the Enberg mechanism relates solely to this direct system of multiplication, and no means is shown whereby a saving in any one registering cycle may be effected. For instance, addition is effected on this machine by multiplying by 1, in which he has a maximum of 5 steps of numeral wheel movement in registering the units and 1 step of movement in separately registering the necessary tens, in addition to which he must operate his tens transfer mechanism after the registration of the units and again after the registration of the tens, this transfer being carried successively across the machine from right to left in each instance. The separate registration of the tens is necessary because he provides no means for merging these values with the unit values registered in the same columns, and the necessity for two separate tens transfer operations will be apparent from a study of the alternatives provided in the present disclosure. All this is in addition to the idle movement required by Enberg in rotating the entire field of partial product elements past the registering point during each cycle of operation. It is to be noted that the greater portion of the novel features of the present invention are involved in the presetting and registration of the values which are to be registered complementally, and it will be obvious that any desired digits may be so handled. Carried to the extreme, this would provide a completely complemental machine of novel construction, wherein there is no problem of the "fugitive one" nor special rules for manually setting values in the keyboard.

The invention consists in the novel construction and combination of parts as set forth in the appended claims.

In the accompanying drawings, illustrating preferred embodiments of the invention:

Fig. 1 is a section taken immediately inside the right hand frame plate of a calculating machine embodying the invention.

Fig. 2 is a detail projection of an actuator drum.

Fig. 3A is a section, taken on line A—A of Fig. 1.

Fig. 3B is a section, taken on line B—B of Fig. 1.

Fig. 3C is a section, taken on line C—C of Fig. 1.

Fig. 4 is a fragmentary plan view of a machine with parts of the casings broken away.

Fig. 5 is an enlarged fragmentary sectional view similar to Fig. 1, showing a modified form of tens transfer mechanism.

Fig. 6 is a detail end view of an actuator drum and pinion designed for use with the mechanism of Fig. 5.

Fig. 7 is a section of the transfer mechanism of Fig. 5, the supporting shafts of the intermediate pinions and the alignor cams being rotated to diametrically opposite positions relative to the numeral wheel shaft, for convenience of illustration.

These drawings illustrate a calculating machine having actuator drums provided with offset teeth, as in the well known "Thomas" machines; slide set selector mechanism, and hand crank driving means, these mechanisms being chosen for convenience in illustrating the invention and having each well known alternatives, which might equally well be employed in connection with the features of the invention.

Although column actuators and tens transfer mechanism of the Thomas type are shown, the structure disclosed is of the reversible cycle type. A similar combination is shown in the U. S. patent to Rauscher No. 1,136,484, issued April 20, 1915.

The actuator drums 33 (Figs. 1, 2 and 3) are

each provided with five teeth 34, so arranged as to provide that an actuator pinion 35, moved step by step from its rearmost position toward the front of the machine, will come successively opposite 0, 1, 2, 3, 4, 5, 4, 3, 2, 1, 0 teeth 34, so that corresponding registrations may be effected upon the numeral wheels 36, when the drums 33 are given a complete rotation. One arrangement of teeth 34 for securing the above result is illustrated in Fig. 2.

The pinions 35 are set along the drums 33 by sliding movement upon squared shafts 37, said shafts being provided with bevel gearing 38, having spur gear connections including the gears 39 for driving the numeral wheels 36.

The pinions 35 are slid along the shafts 37 by selector mechanism comprising sliding forks 40 mounted upon bars 41 and carrying pinions 42 which mesh with the opposed racks 43 and 44 as shown in Fig. 4. The racks 44 are normally held stationary, while the racks 43 are provided with buttons 45 movable along graduated slots of the cover plate of the machine. Movement of a button 45 along its graduations will rotate the related pinion 42, causing said pinion to move along the stationary rack 43 and impart the desired setting movement to the actuator pinion 35.

The various sliding selector members are shown as held in adjusted position by springs 76, secured upon the racks 43 and engaging notches of the fixed bars 41.

Thus, from its 0 position, in rear of the drum 33, actuator pinion 35 may be moved into registry with 1, 2, 3 or 4 teeth of the drum to register one of the digits 1 to 4. As pinion 35 is set one more step forward, to register the digit 5, means will be operated for reversing the direction of rotation of the related drum 33 and for setting up an additional unit in the next higher order selecting mechanism.

This means comprises a rocker 46 (one of such rockers being employed in each selector column of the machine) provided with opposed lugs 47, engageable with a depending flange 48 of the related rack 43. The rocker is also provided with a tooth 49 engaging a perforation of the next higher order rack 44. As seen in Fig. 1, when the rack 43 stands in 0 position, its flange 48 will lie over the rear lug 47, serving to hold the rocker 46 in clockwise rocked position and thereby holding the higher order rack 44 rearward. As rack 43 passes from 4 to 5 registering position, the flange 48 will leave the rearward lug 47 of rocker 46 and will simultaneously come in contact with the forward lug 47, moving rocker 46 in counter-clockwise direction and thus moving the higher order rack 44 one step forwardly. This will add a step of adjusted movement to the higher order actuator pinion 35, irrespective of the position to which such pinion may have been adjusted by the higher order button 45.

Each rack 44 is engaged at its forward end by a tooth 50 of an individual reversing lever 51, said lever having a cam extension 52 engaging a slidable clutch member 53, keyed to the driven shaft 54, and adapted for movement by the lever 51 out of engagement with one of the opposed beveled gears 55, providing for normal registration, and into engagement with the opposite gear 56, providing for reverse registration upon the numeral wheel of lower order.

Thus upon movement of a button 45 to a position opposite the graduation 5 of its scale, the actuator pinion 35 will be moved opposite the 5-toothed portion of the drum 33, and the drum will be reversely rotated, to register 5 subtractively in the lower order, an additional unit being set up in the next higher order at the same time. Further movement forward of the button 45 will progressively reduce the number of teeth representing the number of subtractive registrations to be made in the lower order, the additional unit remaining unchanged in the higher order actuator. In any of these latter positions, the flange 48 will lock the higher order rack 44 and the reversing lever 51 in adjusted position by means of engagement of such flange with the forward lug 47 of rocker 46.

The additional step of movement given to the higher order actuator pinion 35 will bring said pinion into position to register the next digit of the series 0, 1, 2, 3, 4, 5, 4, 3, 2, 1, 0 previously referred to. For example, if the higher order button 45 stands in 4 registering position, and one of the digits 5 to 9 is set up on the next lower order button 45, the higher order actuator pinion 35 will move from 4 to 5 registering position, but the higher order reversing gears will remain set for registration like the sign of the operation, so that in addition, for instance, the registration will be +5. This illustrates the utility for the change from forward to reverse registration as the button 45 in the related column is moved from 4 to 5 instead of making such change as the button moves from 5 to 6, since in the latter case an actuator pinion 35 set to +5 by its button 45 would have to be set to +6 (an extra tooth 34 being provided) by any movement of the rack 44 by the lower order devices, giving a maximum registration of 6 instead of 5.

Shaft 54 is driven through bevel gear connections 57, shaft 58, bevel gear connections 59, shaft 60 and crank handle 61, as shown in Fig. 1. Rotation of crank handle 61 in one direction provides for addition and multiplication, wherein the digits 1 to 4 will be registered by forward rotation of the numeral wheels, and the digits 5 to 9 will be registered by subtractive rotation of such wheels. Reverse rotation of the crank handle 61 will reverse the movements of the parts throughout the machine, effecting reverse rotation of the numeral wheels to register the digits 1 to 4 and forward rotation of said wheels to register the digits 5 to 9.

In the machine illustrated in Figs. 1 to 4, the tens transfer mechanism includes slidable teeth 62, mounted upon the shafts 63 of the drums 33, each tooth 62, when slid into active position, being adapted to engage the teeth of a pinion 64 on the higher order shaft 37.

It will be noted from an inspection of Fig. 3 that the drum 33 of any given shaft 63 cooperates with a pinion 35 of lower order and that the tooth 62 mounted on said shaft cooperates with a pinion 64 of higher order, the teeth 62 being of greater radius than the teeth 34 of the drum and being also offset from the teeth 62 in adjacent columns. It follows from this arrangement that reversal of an actuator drum 33 will be accompanied by a reversal of any tens transfer impulse transmitted to the higher order wheel.

Each tens transfer member is set into active position, upon movement of the lower order wheel 36 from 0 to 9 or from 9 to 0 registering position, by means of a transfer pin 65 secured upon the pinion 39 and engaging the beveled tooth of a lever 66, which lever at its opposite end acts to move a slide 67 having a yoke engaging the hub of carry tooth 62.

Under certain conditions it will happen that during the registering movement of the actuator drums **33**, one or more numeral wheels **36** will move through the transfer position, and that during the succeeding operation of the tens transfer elements these wheels will move reversely through such transfer positions. In the form of the invention shown in Figs. 1 to 4, it becomes necessary to make the two settings of the transfer mechanism involved in the above-noted example cancel each other, so that no transfer shall occur either in additive or subtractive direction. This is done to avoid the alternative of providing two transfer impulses to be carried across the machine from right to left and which would also cancel each other and result in no transfer registration in the denominational orders in question.

For this purpose, a pawl **68** is pivotally mounted upon each slide **67**, said pawl being normally held in raised position by contact of a lug **69** of said pawl with a rod **70** fixed in the frame of the machine. Upon movement of slide **67** forwardly, upon the first operation of lever **66**, pawl **68** will drop upon the top of a lug **90** on the lower end of lever **66**, and upon the retraction of said lever by its spring **71**, the spring **72** of pawl **68** will move said pawl downwardly into the path of movement of lever **66**. Therefore, upon a second movement of lever **66**, caused by a reverse movement of the numeral wheel, slide **67**, through pawl **68** will receive a second step of forward movement, and the tooth **62** which is moved into registry with its pinion **64** by the first movement, will now be carried beyond said pinion, and will be ineffective to register a transfer. The lug **69** of pawl **68** is also designed to act as a stop to limit the movement of slide **67** at the end of each of its steps of forward movement. It will be noted that during the first step of forward movement, the lug at the bottom of lever **66** holds pawl **68** in raised position throughout the movement. At the end of the step of forward movement given to slide **67**, the lug **69** of the pawl will therefore be brought in contact with a frame plate **89** of the machine and will prevent overthrow of the slide **67**. Upon the retraction of lever **66** by its spring **71** and movement of pawl **68** into its lower position by spring **72**, the lug **69** will be retracted, so that it again stands against rod **70**, and the same interval is opened up between said lug and the plate **89**. Therefore, upon the second step of forward movement of slide **67**, lug **69** will again be brought against **89**, and the movement of the slide will again be checked. During this second step of movement pawl **68** will be prevented from clockwise movement as viewed in Fig. 1 by engagement of the lug of the pawl with the top of slide **67**.

The lower end of pawl **68** is provided with opposed cam faces, operated upon by the restoring cams **73** to restore the pawl **68** and slide **67** to normal position. The restoring cams **73** are mounted upon a cyclically driven shaft **74** and are preferably offset spirally from right to left of the machine in order to give a successive action. It will be appreciated that the cams **73** and teeth **62** are provided in two opposed series (the teeth **62** being also spirally offset from right to left of the machine), one series operating during forward rotation and the other during reverse rotation of the parts. The slides **67** are held in any one of their three adjusted positions by means of spring clicks **75**.

Two extra places to the left of the buttons **45** are provided in the tens transfer mechanism, and the column immediately to the left of such buttons is also provided with a single tooth actuator **86**; (Fig. 3B) cooperating with a pinion **35**, positioned by a rack **44** as in the lower columns, this taking care of the setting of the tens from the extreme left hand selector mechanism. The shaft **63** upon which the actuator tooth **86** is mounted is acted upon permanently by the related gear **55**, and no gear **56** is provided in this column, since the registration should always be like the sign of the operation.

It has been stated that this is a reversible cycle calculating machine and it is, therefore, desirable to provide a check spring **85** (Fig. 1) operating between the teeth of the gears in the base of the machine to prevent overthrow and to hold the gears in alignment. A spring detent similar to the check spring **85** is disclosed in the U. S. patent to Phinney 1,308,366, issued December 12, 1916. Since the tens transfer teeth **62** provide for a more rapid operation of the transfer, it may also be desirable to employ positive stopping mechanism to operate after each transfer movement has been effected. This may be of the type commonly used in Thomas calculating machines, and need not be specifically shown.

Revolution counter wheels **77**, upon which a multiplier or a quotient may be registered, are shown as operated by a counting tooth **78** driven by a cam **79** on shaft **74**, this mechanism being of well known character, and illustrated in U. S. patent to Baldwin 1,080,245, issued December 2, 1913.

Any suitable clearing mechanism may be provided for the numeral wheels.

It will be noted that when the actuator pinions **35** are located at the rear of the drums **33**, in their 0 positions, the related tens transfer mechanisms are set for forward or normal registration. It will also be noted that when an actuator pinion **35** has been moved to 9 registering position by its button **45**, it may be given an additional step of movement to a point in front of the related drum **33** when the registration in the next lower column stands anywhere from 5 to 9. In this latter 0 position of the pinion **35**, the reversing mechanism will be held in reverse or abnormal registering condition, which is in accordance with the requirements of the registration of the tens transfer under this condition.

The method of shortcut registration forming the subject matter of the present invention may advantageously be employed in combination with a direct wheel to wheel tens transfer mechanism.

A tens transfer mechanism of this type which may be employed in combination with the selecting mechanism above described, is disclosed in the U. S. patent to Chase No. 1,964,314, issued June 26, 1934. This comprises a direct gearing connection between the numeral wheels, the gearing being of the entocyclic type, distinguishing from epicyclic gearing in that a floating gear is carried in an orbit within the circumference of an internal gear. Registrations according to the setting of pinions **35'** (Fig. 6) along the drums **33'** are transmitted through the shafts **37'**, bevel gearing **38'** (Fig. 5), gear **80**, pinion **10** and a twelve-toothed pinion **91**, to the floating gear **14**. Pinion **35'** is provided with six teeth and gear **80** with twenty-four teeth, whereby a single tooth movement of pinion **35'** will transmit a four tooth movement or a third of a rotation to the twelve-toothed pinion secured to the eccentric hub of floating gear **14**. This floating gear en-

gages the teeth of a pinion 25 and also engages an internal gear 15, secured to the numeral wheel 16. There is a difference of three teeth in the number of teeth in gear 25 and internal gear 15, so that a third of a revolution of the floating gear 14 within the gear 15 will impart a one tooth movement to the numeral wheel in the well known manner. Geared to each numeral wheel 16 is a transfer roller 22 movable through the teeth of a star wheel 23, fast with the pinion 25. This will impart a direct gear movement to the floating gear 14, to register the tens transfer. A locking plate 21, rotatable with the roller 22 and acting upon a detent 28, and thereby upon the star wheel 23, serves to prevent overthrow of the tens transfer mechanism. Lost motion is taken out of the gear train connection between the numeral wheels, and the tens transfer is completed at the end of each cycle, by means of a series of successively acting alignor cams 29, operating upon the detents 28 through an intermediate member 30. These alignors are secured upon the numeral wheel supporting shaft 24, which is driven through gearing 81, pinion wire 82, and gearing 83 in the base of the machine, the latter being connected with the crank handle by suitable means.

A detent and locator mechanism similar to that shown in Fig. 1 is provided by the employment of star wheels 87, fixed upon the shafts 37' and engaged by springs 88 secured at their ends in frames of the machine.

Numeral 84 designates a multiplier or quotient register, which may be operated similarly to the register 77 previously described. The selecting and actuator mechanism used with this entocyclic registering mechanism is the same as that shown in Figs. 1 to 4, except for the gear ratio of the actuator elements 33' and 35'. Because the tens transfer to a higher order wheel is substantially effected at the time the lower order wheel passes from 9 to 0 or 0 to 9, tens transfers of opposite sign will be correctly registered, since movement of the higher order wheel in the forward direction will be counteracted by movement of the wheel reversely during the second transfer action, and the succeeding action of the alignor mechanism will bring the higher order wheel fully back to its non-transfer position.

In this form of the invention, it is to be noted that the reduction of the amount of work to be done in registering the actuator setting effects a direct saving in the tens transfer effort required, since a reduction in the speed at which the numeral wheel is driven effects a reduction of the speed at which the tens transfer is effected, this latter building up from right to left of the machine in case of a through tens transfer and consequently encountering increased resistances.

It may be further noted that the employment of a wheel to wheel tens transfer mechanism permits the elimination of the special mechanism necessary to reconcile the transfer settings of opposite sign, so that both the shortcutting devices and the tens transfer mechanism are improved when they are used in combination.

Operation

The following description of the operation of the machine will refer, except where otherwise stated, to the form of the invention shown in Figs. 1–4. It is also assumed that the sign character of the values set in the machine refer to the values which will be registered during a succeeding additive operation, customarily effected by clockwise rotation of the crank handle 61.

To illustrate the process of addition on this machine, the following example is taken

$$600+9355=9955$$

Assuming the buttons 45 to be standing in 0 position, and 6 to be registered on the wheel 36 located in rear of the third button from the right (that is to say, the button in the hundreds column), the fourth button from the right is pulled down along its scale, until it is opposite the figure 9 thereof. This movement, through the rack 43 and pinion 42 sets the fourth actuator pinion 35 into position opposite one tooth on the forward end of drum 33. The movement of rack 43 also carries the flange 48 against the forward lug 47 of the related lever 46, moving said lever counterclockwise about its fulcrum as viewed in Fig. 1, and thereby, through tooth 49 moving the rack 44 related to the fifth column from the right one step forwardly. This moves the actuator pinion 35 of the fifth column also one step forwardly, into line with one tooth at the rearward end of its drum 33. Movement of the rack 44 will also operate lever 51, to move the clutch member 53 of the fourth column from the right out of engagement with gear 55 and into engagement with gear 56. The third button 45 from the right is now moved opposite the figure 3 of its scale, moving the related actuator pinion 35 opposite three teeth of the drum 33. Upon movement of the second button from the right the actions will be the same as described for the fourth column, except that the actuator pinion 35 of the third column, being moved one step forwardly, will change from a registration of 3 to a registration of 4, and the second pinion 35 from the right will be moved opposite five teeth of the related drum 33. Movement of the right hand button 45 to number 5 of its scale will move the second pinion 35 forwardly, so that it is now opposite four teeth of its drum and the registration in this second column will thereby be changed from −5 to −4. These setting operations may be summarized as follows:

9 =	+1	−1			
3 =			+3		
5 =			+1	−5	
5 =				+1	−5
set up	+1	−1	+4	−4	−5

Upon the first two-thirds of the clockwise rotation of crank handle 61 this setting will be registered as follows on the numeral wheels 36:

	0	0	6	0	0
	+1	−1	+4	−4	−5
	1	9	0	6	5

In passing from 0 to 5 registration, the right hand numeral wheel, moving subtractively, has passed from 0 to 9, and the related lever 66 will thereupon be operated to move the slide 67 one step forward, bringing the transfer tooth 62 opposite pinion 64, and a similar transfer setting is effected between the second and third columns. The first and second shafts 63 are set for subtractive rotations, so that the subsequent operation of the transfer teeth 62 will also be subtractive. The third numeral wheel from the right will pass additively from 9 to 0 registering position, thereby setting the transfer tooth 62 along its additively rotating shaft 63 into position op-

posite the pinion **64** of the fourth numeral wheel from the right. The fourth numeral wheel will also set a subtractive transfer in the fifth column, but the fifth numeral wheel will not be moved to set any transfer to the sixth column.

During the last third of the rotation of the crank handle **61**, therefore, the registration on the wheels **36** is to be modified as follows:

```
  1 9 0 6 5
 -1+1-1-1
-----------
```

It is noted that in the right hand column the registration of 5 is not changed, and that in the second column the registration of 6 is changed to 5. In the third column the transfer operation will move the numeral wheel from 0 to 9, registering position, and the slide **67** between the third and fourth numeral wheels **36**, which slide had previously been moved one step forwardly, will be given a second step of forward movement, bringing the transfer tooth **62** in front of and out of alignment with the pinion **64** related to the fourth numeral wheel **36**. This has the effect of cancelling the transfer of +1 in the fourth column above-noted, so that the machine will complete the registration as follows:

```
  1 9 0 6 5
 -1  -1-1
-----------
  0 9 9 5 5
```

Where a wheel to wheel tens transfer is employed, such as that illustrated in Figs. 5 and 6, it will be impossible to follow the various adjustments of the numeral wheels **16**, because of the merging of simultaneously occurring additive and subtractive impulses. However, taking the above example and considering 19065 to have been registered by primary action of the actuator pinions **35'**, the following notation will illustrate the various tens transfer movements which take place:

```
                  1 9 0 6 5
Tens transfer    -1+1-1-1
-------------------------
                  0 0 9 5 5
Tens transfer    +1-1
-------------------------
                  1 9 9 5 5
Tens transfer    -1
-------------------------
                  0 9 9 5 5
```

To illustrate the operation of the machine in subtraction, the following example is taken:

9955—9355=600

The setting of the actuator pinions **35'** is the same as in the example of addition given above, but it is to be noted that the sign characters of the set up digits are to be reversed, so that the previous item, +1—1+4—4—5 becomes —1+1—4+4+5. The registration is effected as follows:

```
                  0 0 9 9 5 5
                   -1+1-4+4+5
-------------------------------
                  0 9 0 5 9 0
Tens transfer    -1+1     +1
-------------------------------
                  9 0 0 5 0 0
Tens transfer    +1     +1
-------------------------------
                  0 0 0 6 0 0
```

Here it is to be noted that the first two-thirds counter-clockwise rotation of crank handle **61** will give three tens transfer settings, being —1 to be subtracted from the sixth numeral wheel from the right, +1 to be added in the fifth wheel and +1 to be added in the second wheel. The transfer action between the first and second columns brings the second numeral wheel from 9 to 0 registering position, and this sets the related tooth **62** from normal into transfer position, this action occurring immediately before the tooth has been rotated into mesh with the pinion **64**. An additional transfer setting movement will also occur between the fifth and sixth columns, because of the carrying up of a transfer action from a lower order wheel, but in this case, the slide **67** had previously been moved into active position, and the second operation of the lever **66** will move the tooth **62** forwardly out of line with the gear **65**, and the transfers in this column which were of opposite sign, will cancel each other.

Multiplication is performed upon this machine by repeated addition, and division by repeated subtraction, in the well known manner.

The above descriptions have related to decimal calculation, but machines which are designed to handle non-decimal calculations may be built to operate according to the invention without requiring any additional mechanism. For instance, in a machine for registering duodecimals, the only change would be that the maximum number of actuator teeth would be six instead of five, and the change to complemental registration would be effected as the setting is changed from 5 to 6 instead of from 4 to 5 as in the examples illustrated.

I claim:

1. In a calculating machine having numeral wheels, ordinal digit entering members, ordinal rotary differential actuating mechanism adapted in each order, under control of said members, to transmit to said numeral wheels movement of an extent corresponding to the complement of the value of given selectively entered digits, and including individually settable ordinal actuation reversing gears, and devices cooperating with the digit entering members to control registration on the numeral wheels of said complemental values, including elements settable each by a digit entering member of given denominational order to advance an element of the next higher order actuating mechanism to the next higher digital registering position and thereby set a unit of normal sign or cancel a unit of reverse sign therein, and elements cooperating with said settable elements to set the reversing gears of said given order for reverse transmission.

2. In a calculating machine having numeral wheels, ordinal digit entering members, ordinal rotary differential actuating mechanism adapted in each order, under control of said members, to transmit to said numeral wheels movement of an extent corresponding to the value of given selectively entered digits and corresponding to the complement of the value of other selectively entered digits, and including individually settable ordinal actuation reversing gears, and devices cooperating with the digit entering members to control registration on the numeral wheels of a complemental value, including elements settable each by a digit entering member of given denominational order to adjust an element of the next higher order actuating mechanism to determine the registration of an additional unit of

value, and elements cooperating with said settable elements to set the reversing gears of said given order for reverse transmission.

3. In a calculating machine having numeral wheels, ordinal digit entering members, ordinal rotary differential actuating mechanism adapted in each order, under control of said members, to transmit to said numeral wheels movement of an extent corresponding to the value of given selectively entered digits and corresponding to the complement of the value of other selectively entered digits, and including individually settable ordinal actuation reversing gears, and devices cooperating with the digit entering members to control registration on the numeral wheels of a complemental value, including elements settable each by a digit entering member of given denominational order to advance an element of the next higher order actuating mechanism to the next higher digital registering position and thereby set an additional unit of normal sign or cancel a unit of reverse sign therein, and elements cooperating with said settable elements to set the reversing gears of said given order for reverse transmission.

4. In a calculating machine having numeral wheels, ordinal digit entering members, ordinal rotary differential actuating mechanism adapted in each order, under control of said members, to transmit to said numeral wheels movement of an extent corresponding to the complement of the value of given selectively entered digits, and including individually settable ordinal actuation reversing gears, and devices cooperating with the digit entering members to control registration on the numeral wheels of the complemental values, including elements settable and positively held each by a digit entering member of given denominational order to advance an element of the next higher order actuating mechanism to the next higher digital registering position and thereby set a unit of normal sign or cancel a unit of reverse sign therein, and elements cooperating with said settable elements to set the reversing gears of said given order for reverse transmission.

5. In a calculating machine having numeral wheels, ordinal digit entering members, ordinal rotary differential actuating mechanism adapted in each order, under control of said members, to transmit to said numeral wheels movement of an extent corresponding to the value of the selectively entered digits one to four and corresponding to the complement of the value of the selectively entered digits five to nine, and including individually settable ordinal actuation reversing gears, and devices cooperating with the digit entering members to control registration on the numeral wheels of a value of the series five to nine by the complemental method, including elements settable each by a digit entering member of given denominational order as the setting thereof changes to a complemental value to adjust an element of the next higher order actuating mechanism to determine the registration of an additional unit of value, and elements cooperating with said settable elements to set the reversing gears of said given order for reverse transmission.

6. In a calculating machine having numeral wheels, ordinal digit entering members, ordinal rotary differential actuating mechanism adapted in each order, under control of said members, to transmit to said numeral wheels movement of an extent corresponding to the complement of the value of given selectively entered digits, and including individually settable ordinal actuation reversing gears, and devices cooperating with the digit entering members to control registration on the numeral wheels of said complemental values, including differential gearing and cooperating elements settable each by a digit entering member of given denominational order to advance an element of the next higher order actuating mechanism to the next higher digital registering position and thereby set a unit of normal sign or cancel a unit of reverse sign therein, and elements cooperating with said settable elements to set the reversing gears of said given order for reverse transmission.

7. In a calculating machine having numeral wheels, ordinal digit entering slides, ordinal rotary differential actuating mechanism adapted in each order, under control of said slides, to transmit to said numeral wheels movement of an extent corresponding to the complement of the value of given selectively entered digits, and including individually settable ordinal actuation reversing gears, and devices cooperating with the digit entering members to control registration on the numeral wheels of said complemental values, including levers operable each by a digit entering slide of given denominational order to advance an element of the next higher order actuating mechanism to the next higher digital registering position and thereby set a unit of normal sign or cancel a unit of reverse sign therein, and elements cooperating with said levers to set the reversing gears of said given order for reverse transmission, said levers each including opposed arms cooperating with the related slide to hold the actuating mechanism as set during further advance of said slide.

STUART HILDER.