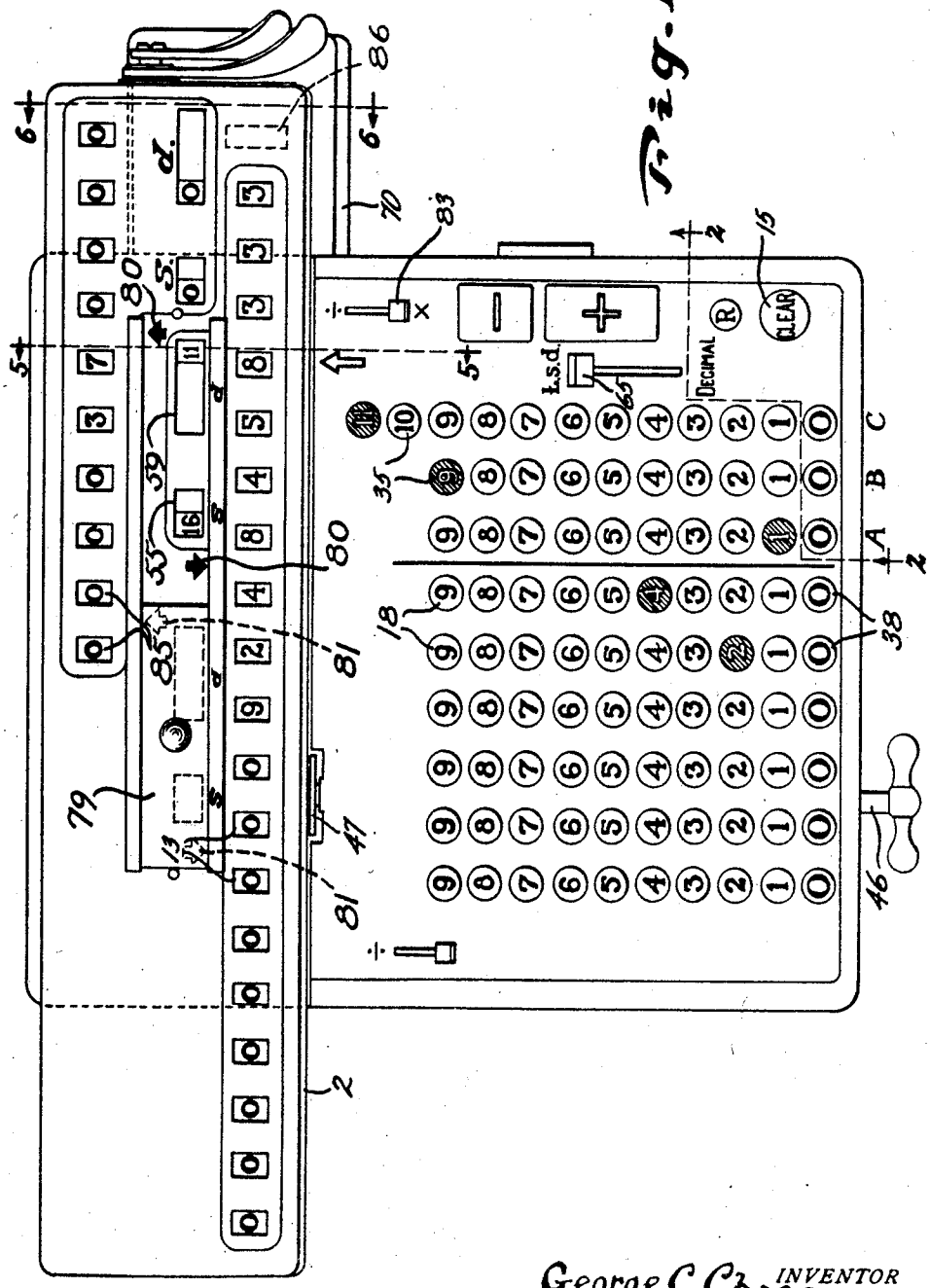
Dec. 30, 1941. G. C. CHASE 2,268,374

CALCULATING MACHINE

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Fig. 1



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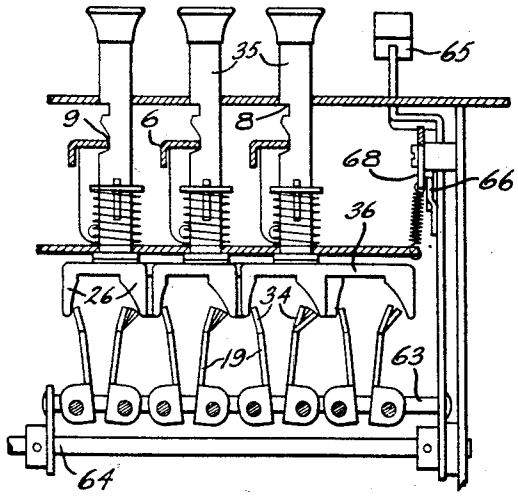
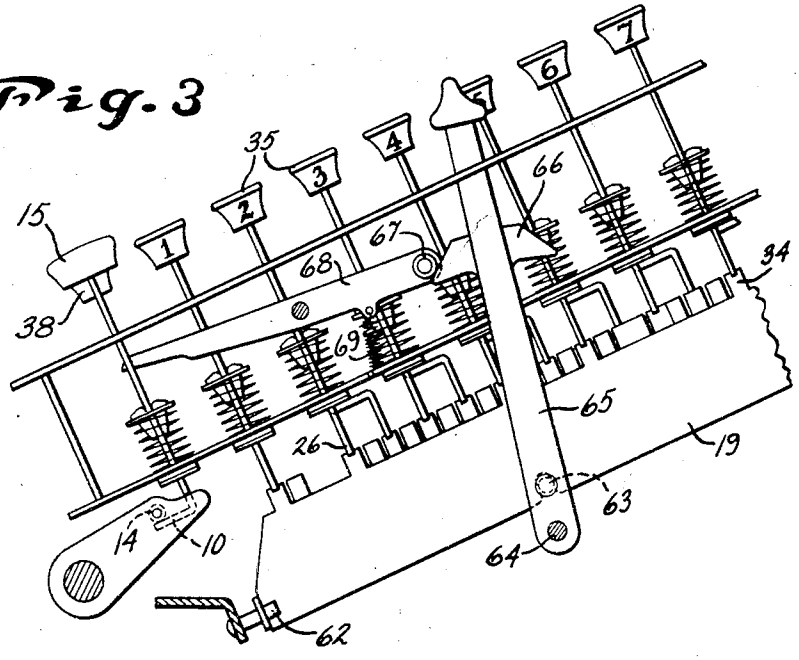


Fig. 2

Fig. 3



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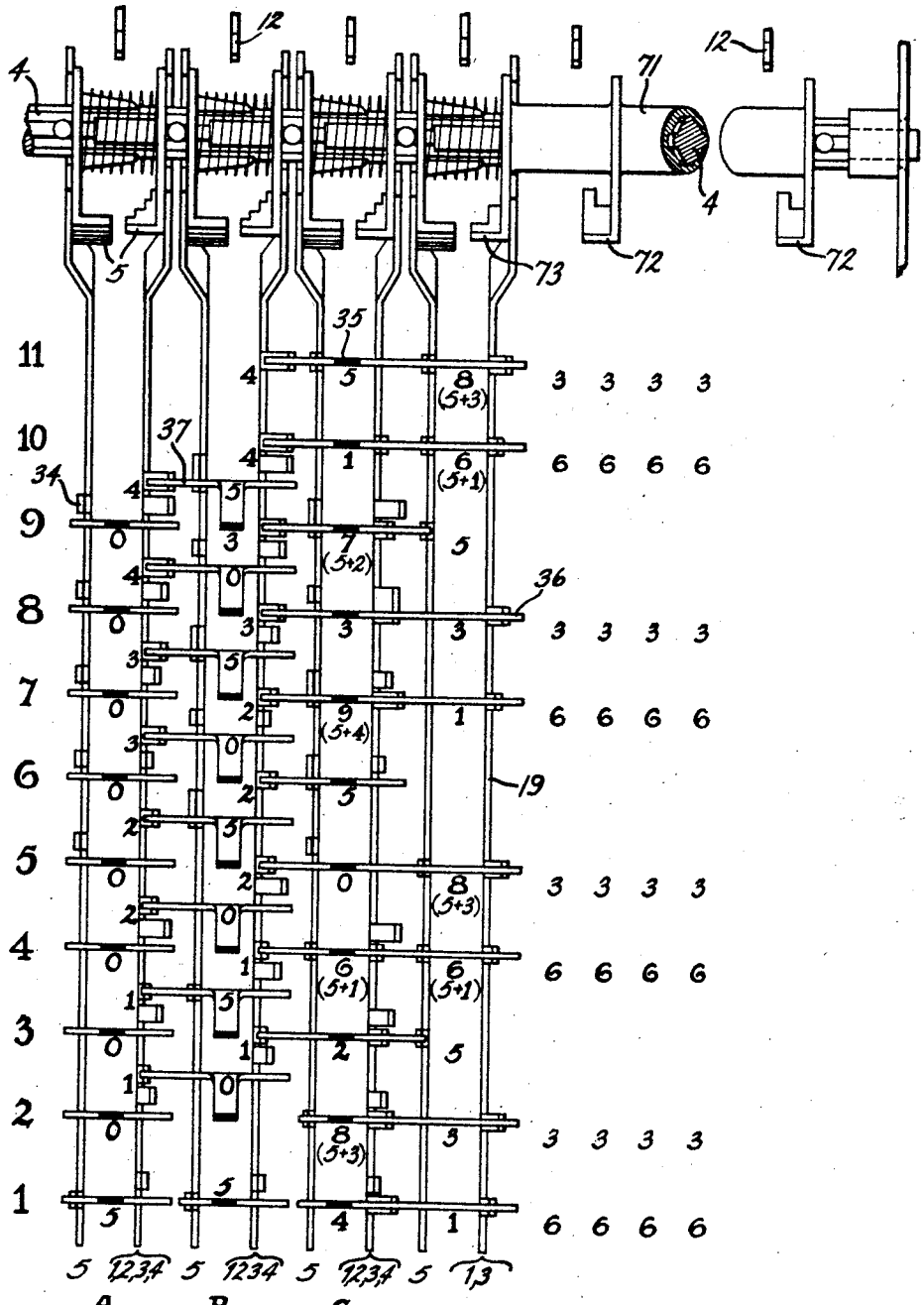


Fig. 4

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FIG. 5

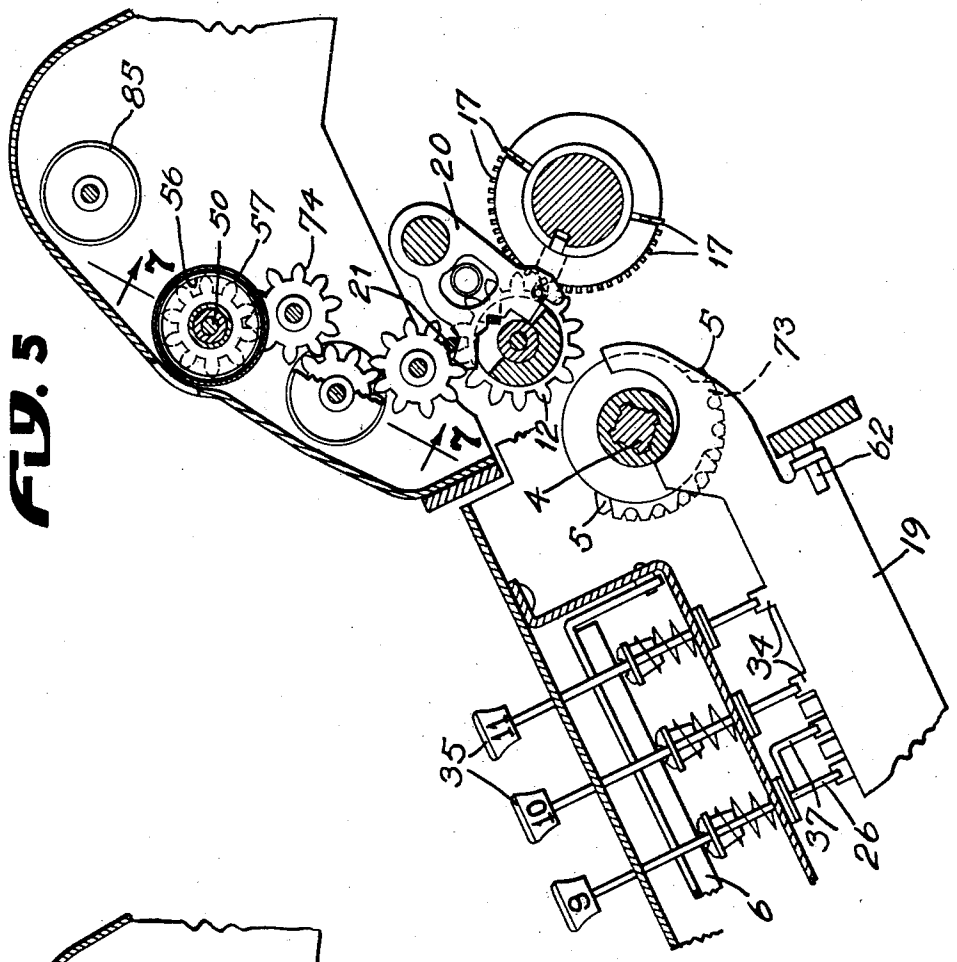
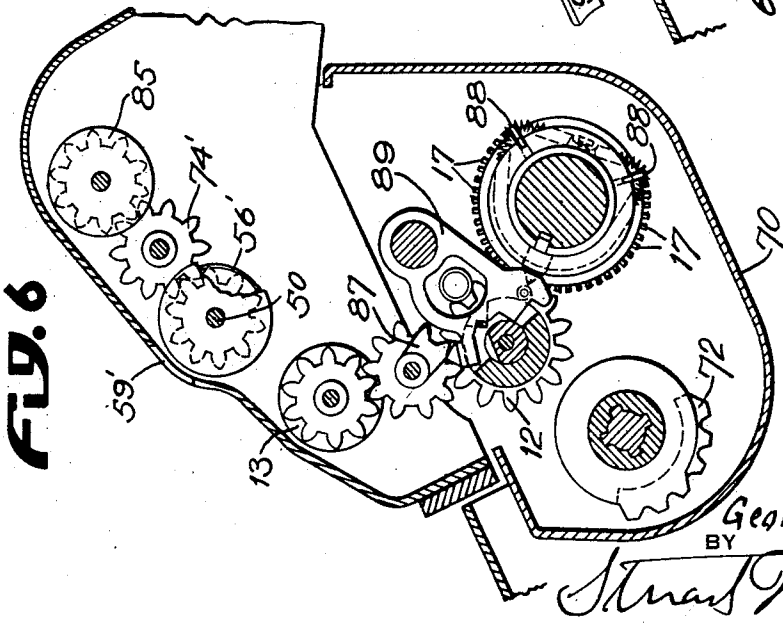


FIG. 6



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FIG. 7

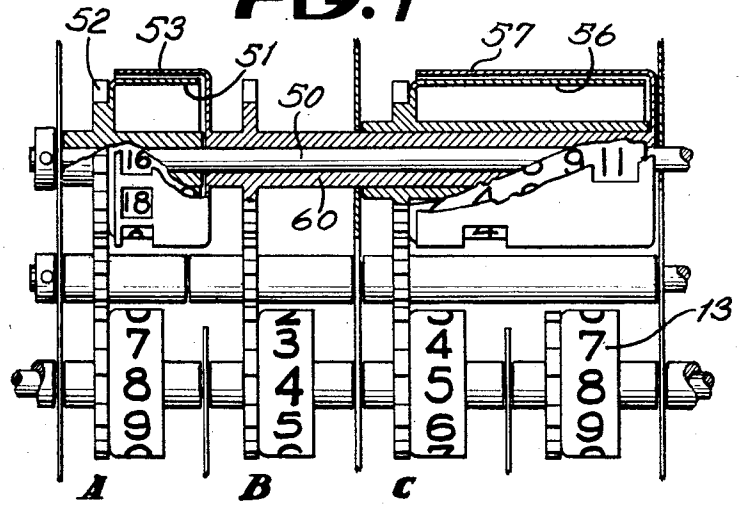
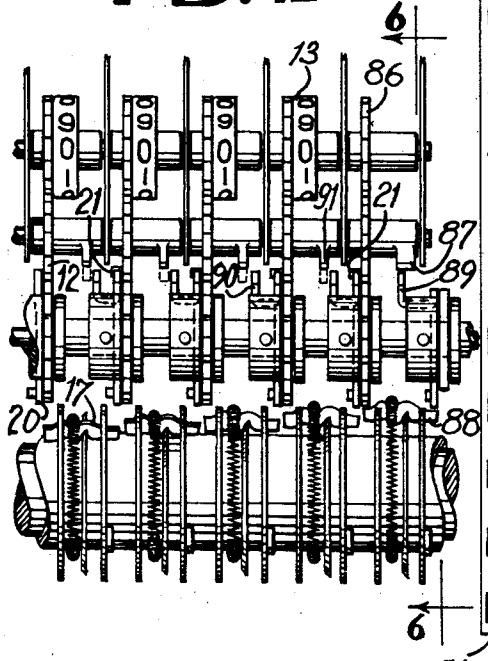
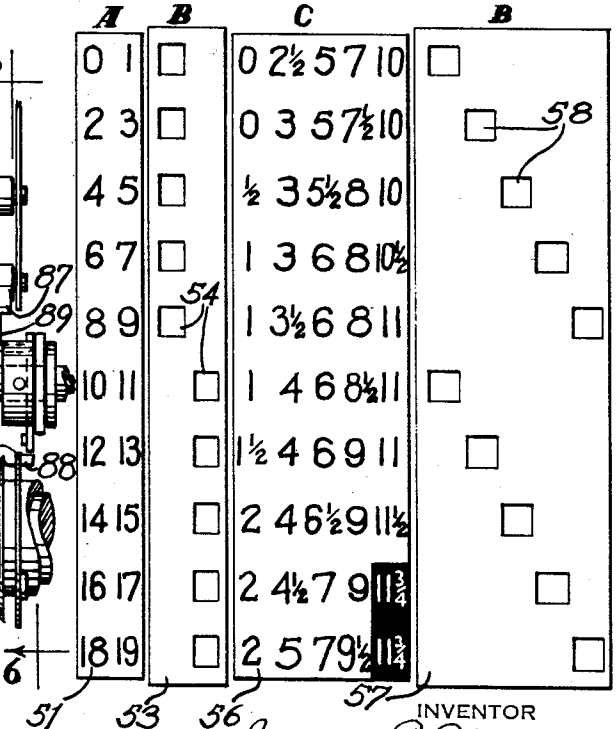


FIG. 8 FIG. 9 FIG. 10 FIG. 11

FIG. 12





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FIG. 14

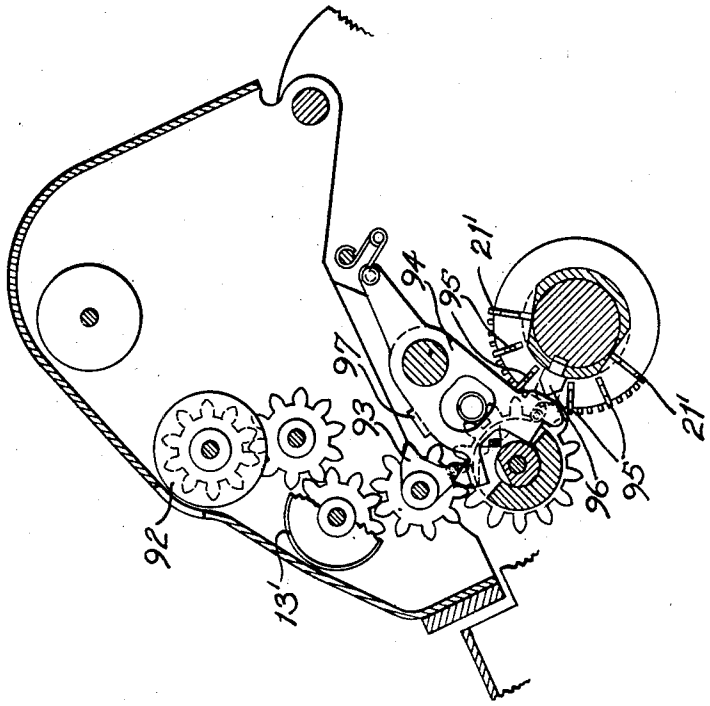
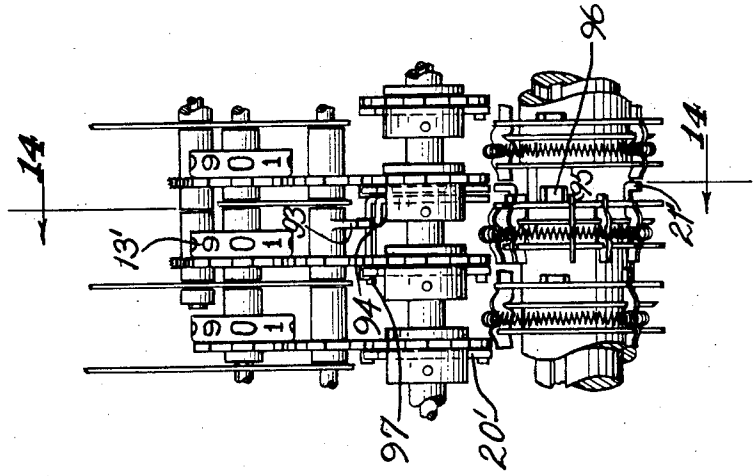


FIG. 13



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Patented Dec. 30, 1941

2,268,374

UNITED STATES PATENT OFFICE

2,268,374

CALCULATING MACHINE

George C. Chase, South Orange, N. J., assignor to Monroe Calculating Machine Company, Orange, N. J., a corporation of Delaware

Application April 16, 1940, Serial No. 329,943

14 Claims. (Cl. 235—79)

The subject matter of this application, other than the means for changing the denominational character of the numeral wheel of lowest order, has been set forth in United States applications Serial No. 212,228, filed June 7, 1938, and Serial No. 277,123, filed June 3, 1939 (both now abandoned), and in part in British Patents No. 497,441 and No. 497,462, granted December 20, 1938, on applications filed June 29, 1937, and February 7, 1938, respectively. The present application forms a continuation in part of the above noted application Serial No. 277,123.

The invention relates to calculating machines and particularly to machines adapted for calculation in sterling currency, or other numerical systems involving the use of non-uniform denominations (herein termed fractional, as distinct from a system employing a common denominator, such as the decimal system).

Machines have been built wherein sterling currency or other fractional keys will set up the decimal equivalents of their fractional values in the differential actuators, the machine thereafter operating according to the decimal system, and giving a product registration consisting of decimal values or the decimal equivalent of a desired fractional value. Such machines are illustrated in United States Patents No. 1,841,170, issued on January 12, 1932, to George C. Chase, and No. 1,877,801, issued on September 20, 1932, to Edwin F. Britten, Jr.

Machines have also been equipped with means for registering a fractional product, from a decimal multiplicand set in the keyboard and a fractional multiplier, represented by the number of repeated registering cycles performed. Such a machine is illustrated in United States Patent No 1,502,952, issued on July 29, 1924, to Hans Herlitz. The patent does not directly refer to the method of entering the multiplier, but is incapable of addition or of registering a single value set in the keyboard devices so that the correct result may always be read from the fractional register without mental rounding off.

It has also heretofore been proposed to embody decimalizing and dedecimalizing mechanisms in a single multiplying machine, but such mechanisms have functioned only in connection with special machine operations, initiated by special manipulation of control devices, both for the decimalizing and again for the dedecimalizing actions.

According to the present invention, for the first time, a factor entered directly into the differential actuators of a calculating machine by manipulation of fractionally designated elements may be multiplied by a second factor by the decimal shifting method and the product concomitantly registered in fractions.

Further, for the first time a machine is provided in which calculations in the four rules of arithmetic may be effected by the entry of fractional amounts and the registration of fractional answers.

Further, for the first time a machine is provided in which commercially accurate registrations of fractions and their decimal equivalents may be simultaneously made.

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

In the accompanying drawings:

Fig. 1 is a plan view of a calculating machine, built in accordance with the invention.

Fig. 2 is a section taken on line 2—2 of Fig. 1.

Fig. 3 is a detail side elevation of a portion of the keyboard mechanism.

Fig. 4 is a partially diagrammatic plan view of the decimal equivalent entering mechanism.

Fig. 5 is a section taken on line 5—5 of Fig. 1.

Fig. 6 is a section taken on line 6—6 of Figs. 1 and 12.

Fig. 7 is a section taken on line 7—7 of Fig. 5.

Figs. 8 to 11 are developments of the shillings and pence drums and of the shutters cooperating therewith.

Fig. 12 is a detail plan view of the thirds registering mechanism.

Fig. 13 is a similar view of a mechanism for registering annas (Indian currency).

Fig. 14 is a section taken on line 14—14 of Fig. 13.

The invention is shown as applied to the known Monroe calculating machine, wherein the depression of decimal keys 18 (Fig. 1) will operate through pivoted bails, such as those shown at 19 in Figs. 2 and 5, to set an appropriate number of teeth of the differential actuators 5 into position to mesh with intermediate gears 12, upon rotation of the actuator shaft 4. As shown there are two actuator gears 5 for each column of keys 18, settable toward each other either singly or in combination, one of these gears having five equal teeth and the other having four teeth of different lengths, stepped back as shown in Fig. 4. The gears 5 may be differentially set by variably offset lugs 34 of the bails 19, engaged by cam faces 26 (Fig. 2) of the keys. Gears 12 have direct gear connection with a series of numeral wheels 13 mounted in a denominationally shift-

able carriage 2. Actuator shaft 4 may be rotated by means of a hand crank or by motor operating means, in the well known manner. The carriage 2 is shiftable by means of a shaft 46, having a crank extension 47 engaging a rack of the carriage, in known manner.

The machine is also provided with a series of numeral wheels 85 which serve to count the rotations of the actuator shaft, and thereby register the multiplier or the quotient. The position of the counting finger which operates the numeral wheels 85 is indicated by an arrow on the keyboard plate, and provision is made for reversing the direction of rotation of wheels 85, relative to the direction of rotation of the wheels 13, this reversal being governed by the setting of the usual change lever 83.

Decimal equivalents

Three columns of fractional keys 35 are provided, these keys being generally similar to the keys 18, and operating through similar bails 19 to set the related differential actuators 5. However, these fractional keys are adapted to set the bails in accordance with the decimal equivalent of their designated values. Thus the tens of shillings key will set the related actuator to register .5, a column of units of shillings keys will set the values from .05 to .45, and a column of pence keys are adapted to set the values .00416, etc., to .04583, etc. In order that certain of the keys 35 may set the appropriate values in several ordinal places, the bottoms of the keys are extended as shown at 36 in Figs. 2 and 4, interference between these extended key portions in the different columns being avoided by offsetting the bottoms of the units of shillings keys as shown at 37, Figs. 4 and 5.

The keyboard, both as to the decimal and the fractional keys, is of the type known as flexible. That is to say the depression of any key will release any other depressed key in the same column from latch 6. A latch 6 is provided for each column of keys, and is held yieldably against the stems of the keys, as shown. The keystems are provided with upper notches 8 and lower notches 9, with which the latches 6 cooperate in known manner.

Zero keys 38 (Figs. 1 and 3) are provided in each column of decimal and fractional keys, these keys engaging the latching bail 6, in order to release any depressed key in the same column, but having no engagement with the bails 19. A keyboard clearing key 15 is adapted to rock a bail 14, overlying lugs 10 of the zero keys 38, thereby depressing all zero keys and clearing the keyboard.

Fractional registers

As shown, a plurality of fractional registers are provided, one cooperating with the product wheels 13 to register shillings and pence, and another giving a similar registration corresponding to the decimal equivalent values registered on the multiplier wheels 85.

Preferably these two fractional registers are mounted upon a single shaft 50 (Figs. 5, 6 and 7) located between the wheels 13 and 85. The shillings values, from 1 to 19 are marked upon the face of a drum 51, in two columns as shown in Fig. 8, this drum being driven by means of the gearing 52 from the wheel 13 representing tenths of a pound, this tenths of pounds column being designated by the letter A in Figs. 1, 4, 7 and 8.

Tubular shutter 53 surrounds the drum 51, and is provided with a series of sight openings 54, arranged in two offset lines so as to select the appropriate column of figures of the drum 51 for display through the laterally extended sight opening 55 of the carriage casing. Shutter 53 is rotatably mounted upon shaft 50, and has gearing connection with the numeral wheel 13 in column B, representing hundredths of pounds.

A pence drum 56 is also mounted on the shaft 50 and is marked with five columns of figures representing the pence from 0 to 11¾, as shown in Fig. 10. Drum 56 has gearing connection with the numeral wheel 13 in column C, representing thousandths of pounds.

Tubular shutter 57 surrounds the drums 56 and is provided with offset series of sight openings 58, as shown in Fig. 11, adapted to show the pence value of one of the five columns on drum 56 through the laterally extended sight opening 59 of the carriage casing. Shutter 57 is rigidly connected with shutter 53 by means of a sleeve 60, so that both shutters are driven by the wheel 13 in column B.

The manner in which a decimal equivalent on the wheels 13 is converted into a fractional value shown in the sight openings 55 and 59 will be best explained in connection with the general description of operation. It may be mentioned here, however, that each registration of a full penny or of a multiple thereof will locate the drum 56 and shutter 57 to one of twelve definite reading positions, showing the exact fractional registration. The remaining thirty-eight numerals marked on drum 56 provide for registering positions which may result from operations of division or of multiplication by a decimal fraction. In each case, these additional figure markings represent an adjustment to the nearest full penny; or to the halfpenny, in case of values approximating that figure; or, in the case of the last two figures, to a registration of 11¾, preferably marked in a distinctive color, which serves to indicate that the registration should be mentally rounded off by the operator to the next higher shilling. The fractional product register wheels are driven in one-to-one ratio from the numeral wheels 13, through intermediate gearing 74.

The fractional multiplier register is precisely the same as the fractional product register above described, except that the drums and shutters are driven through intermediate gearing 74' (Fig. 6), located on the opposite side of shaft 50 and meshing with the gears of the wheels 85. The reference numerals applied to the elements of this register are like those applied to the product register, but distinguished by the exponent "'".

In order to provide capacity for calculation by a multiplier carried out to a number of decimal places or for the computation of an intermediate result which is to be treated as a decimal dividend, a second fractional product register may be provided, shown in Fig. 1 as located five places to the left of the fractional product register above described. A sliding shutter 79 is adapted for adjustment to cover the sight openings of one or the other of the fractional product registers, since, obviously, only one such register can be properly related to the keyboard at any given time.

It may be noted, that since the fractional registers are directly geared to certain of the numeral wheels 13 and 85, the fractional product registers will be reset to zero registering condition whenever amounts are cleared from the

product wheels 13, and that the fractional multiplier register will be reset whenever the counting wheels 85 are cleared. These clearing operations are effected by any of the well known clearing devices.

When the present machine is used for fractional calculations, it will be noted that the decimal point of amounts set in the actuators 5 lies between the pounds and shillings keys, and this position may be indicated by a permanent marking of the keyboard as shown in Fig. 1. Bringing the carriage 2 into the correct position for registration in the units order, it will be found that the decimal point of the wheels 13 is directly in line with the decimal mark on the keyboard, and here again a permanent mark may be placed on the carriage in this position. With the carriage so placed, the decimal point of the wheels 85 will lie immediately to the right of the wheel engaged by the counting finger (indicated by the arrow mark on the keyboard), and this decimal point may also be permanently marked upon the carriage.

The fixed decimal point marks on the carriage and relating to computations involving the right hand fractional product register are designated 80 and it will be desirable to provide additional fixed decimal point marks 81, related to the left hand fractional register, located so that the shutter 79 will cover the pair of marks not in use.

Location of the decimal point

It is preferable to determine the positions of the decimal points before setting into the machine the factors of multiplication or division calculations involving one or more fractional values, in order to know where each factor should be placed. The position of the decimal point is governed by the following rules:

1. All fractional values must be set into the keyboard according to the prefixed keyboard decimal point.

2. If a reading in whole numbers and fractions thereof is desired in one or both registers, the decimal point is prefixed at the left of the fractional register or registers from which the reading is to be taken.

3. If the position of any two decimal points is prefixed, the position of the third decimal point is also prefixed.

4. If the position of but one decimal point is prefixed, the position of one of the other two decimal points is determined according to the well known rule of pointing off, which determines the position of the third decimal point.

Keyboard conversion

Preferably the machine is so constructed that the entire keyboard may be used for fractional or alternatively for decimal calculations, for which purpose means are provided for changing the control of the fractional keys 35, so that instead of setting up the decimal equivalents of their indicated values they will set these values directly into the actuators 5 in the same manner that the values of the keys 18 are entered.

Therefore the four pairs of bails 19 to the right of the decimal mark on the keyboard are arranged to be shifted longitudinally, to bring a second series of lugs 34 under the portions 26 of the keys 35. These bails 19 are slidable upon their trunnions 62 (Figs. 3 and 5) and are notched along their bottom surface for the reception of a bail 63 (Figs. 2 and 3) pivoted in the frame of the machine at 64. One supporting arm of bail 63 is extended upwardly through the keyboard plate as an operating lever 65, said lever having attached thereto cam plate 66, cooperating with a roller 67 mounted in one end of an intermediately fulcrumed lever 68 whose other end engages a shoulder of the stem of the clear key 15. A spring 69 holds roller 67 against either of the opposed faces of the cam 66, and serves to locate the bails 19 in rearward or forward position.

The connection of lever 68 with clear key 15 insures that during the first portion of the movement of lever 65 from one set position to the other, clear key 15 will be depressed, thereby pulling down all of the zero keys 38 and releasing any depressed keys 35, so that their cam ends 26 will be raised by the key springs out of the path of movement of the lugs 34 of the bails 19. Therefore, in shifting the bails 19, no interference between the lugs 34 and cam ends 26 of the keys will occur. In order that this clearing action may occur before the bails 19 are moved too far, the cam angles of the plate 66 are made somewhat steep, and the upper end of the plate is formed as a dwell for the roller 67 as will be apparent from an inspection of Fig. 3.

When lever 65 is pushed rearwardly, toward the marking "£ s. d." on the keyboard, the right hand bails 19 will be carried rearward, into the position illustrated in the drawings. In this position the active lugs 34 are indicated in Fig. 4 as lying immediately beneath the bottoms of the keys 35. The lugs 34 which are used for decimal calculations are shown in Fig. 4 as standing clear of the stems of keys 35, and are brought beneath the bottoms of these keys upon forward movement of lever 65 toward the position marked "Decimal" on the keyboard. This decimal series of lugs 34 is precisely the same as the lugs of the bails related to the keys 18, and corresponds to the known arrangement in the Monroe calculating machine. The arrangement of the decimal equivalent lugs 34 may best be understood in connection with the general description of operation.

When the machine is set for sterling currency operation, the keys numbered 2 to 9 of the tens of shilings column are not used, and if such keys should be depressed they will have no effect, as will be noted by inspection of Fig. 4, column A, wherein no lugs 34 are opposite the stems of keys 2 to 9. Likewise when the machine is set for decimal operation the 10 and 11 keys of the right hand column are not used, and by reference to Fig. 4 it will be seen that no lugs 34 are in position to be shifted under these keys in the column C when the bails 19 are shifted forwardly.

Repeating decimals

A serious problem in the construction of sterling currency calculators has been encountered in providing for sufficient capacity in the machine, without such an extension of the digit entering columns as to become unwieldy. According to the present invention, this problem has been solved by the provision of a very compact means for entering the required repeating decimals at the right of the value set up. In the present drawings, nine columns of keys are illustrated, cooperating with ten pairs of bails 19, and the base of the machine is of the size ordinarily employed for ten place decimal calculators. In addition to this, provision is made for the registration of four places of repeating decimals, the necessary mechanism being housed within an ex-

tension 70 of the casing of the machine (Figs. 1 and 6).

The actuator shaft 4 is extended into the casing 70, and a sleeve 71 is splined upon said shaft and capable of longitudinal sliding movement thereon. Four differential actuator gears 72 (Figs. 4 and 6) are fixed upon the sleeve 71, and a differential actuator gear 73 is also fixed upon the left hand end of said sleeve. Gear 73 is engaged by the extreme right hand bail 19, and might be made like the four step differential actuators 5. Gear 73 however will be used only to register the values 1 or 3 and may therefore be designed with teeth of two lengths, as shown. Moving from right to left, into active position, gear 73 will bring first a single tooth and by a second step of movement will bring three teeth into the plane of the intermediate gears 12. These same movements of the gear 73, being transmitted through sleeve 71, will move gears 72 to bring first six teeth, and by the additional step of movement three teeth into the plane of the related intermediate gears 12.

It will further be noted that the repeating decimal 3 3 3 3 is associated with a setting of 3 by the right hand bail 19, and that the repeating decimal 6 6 6 6 is associated with a setting of 1 by the right hand bail 19, and it is further to be noted that a digit in the column related to the right hand bail 19 may be modified by the setting of the five tooth gear in this column into active position, so that the setting of 3 will be augmented to 8 or the setting of 1 will be augmented to 6. The various combinations thus effected will be evident from an inspection of Fig. 4, wherein the decimal equivalents set up by each of the keys 35 is appropriately designated.

The provision for registration for four places to the right of the usual digit entering devices leads to a considerable extension of the tens transfer mechanism for the wheels 13, this tens transfer mechanism customarily operating successively from right to left, as by the provision of a spirally disposed series of gear teeth 17 extending radially from a shaft driven in time with the actuator shaft 4. In fact there are two such spirals, since the actuator and carry shafts of the Monroe machine are operated in one direction for additive calculations and in the opposite direction for subtractive calculations, necessitating two oppositely pitched spiral series of teeth 17 to provide for the additive and for the subtractive transfers respectively. The teeth of the differential actuators 5 and the teeth 17 are so arranged about their shafts that a cycle of the machine will first move a series of teeth 17 idly past the intermediate gears 12; shaft 4 will thereafter move any of the nine teeth of the differential selectors through the teeth of the intermediate gears 12, and finally the remaining series of teeth 17 will be in position to act on intermediate gears 12 to effect the tens transfer.

It will therefore be seen that an extension of the tens transfer four places to the right, as called for by the provision of the gears 72 (virtually five places, as will be seen), will necessitate an extension of the spiral series of teeth 17 about their shaft. This however will not necessitate the relocating of the teeth of the actuators 5 or of the teeth 17 cooperating therewith. It will be noted from an inspection of Fig. 4 that the right hand pair of bails 19 set a maximum of eight teeth on the related gears 5 and 73, whereas all columns to the left of this have a maximum setting of nine actuator teeth. Therefore the eight teeth of the gear 73 and its cooperating gear may be set back with relation to the teeth of the actuators to the left thereof, so that they will complete their registering action half a step sooner than the last mentioned gear, as shown in Fig. 5. Likewise the gears 72 have a maximum of six teeth and these gears may be further set back with relation to the actuators 5, so that they will complete their action one and a half steps before the completion of the registration of the actuators 5. Therefore the tens transfer teeth 17 opposite the gears 72 may be extended further around their shaft, so that they will begin the carry action, from right to left, while the registration is still being effected in the left hand columns.

As usual in the Monroe calculating machine structure, the teeth 17 are cammed into active position by members 20, set into the path of the teeth by means of pins 21 located on gears mounted in the carriage 2 and meshing in 1 to 1 ratio with the gears of the numeral wheels 13.

Registering the thirds

In successive registrations of a repeating decimal there will be occasional loss through failure to transfer from the denominational orders extending theoretically to the right of those provided. In the registration of thirds, as by the gears 72 of the present machine, the registration in each of the associated numeral wheels 13, as so far described, will run 3, 6, 9 and not 3, 6, 0, as required. Therefore, the lowest order wheel in passing additively beyond the 8 registering position is adapted to set means whereby said wheel will skip the digit 9 and be advanced another step, to 0, the remaining repeating decimal wheels being brought to 0 by the tens transfer mechanism, and 1 being transferred to the numeral wheel 13 standing adjacent the left hand repeating decimal wheel. In subtraction, this skip digit movement is given to the lowest order numeral wheel which is operated as it passes beyond 0 registering position, the successive registrations reading 6, 3, 0.

Thus, the lowest order numeral wheel which is operated becomes in effect a nine point wheel, passing through its digital cycle upon the registration of nine. In other words, the denominator has been changed from ten to nine. Two special requirements are involved; first, that the extreme right hand numeral wheel should act as a nine point wheel in any shifted position in which the wheel is driven by an actuator 72, and second, that any numeral wheel driven by the extreme right hand actuator 72 should function as a nine point wheel.

The following mechanism is provided to effect this registration of thirds:

Preferably, as indicated in Figs. 1 and 12, a dummy wheel 86 is located to the right of the numeral wheels 13 of the product register, this dummy wheel having no visible numerals but being provided with a pair of thirds conversion teeth 87 and a transfer pin 21. This dummy wheel cooperates with the repeating decimal gears 72, but never comes into register with the decimal key columns. As shown, it may come into the column immediately to the left of the repeating decimal gears, in which case the error in the dummy wheel 86 could not exceed £.00000005.

When located opposite the extreme right hand gear 72, the gearing of the dummy wheel 86 lies in the path of movement of a pair of skip

digit teeth 88, forming continuations of the two spiral series of transfer teeth 17. The teeth 87 (Figs. 6 and 12) are so located that upon passage of the dummy wheel from 8 to 9 or from 0 to 9 registering position (the carriage being located as stated) one of the teeth will engage and set a camming member 89 (similar to the members 20) into position to cam one of the teeth 88 into active position, to impart an extra step of movement to the wheel 86, and thereby cause it to skip the digit 9.

To the left of the member 89 the tens transfer mechanism related to the four repeating decimal columns includes special camming members 90 having forked upper ends, one fork lying in operative relation to the numeral wheel pins 21 and the other fork lying in position to be engaged by the tooth 87, when the carriage is shifted to the left. Thus the dummy wheel 86 will be operated as a nine point wheel whenever it lies opposite a repeating decimal gear 72, 73 being advanced as required, either by the tooth 88 or by one of the transfer teeth 17.

Each of the five wheels to the left of the dummy wheel 86 is provided with a pair of teeth 91, similar to the teeth 87 of the dummy wheel, any of these teeth 91 being adapted to engage and set the member 89 but not to engage the forks of the members 90, which lie in different zones from the zone of member 89. Teeth 87 operate either member 89 or members 90, being broad enough to bridge both zones. It will be seen that, as the carriage is shifted toward the right, the lowest order active numeral wheel 13 will be operable as a nine point wheel, being advanced by the tooth 88 to skip the digit 9 in the same way as is the dummy wheel. It follows that, since thirds are always registered to the extreme right of the carriage, the thirds registering mechanism serves to correct the action either of the right hand or of the left hand fractional product register.

The effect of this thirds or skip digit mechanism upon the fractional registration may be noted by reference to the actions involved in multiplying eight pence by three. The decimal equivalent .03333333, if increased to .09999999, would give a fractional reading in the right hand register of 0/1/11¾. The action of the skip digit mechanism would correct the decimal equivalent reading to .10000000 and the fractional reading to 0/2/0.

Registration in sixteenths

Figs. 13 and 14 of the drawings show a modification of the mechanism of this machine which adapts it for the addition and subtraction of the money values of Indian currency, according to which

12 pie=1 anna.
16 annas=1 rupee.

Although Indian money involves fractions of sixteenths and one hundred ninety-seconds, instead of twentieths and two hundred fortieths as used in the British system, the value entering mechanism of the machine need not be changed. The shillings keys are used for entering values in annas, in which values 16 to 19 are never set. The pence keys are used for entering values in pie. Of course, since these values are not the decimal equivalents of annas or pie, the numeral wheels 13 at the right of the decimal point should be ignored and may be hidden from view, even though essential to a correct fractional registration in the fractional registering wheels, which are also constructed as in a machine used for £ s. d. registrations.

The only modification required to provide for this correct fractional registration of Indian money values is to adapt the skip digit mechanism to cause the tenths decimal wheel to skip the digits 8 and 9, which in turn causes the related fractional wheel 51 to skip the digital values 16, 17, 18 and 19, converting it in effect into a sixteen point wheel for the registration of annas.

The numeral wheel 13' with which the annas wheel is meshed is provided with a pair of teeth 93 adapted, upon passage of the wheel additively to or through 16 registering position, or subtractively to a registration below 0, to engage and set a camming member 94 into the path of movement of two skip digit teeth 95, mounted upon the tens transfer shaft, just beyond the transfer tooth 21', serving to transfer from the numeral wheel of next lower order. The two teeth 95 are both cammed into position to operate the annas wheel, before the member 94 is restored to normal position by the restoring pin 96, so that the annas wheel is advanced two steps, equaling a registration of 4 (compare Fig. 8), completing its cycle of movement upon a registration of 16.

Since the teeth 95 are timed to operate after the tooth 21' which serves to transfer values from the annas wheel has passed through operating position, provision must be made for insuring the transfer of values from the annas to the rupees wheels. For this purpose, an extension 97 of the member 94 overlies the adjacent left hand camming member 20', so that whenever the annas wheel 92 passes from 15 to 0 or from 0 to 15, said member 20' will be set to active position, effecting a registration of one rupee.

It will be noted from Fig. 13 that the teeth 95 and the tooth 21' operating upon the annas gear, are adapted to be set independently, the member 94 and the adjacent member 20' operating in different planes.

Fractions other than sterling

Obviously, calculations involving various fractional values may be provided for in a machine designed in accordance with the present invention; the values set in the actuators by the fractional keys and the number of separate value designations of the fractional register wheels being determined with relation to each other according to appropriate mathematical formulae.

For instance, taking the formula

$$p=\frac{f(s+c)}{a}$$

in which

p=the number of registering places or steps of the fractional wheel;
f=the fractional denomination;
s=the set value directly registered on the wheel by the

$$\frac{1}{f}$$

key;
c=the set value registered in lower orders by the

$$\frac{1}{f}$$

key (for later transfer);
a=the order of the machine in which s is set and registered.

Applying this formula to the machine illustrated, we have

$$p=\frac{12(.004+.00016666+)}{.001}=50$$

In this instance the value $(s+c)$ has been taken as the decimal equivalent of

$$\frac{1}{240}$$

It has been shown above, however, that this invention may be used for the addition and subtraction of Indian currency, by setting values which are not the decimal equivalents of the given fractional value.

This is possible because of the arrangement of the transfer mechanism, the principle of which should be well understood. In the £ s. d. structure the ratio of the transfer from the thousandths to the tenths numeral wheels **13** is 100 to 1, while in the fractional register, the shillings wheel must be advanced one reading point at each fifty point advance of the pence wheel. As shown, the shutter **53** of the fractional register supplements the action of the transfer mechanism of the decimal wheels to effect the 50 to 1 transfer ratio in the fractional wheels. If a decimal equivalent answer is not required, the 100 to 1 transfer ratio from the thousandths to the tenths wheel is not required; any means providing for the 50 to 1 ratio in the fractional register is all that is needed.

In the Indian money embodiment of the invention in which the answer is read in annas and pie only, and not as a decimal equivalent, it will be noted that the transfer ratio from the hundredths to the units numeral wheels **13** is 80 to 1. Such a ratio is, of course, meaningless to decimal wheels, its purpose being to establish a 16 to 1 ratio from the annas wheel to the units of rupees wheel. Thus the only transfer to the units wheel is in effect from the annas wheel.

From this it may be seen that if a decimal equivalent reading of the fractional value is not required, the transfer mechanism may be constructed according to the requirements of the fractional register only, and the digit entering mechanism need not be set in accordance with the decimal equivalents of fractional values.

For example, it may be noted that one may construct a machine to add and subtract in £ s. d. values according to the above formula by taking:

$$s=.002$$
$$c=.0005$$

whereby

$$p=\frac{12(.002+.0005)}{.001}=30$$

That is, the pence wheel **56** is to be provided with thirty reading points, and a 30 to 1 transfer ratio established to the shillings wheel. In such a machine the indeterminate decimal equivalent with the repeating decimal digits and the skip digit thirds mechanism is eliminated.

In the examples of mechanical arrangement wherein the decimal equivalent is not used, it will be noted that it is replaced by a series of values which are invariably finite, whereas in the principal form of the invention finality is secured by the provision for registration in ninths in the extreme right hand order. In both cases, of course, the effect is to prevent loss by failure to transfer, and in both cases the result is attained by the inclusion of a non-decimal transfer element. Thus, in the principal form of the invention, a ninths transfer to the decimal wheels is provided, while inspection of the non-decimal value settings referred to in the foregoing examples will show that a wholly decimal series of transfer elements, from the subpence wheels **13** through to the pounds wheels, cannot be employed.

Examples of operation

I

To illustrate the operation of the machine the following example will be taken:

£24/19/11×37=£924/16/11

This example is illustrated in Fig. 1, wherein the depressed keys **18** and **35** are indicated by shade lines, and wherein the registration on the wheels **13**, **85** and the fractional registers cooperating therewith are those shown at the completion of the calculation.

The twenty-four pounds are set in the two right hand columns of keys **18**, to set the value 24 into the related actuators **5**. Depression of the ten shillings key will set up the value 5 in column A, Fig. 4, since it will be noted that the left hand bail of this column only has a lug **34** engaged by the ten shillings key, this bail setting the five tooth gear of the related actuator **5** opposite the intermediate gear **12**. The nine shillings key will be seen by reference to Fig. 4 to have a bottom portion extended over and acting upon a lug **34** of the right hand bail of column A which is offset sufficiently to provide for the setting of four teeth of the related actuator **5** into line with the intermediate gear **12**. Thus in column A the left hand actuator gear is set to register 5 and the right hand actuator to register 4, giving a registration of 9 in this column. The nine shillings key also engages a lug of the left hand bail **19** of column B, adapted to set the five tooth gear in this column into active position. The 11 pence key has a bottom extended to the left into engagement with a lug of the right hand bail **19** of column B; engages a lug **34** of the left hand bail of column C, and engages lugs of both bails of the extreme right hand column, these lugs representing a registration of 4 in column B, 5 in column C and 5 and 3 or 8 in the right hand column. Also the setting of the gear **73** by the extreme right hand bail **19** has set each of the gears **72** to register 3. Thus the decimal equivalent of £24/19/11 is set up as follows:

£	24.
10s.	.5
s.	.45
d.	.04583333
£	24.99583333

which is the decimal equivalent of the multiplicand.

With the carriage set to register in the tens multiplier wheel **85**, the machine is now operated to effect three rotations of shaft **4**, registering 30. in the multiplier dials **85** and multiplying the set up value by three in the usual manner. Carriage **2** is now stepped one place to the left, into the position illustrated in Fig. 1, giving the effect of a multiplication by ten, and the machine is operated to effect seven rotations of shaft **4**, registering 7. in the wheels **85** and multiplying the set up value by seven. This gives the decimal registration of 37. in the wheels **85**, and since there are no fractional values, the fractional multiplier register remains at zero. The decimal registration 924.8458333 appears in the dials **13**, and the corresponding sterling values will appear

in the cooperating fractional register as follows:

In column B (Figs. 4–7 and 12) there is now a registration of 4, therefore the shutters **53** and **57** have been moved four steps upwardly from the position illustrated in Figs. 9 and 11. Counting from the upper sight opening of shutter **53** it will be noted that four steps will not be sufficient to change the opening from the left hand to the right hand column of drum **51**. The four steps of movement of shutter **57** however have changed the sight opening at the reading line from the left hand to the extreme right hand column of drum **56**. We will therefore read the left hand column of figures of drum **51** and the right hand column of figures on drum **56**.

In column A, drum **51** has been given eight steps of movement, which would bring the figure 16 up to the reading line. In column C drum **56** has been given five steps of movement, bringing the figure 11 of said drum up to the reading line. Thus the product is registered both fractionally as £924/16/11 and decimally as £924.8458333.

The example above set forth has been one of multiplication, but it will be readily understood that a machine constructed as herein described will be capable of calculations in addition, subtraction, multiplication or division in any manner in which these operations may be performed on a decimal system calculating machine.

Generally speaking, multiplication may involve shifting of the carriage in either direction. The above example was explained as it would be done with shifting of the carriage toward the left, taking the multiplier digits in natural reading order. It is to be noted, however, that in some examples the decimal fraction readings in the numeral wheels **13** are accurate to more places to the right of the decimal point if multiplication is done with shifting of the carriage toward the right. This is true because with shifting toward the right the skip digit mechanism invariably initiates a tens transfer through a series of nines which may be accumulated in the lower order numeral wheels **13** from the repeating decimal digit gears **72**, and thereby eliminates any loss of registration which might otherwise result from an indeterminate decimal equivalent registration. For instance, if 11d. is multiplied by 2100, shifting the carriage toward the right, the numeral wheels **13** would show £96.2500030, which the fractional wheels show as £96/5/0. If the same example is done with carriage shifting toward the left the numeral wheels **13** would show £96.2499930 and the fractional register will show £96/4/11¾, which, as explained above, is to be mentally "rounded off" and read as £96/5/0. This action in carriage left shifting results from the fact that values were not registered in that wheel in the first position, which is in line for the skip digit action in the second position. In no case, however, can this error exceed a farthing, which is taken care of in the "rounding off." So it is seen that if multiplication is done by shifting the carriage toward the right, this occasional discrepancy which entails a mental "rounding off" of the answer will be eliminated.

It has been observed hereinbefore that in providing a satisfactory sterling currency four rules calculator, the principal problem lies in the provision of sufficient capacity, without expanding the machine to unwieldy proportions. This has been achieved in the keyboard by providing for a fourteen place setting by means of nine columns of keys, and is achieved in the register carriage by permitting the carriage to be shifted to the left until the right hand wheels of the product register are out of register with the gears **72** and in position to register with the gears **5** and **73**.

Thus, in the machine illustrated, there are twenty places in the product register and the carriage is shiftable into ten denominational positions.

It will be further noted that because of the range of the carriage to the left, above referred to, upon converting the machine to decimal calculating condition, the nine columns of keys cooperate with a carriage of normal decimal capacity, such capacity customarily providing twice the number of denominational places in the carriage as are found in the keyboard.

The machine illustrated has ten columns of bails **19** (corresponding to a ten column straight decimal machine); provides for the entering of decimal equivalent values to eight places to the right of the decimal point, and sacrifices but one column of capacity in decimal calculation.

II

The following example illustrates the cooperation of the different groups of mechanism in simplifying operations involving both fractional and decimal calculations. It illustrates, for instance, the proposition that an essentially decimal product or quotient which is to be copied to the keyboard for further computation, may occasionally with advantage be read and reset as a fractional equivalent value, producing the effect of having been copied and reset as a decimal, with sufficient accuracy for the general run of commercial work, this method of operation being particularly desirable in order to avoid frequent resetting of the machine for different classes of work.

Pro-rate total expense of 3,146/6/0 to the following amounts:

25,326/ 4/0
66,721/15/3
71,124/ 7/6
163,172/ 6/9

Each pro-rated value may be computed according to the following formula:

$$X=\frac{EA}{T}=\frac{A}{T/E}$$

in which

X is the desired pro-rated expense,
E is the total expense,
A is any one of the amounts to which the expense is pro-rated, and
T is the total of the amounts A.

Since in many machines, and particularly according to the machine of the disclosure, it is easier to divide than to multiply, we shall assume that this prorating is to be done according to the formula

$$X=\frac{A}{T/E}$$

This pro-rating is done in four operations, as follows:

Computation *a* $\frac{163,172/6/9}{3,146/6/0}=51.8616/11/9\frac{1}{2}$

Computation *b* $\frac{25,326/4/0}{51.8616/11/9}=488/6/10$

Computation *c* $\frac{66,721/15/3}{51.8616/11/9}=1286/10/8$

Computation *d* $\frac{71,124/7/6}{51.8616/11/9}=1371/8/6$

In computation *a*, the decimal point in the keyboard is the only one which is prefixed, the setting of the dividend and the divisor being determined thereby. It is known that the quotient is to be computed to the capacity of the quotient register. Inspection of the dividend and the divisor shows that there will be two digits at the left of the decimal point in the quotient. This fixes the quotient decimal point in the eighth place. Since the keyboard point is in the third place, the point is located in the dividend register in the eleventh place (8+3=11). Place the carriage so that this point aligns with the keyboard decimal point, turn the dividend into the numeral wheels **13**, and clear the keyboard. Now set the divisor into the keyboard, according to the keyboard decimal point, and shift the carriage into position to start the division (in this case one step toward the right). After the division the counting wheels **85** register 51.861,658,93. This value is the common divisor for computations *b*, *c* and *d*, but in order to set this entire value into the keyboard as a decimal, the lever **65** would have to be shifted to its decimal position every time the divisor is installed, and back to the £ s. d. position for the installation of the next dividend. If, however, the lever **65** is allowed to remain set for £ s. d. throughout computations *b*, *c*, and *d*, the value 51.861,658,93 may be copied to the keyboard as a fractional instead of as a decimal equivalent value. This quotient appears fractionally as 51.861,6/11/9½ and may be copied to the keyboard as 51.861,6/11/9. This sets the value 51.861,658,75 into the selector mechanism, the error of −.000,000,18 being negligible, particularly in a divisor. Alternatively the quotient might have been copied as 51,861,6/11/10, setting the value 51.861,659,16666 into the selector mechanism. In this case, the error of +.000,000,23666 is also negligible, each pro-rated value being the same with either setting.

In computations *b*, *c* and *d*, the dividends must be set into the keyboard according to the prefixed decimal point in the third place. In the common divisor, however, the decimal point does not stand between the decimal and the fractional digits. Consequently these computations do not follow the rule of prefixed decimal points as stated above. Since there are four decimal digits in the divisor between the decimal point and the fractional digits, the keyboard decimal for the divisor is in the seventh place. Inasmuch as a fractional quotient reading is desired, the quotient decimal point is prefixed in the fourth place. The divisor and the quotient decimal points determine the position of the dividend decimal point to be in the eleventh place (7+4=11). This dividend point is brought into alignment with the prefixed point in the third place of the keyboard in adding the dividend into numeral wheels **13**. Then the divisor is set into the keyboard, working to the divisor keyboard decimal point in the seventh place, the carriage is shifted into position for starting a division, and the division is made.

This latter method of solving problems in prorating illustrates a novel use of the fractional registers, in combination with keyboard decimalizer mechanism.

III

The following example shows that it may be important to secure a fractional reading and also a decimal equivalent reading of the same result, this being secured, according to the showing of Figs. 1–12, in the computation of every fractional answer.

Last year a company had outstanding 56,127 bonds at a par value of £100 each, yielding £4/5/0. The company's earnings for the year were £765,127/10/3. What were the earnings per bond, the percentage of earnings, and how many times over was the interest earned, computed to two decimal places?

$$\frac{765,127/10/3}{56,127}=\begin{cases}£13/12/8\\13.6320\%\end{cases}$$

$$\frac{13/12/8}{4/5/0}=3.21 \text{ times}$$

The first computation gives the first two required answers, which will appear on the fractional and on the decimal quotient registers.

The second computation has been shown as it would be done fractionally. It may equally well be done decimally either by changing the lever **65** to the decimal position, or by leaving the lever **65** set in its £ s. d. position and by working to a decimal point in the seventh place of the keyboard. The answer, computed to two decimal places, will be the same by either method.

I claim:

1. In a calculating machine having value entering devices provided with non-decimal designations including designated fractions having repeating decimal equivalents; the combination with means for accumulating finite values equivalent to the accumulated designated fractions, including a series of differential actuators, digit entering bars operable under control of said entering devices to set given equivalent values in said actuators, and a series of accumulator gears operable by said actuators and provided with transfer mechanism including a non-decimal transfer element; of a register cooperating with certain of said accumulator gears to convert accumulated values into equivalent fractional registrations.

2. In a calculating machine, the combination with value entering devices provided with fractional designations, a denominational series of differential actuators, and digit entering bars operable to set in said actuators the decimal equivalent of a fractional value entered in said devices, of a denominationally shiftable carriage, a series of decimal accumulator wheels in said carriage operable by the differential actuators, an auxiliary register cooperating with given accumulator wheels and a second auxiliary register cooperating with higher order accumulator wheels said auxiliary registers being so located that when the carriage stands in extreme right hand shifted position the accumulator wheels related to both said registers will stand in operative rotation with certain of the equivalently set actuators.

3. In a calculating machine, the combination with a denominational series of differential actuators including each a plurality of part digit gears, and a denominational series of digit entering bars each operable to set a related part digit gear to effective position, of supplemental lower order actuator means operable to register a series of constant digit values as a continuation of values set in the differential actuators, including a series of gears and a connecting element between the individual gears and between said gears and one of the part digit gears, whereby one of the digit entering bars will set the supplemental actuator gears to effective position.

4. In a calculating machine, the combination with a denominational series of normally inac-

tive differential actuator gears, and a denominational series of digit entering bars each selectively settable to move a related actuator gear into active position, of supplemental actuator means operable to register a series of constant digit values as a denominational continuation of values set in the differential actuators, including a series of actuator gears connected with each other and with one of said first-named actuator gears by sleeves, to move and rotate as a unit.

5. In a calculating machine having differential actuators; the combination with a register comprising a series of decimal accumulator wheels and a lower denominational order wheel provided with a non-decimal transfer connection with the adjacent decimal wheel, said wheels having operative connection with the differential actuators, of a register comprising wheels provided with non-decimal designations and having driving connection with the decimal wheels of the first-named register.

6. In a calculating machine having cyclic differential actuators, the combination with a register comprising a series of decimal accumulator wheels having operative connection with the differential actuators, and a register cooperating with certain of said wheels to convert accumulated decimal values into equivalent fractional registrations, of means for converting repeating decimals accumulated in said wheels into related finite values, for transmission to the fractional register, including means cooperating with one of the numeral wheels and operable upon rotation of said wheel to a given value registering position to further rotate said wheel during the actuator cycle.

7. In a calculating machine, having a fixed frame and a laterally shiftable carriage, the combination with value entering devices provided with fractional designations, a series of cyclic actuators including a denominational series of interconnected gears settable as a whole to represent a repeating decimal, and digit entering bars operable to set in said actuators the decimal equivalent of a fractional value entered in said devices, of a register mounted on said carriage, having operative connection with the differential actuators and comprising decimal numeral wheels and tens transfer mechanism between said wheels, and denominator conversion means including a series of elements each related to a numeral wheel cooperating with one of the interconnected actuator gears, and elements mounted in the fixed machine frame, said conversion means being responsive to the lowest order cooperating numeral wheel upon rotation thereof to a given value registering position by an actuator to further rotate said wheel during the actuator cycle.

8. In a calculating machine having cyclic differential actuators, the combination with a register comprising decimal numeral wheels, of denominator conversion means comprising driving and driven elements cooperating with one of the numeral wheels said elements being adjustable and operable upon rotation of said wheel to a given value registering position by an actuator to further rotate said wheel during the actuator cycle, and other means for adjusting said elements to render same alternatively effective or ineffective.

9. In a calculating machine having a fixed frame, a laterally shiftable carriage, and differential cyclic actuators in said frame, the combination with a register comprising a series of decimal accumulator wheels mounted in said carriage and operable by the differential actuators, and transfer mechanism between said wheels, of means for converting repeating decimals accumulated in said wheels into related finite values, including a member related to the extreme right hand numeral wheel and cooperating elements operable upon rotation of said wheel to a given value registering position by any actuator brought by the carriage into operative relation with said wheel to operate the transfer mechanism to further rotate said wheel during the actuator cycle.

10. In a calculating machine having a fixed frame, a laterally shiftable carriage, and cyclic differential actuators in said frame; the combination with a register comprising a series of decimal accumulator wheels mounted in said carriage and operable by the differential actuators, and transfer mechanism between said wheels, of means for converting repeating decimals accumulated in said wheels into related finite values, including a series of elements each related to a numeral wheel, and elements mounted in the fixed machine frame, said conversion means being responsive to the lowest order numeral wheel brought by the carriage into operative relation with an actuator, upon rotation of said wheel to a given value registering position, to further rotate said wheel during the actuator cycle.

11. In a calculating machine having a fixed frame, a laterally shiftable carriage, and cyclic reversible differential actuators in said frame, the combination with a register comprising a series of decimal accumulator wheels mounted in said carriage and operable by the differential actuators, of denomination conversion means including two spaced teeth rotatable with one of said numeral wheels, and means cooperating in a given shifted position of said wheel alternatively with one or the other of said teeth, upon rotation of said wheel by forward or reverse operation of an actuator respectively, to further rotate the wheel during the actuator cycle.

12. In a calculating machine having cyclic differential actuators, the combination with a register comprising a series of decimal accumulator wheels having operative connection with the differential actuators, and a register including a non-decimal wheel having parallel series of figure designations and gear connection with a decimal wheel, a revolvable shutter surrounding the non-decimal wheel, having laterally staggered openings therein and gear connection with another decimal wheel, of denomination conversion means cooperating with the non-decimal wheel and operable upon rotation of said wheel to a given value registering position by operation of an actuator to further rotate the non-decimal wheel and the associated decimal wheel during the actuator cycle.

13. In a calculating machine having differential actuators; the combination with a register comprising decimal numeral wheels and tens transfer devices between said wheels, of denomination conversion means including an element having one-to-one ratio driving relation with one of said numeral wheels and operable in the movement thereof to a value registering position representing a non-decimal denominator to initiate a transfer to the adjacent higher order wheel, and an element adjustable by the one-to-one ratio element to effect movement of said wheel in addition to the movement imparted by the cooperating actuator.

14. In a calculating machine having reversible rotary differential actuators; the combination with a register comprising decimal numeral wheels and settable transfer devices between said wheels, of denomination conversion means including a settable element, cooperating elements operable during forward or reverse actuator rotation to effect movement of one of said numeral wheels in addition to the movement imparted by the cooperating actuator, and an element having one-to-one ratio driving relation with said wheel and operable in forward or reverse rotation in given value registering positions thereof to set the related transfer device and to set the conversion element to active position.

GEORGE C. CHASE.

CERTIFICATE OF CORRECTION.

Patent No. 2,268,374. December 30, 1941.

GEORGE C. CHASE.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 47, for "shilings" read --shillings--; page 8, second column, line 57-58, claim 2, for "rotation" read --relation--; page 9, first column, line 40, claim 7, after "cyclic" insert --differential--; line 56, after "wheel" and line 58, after "actuator", same claim, insert a comma; and lines 73 and 74, claim 9, for "differential cyclic" read --cyclic differential--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 3rd day of March, A. D. 1942.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

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