Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 1

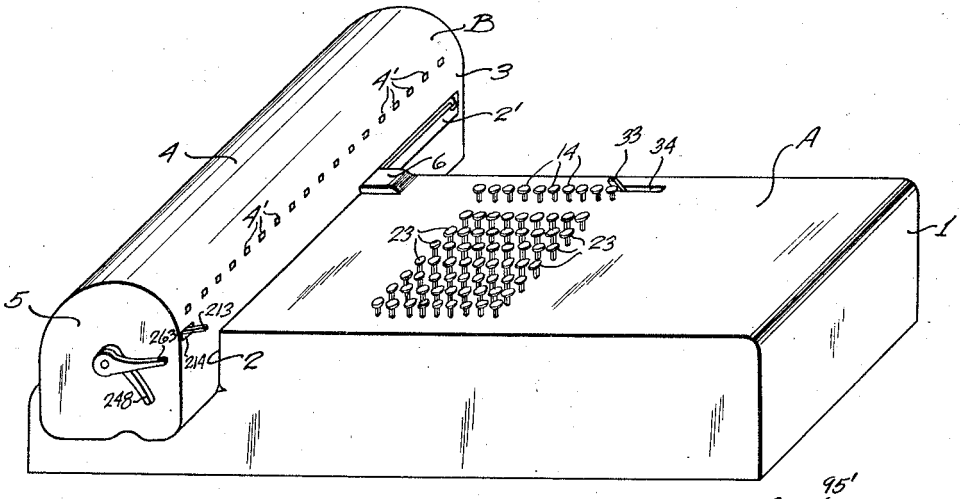

FIG. 1.

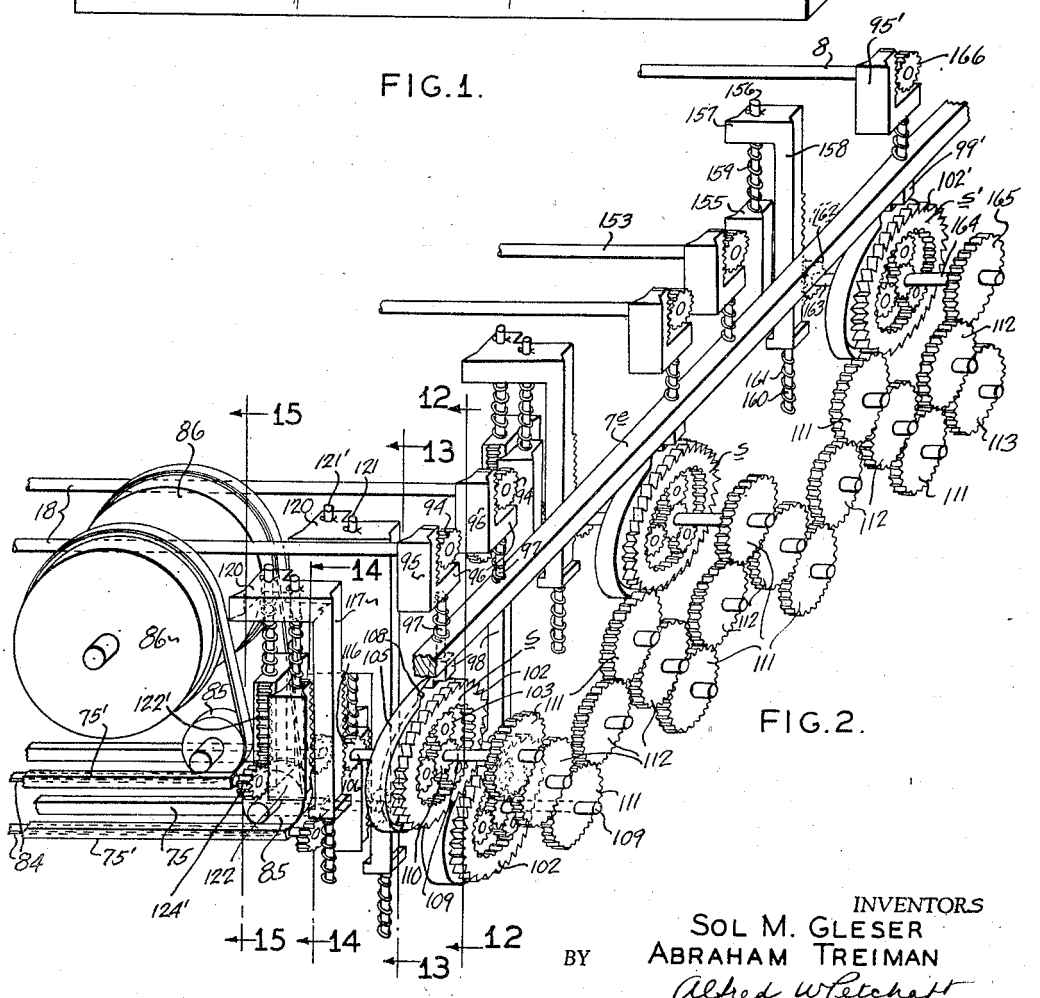

FIG. 2.

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PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 2

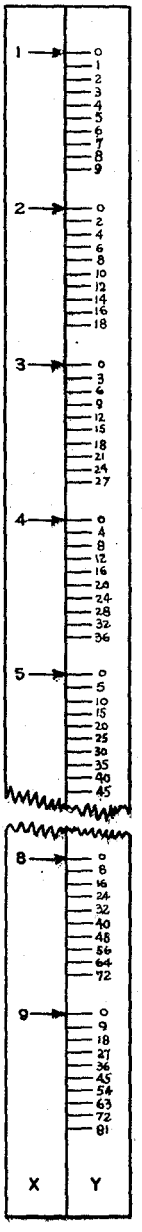

FIG. 1a

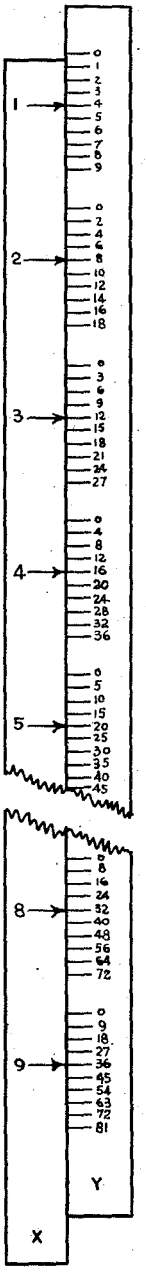

FIG. 1b

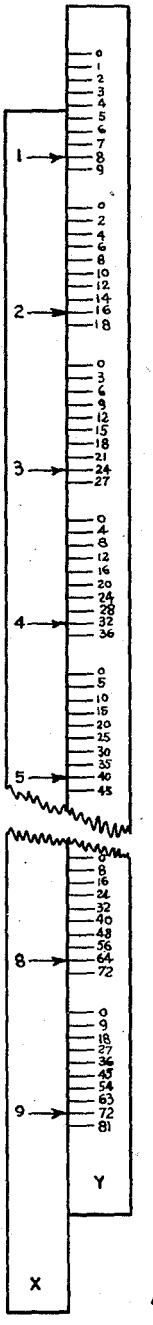

FIG. 1c

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 3

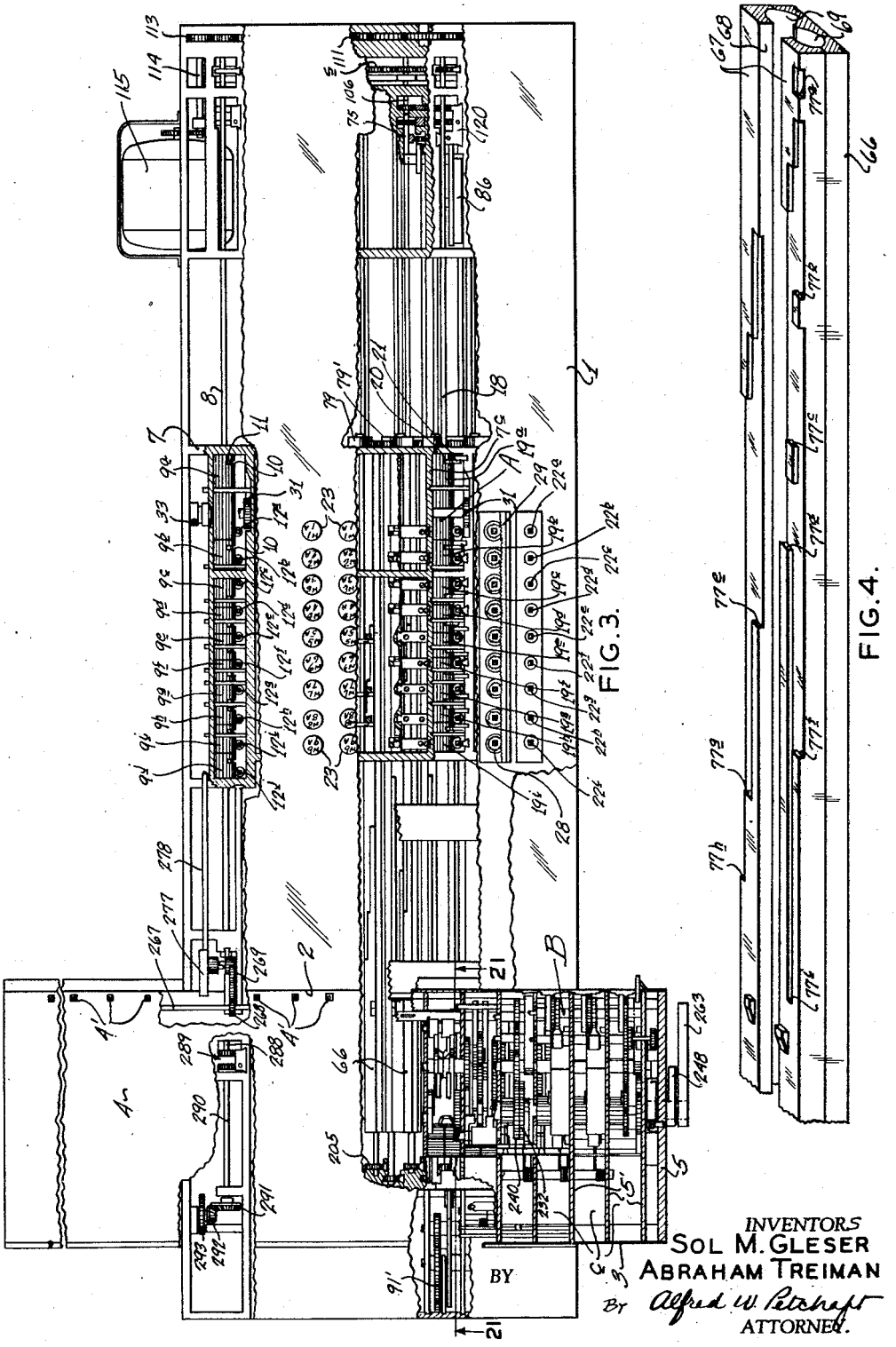

FIG. 3.

FIG. 4.

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 4

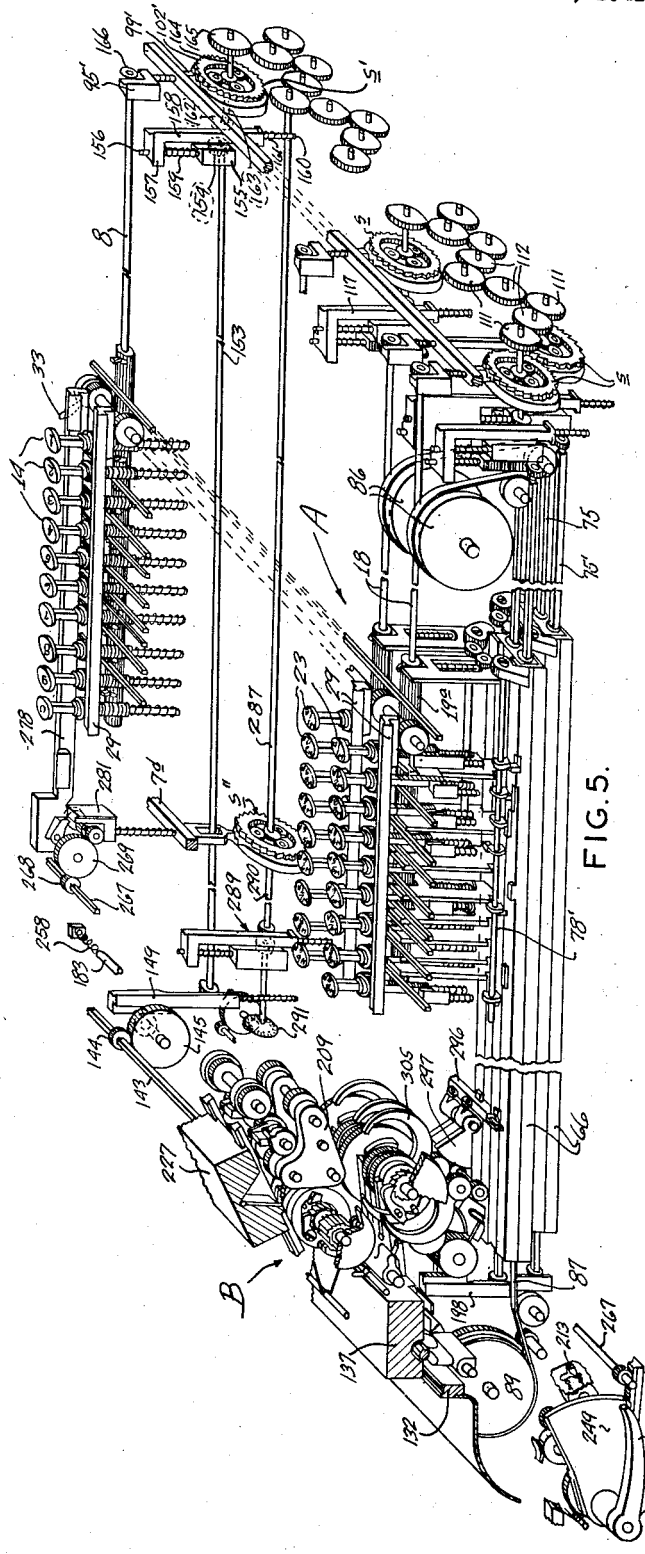

FIG. 5.

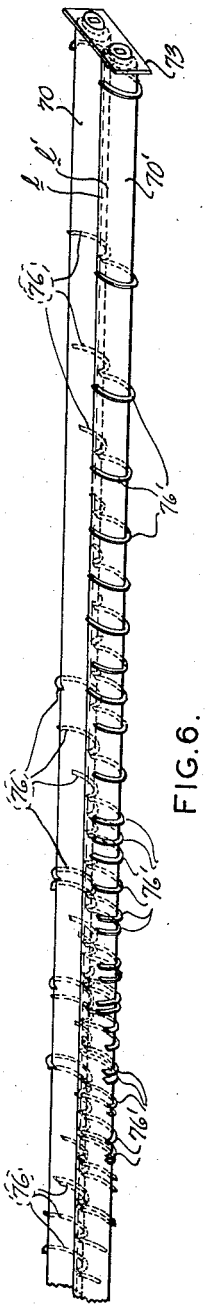

FIG. 6.

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 5

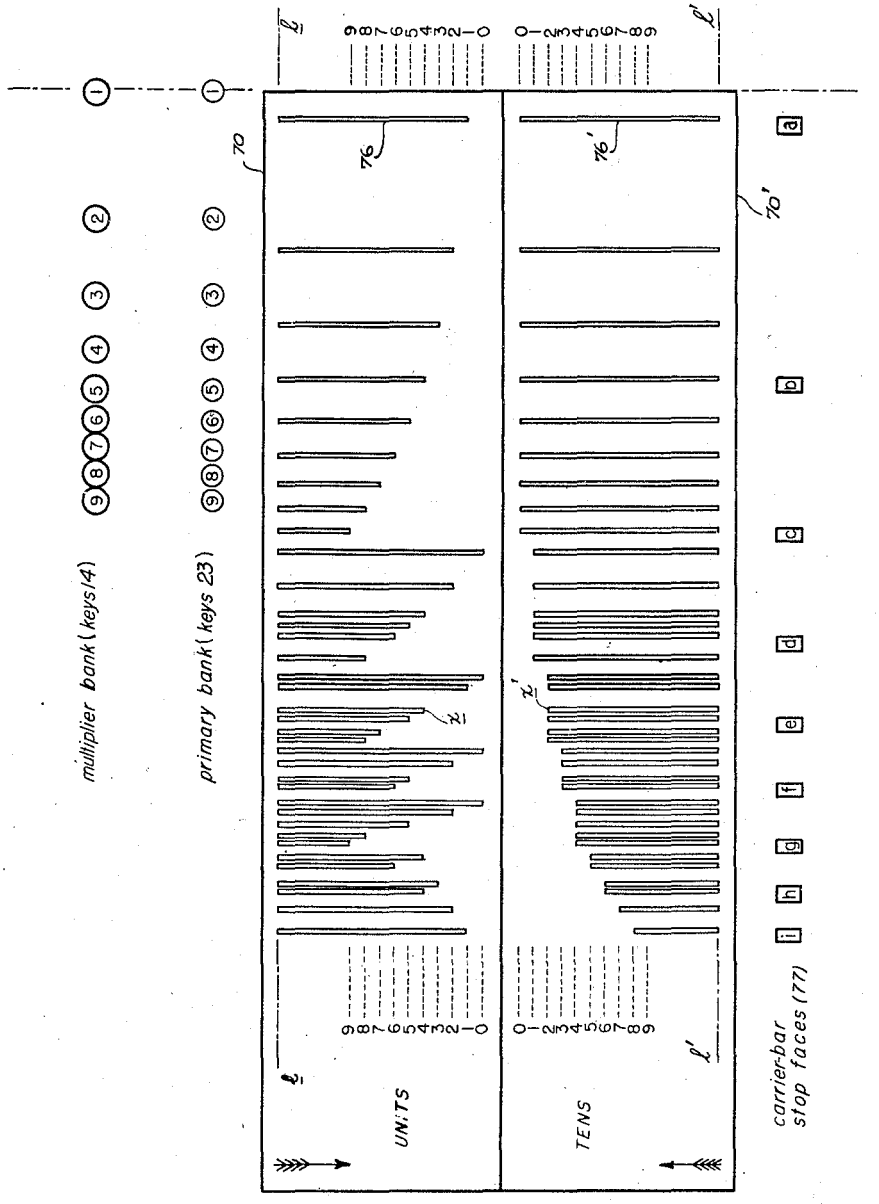

FIG. 6a

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 6

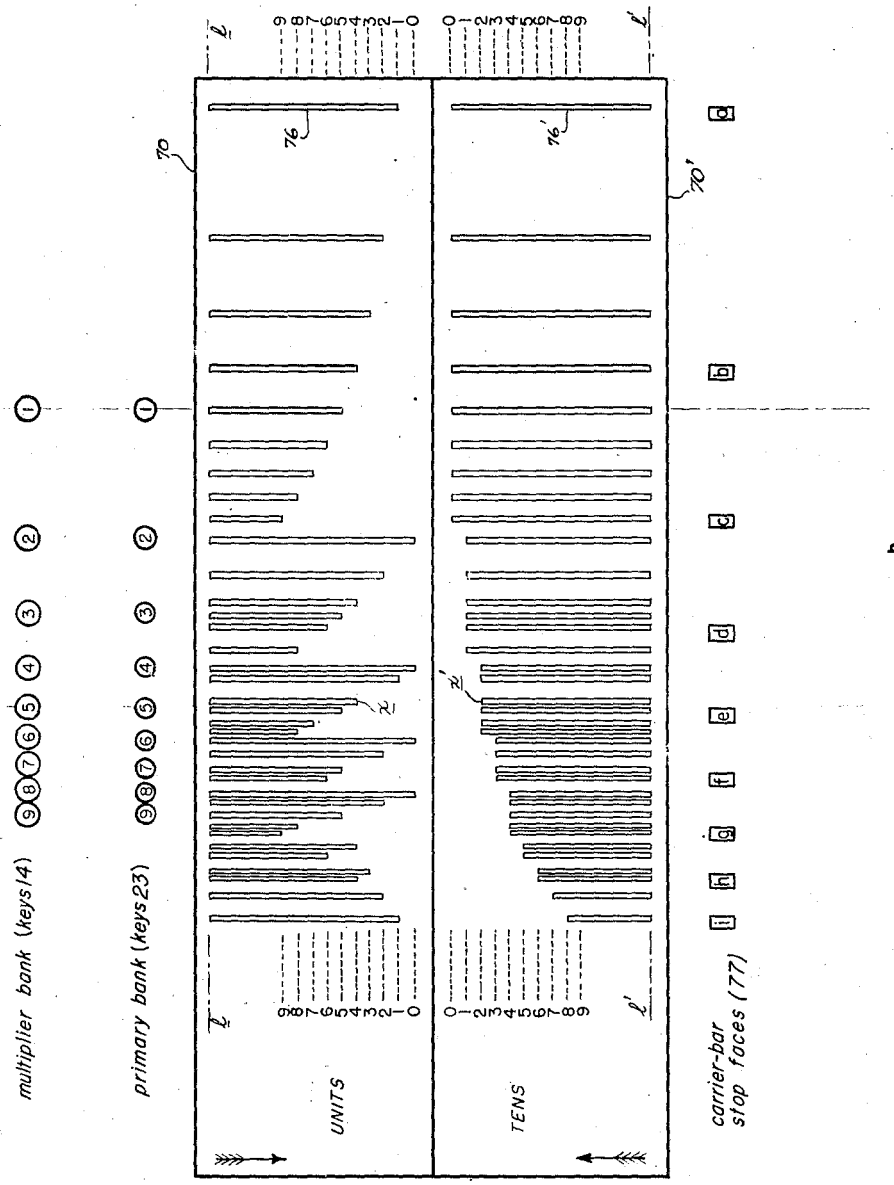

FIG. 6b

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 7

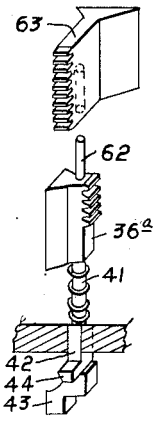

FIG. 28

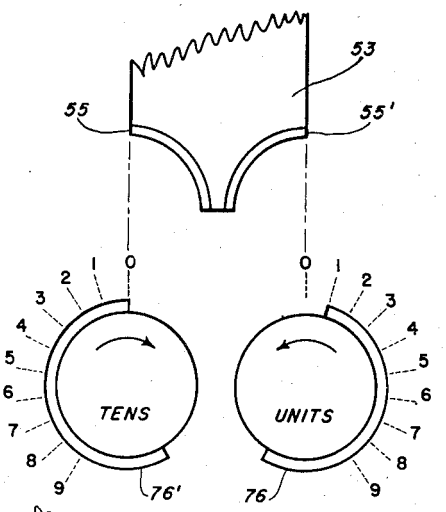

FIG. 6c

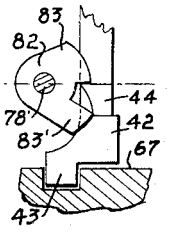

FIG. 19a

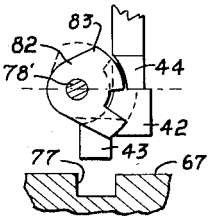

FIG. 19b

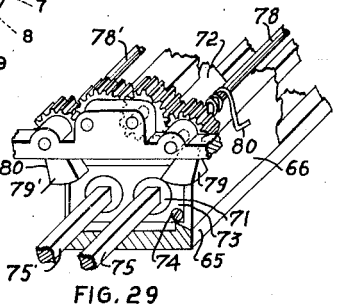

FIG. 29

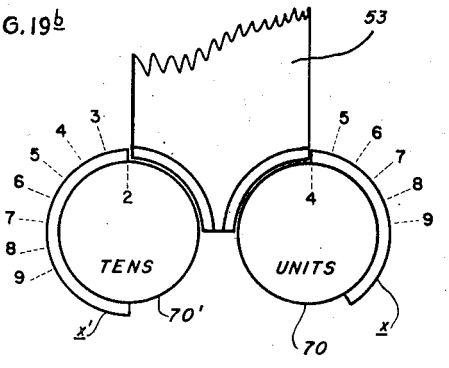

FIG. 6d

INVENTORS

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 8

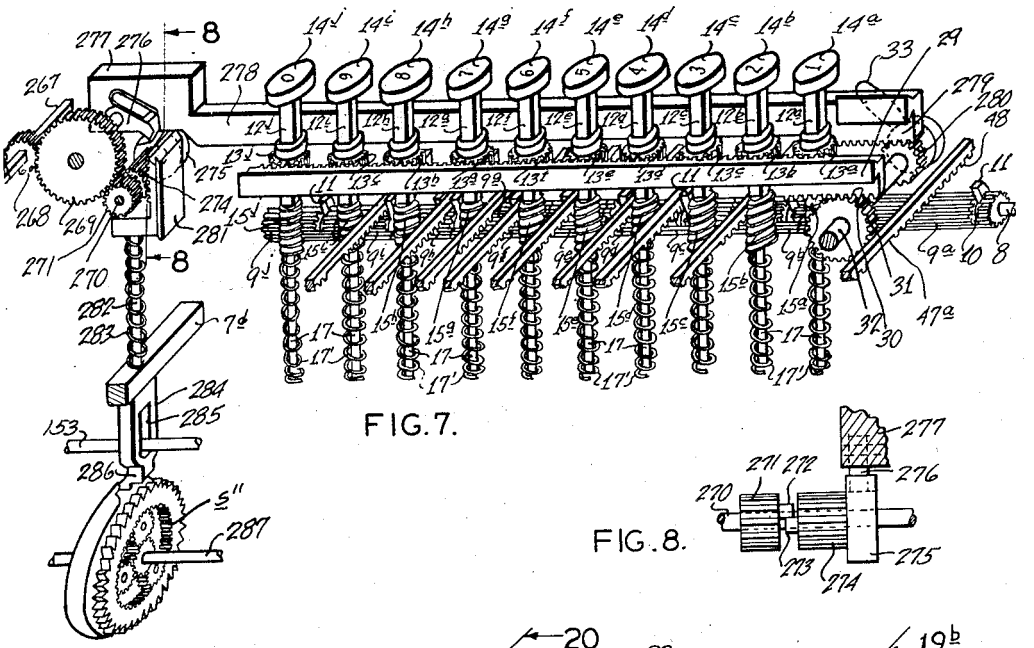

FIG. 7.

FIG. 8.

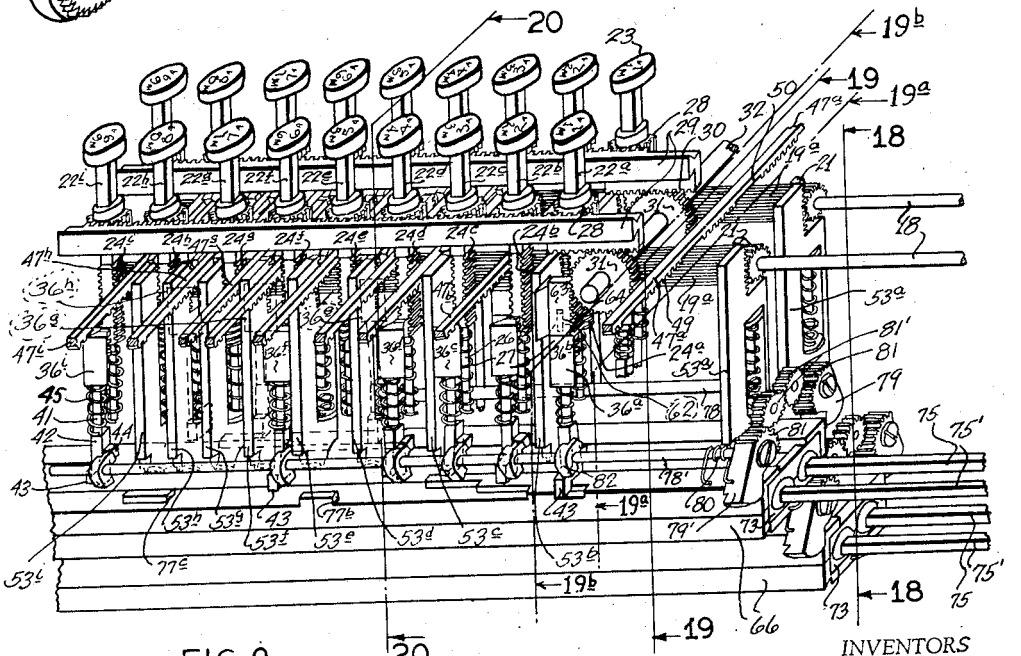

FIG. 9.

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 9

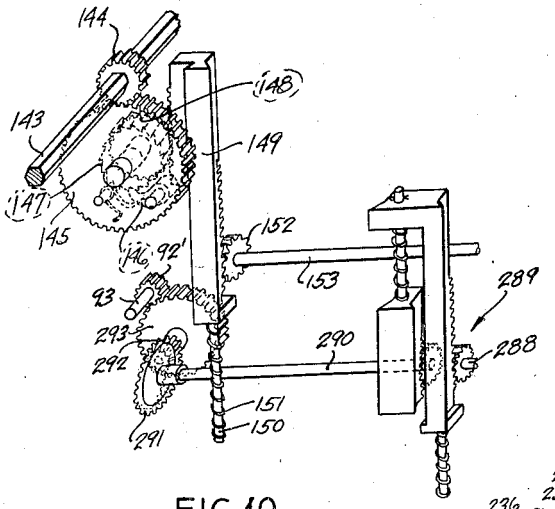

FIG. 10.

FIG. 11.

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 10

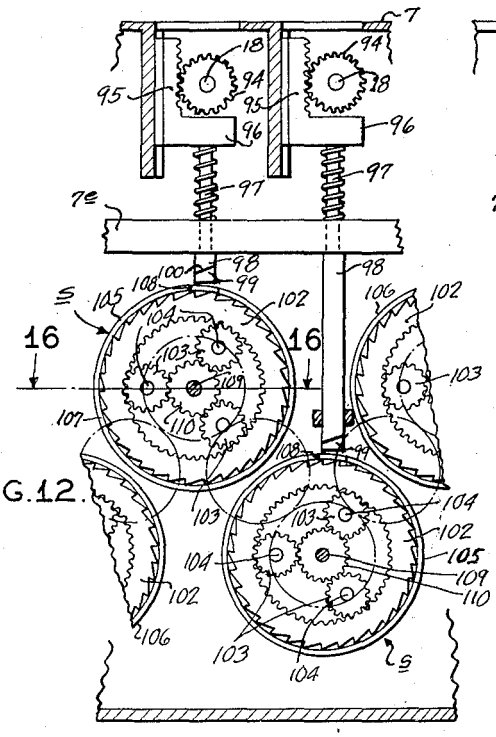

FIG.12.

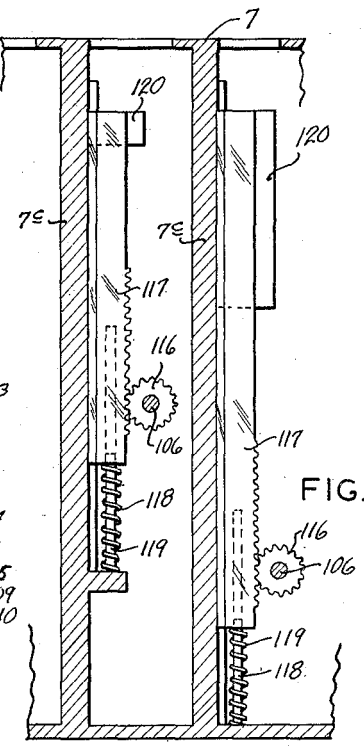

FIG.13.

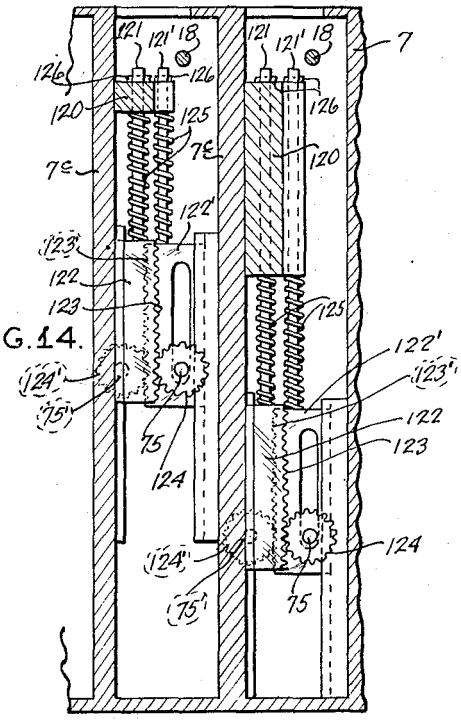

FIG.14.

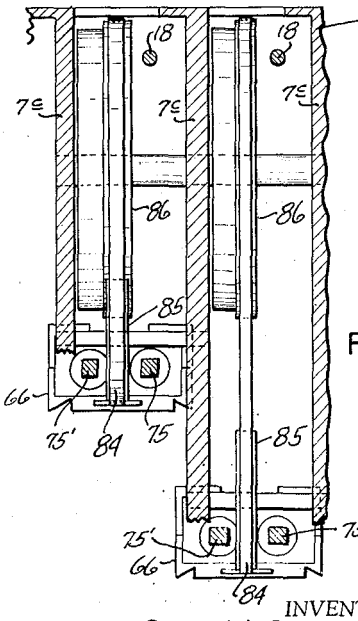

FIG.15.

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 11

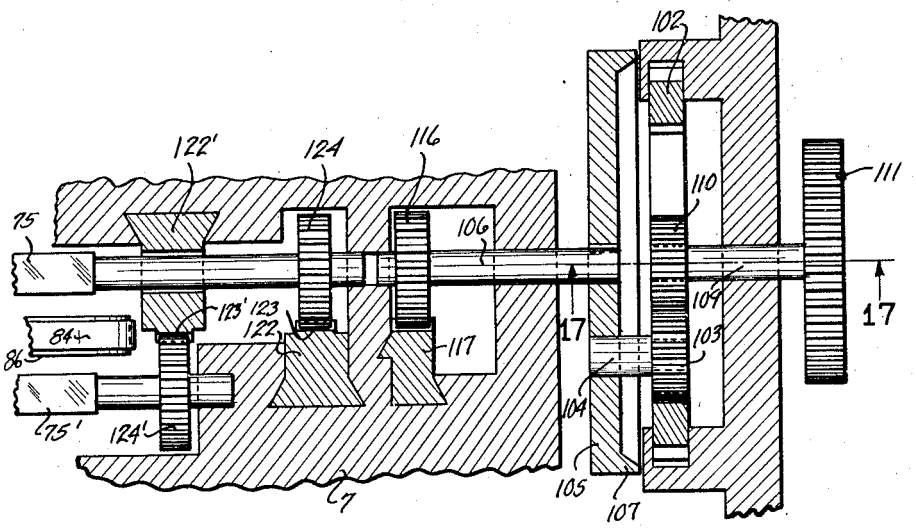

FIG.16.

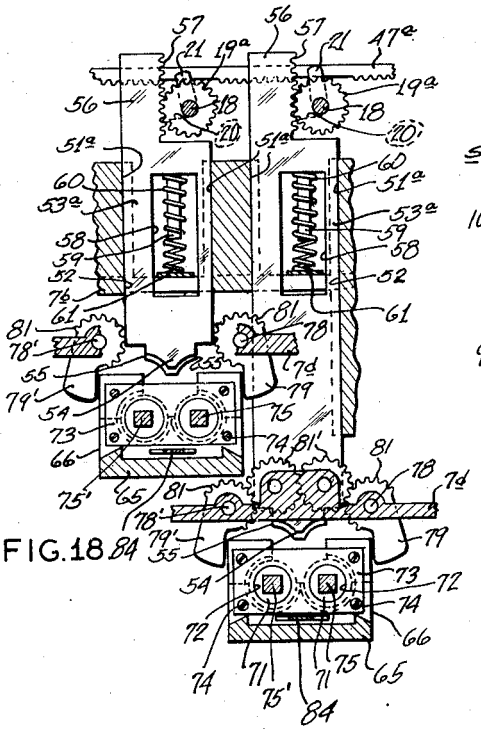

FIG.18

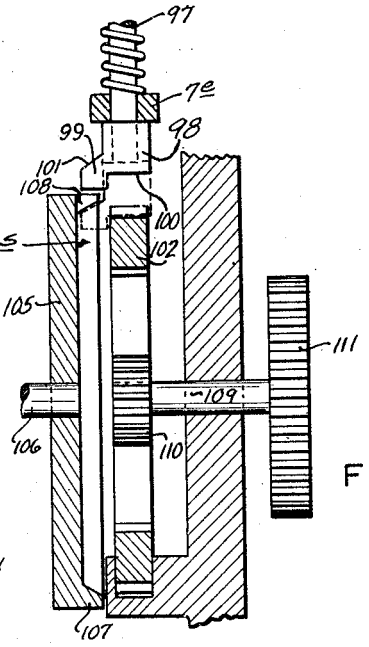

FIG.17.

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 12

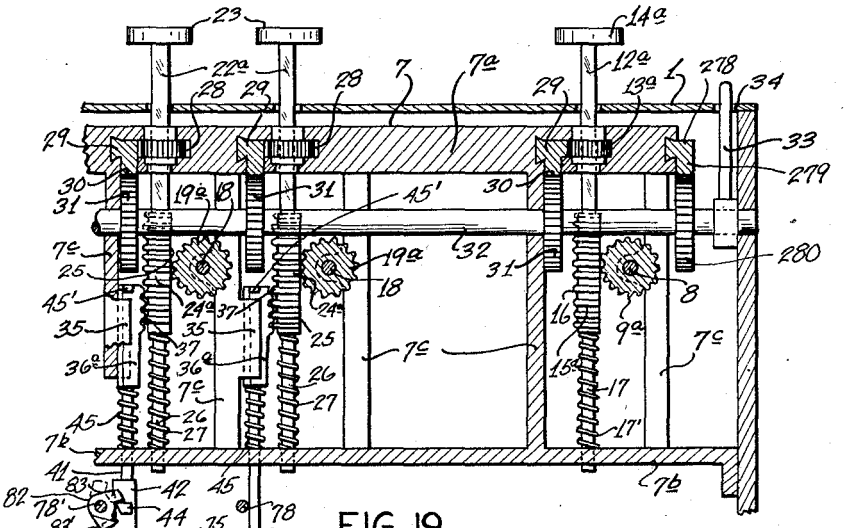

FIG. 19

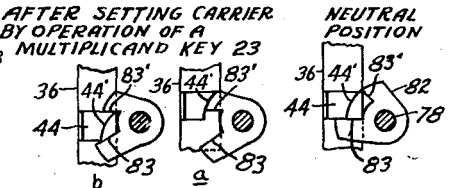

FIG. 20a

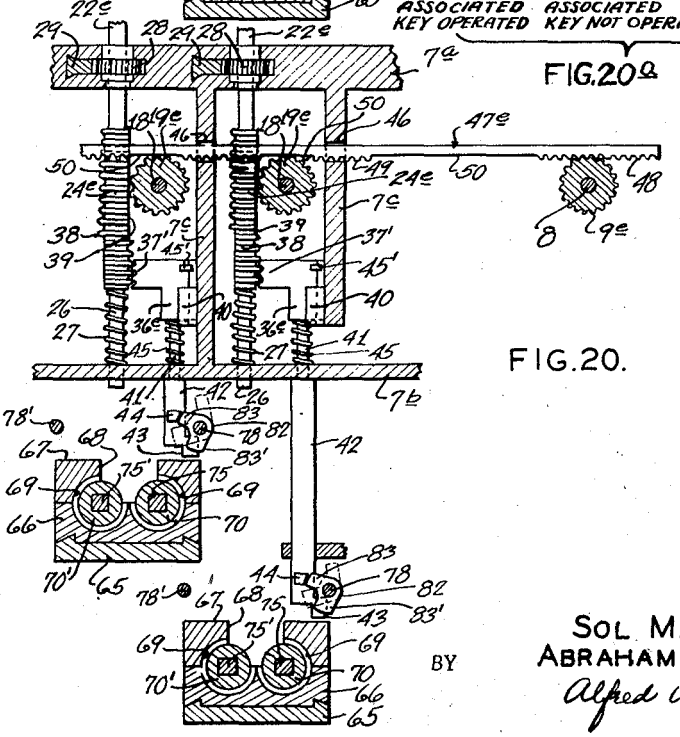

FIG. 20.

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 13

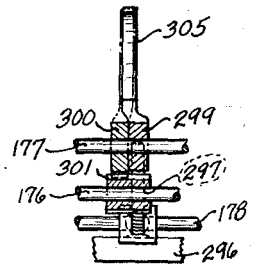

FIG. 22.

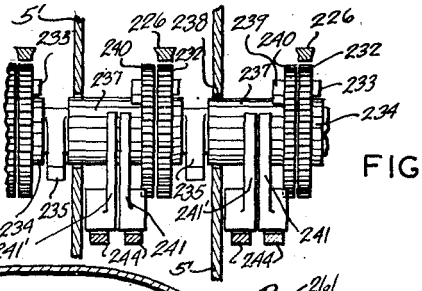

FIG. 23.

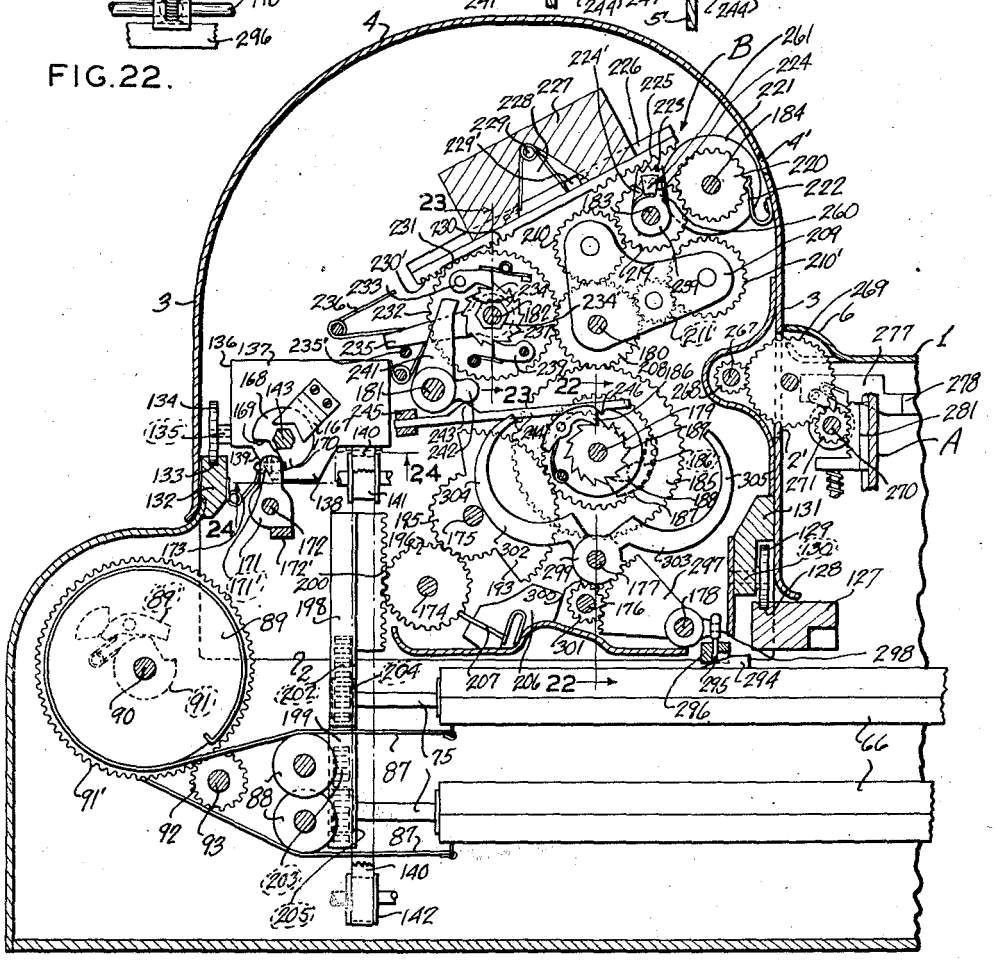

FIG. 21.

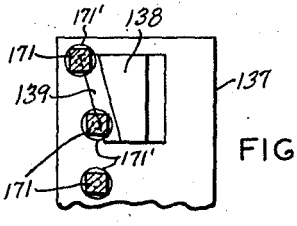

FIG. 24.

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 14

FIG. 24a

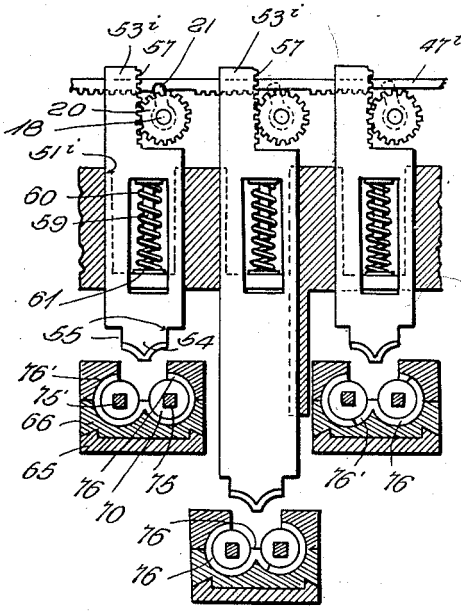


FIG. 24b

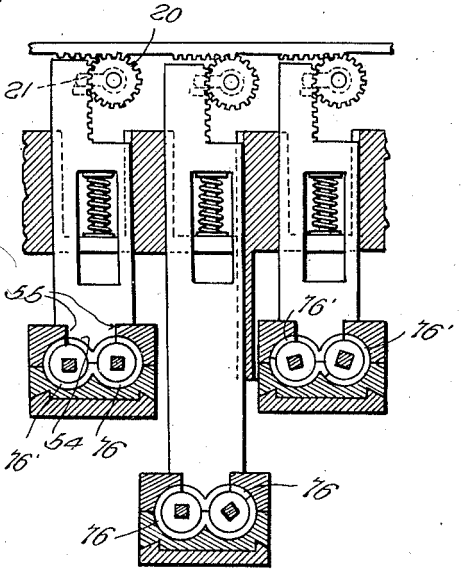


FIG. 24c

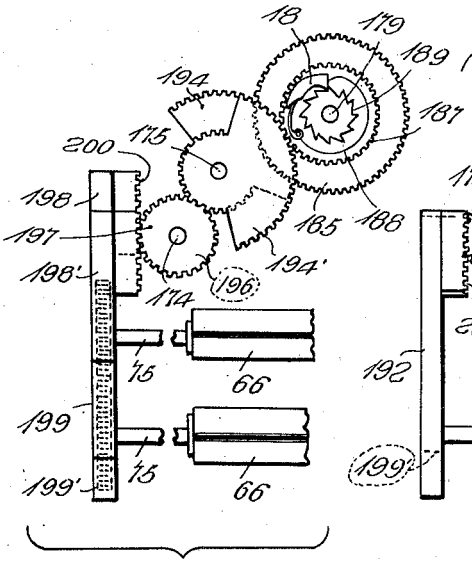
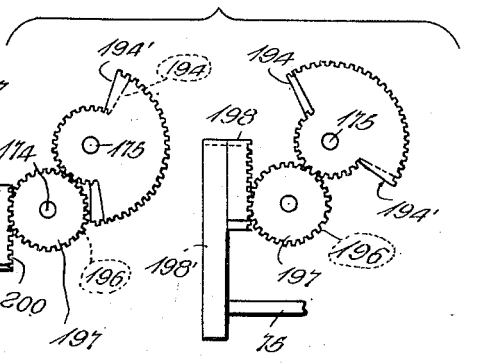


FIG. 24d



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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 15

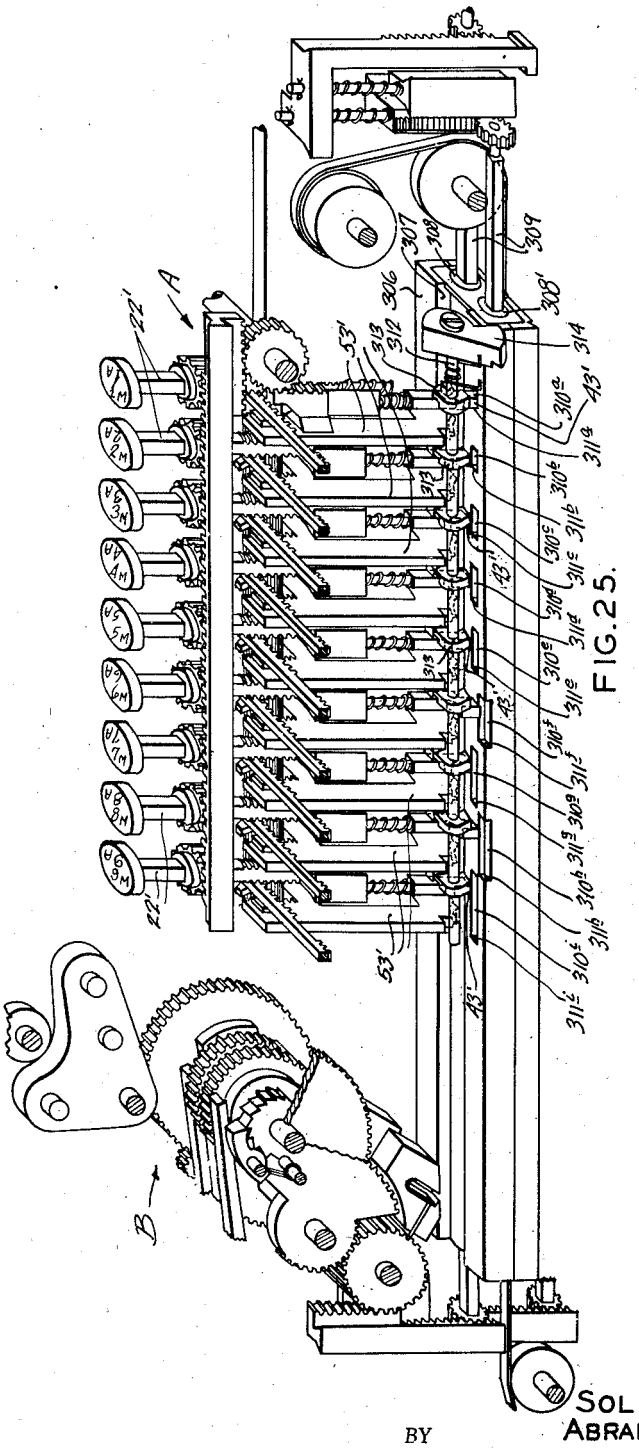

FIG. 25.

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Dec. 16, 1947. S. M. GLESER ET AL 2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Filed Oct. 16, 1941 16 Sheets-Sheet 16

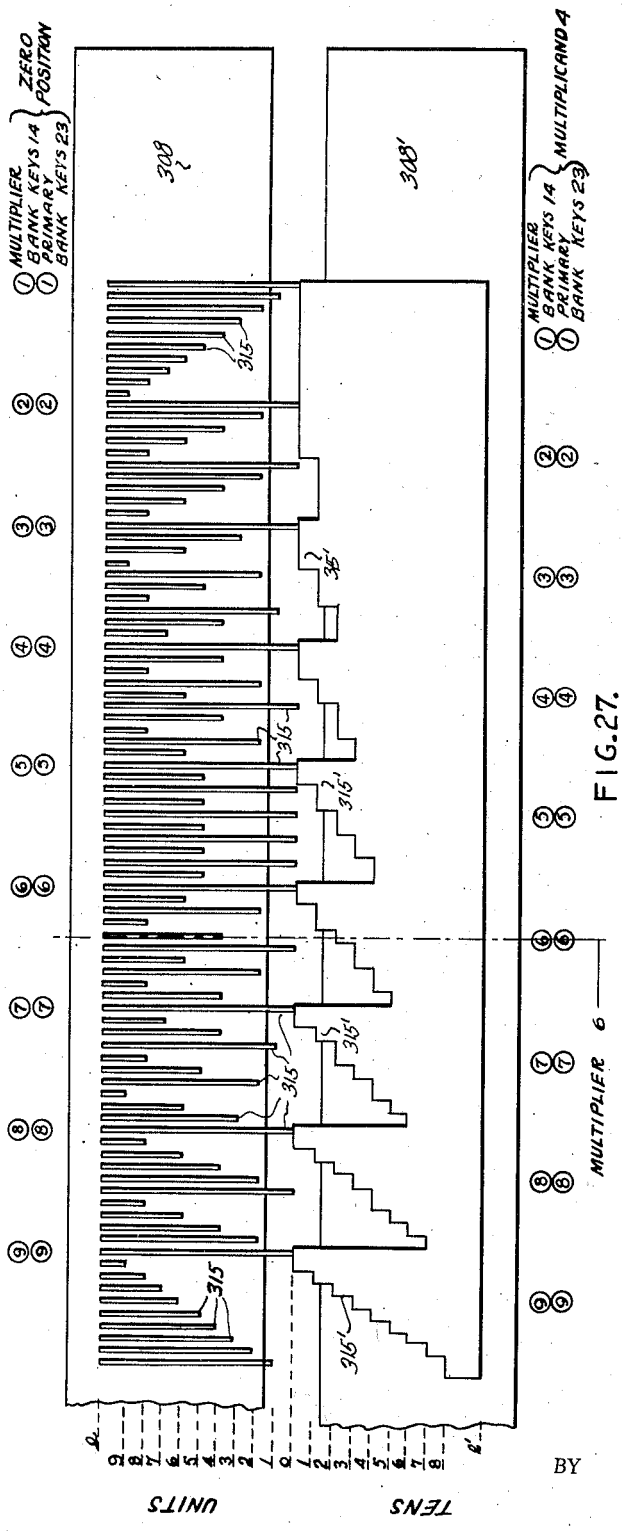

FIG. 27.

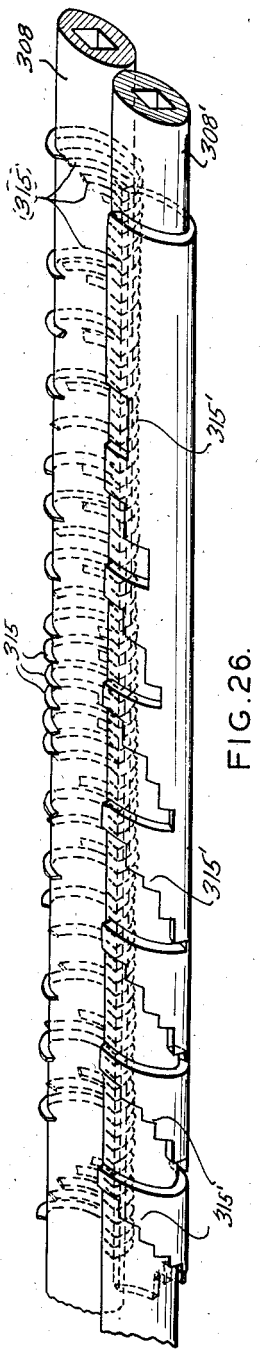

FIG. 26.

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Patented Dec. 16, 1947

2,432,569

UNITED STATES PATENT OFFICE

2,432,569

PARTIAL PRODUCT MULTIPLYING MACHINE

Sol M. Gleser, Olivette, and Abraham Treiman, St. Louis, Mo.

Application October 16, 1941, Serial No. 415,200

15 Claims. (Cl. 235—61)

1

This invention relates in general to partial product multiplying machines and, more particularly, to a unique calculator which is capable of adding, subtracting, and multiplying.

Our invention has for its primary objects the provision of a partial product multiplying machine which is capable of efficiently performing the several arithmetic operations of addition, subtraction, and multiplication, which will keep a running total of a whole series of such operations successively performed, thus facilitating such clerical work as billing, ledger posting, and the like, which is very speedy in both manipulation and internal functioning, performing its several arithmetical operations at a rapid rate and with a minimum of lost time, which is simple in manipulation, requiring no great skill or extended period of study on the part of the operator to attain proficiency, which is power-driven, thereby materially relieving physical strain upon the operator, and which is otherwise highly satisfactory and efficient in the performance of its stated functions.

And with the above and other objects in view, our invention resides in the novel features of form, construction, arrangement, and combination of parts presently described and pointed out in the claims.

In the accompanying drawings (12 sheets)—

Figure 1 is a perspective view of a calculating machine constructed in accordance with and embodying our present invention;

Figs. 1*a*, 1*b* and 1*c* are schematic diagrams illustrating the general principles upon which the calculating machine of our invention is based.

Figure 2 is a fragmentary perspective view of the power-transmitting mechanism of our invention;

Figure 3 is a top plan view, partly broken away and in section, of the calculating machine;

Figure 4 is a fragmental perspective view of the sliding carrier bar forming a part of our invention;

Figure 5 is a fragmental perspective view of the essential component mechanisms of the machine shown in spatial relationship to each other;

Figure 6 is a fragmental perspective view of a pair of matched computing barrels forming a part of our invention;

Figs. 6*a*, 6*b*, 6*c* and 6*d* are diagrammatic representations illustrating the cooperative relationship between the component parts of the calculating machine showing in particular the developed surface of the computing barrels.

Figure 7 is a fragmental perspective view of

2

the bank of multiplier keys and associated mechanism;

Figure 8 is a fragmental sectional view taken along the line 8—8, Figure 7;

Figure 9 is a fragmental perspective view of two primary banks of keys and associated mechanism;

Figure 10 is a fragmental perspective view of the carrier bar return actuating mechanism;

Figure 11 is a fragmental perspective view of the totalizer showing two duplicate and parallel trains of mechanism and also the carrier bar return mechanism associated with the two selected primary key banks shown in Figure 8;

Figures 12, 13, 14, and 15 are fragmental sectional views of the power-driven computing barrel rotating mechanism taken respectively along the lines 12—12, 13—13, 14—14, and 15—15, Figure 2;

Figure 16 is a fragmental sectional view of the computing barrel rotating mechanism taken along the line 16—16, Figure 12;

Figure 17 is a fragmental sectional view of the computing barrel rotating mechanism taken along the line 17—17, Figure 16;

Figures 18, 19, and 20 are fragmental sectional views of the primary key banks taken respectively along the lines 18—18, 19—19, and 20—20, Figure 9;

Figure 20*a* is a schematic view of a detail of operation of the latch member and detent lug which co-operate for holding down the slide positioning mechanism.

Figure 21 is a fragmental sectional view of the totalizer and associated mechanism taken along the line 21—21, Figure 3;

Figures 22, 23, and 24 are fragmentary vertical sectional views of a detail of the totalizer mechanism taken approximately along the lines 22—22, 23—23, and 24—24, respectively, Figure 21;

Figures 24*a* and 24*b* are fragmentary transverse sectional views of the calculating mechanism, respectively showing the mechanism associated with three primary key banks in initial and final positions of a single computing cycle; that is to say, the position before the keys in the three key banks are depressed, and the position after such keys have been completely depressed.

Figures 24*c* and 24*d* are fragmentary views of the mechanism for transferring the computed values into the totalizer or accounting mechanism; the position shown in Figure 24*c* being that assumed by the mechanism when the key bank

mechanism is in the position shown in Figure 24*a* and similarly the position shown in Figure 24*d* being that assumed by the mechanism when the mechanism associated with the primary key banks is in the position shown in Figure 24*b*.

Figure 25 is a perspective view of a modified form of primary key bank and associated mechanism;

Figure 26 is a perspective view of the computing barrels associated with such modified form of primary key bank;

Figure 27 is a schematic plan view of the developed surface of the computing barrels shown in Figure 26, and

Figures 28 and 29 are fragmentary detail views, partly broken away and in section, respectively illustrating the operation of the detent lugs and stop dogs which co-operate with parts of the computing slide mechanism.

General principle of operation

Before entering upon a detailed description of the embodiments of our invention, and in order to render such description more readily understandable, it is thought desirable to set forth the general principles of operation involved, by reference to the simplified and wholly schematic arrangement of members shown in Figures 1*a*, 1*b* and 1*c*. Assume that there are two elongated, edgewise abutting strips X and Y. The member X is stationary and for convenience may be referred to as the "stationary" member, while the member Y is disposed for lengthwise shifting movement in relation to the member X and may for convenience be referred to as the "slide" member. The stationary member X is provided with a series of uniformly spaced arrows, numbered consecutively from 1 to 9 as shown. The slide member Y is provided with nine sets or series of uniformly spaced graduations, each such set or series comprising ten graduations and extending over a distance which is somewhat smaller than the distance between two successive arrows. The first graduation of each series is designated "0" and is directly opposite the particular arrow with which such series is associated. The successive graduations in each series are respectively numbered with the first nine consecutive multiples of the number represented by such arrow.

For instance opposite the "1" arrow is a zero graduation followed by graduations designated 1, 2, 3, 4, 5, 6, 7, 8, 9, which are the first nine consecutive multiples of 1, in other words the products of 1×1, 1×2, 1×3, and so on. Similarly opposite the "2" arrow is a zero graduation followed by graduations designated 2, 4, 6, 8, 10, 12, 14, 16, 18, i. e. the products of 2×1, 2×2, 2×3, and so on.

As shown in Fig. 1*a* the slide is set at "zero" and opposite each arrow is the product of the number represented by such arrow when multiplied by "zero," that is to say "zero," since zero multiplied by any number is always zero. If the slide number is shifted to the right 4 units of length for instance (a unit being taken as the distance between any two consecutive graduations within the series of graduations) then the "4" graduation will come into alignment with the "1" arrow as shown in Fig. 1*b*. At the same time the fourth graduation in each successive set will also come into alignment with the particular arrow with which such set is associated. In this shifted position, 8 lies opposite the "2" arrow i. e. the product of 2×4 and similarly opposite

each arrow lies the product of the number represented by such arrow when multiplied by "four." From this it will be evident that if the slide is moved a number of units corresponding to the multiplicand then the product will lie under the arrow representing the number which is the multiplier.

For example if it were desired to multiply "8" by "3" the slide Y would be shifted eight units as shown in Fig. 1*c* and the slide may be said to be "conditioned" for multiplying the number "8" by any one of the integers represented by the arrows on the stationary member X. Thus opposite the "3" arrow is the graduation designated "24" which is the product of 8×3.

In order to achieve such results mechanically it will, obviously, be necessary to provide a series of keys or other manually manipulable means corresponding to the integers 1 to 9 and arranged for mechanically effecting the shifting movement of the slide member. Similarly the slide member must be provided with a whole series of elements or mechanisms each corresponding to a graduation on the slide member and arranged so as to be capable of achieving an amount of mechanical motion proportional to the value of the particular product or multiple represented by such corresponding graduation. Thus, for instance, at the position of the graduation designated "24" (again using the example 8×3 as illustrated in Fig. 3) a suitable element or mechanism must be placed, which is capable of effecting an amount of mechanical motion proportional to the number 24. Such proportionate motion must be transmitted into suitable totalizing mechanism for recordation or accumulation.

Finally, the stationary member must be provided with a series of keys or other suitable manually manipulable members each corresponding to one of the arrows representing an integer, and in the case of the example under discussion the manipulation of such key or member corresponding to "3" would in some suitable way initiate the mechanical movement of the "24" element on the slide which has already been shifted into such relative position that the "24" element is in proper juxtaposition.

Although the above discussion is entirely hypothetical, the provision of such mechanical elements for embodying the basic principle outlined is achieved in the embodiments hereinafter described. The mechanism described under the sub-heading "Primary key banks" actually is the mechanical means for shifting the slide member responsive to a selected multiplicand and similarly the mechanism described under the subheading "Computing slide and barrel mechanism" is mechanical embodiment of the slide with mechanisms for converting the several products or multiples into mechanical movement proportional to the values of such products. Likewise the mechanism described under the subheading "Multiplier key bank" is actually the mechanical means for initiating the operation of the mechanism which converts the product into proportionate movement and finally the mechanism described under the sub-heading "Totalizer" is actually the mechanical means for receiving and recording or accumulating such proportionate mechanical movement.

By way of further introductory explanation it may be pointed out that graduations on both the stationary member X and the slide member Y are uniformly spaced and the spatial relationship, therefore, may be said to be "arithmetical." If

for example the unit of length chosen for the stationary member be inches, then the distance between the "1" arrow and the "2" arrow is one inch and similarly the distance between the "2" arrow and the "4" arrow will be 2 inches. In each case the spatial distance between any two arrows will be the same number of inches (or whatever other length unit may be employed) as the arithmetical difference between the numbers represented by such arrows. Likewise if the slide member X is uniformly graduated in sixteenths of the inch, then the slide will be shifted $\frac{1}{16}$ (or one such length unit) if the multiplicand is 1, $\frac{2}{16}$ (or two such length units) if the multiplicand is 2 and so on.

In the case of "arithmetical" spacing, however, the slide member Y must carry some ninety graduations in effect corresponding to every product in the multiplication table from $1\times0=0$ to $9\times9=81$. Consequently, in the mechanical embodiment it would be necessary to employ a corresponding ninety elements or mechanisms for converting such products into proportionate mechanical motion. This is not a very serious problem and in fact one of the specific embodiments hereinafter described employs such "arithmetical" spacing.

We have found, however, that in addition to the simple arithmetical system of spacing illustrated schematically in Figs. 1*a*, 1*b* and 1*c*, it is possible, and for some purposes even advantageous, to employ as a basis for the spacing, other systems of mathematical functions which follow the law.

$$f(x)+f(y)=f(xy)$$

That is to say any system of functions in which the sum of the functions of any two selected numbers is equal to the function of the product of such numbers. A familiar example of this type of mathematical system is the system of logarithmic functions.

As an example of the employment of such systems of mathematical functions as a basis for the spacing, it is, therefore, possible to employ "logarithmic" spacing of which the ordinary "slide rule" provides a familiar illustration. Such logarithmic spacing makes it possible to avoid recurrence of products at several different positions on the slide. In the case of the slide member Y above discussed, for instance, the product 24 occurs at four different positions, i. e. in the "3" series, the "4" series, the "6" series, and the "8" series, because 3, 4, 6, and 8 are all factors of 24. Actually, as will presently be more fully discussed, in the entire multiplication table from 1×1 to 9×9 there are only thirty-six different products. By employing logarithmic spacing it is necessary that each of these thirty-six products occur only once on the slide member.

In the light of this discussion of general principles, we shall now describe, as the first and preferred embodiment of our invention, a calculating machine involving these principles and employing the logarithmic system of spacing. Thereafter, as a second or modified embodiment we shall describe the employment of "arithmetical" spacing.

The calculator

The preferred form of calculating machine embodying our invention, comprises a computing mechanism A mounted within an outer rectilinear housing 1 formed of sheet metal or other suitable material and cut away along its top and

side walls adjacent its rear end in the provision of an opening 2 for accommodating a transversely shiftable totalizer B also having an elongated open-bottomed shell 3 constructed preferably of sheet-metal and including an arcuate top wall 4 closed at its ends by side walls 5 and interiorly subdivided transversely into a series of compartments *c* by uniformly spaced partitions 5', each compartment *c* being provided with a forwardly presented rectangular aperture or window 4' formed in the top wall 4. In its front face, the totalizer shell 3 is provided with an elongated horizontal slot 2' for receiving the carrier bar resetting mechanism, which will presently be more fully described and which is mounted in the housing 1 extending partially into an upwardly enlarged deformation or offset 6 formed in the upper wall of the housing 1.

Suitably fixed within the housing 1, is a main frame 7 preferably formed as an integral casting and having suitable upper and lower horizontal bed-plates 7^a, 7^b, and cross-members 7^c in which the various moving parts of the machine are journaled or slidably mounted as may be expedient from the viewpoint of production, convenience, and economy. For simplicity in illustration and description, however, these features, being largely a matter of conventional design, have been shown more or less schematically.

Multiplier key bank

Journaled horizontally in the frame 7 and extending lengthwise of the housing 1 along the right-hand side thereof as an operator faces the machine looking toward the totalizer B, is a rotary shaft 8 provided with ten identical externally toothed barrel gears 9^a, 9^b, 9^c, 9^d, 9^e, 9^f, 9^g, 9^h, 9^i, 9^j. Each of these gears 9 is provided with a segmental slot 10 for receiving a narrow finger 11 fixed to and projecting radially from the shaft 8, the slots 10 being shaped and sized in relation to the fingers 11, so that rotation of any one of the barrel gears 9 will be transmitted, through its associated finger 11, to produce rocking movement of the shaft 8, but will not affect any of the other barrel gears 9.

Shiftably and rotatably mounted in the frame 7 and projecting through the top wall of the housing 1, are ten vertical key-plungers 12^a to 12^j, inclusive, each being of rectangular cross-section and slidably fitted with an external gear collar 13^a to 13^j, inclusive. At their upper ends, the key-plungers 12 are provided with conventional key-buttons 14^a to 14^j respectively provided on their upper faces with numerals ranging from "1" through "9" and including a cipher or zero designating "0" and constituting a bank of so-called "multiplier" keys. At their lower ends, the plungers 12 are provided with cylindrical rack portions 15^a to 15^j, inclusive, each having a flattened or ground-off side face 16 so arranged that, when the flat side face 16 is presented toward the adjacent barrel gear 9, vertical movement of the plunger 12 will not rotate the barrel gear 9. On the other hand, when the plunger 12 is rotated 180°, the cylindrical rack portion 15 will engage the barrel gear 9. Projecting downwardly from the lower end of the rack portions 15, are elongated guide rods 17 shiftably and rotatably mounted in the lower portion of the frame 7, and disposed encirclingly about each of the guide rods 17, is a compression spring 17' abuttingly engaged at its opposite ends between the upper frame of the lower frame

plate 7b and the under face of the plunger rack portion 15, as best seen in Figure 19.

Similarly journaled horizontally in and extending between selected members 7c, is a plurality of like parallel shafts 18 substantially similar to the shafts 8 and each provided with nine endwise abutting gear barrels 19a to 19i, inclusive, having segmental slots 20 for receiving radial fingers 21 fixed on the shafts 18 in the same manner and for the same purpose as the fingers 11 on the shaft 8.

Primary key banks

Shiftably and rotatably mounted in the frame 7 and projecting upwardly through the upper wall of the housing 1. is a plurality of rows of key-plungers 22a to 22i, inclusive, provided at their upper ends with key-tops or buttons 23 having indicia ranging from "1" to "9," one such row being associated with each shaft 18 in the formation of a series of primary key banks. Although, as shown in Figures 1 and 2, the machine is equipped with seven such primary key banks for accommodating a seven digit number, it will, of course, be understood that a greater or smaller number of such banks may readily be employed.

Each of the key-plungers 22 is similar to the key-plungers 12 and includes a cylindrical rack portion 24 having a flat side face 25 and a downwardly extending guide rod 26 provided with a coiled compression spring 27, and slidably mounted on each key-plunger 22 and rotatably secured in the frame 7, are gear-collars 28. As above pointed out in connection with the plungers 12, the plungers 22 are likewise rotatable about a vertical axis through 180° to bring the rack portions 24 into or out of meshing engagement with the barrel gears 19.

Slidably mounted in the upper frame plate 7a, is a plurality of horizontal key-inverting rack bars 29, one for each primary key bank and one for the multiplier key bank, each being positioned for meshing engagement with the entire series of gear collars 28 in the key bank with which it is associated. Each of the rack bars 29 is provided at its forward end with a depending horizontal rack section 30 meshing with an inverting pinion 31 keyed upon a cross-shaft 32, which is, in turn, journaled at its ends in and extends horizontally across the frame 7 from left to right, being provided at its right end with a radial handle 33, which, in turn, projects upwardly through a slot 34 in the top wall of the housing 1, and adjacent the front and rear ends, respectively, of the slot 34 the upper face of the housing 1 is marked with the indicia "Add" and "Mult.," thus designating that, when the handle 33 is in one or the other of its positions, the machine will add or multiply, as the case may be. In this connection, it should be noted that, when the handle 33 is in "Add" position, the rack portions 15 of the multiplier plungers 12 are disengaged from their associated barrel gears 9, whereas the rack portions 24 of the primary key-plungers 22 are engaged with their associated barrel gears 19. On the other hand, when the handle 33 is in "Mult." position, the reverse is true, that is to say, the rack portions 15 of the plungers 12 are engaged and the rack portions 24 of the plungers 22 are disengaged.

Shiftably mounted in vertical ways 35 formed in and projecting laterally from the frame members 7c, are vertical slide bars 36a, 36b, 36c, 36d, 36f, and 36i, each provided with a laterally projecting rack section 37 and positioned for meshing

engagement with the lower ends of the plunger rack sections 24a, 24b, 24c, 24d, 24f, 24i, respectively. Because of space requirements and to achieve greater compactness, the key-plungers 22e, 22g, and 22h are provided with auxiliary rack sections 38 positioned below their principal rack sections 24 and likewise having a flattened side 39, the latter being disposed at 180° with respect to the flattened portions 25 of the principal rack portions 24. Shiftably mounted in ways 40 formed in and projecting laterally from suitably adjacent frame members 7c, are vertical slide bars 36e, 36g, and 36h having laterally projecting rack sections 37' for meshing engagement with the auxiliary rack portions 24e, 24g, and 24h, respectively. Thus it will be seen that, when the handle 33 is in "Add" position, all of the slide bars 36 are disengaged, whereas when the handle 33 is in "Mult." position and the plungers 22 are turned 180°, the slide bars 36 are engaged, so that downward movement of any key 23 will produce corresponding downward movement of its associated slide bar 36.

Each of the slide bars 36 is further provided at its lower end with a depending guide rod 41 extending slidably through the lower frame plate 7b, and fixed upon the lower end of each such rod 41 beneath the frame plate 7b, is a block 42 having a depending stop finger 43 and forwardly projecting detent lug 44. Disposed encirclingly about each rod 41 and abuttingly engaged at its opposite ends between the upper face of the frame plate 7b and the under face of the slide bar 36, is a compression spring 45 for normally urging the bar 36 and rod 41 upwardly, such upward movement being limited by abutment of the upper face of the block 42 against the under face of the frame plate 7b. In the downward direction, movement of the bar 36 is limited by small laterally projecting lugs 45' formed on the bar 36 adjacent its upper end and positioned for abutment with the upper end faces of the ways 35, all as best seen in Figures 19 and 20.

Slidably mounted in suitable slots 46 formed in and extending transversely through the member 7c, is a plurality of spaced horizontal cross-connecting racks 47a to 47i, inclusive, extending from right to left across the machine and provided at their right ends with depending toothed sections 48 for meshing engagement with the barrel gears 9a to 9i, respectively, and to the left of the sections 48, the racks 47a to 47i, inclusive, are provided with a plurality of depending toothed sections 49 separated by blank sections 50, the latter being normally positioned above the barrel gears 19. In this connection, it should be noted that when the machine is set for addition and the rack sections 15 of the key-plungers 12 are disengaged from the barrel gears 9, the cross-connecting racks 47 are inactive and do not engage or otherwise affect movement of the barrel gears 19. However, when the machine is set for multiplication and the barrel gears 9 are engaged, manual depression of one of the key-plungers 12 will rotate its associated barrel gear 9, shifting the associated cross-connecting rack 47 to the left, bringing the toothed sections 49 into engagement with all of the barrel gears 19 which are in transverse alignment with the rotating barrel gear 9.

Adjacent to each key-plunger 22 and on either side thereof, the frame members 7c are provided with opposed vertical ways 51a to 51i, inclusive, and beneath each of the pairs of ways 51 the lower frame plate 7b is provided with a rectan-

gular slot 52 cooperating with the ways 51 in slidably supporting stop plates 53a to 53i, inclusive, spatially arranged as best seen in Figures 5 and 9 and in a manner presently more fully explained.

At their lower ends, the stop-plates 53a to 53i, inclusive, project below the lower frame plate 7b and are provided with arcuately shaped tongues 54 having oppositely presented vertical abutment faces 55, and at their upper end the stop-plates 53a to 53i are provided with narrow upstanding extensions 56 having laterally presented rack-forming teeth 57 for meshing engagement with the barrel gears 19a to 19i, respectively. Intermediate their ends and above the lower frame plate 7b the feelers are provided with vertical slots 58 having centrally disposed guide rods 59 extending downwardly from the upper transverse margin thereof for stabilizing compression springs 60 seated within the slots 58 in endwise abutment at their upper ends against the upper transverse margin of the slots 58 and at their lower ends against spring-retaining washers 61 set within the slots 58 and bridging the slots 52 in the lower frame plate 7b.

The first slide bar 36a in each key bank is further provided with an upstanding guide pin 62, and slidably mounted thereon in endwise abutting vertical alignment with the slide bar 36a, is an auxiliary slide bar 63 having a forwardly presented toothed or rack-forming face 64 meshing with the inverting pinion 31, all as best seen in Figure 28.

Computing slide and barrel mechanism

Slidably mounted in suitable horizontal ways 65 beneath each bank of primary keys, is a computing slide 66 provided centrally of its upper face 67 with a longitudinal groove 68 having a transverse cross-sectional shape for receiving the lower end and tongue portion of the stop-plates 53. At the bottom and on either side of the groove 68, the slide 66 is provided with two longitudinal bores 69 opening sidewise into the groove 68 for receiving two elongated cylindrical computing barrels 70, 70', of smaller diametral size than the bores 69 and having diametrally reduced concentric end portions 71 journaled in suitable apertures 72 in end plates 73 secured by means of screws 74 upon, and extending across the transverse ends of, the computing slides 66, thus holding the computing barrels 70 within the slide 66 for lengthwise movement therewith and axial rotation therein, and extending axially through each computing barrel 70 and projecting therefrom, is a square shaft 75, which is, in turn, rotatably and non-shiftably held in the frame 7.

Intermediate their ends, the computing barrels 70, 70', are provided with an axially spaced series of segmental upstanding shoulders or arcuate stops 76, 76'. Each of the stops 76 is transversely paired with a corresponding stop 76'.

Broadly speaking, the arcuate length of the several stops 76, 76', measured from common axial base lines theoretically indicated by dotted lines *l*, *l'*, on the outer cylindrical faces of the barrels 70, 70', in some selected length units is such that every possible product of two numbers from "1" to "9" is represented.

Since "eleven" is a prime number and does not result from multiplication of any two numbers from "one" to "nine," it does not appear in the series of products, and this is likewise true of all prime numbers from "one" to "eighty-one," as well as all intermediate products resulting from multiplication of any prime number over eleven

by any other number in this entire number series, the resulting series of products thus consisting of thirty-six numbers, as follows: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 15, 16, 18, 20, 21, 24, 25, 27, 28, 30, 32, 35, 36, 40, 42, 45, 48, 49, 54, 56, 63, 64, 72, 81. It will be noted that only the first nine products in the series are single digit numbers and, furthermore, it will be apparent to anyone familiar with calculating machines that as to all other products (i. e. products which are two-digit numbers) the "tens" digit must be accumulated in the totalizer of the next higher order, as will presently be more fully discussed. For these reasons, we employ two co-operating or paired barrels 70, 70', which may, for convenience, be respectively referred to as the "units" barrel and the "tens" barrel, as shown in Figs. 6*a* and 6*b*. Each pair of arcuate stops 76, 76', corresponds to one of the products in the above series. By reference to Fig. 6*a*, it will be seen that every one of the stops 76, 76' have a length measured from line *l*, *l*, and *l'*, *l'*, respectively, so that the end or abutment face thereof lies along one of ten uniformly spaced parallel coordinates 0—0, 1—1, 2—2, 3—3, 4—4, 5—5, 6—6, 7—7, 8—8, 9—9. For instance, the first stop 76 (reading from left to right on Fig. 6*a*) has its end or abutment face along the 1—1 coordinate of the "units" barrel 70, while its companion stop 76', lying directly opposite on the tens" barrel 70', has its end or abutment face along the 0—0 of the "tens" barrel 70'. It should further be stated in this connection that the 0—0 (or "zero") coordinates of barrels 70, 70', respectively, lie in the same vertical planes as the oppositely presented abutment faces 55, 55', of the stop-plates 53, as may be seen in Fig. 6*c*. Consequently, if a selected stop-plate 53 is operatively interposed between the barrels 70, 70', in line with the first pair of arcuate stops 76, 76', it will be apparent that the "units" barrel can be rotated (counterclockwise as indicated by the arrow in Fig. 6*d*) until the end or abutment face of the stop 76 engages the stop-plate abutment face 55'. The "tens" barrel 70', however, cannot be rotated at all since its arcuate stop 76' is already in abutment against the stop-plate abutment face 55. Hence, the "units" barrel will move 1 unit and the "tens" barrel no units or zero, thus producing an amount of mechanical motion proportionate to the product 1. Similarly, if the eighteenth pair of stops 76, 76' (for purposes of the present discussion designated *x*, *x'*, in Figs. 6*a* and 6*d*), are considered, it will be seen that the stop *x* on the "units" barrel ends at the 4—4 coordinate and the stop *x'* on the "tens" barrel ends at the 2—2 coordinate. Thus, if a selected stop-plate 53 is interposed between the barrels 70, 70', in line with this eighteenth pair of stops *x*, *x'*, as shown in Fig. 6*d*, the "tens" barrel 70' can rotate through the arcuate distance corresponding to "2" while the "units" barrel 70 can rotate through the arcuate distance corresponding to "4," thus making 24 which is the eighteenth product in the above series of products.

It will thus be evident that the first 9 pairs of stops 76, 76' (reading from right to left in Fig. 6*a*), correspond to the first 9 products in the above series of products and accordingly the units stop 76 of each such pair have decreasing lengths, so that their end faces respectively lie on the coordinates from units 1—1 to 9—9, while the corresponding "tens" stops all have full arcuate length so that their end faces lie on the 0—0 coordinate, thus, in effect, yielding the numbers "01" to "09." The tenth pair of stops 76, 76' however,

consists of a "tens" stop, the end face of which lies on the 1—1 coordinate of the "tens" barrel 70' and a "units" stop, the end face of which lies on the 0—0 coordinate of the "units" barrel 70, permitting the "tens" barrel to rotate an arcuate distance corresponding to "1" while the "units" barrel does not rotate at all, thus yielding the number "10." The eleventh pair of stops 76, 76', are of such arcuate length as to permit the "tens" barrel 70' to rotate one length unit and the "units" barrel 70 to rotate two length units, yielding the number "12," and so on through the series of thirty-six products, the last pair of stops 76, 76', being of such length as to permit the "tens" barrel 70' to rotate eight length units and the "units" barrel 70 to rotate one length unit, yielding the number "81."

The upper horizontal faces 67 of each of the carrier bars 66 is milled out or recessed to provide a series of narrow vertical stop faces 77^a to 77^i, inclusive, the faces 77^a, 77^b, 77^c, 77^d, 77^f, and 77^i being on the left side of the groove 68 and the faces 77^e, 77^g, and 77^h being on the right side of the groove 68 for the same reasons of compactness as applied to the location of the several slide bars 36a to 36^i, inclusive. The stop faces 77^a to 77^i, furthermore, are spaced longitudinally from each other along the carrier bar 66 by distances determined mathematically, as will presently be more fully discussed, and are staggered transversely across the width of the carrier bar 66 for respective engagement with the stop fingers 43 associated with the slide bars 36, that is to say, the face 77^a will engage only the stop finger 43 of the slide bar 36^a, the face 77^b will engage only the stop finger 43 of the slide bar 36^b, and so on, assuming, of course, proper manipulation of the machine for shifting such stop finger down into position for such engagement as will presently more fully appear.

Journaled in and extending horizontally between auxiliary frame members 7^d, parallel to and on opposite sides of each carrier bar 66, are two paired shafts 78, 78', each rigidly provided on its forward end with stop dogs 79, 79', normally urged downwardly and inwardly by springs 80 for engagement against the end face of the carrier bar 66, as shown in Figure 29, and having toothed segments 81 meshing with idler gears 81' for causing the dogs 79, 79', and their associated shafts 78, 78', to rock simultaneously. Fixed upon the shafts 78, 78', in respective lateral alignment with the detent lugs 44, are L-shaped latch members 82 normally disposed in the position shown in dotted lines in Figures 18 and 19 and each having an inwardly projecting leg 83 interposed beneath the detent lug 44 and an upwardly extending leg 83' adapted, upon rocking movement, to clear the lug 44.

Secured upon the forward end face of each carrier bar 66, is a ribbon 84 which extends horizontally forwardly and around a suitably journaled idler roller 85 and is fastened at its other end to a conventional coil-spring winding drum 86 of the type commonly employed in actuating typewriter carriages and the like. Similarly secured to the rear end face of each carrier bar 66, is a rewind ribbon 87 which extends horizontally rearwardly over a suitably journaled idler roller 88 and is fastened at its other end to a rewind drum 89 rotatably mounted on a shaft 90 and provided on its side face with a spring-pressed pawl 89' positioned for engagement with a single toothed ratchet 91 also journaled on the shaft 90 and carrying a gear 91' diametrally larger than the drum 89 and meshing with a rewind drive pinion 92, which is, in turn, fixed upon a shaft 93, as best seen in Figure 21.

Keyed upon the forward end of each shaft 18, is a control pinion 94 meshing with a vertically shiftable control rack 95 provided at its lower end with a horizontal arm 96 which extends beneath the pinion 94. Fixed in and extending downwardly from the arm 96, is a vertical guide pin 97 shiftably supported in a cross-bar 7^e forming part of the machine frame 7. On its lower end, the pin 97 is rigidly provided with an enlarged end-block 98 having a depending and rearwardly offset pawl-like finger 99 provided with oblique under and side faces 100, 101, for engagement, when shifted downwardly, with a ratchet ring 102 toothed around its inner periphery for meshing engagement with three identical planetary gears 103 respectively mounted for free rotation upon three horizontal pintles 104 symmetrically mounted in and projecting from the forward face of a driven wheel 105 somewhat larger in diametral size than the ratchet ring 102 and fixed upon a suitably journaled horizontal jack shaft 106. Around its periphery, the driven wheel 105 is provided with a forwardly projecting concentric flange 107 having a circumferential gap 108 and chamfered on its inner face complementarily with the side face 101 of the pawl-like finger 99.

Also suitably journaled in the frame 7 in axial alignment with each jack shaft 106, is a short drive shaft 109 provided on its rear end with a pinion 110 disposed within and meshing with the planetary gears 103, and on its forward end the shaft 109 is provided with a driving pinion 111.

In this connection, it will be noted that, for reasons of compactness, every other carrier bar 66 and its associated mechanism is positioned below the other carrier bars 66 and the drive pinions 111 thereof are also below the other pinions 111, all being connected by intermediate idler gears 112 in the formation of a gear train extending transversely across the front of the machine frame 7 and drivingly meshing with a main drive gear 113 pinned on the shaft 114 of an electric motor 115, the latter being conventionally connected to any suitable source of electric current by the usual flexible cord (not shown).

Fixed upon the rear end of each jack shaft 106, is a pinion 116 meshing with a vertically shiftable rack slide 117 normally urged upwardly by a compression spring 118 disposed encirclingly about a stabilizing pin 119 carried by and projecting downwardly from the rack slide 117. At its upper end, each slide 117 is integrally provided with a rearwardly projecting horizontal arm 120 provided with a pair of spaced shiftable pins 121 and 121' extending vertically downwardly and fixed at their lower ends in slide racks 122 and 122' having inwardly presented toothed faces 123 and 123' for meshing engagement with pinions 124 and 124' respectively mounted drivingly on the computing barrel shafts 75 and 75'. Disposed encirclingly about each of the pins 121 and 121' in endwise abutment between the upper face of the slide rack 122 and 122' and the under face of the arm 120, are compression springs 125 for normally urging the slide racks 122 and 122' downwardly with respect to the arm 120, such downward movement being limited by cotter pins 126 inserted through the upwardly projecting end of the pins 121 and 121' and bearing against the upper face of the arm 120.

When any one of the shafts 18 is rotated as a result of rocking movement of the fingers 21, the

pinion 94 will rotate, shifting the control rack 95 downwardly and causing the pawl-like finger 99 to engage and hold the ratchet ring 102. As soon as the ratchet ring 102 is held stationary, the planetary gears 103 cease to act as idlers and instead transmit rotary motion from the shaft 109 to the wheel 105, moving the wheel flange 107 into engagement with the oblique side face 101 of the pawl-like finger 99 and holding the latter in engagement with the ratchet ring 102 for that part of one revolution as determined by the gap 108 in the formation of a partial-revolution clutch *s*.

Rotation of the jack shaft 106 depresses the rack slide 117 and, through the springs 125, moves the slide racks 122 and 122' downwardly, rotating the pinions 124 and 124' and their associated shafts 75 and 75'. It will be evident that the rotation of the shafts 75 and 75' will rotate the computing barrels 70, 70', until the latter are stopped by impinging against any one of the stop-plate tongue abutment faces 55 which may be interposed as a result of key manipulation, arresting downward movement of the slide racks 122, the remainder of the downward movement of the rack slide 117 being absorbed in the springs 125. When the drive wheel 105 completes its predetermined part revolution, the pawl-like finger 99 is released from the wheel flange 107 through the gap 108, freeing the ratchet ring 102 and disconnecting the driven wheel 105 from the drive shaft 109, and thereupon, under influence of the springs 118, the rack slides 117 and all associated mechanism, including the computing barrels 70, 70', are returned to initial position.

The several spatial relationships lengthwise of the computing mechanism A between the vertical ways 51^a to 51^i, inclusive, and the associated stop plates 53^a to 53^i, inclusive, the arcuate stops 76, 76', on the computing barrels 70, 70', the stop faces 77^a to 77^i, inclusive, on the carrier bar 66 and the depending stop fingers 43^a to 43^i, inclusive, of the blocks 42 are mathematically determined as outlined below:

Let $f(\alpha)$ be a mathematical function obeying the law: $f(a)+f(b)=f(a\cdot b)$ where a and b are any arbitrarily selected numbers.

Let m be an arbitrarily selected unit of length.

Then the position of any particular vertical way 51 and associated stop plate 53 with respect to an arbitrarily chosen point in the machine is determined by the equation

$$s=mf(a)$$

where s is the distance rearward from the arbitrarily chosen point and a is that integer indicated on the particular key 12' with which the particular stop plate 53 is transversely aligned and to which it is connected by the respective rack 47 when the machine is set for multiplication and the plunger 12 is depressed.

The position of any arcuate stop 76, 76', on the computing barrels 70, 70', with respect to each other and an arbitrary point on the barrels 70, 70', is determined by the equation

$$s'=mf(c)$$

where s' is the distance rearward from the arbitrary point on the barrels 70, 70', of any particular pair of stops and c is any number which is one of the thirty-six products listed above.

The position of any stop face 77^a to 77^i, inclusive, on the top of the carrier bar 66 with respect to the rearward face of its respective depending stop finger 43^a to 43^i, inclusive, and the position of the arcuate stops 76, 76', with relation to the stop faces 77^a to 77^i, inclusive, is arranged so that, when the rear face of the stop finger 43^a is in contact with the stop 77^a, the first pair of arcuate stops 76, 76', will be in position to engage the abutment faces 55 of the tongue 54 of the stop-plate 53^a when it is shifted down into the slide groove 68. In like manner, when the rear face of the stop finger 43^b is in contact with the stop 77^b, the second pair of arcuate stops 76, 76', will be in position to be stopped by the stop plate 53^a. In like manner, for each of the other combinations, until the rear face of the stop finger 43^i is in contact with the stop 77^i, the ninth pair of arcuate stops will be in position to engage the stop plate 53^a. If this is done, it is evident that the carrier bar 66 will move forward according to the equation

$$s'=mf(b)$$

where s'' is the distance the carrier bar 66 moves forward with respect to the stop plate 53^a from its position during the process of addition.

Thus it is seen that, in the process of multiplication, the depression of any key 22 permits the carrier plate to move forward a distance past its position when the machine is set for addition of

$$s=m\cdot f(b)$$

where b is the indicated numeral on the particular key 22 and that, when any key 12' is depressed, the positions of all stop plates 53 actuated thereby is at a location rearward of the stop plate 53^a of

$$s'=m\cdot f(a)$$

where a is the indicated numeral on the particular key 12' and that this automatically brings into position a pair of arcuate stops 76, 76', so that the distance from the arbitrary point is

$$s+s'=s'' \text{ or } m\cdot f(a)+m\cdot f(b)=m\cdot f(c)=m\cdot f(ab)$$

For the particular machine shown in Figures 1 to 20, inclusive, $f(\alpha)$ is the logarithm of (α) or log (α). The vertical ways 51 are spaced with respect to the way 51^a in accordance with the law

$$s=m\cdot\log\ a$$

where s is the distance rearward of the way 51^a, m is an arbitrary unit of length, and a is the digit identifying the particular key 12'. Thus for the ways 51^b to 51^i, inclusive, a is 2, 3, 4, 5, 6, 7, 8, and 9, respectively. The arcuate stops 76, 76', on the computing barrels 70, 70', are spaced with respect to the first pair of stops in accordance with the law

$$s'=m\ \log\ c$$

where s' is the distance of any pair of arcuate stops 76, 76', rearward of the first pair of stops and c is the numerical value of any one of the thirty-six products listed above.

The stop faces 77^a to 77^i, inclusive, are arranged exactly as described above, that is to say by logarithmic spacing so that the distance moved forward by the carrier bar 66 when any particular key 22 is depressed is

$$s''=m\ \log\ b+k$$

where s'' is the actual distance moved forward from zero position, b is the digit identifying the particular key 22 depressed, and k is the arbitrary distance that the carrier bar 66 moves forward when the key 22^a (identified by the digit 1) is depressed, since the value of log 1=0.

Thus it will be seen that the machine obeys the law

$s+s'=s''$ or $m \log a+m \log b=m \log c=m \log a \cdot b$

For example if the key 22e is depressed the carrier bar 66 will be shifted forwardly so that the stop 77e will come into abutment with the appropriate one of the latch members 82 and the fifth pair of arcuate stops 76, 76' will be aligned with the feeler 53a, as shown in Fig. 6b. This operation in effect "conditions" the machine for the multiplication of "5" by any other integer. Since the nine products or multiples of 5 are 5, 10, 15, 20, 25, 30, 35, 40, and 45 it will be found that the tenth pair of arcuate stops 76, 76' corresponding to the product "10" will be aligned with the feeler 53b associated with the "2" multiplier key 14b; the thirteenth pair of arcuate stops 76, 76' corresponding to the product 15 will be aligned with the feeler 53c associated with the "3" multiplier key, and so on.

Totalizer

Rigidly mounted in the machine housing 1 in downwardly spaced alignment with the forward transverse margin of the opening 2, is a horizontal track bar or rail 127 provided on its upper face with a longitudinal milled channel 128 for receiving traversing rollers 129 mounted on horizontal pintles 130, which are, in turn, fixed in brackets 131 welded or otherwise suitably secured upon the inner front-wall face of the housing 3 of the totalizer B. Similarly mounted rigidly on and extending along the rear transverse margin of the opening 2, is a second track bar or rail 132 also provided in its upper face with a longitudinal milled channel 133 for receiving traversing rollers 134 rotatably mounted on pins 135 set into the rear vertical face 136 of an indexing carriage 137 which is firmly secured within and extends horizontally across the rear of the totalizer housing 3.

On its under face, the carriage 137 is provided with a depending stop-lug 138 having a rear inclined face 139, which extends a short distance to the right lengthwise of the carriage 137 and is curved forwardly in a camwise manner, as best seen in Figure 24, and also secured upon the under face of the carriage 137, is a flexible ribbon 140 extending horizontally across the machine over an idler roller 141 and thence downwardly, as shown in dotted lines in Figure 21, being trained around and secured to a coil-spring actuated winding drum 142 rotatably mounted in the lower part of the machine housing 1.

Slidably extending through the carriage 137 and journaled at its ends in the side walls of the totalizer housing 3, is a hexagonal shaft 143 provided at its one end with a sliding drive pinion 144 mounted rotatably, but non-shiftably, in the framework of the computing mechanism A and meshing with an intermediate drive gear 145 connected for unidirectional rotation by means of a pawl 146 and ratchet 147 to a pinion 148 meshing with a double-faced vertically shiftable rack 149 having a depending guide pin 150 around which is disposed a compression spring 151 for normally urging the rack 149 upwardly. Also drivingly meshing with the rack 149, is a pinion 152 fixed upon the end of a forwardly extending horizontal shaft 153, which is, in turn, provided at its other end with a similar pinion 154 meshing with a vertical slide rack 155 having an upstanding guide pin 156 slidably mounted in a horizontal arm 157 integrally formed with a vertically shiftable driving rack 158 and provided with a compression spring 159 disposed encirclingly thereon for endwise abutment between the upper face of the slide rack 155 and the under face of the arm 157. The driving rack 158 is further provided with a depending guide pin 160 having a compression spring 161 for normally urging the rack 158 upwardly, and the rack 158 is connected by means of a pinion 162, jack shaft 163, and part revolution clutch s' to the driving gear shaft 164 and driving gear 165 substantially in the manner previously described in connection with the computing barrel driving clutch s. The clutch s' is provided with a ratchet ring 102' adapted for engagement with a pawl-like finger 99' carried by a control rack 95', which, in turn, meshes with a pinion 166 keyed or otherwise suitably fixed on the forward end of the shaft 8.

Slidably mounted on the shaft 143 and secured rotatively against the transverse end face of the carriage 137 for translative movement therewith by means of a retainer bracket 167, is a carriage release cam 168 having an indentation 169 and abutment 170 for engaging any one of a plurality of uniformly spaced stops 171 rockably mounted on a shaft 172 fixed at its ends in the framework of the computing machine A. Each of the stops 171 is provided at its upper end with a horizontal roller 171' for facilitating sliding movement across the cam-like face 139 and at its lower end with a flat normally horizontal face for stopwise abutment against a stop-bar 172', the stops 171 being normally urged forwardly against the stop-bar 172' by means of a hair-spring 173.

It should be noted in this connection that the cam 168 is so shaped that one of the stops 171 will be interposed abuttingly against the lateral end face of the carriage stop-lug 138 and, when rotated by rotation of the shaft 143, will rock the stop 171 rearwardly, permitting the carriage 137 and the entire totalizer B supported thereby to be shifted sidewardly into engagement with the next succeeding stop 171. As the carriage 137 moves, the shifted stop 171 slides against the face 139 and is restored to upright position. When the carriage 137 is returned to initial position, the stops 171 are successively shifted out of the path of the carriage 137 by the cam-like face 139. There are as many stops 171 as there are compartments c in the totalizer B and they are so spaced as to align the compartments c with the primary key banks, as best seen in Figure 3 and for purposes presently more fully appearing.

Mounted at their ends in and extending horizontally between the side walls 5 and through the partitions 5' of the totalizer shell 3, is a plurality of horizontal shafts 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, and 184 arranged in suitably spaced and staggered relationship, as shown in Figure 21, for supporting the various gears and wheels of the totalizer B, as will presently more fully appear. The shafts 174, 175, 176, 177, 178, 179, 181, 182, and 184 are stationary, while the shaft 180 is rotatable and the shaft 183 is both rotatable and longitudinally shiftable.

Mounted for free rotation on the shaft 179 midway between the partitions in each totalizer compartment c, is an accumulator gear 185 rigidly provided on its left and right side faces, respectively, with spring-pressed pawls 186, 186', the pawl 186 being, for clarity, designated the "primary" pawl and the pawl 186' being similarly designated the "secondary" pawl.

Also mounted for free rotation on the shaft

179 on the left side of the gear 185, is a gear 187 provided on its side face with a single tooth gear 188, which is, in turn, provided on its side face with a concentric ratchet 189 engaging and driving the primary pawl 186 when rotated in a counter-clockwise direction and passing the pawl 186 when rotated in a clockwise direction (reference being made to Figure 21). Similarly mounted on the shaft 179 on the right side of the gear 185, is a similar gear 190 provided on its side face with a single tooth gear 191, which is, in turn, provided on its side face with a ratchet 192 for engaging and driving the secondary pawl 186' when rotated in a counter-clockwise direction and passing the pawl 186' when rotated in a clockwise direction. Similarly mounted for free rotation on the shaft 175 for respective meshing engagement with the gears 187 and 190, are segmental gears 193, 194, each having a reduced peripheral toothed hub portion 195 for meshing engagement, respectively, with intermediate driving gears 196, 197, which are, in turn, mounted for free rotation on the shaft 174.

Mounted for vertically shiftable movement in the framework 7 of the computing mechanism A, is a plurality of spaced parallel pairs of double racks 198, 199, provided at their upper ends with forwardly presented toothed faces 200, 201, and at their lower ends with laterally presented toothed faces 202, 203, for respective meshing engagement with pinions 204, 205, which are, in turn, fixed upon the rearwardly extending ends of the computing barrel shafts 75, the pinion 205 being fixed upon the shaft 75 extending through the "tens" computing barrel 70 of one carrier bar 66, and the pinion 204 being fixed on the shaft 75 extending through the "units" computing barrel 70' of the next carrier bar 66 to the left, that is to say, the carrier bar 66 associated with the next higher bank of primary keys.

Also mounted in and extending transversely across the frame 7 of the computing mechanism A beneath the intermediate driving gears 196, 197, is a horizontal bar 206 provided with a plurality of upwardly and rearwardly projecting spring-pressed slide tongues 207 feathered at their outer edges for slidably engaging the teeth of the respective gears 196, 197, for insuring that the latter will always come to rest in position for precise sliding enmeshment with the rack faces 200, 201, as the carriage slides from right to left and left to right. The double racks, furthermore, are positioned in relation to the totalizer carriage stops 171 and the computing barrel carrier bars 66, so that, as the totalizer comes to rest against any one of the stops 171, the gears 196, 197, will respectively slide into meshing engagement with the rack faces 200, 201, of any one of the pairs of double racks 198, 199.

During the process of addition, as has been above pointed out, only the "units" computing barrels 70 will be rotated, therefore, only the associated or so-called "units" rack 198 will be moved, rotating the intermediate driving gear 174 and rocking the segmental gear 194, so that, as the double rack 198 moves up the gear 194 swings up and as the double rack 198 moves down to initial position the gear 194 likewise swings down to initial position. As the gear 194 moves up, the meshing gear 187 is rotated by an amount proportional to the movement of the rack 198 and returned to initial position, and, through the unidirectional drive of the primary pawl 186, the accumulator gear 185 is proportionately advanced, thus accumulating the numerical value computed by the "units" computing barrel 70.

During multiplication, however, in addition to the above described operation for introducing numerical values into the accumulator gear 185 from the particular "units" computing barrel 70, the "tens" rack 199, which is actuated by the computing barrel 70' of the next preceding key bank on the right, moves up and down simultaneously with the double rack 198, although it may move a different distance. Such movement of the rack 199 rotates the intermediate driving gear 197 and rocks the segmental gear 194 up and down, driving the gear 190 and ratchet 192 clockwise proportionately to the rotation of the computing barrel 70'. Since, upon clockwise rotation, the ratchet 192 passes the secondary pawl 186', such rotary movement is not transferred to the accumulator gear 185, the latter being moved solely by the contemporaneous rotation of the ratchet 189, which, upon clockwise rotation, engages the primary pawl 186.

All of the computing barrels 70, 70', are simultaneously rotated from a single main driving source, that is to say, the motor 115, through identical part revolution clutches *s*. Consequently, all of the computing barrels 70, 70', rotate and all of the double racks 198, 199, are lifted at one time. Although the amount of rotation of the computing barrels 70, 70', and the corresponding amount of upward movement of the double racks 198, 199, will vary, dependent upon the numbers which have been set into the machine by manipulation of the various keys, nevertheless they are all respectively held in rotated and lifted position until the clutches *s* have completed their part revolution and then are simultaneously released for return to initial position. It will thus be evident that the "units" values will be introduced into all of the accumulator gears 185 across the machine on the up stroke of the several double racks 198, 199, and thereafter the "tens" values will be transferred, so to speak, into the several accumulator gears 185, the "tens" digits from any pair of computing barrels 70, 70', being, of course, transferred to the accumulator gear 185 which has received the "units" value from the pair of computing barrels 70, 70', associated with the next higher bank of primary keys. This successive order of transference of "units" and "tens" values prevents accidental loss of numerical values.

Mounted for free rotation on the shaft 180 and disposed midway between the partition 5' in each compartment *c*, is a transmittal gear 208 meshing with the accumulator gear 185, and splined to the shaft 180 for rockable movement therewith adjacent each of the gears 208, is an L-shaped rock-plate 209 rotatably carrying a first auxiliary gear 210 meshing directly with the transmittal gear 208 and a second auxiliary gear 210' of identical size driven indirectly from the gear 208 through an idler gear 211 also rotatably mounted on and carried by the rock-plate 209. Also splined to the shaft 180 adjacent the inner face of the left side wall 5 of the totalizer housing 3, is an actuating plate 212 having a forwardly projecting lug 213 extending through a slot 214 in the totalizer housing top wall 4 and provided with a laterally extending pointer finger 215 for alignment with the position-designating indicia "Add" and "Sub." In its upwardly presented edge face 216, the plate 212 is provided with two spaced indentations 217, 218, for engagement with a spring

detent 218' suitably secured on the inner face of the totalizer housing wall 4.

Mounted freely on the shaft 183 in each totalizer compartment c for alternative meshing engagement with the auxiliary gears 210, 210', is an intermediate gear 219, which, in turn, drivingly meshes with a gear 220 mounted for free rotation on the shaft 184 and provided on its side face with a diametrally enlarged wheel 221 inscribed upon its peripheral face with ten equally spaced numerals from "0" to "9" and positioned in alignment with the window 4' of the particular totalizer compartment c in which it is located, the numerals being of such size that only one such numeral will be visible when the wheel 221 is stationary, and fixed on the inner face of the housing top wall 4 in each compartment, is a bent spring click 222 engaging the gear 220 for insuring that the latter will always come to rest with some numeral properly positioned in juxtaposition to the window 4'.

Decimal storage and tens carry mechanism

The decimal storage and tens carry mechanism can best be seen in Figures 11, 21, and 23.

Secured upon the side face of each gear 219, is a radially projecting arm 223 provided in its radially extending side faces with oppositely presented arcuate recesses 224, 224', having an arcuate end face provided with three teeth for meshing engagement with the downwardly presented toothed face 225 of a rearwardly and downwardly inclined rack 226 slidably mounted in a cross bar 227, which is, in turn, fixed at its ends to and extends horizontally between the side walls 5 of the totalizer housing 3. Centrally of its under face the bar 227 is provided with a longitudinal V-shaped slot 228 for accommodating a plurality of spaced V-springs 229, one for each rack 226, and adapted to project downwardly for engaging bosses 229' formed integrally on the rack 226, thereby normally holding the latter at a central or neutral position with reference to the bar 226. At its rear end, each rack 226 is provided with two short toothed sections 230, 230', spaced by an intermediate clearance gap 231. The radial arms 223 are so set in relation to the gears 219 and number wheels 221 that they will mesh with and move the rack bar 226 a short predetermined distance once during each revolution of the number wheel 221 as the numeral "0" passes the window 4', whether forwardly as in addition and multiplication or reversely as in subtraction.

Rotatably mounted on the shaft 182, is a plurality of decimal storage gears 232, one for each rack bar 226, and being sized for projection along a segment of its periphery within the gap 231, so that, upon either forward or rearward movement of the rack bar 226, the associated decimal storage gear 232 will accordingly be rotated forwardly or rearwardly. Operatively mounted on the side face of each decimal storage gear 232, is a spring-pressed pawl 233 for engagement with ratchet 234 of the ratchet barrel 237' rotatably mounted on the shaft 182. The ratchet barrel 237' consists of four parts, namely, a hexagonal hub 234' concentric with shaft 182 extending axially from the face of gear 232 across the remainder of its own totalizer compartment c and through a suitable concentric opening 238 in partition 5 into the next higher order totalizer compartment c to the face of gear 240; a toothed ratchet 234 mounted on hub 234' and concentric therewith; an arm 235 mounted on hub 234' and extending radially and rearwardly and held against a stop 235' by a hairpin storage spring 236; and a toothed ratchet barrel 237 mounted on hub 235 and concentric therewith, extending axially across the remainder of the width of its own totalizer compartment c and through a suitable concentric clearance aperture 238 in the partition 5 into the next higher totalizer compartment c to the left for engagement with a spring-pressed pawl 239 operatively mounted on the side face of a decimal storage transfer gear 240 rotatably mounted on the shaft 182 and meshing with the transmittal gear 208 of such next higher totalizer compartment.

Rockably mounted on the shaft 181 in each compartment c, is a pair of axially spaced spring-pressed pawl arms 241, 241', both engageable with the portion of the ratchet barrel 237 which projects through the partition aperture from the next lower compartment c on the right, each arm having forwardly projecting radial fingers 242, 242', respectively engaging raised bosses 243, 243', formed upon the upper faces of forwardly extending slide bars 244, 244', shiftably mounted in a horizontal slide bearing 245 fixed in the frame 7 of the computing mechanism A. At their forward ends, the bars 244, 244', are provided with depending teeth 246, 246', for engagement, respectively, with the single tooth gears 188, 191, associated with the accumulator gear 185 of that particular compartment c in such manner that the pawl arms 241 are lifted to permit movement of the ratchet barrel 237 only when the single tooth gears 188 and 191 are in neutral position. Consider now any compartment c in relation to the next higher-order compartment and assume that either or both gears 186 and 190 in the higher-order compartment are out of neutral position, so that either or both pawl arms 241 and 241' thereof will be in engagement with ratchet barrel 237 of the particular compartment c under consideration. Assume further that, due to clockwise rotation of gear 219 of compartment c, arm 223 thereof has actuated bar 226 thereof twice. As a result of such conditions, the following movements will occur:

On the first actuation, said arm 226 is moved to the right (reference being had to Figure 21) a predetermined distance against the resistance of V-spring 229 acting on boss 229', causing toothed section 230' to engage gear 232 and rotate it clockwise. At the same time, pawl 233 mounted on gear 232 engages ratchet 234, causing ratchet barrel 237' to rotate clockwise together with arm 235 and ratchet barrel 237, all mounted on hub 234'. Clockwise arcuate movement of arm 235 away from stop 235' compresses hairpin storage spring 236. On clockwise rotation, ratchet barrel 237 rides under spring-pressed pawl arms 241, 241', of the next higher-order compartment c and under spring-pressed pawl 239 mounted on decimal transfer gear 240 of said higher-order compartment, and is prevented from returning to its neutral position under torque caused by pressure of spring 236 on arm 235 by reason of engagement of pawl arms 241 and/or 241' therewith as hereinbefore assumed. On return of bar 226 to its neutral position under pressure of V-spring 229 on boss 229', gear 232 is moved counter-clockwise by toothed section 230', causing pawl 233 to ride over ratchet 234. On second actuation of arm 226, the movements hereinbefore described are repeated, except that hairpin storage spring 236 will be compressed an additional amount by virtue of an additional unit arcuate movement of arm 235 and of the ratchet barrel 237'. It will be noted that on each return of bar 226 to neutral, the in-

termediate clearance gap 231 returns to its position over gear 232. Now on return to neutral of both gears 186 and 190 of the higher-order compartment c, all single-tooth gears 180 and 191 will engage depending teeth 246, 246', of bars 244, 244', forcing bosses 243, 243', under radial fingers 242, 242', of pawl arms 241, 241', causing them to disengage themselves from ratchet barrel 237 of compartment c (which extends into next higher-order compartment c through aperture 238). On release of this detention, hairpin storage spring 236 presses arm 235 to return to neutral against its stop 235', causing counter-clockwise rotation of ratchet barrel 237', and, in turn, counter-clockwise rotation of decimal transfer gear 240 of said next higher-order compartment c (due to engagement of spring-pressed pawl 239 mounted thereon with ratchet barrel 237) and gear 232 of compartment c (due to engagement of spring-pressed pawl 233, mounted thereon, with ratchet 234). Rotation of gear 232 has no further effect because it rides clear in clearance gap 231 on bar 226. Rotation of gear 240 in said higher-order compartment actuates meshing gears 208, 210, 219, and 220 in such compartment c and causes number wheel 221 thereof to rotate two units.

It will thus be evident that the decimal storage mechanism of any one compartment c extends into the next higher-order compartment for receiving and storing decimal values (tens carry) from the number wheel 221 of its own compartment and ultimately transferring such stored decimal values to the transmittal gear 208 of the said higher-order compartment. It will also be noted that this transference is controlled by the single-toothed gears 188, 191, of said next higher-order compartment, so that such transference cannot take place until gears 187 and 190 thereof have returned to neutral position. It will be further noted that the transference can take place while the carriage 137 is in motion from one stop 171 to the next stop 171 to the left.

It will be noted that the decimal storage system is so arranged as to be able to store two or more tens carry units. This is necessary because of the possible number combinations which may occur in the operation of the machine. Consider the following:

Assume that the number 99 appears in the windows 4 of the totalizer from a previous computation, to which we wish to add the product of 219 × 9. The multiplicand 219 is set into the machine as heretofore described. Then, upon depressing the multiplier key 9, the following take place in the order diagrammed:

	Thousands Compartment		Hundreds Compartment		Tens Compartment		Units Compartment	
	decimal storage	number wheel	decimal storage	number wheel	decimal storage	number wheel	decimal storage	number wheel
Originally in machine (Showing on wheels 221)						9		9
On forward stroke, add units				8		9		1
(Showing on wheels 221 and in storage)				8	1	8	1	0
On back stroke, add tens		1				8		
(Showing on wheels 221 and in storage)		1		8	2	6	1	0
Decimal storage released (Showing on wheels 221)		2		0		7		0

Resetting mechanism

Journaled in and extending horizontally through the left side wall 5 of the totalizer shell 3, is a short quill 247 integrally provided on its external end with a manipulating lever 248 and on its inner end with a segmental plate 249 normally urged downwardly by a suitable spring 249' and, in turn, provided upon its inwardly presented side face with a circular groove 250 widened at its upper end for loosely accommodating a laterally projecting pin 251 fixed in the opposed side face of the actuating plate 212 and positioned for engagement within the narrow portion of the groove 250 upon upward movement of the plate 249 and thereby swinging the actuating plate 212 to a position midway between its normal "add" and "subtract" positions and accordingly swinging all the rock-plates 209 into a corresponding midway position in which both gears 210, 210', of each rock-plate 209 are disengaged from the gears 219. On its peripheral face, the plate 249 is provided with an initial flat portion 252 subjoined by a peripherally toothed segmental section 253 for meshing engagement with a pinion 254 fixed upon the extended end of the shaft 183. Formed integrally with the plate 249 and extending radially outwardly from the outer side face thereof, is a plate extension 255 provided in its side face with a cam groove 256 having a laterally presented face 257 deeper at its upper end and sloping until flush with the plate side face, the latter coinciding with the initial flat portion 252 of the peripheral face of the plate 249.

The shaft 183 furthermore projects a short distance outwardly beyond the pinion 254 for endwise abutment against the cam face 257 and is provided at its other end with a compression spring 258 for urging the shaft 183 into cam engagement. Keyed upon the shaft 183 in each compartment c, is a fixed clearing collar 259 having an axially projecting clearing pin 260 for alternative engagement in the recess 224' of the arm 223 when the shaft is shifted longitudinally by the cam face 257, and fixed within each compartment c in alignment with the "zero" position of the arms 223, is a stop lug 261 for engagement on its opposite faces with the clearing pin 260 to limit its rotation in either direction.

Rotatably mounted in and extending through the quill 247, is a shaft 262 provided on its outer end with a manipulating lever 263 and upon its inner end with a gear 264 meshing with a horizontally shiftable rack 265 extending forwardly and meshing also with a pinion 266 keyed upon a control shaft 267 extending transversely across the totalizer shell 3 and at its other end splined slidably through a pinion 268, which is held nonshiftably in the frame 7 of the computing mechanism A and meshes with an idler gear 269.

Rotatably mounted on a suitable horizontal pin 270 for meshing engagement with the gear 269, is a gear 271 having an axially projecting tongue 272 for abutment against a similar tongue 273 formed upon a gear 274 also rotatably mounted on the pin 270 and provided on its side face with a single tooth ratchet 275 actuated by a spring-pressed pawl 276 mounted in the under face of a shiftable supporting block 277 formed integrally with and carried by a slide bar 278 extending

horizontally forwardly along the right side of the multiplier key bank and provided at its forward end with a depending rack section 279 for engagement with an actuating gear 280 pinned upon the cross-shaft 32.

Shiftably mounted on the frame 7 of the computing mechanism A, is a vertical control rack 281 for meshing engagement with the gear 274 having a depending guide pin 282 extending slidably through a cross-member 7d and provided with an encircling spring 283 for normally biasing the rack 281 upwardly. On its lower end, the guide pin is provided with a depending plate 284 having a vertical slot 285 for clearing the shaft 153, and formed integrally with the plate 284, is a downwardly projecting finger 286 for actuating a partial-revolution clutch *s''* of the type above described for transmitting rotary motion from a power-driven shaft 287 through a jack shaft 288 and over-travel absorbing rack-and-slide transmission 289 to a horizontal shaft 290 provided at its end with a bevel gear 291, which, in turn, meshes with a companion bevel gear 292 pinned to a concentric spur gear 293 drivingly meshing with a rewind pinion 92' keyed to the rewind shaft 93.

It will thus be evident that, by manually pressing the lever 253 down, the rack 265 is shifted rearwardly, rotating the shaft 267, the pinion 268, the idler gear 269, and the gear 271. The rotary movement of the gear 271 is transmitted through the tongues 272 and 273 to the gear 274, shifting the control rack 281 and its associated plate 284 downwardly. Downward movement of the plate 284 causes the finger 286 to engage the clutch *s''*, rotating the shaft 290 through the transmission mechanism 289 and rotating the bevel gear 291, which, in turn, rotates the bevel gear 292 and spur gear 293, driving the rewind pinion 92' and rewind shaft 93.

Similarly, when the handle 33 is shifted from "Add" to "Mult." position, the gear 280 shifts the bar 278 forwardly, causing the pawl to rotate the gear 274 directly, leaving the gear 271 undisturbed. Rotation of the gear 274, however, actuates the control rack 281, causing engagement of the clutch *s''* for a partial revolution, in the manner above described, for transmitting rotary movement to the rewind shaft 93. In either case, the rewind pinions are simultaneously rotated, driving the several gears 91' and causing the pawls 89' to engage the single tooth gears 91, wind the drums 89, and pull all the carrier bars 66 back to initial or zero position wherein they are held by the stop dogs 79, 79'.

Fixed upon the upper faces of each carrier bar 66 on opposite sides of the groove 68, are rearwardly beveled upstanding wedge blocks 294 positioned for engaging and lifting vertical slide plates 295 when the carrier bars return to "zero" position, the plates 295 being shiftably mounted in a suitable cross-bar 296 rigidly mounted in the frame 7 of the computing mechanism A.

Rockably mounted on the shaft 178 in each totalizer compartment c, is a pair of peripherally toothed gear segments 297 positioned on opposite sides of the accumulator gear 185 and having forwardly projecting pins 298, and rotatably mounted thereon, are rollers for engagement with the slide plates 295. Each gear segment 297 meshes with a toothed collar 299 rockably mounted on the shaft 177. Also rockably mounted on the shaft 177, is a second toothed collar 300 meshing with an idler gear 301, which, in turn, meshes with the gear segment 297 in downwardly spaced relation to the enmeshment of the collar 299.

Formed integrally with and extending radially from the collars 299, 300, are arms 302, 303, provided with companion-shaped semi-circular arms 304, 305. When the slide plates 295 are lifted as the carrier bars 66 return to "zero" position, the gear segments 297 rock downwardly, closing the arms 303, 305, for lifting the primary and secondary pawls 186, 186', and preventing the accumulator gears 185 from being actuated by the primary and secondary pawls 186, 186', through the movement of the ratchets 189 and 192.

Addition

In employing the above-described calculating machine for addition, the handle 33 of the computing mechanism A is shifted into "Add" position. This operation rotates the cross-shaft 32 and the several spaced inverting pinions 31 mounted thereon and shifts the several rack bars 29 rearwardly. The rearward movement of the rack bar 29, which is associated with the multiplier bank acting through the several gear collars 13, will rotate all of the key-plungers 12 in the multiplier bank a full half turn, so that the flattened or ground-off side faces 15 of the cylindrical rack portions 14a to 14j, inclusive, are presented toward the barrel gears 9a to 9j, inclusive, thereby rendering the entire multiplier bank ineffective. The rearward motion of the rack bars 29, which are associated with the several primary key banks, similarly rotate all of the key-plungers 22 a full half turn, bringing the rack portions 24 of the several key-plungers 22a to 22j, inclusive, of each primary key bank into positive engagement with the barrel gears 19a to 19j, respectively.

At the same time, the rotation of each of the inverting pinions 31 associated with the several primary key banks shifts the auxiliary slide bar 93 and its associated slide bar 36a downwardly. As the slide bar 36a is moved downwardly, the detent lug 44 engages and rotates its associated latch member 82, rocking the paired shafts 78, 78', and swinging the stop dogs 79, 79', upwardly and outwardly and permitting the carrier bar 66 to slide forwardly under the influence of the ribbon 84 and winding drum 85 until the stop face 77a comes into abutment with the stop finger 43a. Stop fingers 43 are so constructed that they will not come into frictional contact with the several notches 77 in which they respectively work. As the detent lug 44 completes its downward movement, the upwardly extending leg 83' of the latch member 82 will swing over into locking abutment against the upper face of the detent lug 44. Under such condition, the stop dogs 79, 79', abuttingly engage the side faces of the carrier bar 66 and are thereby prevented from returning to initial position under influence of the springs 80, and hence the paired shafts 78, 78', will be held stationary and the leg 83' of the latch member 82 will restrain the slide bar 36a from upward return movement.

It will thus be evident that, when the machine is set for addition, all of the carrier bars 66 will automatically be set to position corresponding to the digit "1." This, in effect, accomplishes addition by multiplying by "1" each number to be added and transferring the resulting product, which, after all, is the number itself, into the totalizer B.

With the machine set for addition, as shown in Figures 5, 7, and 8, the several numbers to be

added may be successively set into the primary key banks by depression of the appropriate keys in the usual manner. If, for example, the first number to be added is the number "54," the "5" and "4" keys, that is to say, the keys 23e and 23d, will be respectively depressed. Obviously the "4" may be pressed into any key bank having a suitable relation to the placing of the decimal point, as may suit the convenience of the particular operator, and the "5" will, of course, be pressed into the next adjacent key bank to the left. Ordinarily this operation would be carried out, utilizing the first and second primary key banks counting from right to left. In business offices, however, it is common practice to deal with dollars and cents and for such operations it may be convenient to color the first two such key banks in a different color from the remaining five primary key banks, so that the decimal point in all calculations may be considered as occurring between the second and third primary key banks. If such were the case, the operator might very well set the number "4" into the third primary key bank and the number "5" into the fourth primary key bank. In any case, it will make no difference in the present machine whether the "4" or the "5" is set into the machine first or whether both the "4" and "5" are set into the machine simultaneously. The same is true of any number of digits not greater than the number of columns in the machine.

As soon as the "4" key is depressed, the key-plunger 22d and its associated rack portion 24 is shifted downwardly, rotating the barrel gear 19d and shifting the stop-plate 53d downwardly into the groove 68 of the carrier bar 66, so that the abutment faces 55 of the bank portion 54 will be interposed in the path of the stops 76, 76', of the computing barrels 70, 70'. At the same time, the finger 21d is swung downwardly, rotating the shaft 18 and thereby shifting the control rack 95 downwardly.

As above described, downward movement of the control rack 95 shifts the pawl-like finger 99 of the end block 98 into engagement with the freely rotating ratchet ring 102 and causes the single revolution clutch *s* to rotate the jack-shaft 106 for one full revolution. Rotation of the jack-shaft 106 drives the rack slide 117 downwardly and, through the springs 125, drives the slide racks 122 downwardly. Downward movement of the slide racks 122 rotates the square shafts 75 and the computing barrels 70, 70', mounted thereon.

Since the number "4," in the case of addition, is being, in effect, multiplied by the number "1," the product, which is to be computed by the computing barrels 70, 70', is "04," and consequently one of the stops 76' of the computing barrel 70' will immediately engage the abutment face of the stop-plate 53d and prevent movement of the computing barrel 70'. On the other hand, the appropriate stop 76 of the computing barrel 70, which corresponds to the product "04," will come into abutment with the other face 55 of the stop-plate 53d, allowing the computing barrel 70 to move a distance equivalent to four units. This rotary motion is introduced into the totalizer mechanism B through the vertical movement of the racks 198, 199, in the manner previously described. Since, however, only "units" values will come through from the computing barrels 70, 70', only "units" values will be accumulated on the accumulator gear 185.

It will, of course, be evident that if any one of the keys 23 is, through accident or erroneous manipulation, held down by the operator for a period of time longer than a single rotation of the one revolution clutch *s*, the normal operation of the machine will take place during the first revolution and, as the one revolution clutch completes its first revolution, it will be unable to move further because the vertically shifted rack 158 will have reached the lowermost limit of its travel and will not be able to go further. The result will be that the entire driving mechanism through the chains of gears 111, 112, and 113 will become locked and the machine will automatically suspend operations until the depressed key 23 is again released, whereupon the entire machine will return to normal and no adverse result, such as repetitive recordation, will ensue.

The totalizer B will obviously be set or conditioned for addition by moving the pointer finger 215 and associated lug 213 into "Add" position, rocking the actuating plate 212, the shaft 180, and all of the rock-plates 209 into position in which the transmittal gears 208 are directly connected through the bracket carried idlers 210 with the number-wheel driving gears 219. Accordingly, the number-wheel 221, which is connected, as the result of the position of the totalizer B, with the particular primary key bank into which the number "4" has been set, will be rotated to bring the numeral "4" in front of the window 4'. Similarly, the number "5" will be transferred into the totalizer B and appear in the next adjacent window 4' to the left.

Suppose one desires to add the number "65" to the number "54" already set into the machine. In such case, the lug 213 and finger 215 are allowed to remain in "Add" position and the number "65" set into the machine in the same manner as that previously described in connection with the number "54." The series of described operations will be repeated and the "units" value "5" will be transmitted through the appropriate accumulator gear 185 into the first number-wheel 221, which already carries a "units" value of "4," so that the numeral "9" will now appear in the righthand window 4'. Similarly, the "units" value "6" will be introduced into the second number-wheel 221. Since the total of six and five is eleven, the numeral "1" will appear in the second window 4' and the "tens" value resulting from a full rotation of this particular number-wheel 221 will be transmitted through the decimal storage mechanism into the next higher number-wheel 221 to the left, so that the numeral "1" will appear in the third window 4', thus showing the total of "119."

If, on the other hand, it is desired to subtract, for example, the number "32" from the number "54," the lug 213 and its associated finger 215 is shifted to "Sub." and all of the rock-plates 209 are thereby swung rearwardly, connecting all of the transmittal gears 208 to the totalizer compartments *c* through the idlers 211, 210', to the number-wheel driving gear 219. Although the several accumulator gears 185 and the transmittal gears 208 associated therewith will still be rotated in the same direction as they were during addition operations, the interposition of the idler gear 211 in the transmittal train will cause the number-wheel driving gear and its associated number-wheel to be rotated in the reverse direction, so that any number values, which are introduced from the several computing barrels 70, will be deducted from the number already set into the machine. Accordingly, in subtract-

ing the number "32" from the number "54," the "units" value of "2" will be deducted from the number "4" and the "units" value "3" will be deducted from the number "5," so that the result "22" will appear in the windows 4'.

Multiplication

In setting the machine for multiplication, the totalizer B is cleared and reset by swinging the lever 248 upwardly and accordingly rocking the plate 249 in a counter-clockwise or upward direction against the bias of the spring 249'. As the plate 249 moves upwardly, the pin 251 is engaged in the slot 250 and the actuating plate 212, together with all the other rock-plates 209, are swung into neutral position, so that the idler gears 210, 210', are all disengaged from the number-wheel driving gear 219. At the same time, the projecting end of the shaft 183, which abuts endwise against the sloping upper end portion of the cam grooves 256, is pushed longitudinally to the right against the action of the spring 258, shifting the several clearing pins 260 into position for engagement with the recesses 224' of the arms 224. As the plate 249 continues its counter-clockwise or upward movement, the toothed section 253 will come into engagement with the pinion 254, rotating the shaft 183 and the clearing collars 259 for one complete revolution. As each clearing collar 259 makes a complete revolution, its clearing pin 260 will pick up its associated arm 224 wherever such arm may happen to be, returning it to zero position and accordingly, through the number-wheel driving gear 219, returning the number-wheel to zero position, so that the numeral "0" will be visible in the window 4'. When the lever 248 is released, the entire clearing mechanism is returned to initial or inactive position by the spring 249', leaving all of the number-wheels 221 at zero position. As the number-wheels are cleared and preferably as a part of the same manual operation, the totalizer B is pushed from left to right as far as it will go, in which initial position the lefthand totalizer compartment *c* third from the left is aligned with the last primary key bank on the left. There are two extra totalizer compartments *c* further to the left to take care of accumulated orders in higher columns which may result from multiplication of a seven-digit number.

The handle 33 of the computing mechanism A is pushed from "Add" position to "Mult." position, rotating the shaft 32 and the several inverting pinions 31 carried thereby and shifting the several rack bars 29 forwardly. If, as has been presumed for explanatory purposes, the machine has previously been set for addition, the slide bars 36^a of each primary key bank will be held in downwardly disposed position. Since, however, the rack bars 63 are free to slide upwardly therefrom along the supporting pins 62, the locked position of the slide bars 36^a will not prevent rotation of the inverting pinions 31.

The forward shifting movement of the rack bar 29, which is associated with the multiplier key bank, rotates all of the multiplier key-plungers 12 a half turn, bringing the rack portions 15^a to 15^i, inclusive, into engagement with the barrel gears 9^a to 9^i, inclusive, respectively. The forward movement of the rack bars 29, which are associated with the primary key banks, on the other hand, rotates the primary key-plungers 22^a to 22^i, inclusive, of each of the primary key banks a half turn, disengaging them from the respective barrel gears 19^a to 19^i, inclusive, and bringing them into engagement with the toothed faces of the slide bars 36^a to 36^i, respectively. The rotation of the shaft 32 also rotates the gear 280, which meshes with the depending rack portion 279 of the slide bar 278, shifting the latter forwardly and causing the pawl 276 to engage and rotate the single tooth ratchet 275, thereby rotating the gear 274 and shifting the control rack 281 downwardly for actuation of the partial revolution clutch *s'*, which, when actuated, transmits rotary movement through the transmission assembly 289 to the shaft 290 and thence through the bevel gears 291, 292, and gears 293, 92', to the rewind shaft 93 for pulling all of the carrier bars 66 back to initial or zero position. As the carrier bars 66 reach zero position, the stop dogs 79, 79', ride free of the side faces of the carrier bar 66 and are returned to normal locking position, rotating the shafts 78, 78', to initial position, and releasing the slide bars 36^a, the stop dogs 79' at the same time moving into endwise abutment with the end faces of the respective carrier bars for holding the latter in zero position.

Engagement of abutment 43^a with notch 77^a and locking of said abutment in place through elements 44, 83, 78, and 79 will not prevent subsequent restoration of slide 66, as can be seen by reference to Figures 4 and 9. There it will be noted that the length of the notch 77*a* is equal to the distance traveled out of zero position by slide 66 plus the width of abutment 43. Hence, even though abutment 43 remains in place, there is sufficient space between its bottom face and the bottom of notch 77^a to permit slide 66 to move either forwardly or backwardly without permitting frictional contact between said bottom face of abutment 43^a and the bottom of notch 77^a. It will be further seen that rearward movement of slide 66 in exact amount equal to its original forward movement from neutral is permitted, i. e. until forward face of abutment 43^a impinges on forward face of notch 77^a. However, it should be noted that such impingement would not take place since movement of rewind shaft 93 and hence of slide 66 is only sufficient to permit dogs 79, 79', to swing back into locking position in endwise abutment to slide 66.

As the carrier bars 66 return to initial position, the wedge blocks 294 thereof engage and shift upwardly the slide plates 295, which are mounted in the stationary cross bar 296, and accordingly swing the several pairs of gear segments 297 downwardly and thereby close the pairs of semi-circular arms 304, 305, for lifting and holding disengaged the primary and secondary pawls 186, 186', of the several accumulator gears 185. Because of the logarithmic spacing and arrangement of the computing barrels 70, 70', it is impossible to achieve a true arithmetical zero setting of the carrier bars 66 and, therefore, it is always possible that the computing barrels 70, 70', of any primary key bank, which is set at zero, may rotate to some extent. Since the accumulator gear 185 mounted in the particular totalizer compartment *c*, which is aligned with such zero-positioned carrier bars 66, is rendered inactive by the arms 304, 305, no numerical values will be introduced into such totalizer compartments *c*.

Suppose, for example, the number "19" is to be multiplied by "49." The number "9" will be set preferably into the first primary key bank on

the right by manual depression of the key-button 23^{i} and its associated key-plunger 22^{i}. Downward movement of the key-plunger 22^{i} will cause the detent lug 44 thereof to engage the inwardly projecting leg 83 of its associated latch member 82, rocking the shafts 78, 78', and swinging the stop dogs 79, 79', out of stop-forming abutment with the carrier bars 66, thus permitting the latter to be drawn forwardly by the ribbon 84 and spring-actuated winding drum 86 until the stop face 77^{i} comes into engagement with the depending stop finger 43 of the slide bar 36^{i}. In the course of its rotation, the leg 83' of the latch member 82 rocks over into retentive engagement with the detent lug 44, holding the slide bar 36^{i} and all of the other elements associated therewith in downwardly depressed position. It will be noted from Figure 19*a*, view *a*, that latch member 82 and detent lug 44 are so designed that projecting legs 83' of all other latch members 82 in the row will clear their respectively associated detent lugs 44 by swinging in the respective arcuate recesses 44'.

Similarly, the number "1" is set into the next higher primary key bank to the left by depressing the key-button 23^{a} and shifting the associated key-plunger 22^{a} downwardly. The operations and ensuing movements are identical with those previously described in connection with the setting of the number "9" into the first primary key bank, except that the carrier bar 66, which is associated with the second primary key bank, will move forwardly by a distance determined by the stop face 77^{a}.

Thereupon, the first digit, namely, the number "4," is set into the multiplier key bank by depressing the key-button 14^{d}. Since the plunger rack-portion 15^{d} is engaged with the barrel gear 9^{d}, the depression of the key-button 14^{d} will rotate the barrel gear 9^{d} and shift the cross-connecting rack 47^{d} from right to left, accordingly rotating all of the barrel gears 19^{d} associated with the several primary key banks and shifting all of the stop-plates 53^{d} downwardly into position for abutment with the computing barrel stops 76, 76'. At the same time, the shafts 18 are rotated, actuating all of the partial revolution clutches *s* and rotating all of the pairs of computing barrels 70, 70', thus multiplying all of the digits which have been set into the primary key banks by the number "4." Consequently, the particular stops 76, 76', of the first carrier bar 66 to the right which correspond to the product "36," will be positioned in alignment with the tongue 54 of the stop-plate 53^{d}. Similarly, the pair of stops 76, 76', of the second carrier bar 66 which correspond to the product "04," will be positioned in alignment with the tongue 54 of the stop-plate 53^{d}. Upon rotation, therefore, the first computing barrel 70 will immediately come into abutment with the stop 76, which is equivalent to transmitting a six in the "units" column, and the computing barrel 70' will rotate three units, which is equivalent to the value of three in the "tens" column. The "units" value of six is transmitted by the first computing barrel 70 and accordingly accumulated in the accumulator gear 185 mounted in the particular totalizer compartment *c* which is for the moment aligned with the first primary key bank. On the other hand, a "tens" value of three, which is computed on the computing barrel 70', will be transmitted directly into the accumulator gear 185 of the next totalizer compartment *c* to the left. This value, however, as above described, will not be transferred

into such accumulator gear 185 until the units which have been computed on the computing barrel 70 of the next primary key bank to the left are introduced into that accumulator gear 185. Since the number "1" has been set into the next higher primary key bank and the product, which is being computed by the computing barrels 70, 70', thereof is the number "04," a "units" value of "4" will be introduced into the accumulator gear 185 of the particular totalizer compartment *c* aligned, for the moment, with the second primary key bank, that is to say, the next key bank to the left. At the same time, since the numerical value "0" is being computed on the tens barrel 70', no numerical value will be introduced into the accumulator gear 185 of the next higher totalizer compartment *c*, that is to say, the one which is aligned with the third primary key bank to the left. These various values are transmitted additively into the number-wheels 221 and, for the moment, a product "76" will appear in the windows 4'.

The depression of the key-button 14^{d} and the resulting rotation of its associated barrel gear 9^{d} will also rotate the shaft 8, actuating the part revolution clutch *s* associated therewith and rotating the shaft 153. As was above pointed out, the rotation of the shaft 153 and its associated pinion 152 will shift the double-faced rack 149 downwardly, rotating the pinion 148 and its associated ratchet 147. On the down stroke, however, the ratchet passes the pawl 146 and no movement is transmitted to the gear 145. When, however, all of the partial revolution clutches *s* have completed their fixed partial revolution and the numerical values from the computing barrels 70, 70', have been transferred into the totalizer B, the rack 149 will be released and returned to its initial position, moving upwardly under influence of the spring 151. On its upward or return stroke, the ratchet 147 positively engages the pawl 146 and rotates the gear 145, rotating the pinion 144 and the shaft 143, which, in turn, rotates the carriage release cam 168 and, in the manner above described, permits the entire totalizer B to shift to the left by a distance equal to the width of one totalizer compartment, so that the totalizer compartment, which previously was aligned with the first primary key bank, will now be aligned with the second primary key bank. This, it will be evident, has the effect of moving the decimal point one place to the right, and, in effect, converting the product achieved by the depression of the key button 14^{d} from the simple multiplication by four into a multiplication by forty.

Thereupon, the multiplication operation is completed by depressing the key-button 14^{i}, that is to say, the key-button bearing the indicia "9." The above described multiplying operations are again carried through and the number "19" multiplied by "9" and transferring into the appropriate totalizer compartments *c* a numerical value of "171." Since the totalizer B has moved already automatically to the left and thereby achieved the effect of multiplication by "40" instead of "4," the number "760" appears in the windows 4'. To this result "171" is added:

7	6	0
1	7	1
8	13	1

It will be noted that the total of the second column is "13," so that a "tens" digit or decimal value must be stored in the decimal storage mech-

anism and transferred through the transmittal gears 298 into the number wheel 221 of the left-hand column for addition to the numeral "8" and converting it into a "9," so that the resulting product "931" will appear in the windows 4'.

When the multiplication operation has been finished, the machine may be cleared and reset for a subsequent operation by manipulation of the lever 243 to clear all the number-wheels 221 and, at the same time, returning the totalizer B to its initial position by pushing it to the right, in the manner above described. At the same time, the lever 263 is pressed downwardly, sliding the rack bar 265 rearwardly to rotate the pinion 266 and shaft 267, which, in turn, rotates the pinion 268 and the intermeshing gears 269, 273. Rotation of the gear 273 will, in turn, rotate the gear 274, shifting the control rack 281 downwardly and, through actuation of the partial revolution clutch *s''*, resetting all of the carrier bars 66 to zero position.

Where, however, the machine is to be next used for addition, the operation of the lever 263 may be omitted, since the movement of the handle 33 from "Mult." position to "Add" position will actuate the slide bar 278 and alternatively effect actuation of the partial revolution clutch *s''*. In this same connection, it may also be noted that a product, which is obtained in the course of a multiplying operation, may be retained in the totalizer and added to some other number by leaving the product in the totalizer and shifting the handle 33 from "Mult." position to "Add" position. Thereupon a succession of further numbers may be added to the number which is already carried in the totalizer to obtain a cumulative total.

Arithmetical primary key banks

We may also provide a modified form of calculator which is substantially similar in all respects to the previously described calculator, except that it is provided with arithmetically spaced primary key banks, that is to say, key banks in which the distances and measurements are arithmetical rather than logarithmic, as shown in Figure 5. Each arithmetical key bank comprises a computing slide 306, which is substantially shorter in length than the previously described computing slide 66 and is provided with a stop-plate accommodating groove 307 and computing barrels 308, 308', shiftably mounted on square shafts 309 which extend horizontally therethrough. On its upwardly presented horizontal face and on one side of the groove 307, each computing slide 306 is milled out in the provision of a plurality of recesses 310^a, 310^b, 310^c, 310^d, 310^e, 310^f, 310^g, 310^h, 310^i, in the provision of stop faces 311^a to 311^i, inclusive, which receive stop fingers 43' substantially identical with the previously described stop fingers 43 and are so positioned as to permit the slide 306 to move forwardly distances respectively corresponding in arithmetical progression to the numbers "1" to "9."

The modified form of primary key bank is provided with nine stop-plates 53' substantially identical with the stop-plates 53 and co-acting with key-plungers 22', also substantially identical with the key-plungers 22. Since the stop faces 311 are all located on one side of the slide groove 307, it is only necessary to provide a single rotary shaft 312, which is substantially identical with the previously described shafts 78, 78', and is provided with latch members 313 and a stop dog 314, which are respectively identical with the previously described latch members 82 and stop dogs 79, 79'.

The computing barrels 308, 308', are similar in construction to the computing barrels 70, 70', except that they are non-logarithmic in character and are provided with a plurality of pairs of stops 315, 315', corresponding to the products resulting from multiplication of the several numbers in the number series "0" to "9" by each other, the pairs of stops being spaced by uniform or arithmetical distances rather than logarithmic distances. The general principle previously illustrated in Figs. 6*a* to 6*d* inclusive is equally applicable except that instead of 36 pairs of stops 75, 75' which correspond to the thirty-six partial products necessary in the logarithmic arrangement, it is necessary to employ 90 pairs of stops 315, 315' corresponding to the ninety partial products (i. e. all the products in the multiplication table from 1×0 through 9×9). The first product in this series of products will be zero; therefore, the first set of stops will be so arranged as to permit no rotation of the computing barrels 308, 308'. The second pair of stops will correspond to the product of "1"×"1" and will be so arranged as to permit one unit of rotation of the units barrel 308 while permitting no rotation of the tens barrel 308', and so on. Since the arithmetically arranged computing barrels 308, 308', do contain a zero setting within themselves, there is no possibility that numerical values will be transmitted into the totalizer B during multiplication from key banks which remain at a zero setting. Therefore, when arithmetical primary key banks are employed, it is possible to omit the previously described wedge-shaped blocks 294 and the associated gear segments 297, together with the pairs of semi-circular arms 304, 305.

In operation and manipulation, the modified form of calculator having arithmetically arranged primary key banks is identical with the previously described calculator and is capable of being manipulated in the same manner to accomplish addition, subtraction, and multiplication. That is to say the slide 306 will be shifted forwardly upon manipulation of a suitable key in the multiplicand key bank. If, for example, the number "3" is the multiplicand, then by depression of the "3" key in the multiplicand key bank the slide will be shifted forwardly so that the partial products "3," "6," "9," "12," "15," "18," "21," "24" and "27" respectively are positioned under the stop-plates 53*a* to 53*i* inclusive. Thus, if the multiplier key corresponding to the number "6" is depressed (to complete the operation 3×6), the corresponding stop-plate 53*f* will be moved down to engage the stop on the barrel which corresponds to the partial product 18 and the units barrel 308 will rotate eight units while the tens barrel 308' will move one unit. Such movement will be transmitted into the totalizer mechanism in the same manner as previously described in connection with the logarithmic modification.

It should be pointed out that calculating machines may be constructed in accordance with our present invention to embody other spatial relationships between the stops of the computing barrels and slides so as to employ some other mathematical function than the logarithmic and arithmetical functions above described. It should also be noted in this same connection that calculating machines of our invention are extremely flexible in operation and adaptability. As has been stated, the calculating machines described may be readily manipulated to perform addition

and subtraction and are capable of carrying a running total over a whole series of successive and intermixed addition, subtraction, and multiplication operations. In addition, the calculators are capable of multiplying by a process which may be referred to as "direct multiplication," that is to say, multiplication in which the operator merely manipulates the keys a single time to set the multiplicand into the machine and then manipulates either the same or different keys a single time to set the multiplier into the machine, after which key manipulations the machine will calculate the product. This process of so-called direct multiplication is to be distinguished from the process of so-called "multiplication by successive addition," which is employed in practically all calculating machines heretofore designed and commercially used, such process involving a number of repetitive key manipulations whereby the multiplicand is added to itself a number of times equivalent to the numerical value of the multiplier. Obviously this latter process is much slower, more tiring on the operator, and productive of much greater error-frequency. Although the calculating machine of our present invention is capable of performing multiplication by the more desirable direct process, as distinguished from the slower conventional machines, it also may be operated in such a manner as to yield a product by the successive addition process.

It should be understood that changes and modifications in the form, construction, arrangement, and combination of the several parts of the calculating machine may be made and substituted for those herein shown and described without departing from the nature and principle of our invention.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. A multiplying machine having a plurality of banks of multiplicand keys and a single bank of multiplier keys, shiftable carriers individual to the multiplicand banks, means for shifting said carriers rectilinearly and differentially according to the multiplicand keys depressed in the several orders, a pair of computing barrels rotatably supported upon each carrier with their axes parallel to the line of shifting movement of the carrier, one of the barrels of each pair having at intervals in its length formed surfaces representing by their circumferential position units components of the products of all digits and the other barrel having similarly formed and arranged surfaces representative of tens components, shiftable stops arranged in a plurality of ordinal series and mounted between the barrels of each pair to permit a selected stop to arrest both barrels, means under the control of the multiplier keys for shifting like stops in the several orders, means also controlled by the multiplier keys for turning the barrels until arrested, a totalizer and means for simultaneously transmitting to appropriate orders of said totalizer differential movement imparted to the barrels in one or more orders.

2. A calculator comprising a plurality of banks of multiplicand keys and a bank of multiplier keys, a stop-plate in each bank of multiplicand keys operatively connected to and associated with each of said multiplier keys, in such a manner as to be shifted downwardly upon manipulation thereof, a computing slide mounted beneath each row of multiplicand keys, means for shifting the slides rectilinearly and differentially according to multiplicand keys depressed in the several orders, a pair of cooperating barrels operatively mounted in each slide each provided with a plurality of stops respectively positioned so that one of the stops will engage with one of the stop plates, said stops being so arranged circumferentially as to respectively represent the units and tens components of the products of all digits whereby to permit differential amounts of rotation of the corresponding computing barrels depending both upon the position of the slide and upon which stop-plate is shifted downwardly as a result of manipulation of its associated multiplier key for engagement with its corresponding stop, a totalizer, and means for transmitting differential movement to appropriate orders of said totalizer corresponding to the differential movement imparted to the barrels in one or more orders.

3. A calculator comprising a plurality of banks of multiplicand keys and a bank of multiplier keys, driving means, a stop-plate in each bank of multiplicand keys operatively connected to and associated with each of said multiplier keys, in such a manner as to be shifted downwardly upon manipulation thereof, a computing slide mounted beneath each row of multiplicand keys, means for shifting the slides rectilinearly and differentially according to multiplicand keys depressed in the several orders, a pair of cooperating barrels operatively mounted in each slide each provided with a plurality of stops respectively positioned so that one of the stops will engage with one of the stop-plates, said stops being so arranged circumferentially as to respectively represent the units and tens components of the products of all digits whereby to permit differential amounts of rotation of the corresponding computing barrels depending both upon the position of the slide and upon which stop-plate is shifted downwardly as a result of manipulation of its associated multiplier key for engagement with its corresponding stop, means actuable responsive to downward shifting movement of any one of the multiplier keys for connecting the driving means to the computing means for actuating said computing means, a totalizer, and means for transmitting differential movement to appropriate orders of said totalizer corresponding to the differential movement imparted to the barrels in one or more orders.

4. A calculator comprising a plurality of banks of multiplicand keys and a single bank of multiplier keys, a vertically shiftable and optionally rotatable rack disposed in endwise abutment with the lower end of each key, power driving means, a stop-plate in each bank of multiplicand keys associated with and vertically shiftable upon manipulation of, each of said multiplier keys, a computing slide mounted beneath each row of multiplicand keys, means for shifting the slides rectilinearly and differentially responsive to manipulation of selected multiplicand keys, a pair of computing barrels mounted on each slide and having a plurality of stops respectively positioned so that one of the stops will engage with one of the stop-plates, and circumferentially positioned as to respectively represent the units and tens components of the products of each of the nine primary digits and zero with each other whereby to permit different amounts of travel of the computing barrels depending upon which stop-plate is shifted downwardly as a result of manipulation of its associated multiplier key for

engagement with its corresponding stop, means actuable responsive to downward shiftable movement of any one of the multiplier keys for connecting the driving means to the computing barrels to produce corresponding travel of said computing barrels, a totalizer, and means actuated by the travel of the computing barrels for transmitting to appropriate orders of the totalizer the rotary movement imparted to the barrels.

5. A calculator comprising a plurality of banks of multiplicand keys and a bank of multiplier keys, the keys in each bank respectively representing successive integers, a power driving means, a stop-plate in each bank of multiplicand keys operatively connected to and associated with each of the multiplier keys for vertical movement upon manipulation thereof, a computing slide mounted beneath each row of keys and having a plurality of stop-recesses spaced from each other lengthwise of the slide by distances which, in terms of a select unit of measure, represent successive integers, said slide having a pair of barrels each provided with a plurality of stops respectively positioned for engagement each with one of the stop-plates, said stops being circumferentially so arranged to respectively represent the units and tens components of the products of all digits whereby to permit different amounts of rotary travel of the computing barrels depending upon which stop-plate is shifted downwardly as a result of manipulation of its associated multiplier key for engagement with its corresponding stop, a vertically shiftable stop-member associated with each multiplicand key and each being engageable, upon manipulation of its associated multiplicand key, with only the stop-recess of the slide corresponding to the integer which the manipulated multiplicand key represents, means actuable responsive to manipulation of any selected multiplicand key for shifting the slide until the corresponding stop-member and stop-recess become engaged, partial-revolution clutch means actuable responsive to downward shiftable movement of any one of the stop plates for connecting the driving means to the computing barrels for rotating the computing barrels for a portion of one revolution and thereupon releasing them, means for returning the released computing barrels to initial position, a totalizer, and means for simultaneously transmitting the rotary movement of the barrels to appropriate orders of said totalizer.

6. A calculator comprising a plurality of banks of multiplicand keys and a bank of multiplier keys, the keys in each bank respectively representing successive integers, a power driving means, a stop-plate in each bank of multiplicand keys operatively connected to and associated with each of the multiplier keys for vertical movement upon manipulation thereof, a computing slide mounted beneath each bank of multiplicand keys and having a plurality of stop-recesses spaced from each other lengthwise of the slide by distances which, in terms of a select unit of measure, represent successive integers, said slide having a pair of barrels each provided with a plurality of stops respectively positioned for engagement each with one of the stop-plates, said stops being circumferentially so arranged to respectively represent the units and tens components of the products of all digits whereby to permit different amounts of rotary travel of the computing barrels depending upon which stop-plate is shifted downwardly as a result of manipulation of its associated multiplier key for engagement with its corresponding stop, a vertically shiftable stop-member associated with each multiplicand key and each being engageable, upon manipulation of its associated multiplicand key, with only the stop-recess of the slide corresponding to the integer which the manipulated multiplicand key represents, means actuable responsive to manipulation of any selected multiplicand key for shifting the slide until the corresponding stop-member and stop-recess become engaged, over-running transmission means actuable responsive to downward shiftable movement of any one of the stop plates for connecting the driving means to the computing barrels for rotating the computing barrels for a portion of one revolution and thereupon releasing them, means for returning the released computing barrels to initial position, a totalizer, and means for transmitting the rotary movement of the barrels to appropriate orders of said totalizer.

7. A calculator, comprising in combination, a totalizer, power means, a plurality of shiftable selector elements, shiftable carriers, a pair of computing barrels mounted on each shiftable carrier with their longitudinal axes parallel to the line of carrier shift, one of the barrels of each pair having formed contours in its surface spaced along its length at intervals predetermined in accordance with a selected mathematical function and, by their position with relation to a predetermined reference line on the barrel, representing the unit components of the products of all digits, and the other barrel having similarly spaced and formed contours representative of the tens components of such products, means for transmitting to the appropriate orders of said totalizer differential movements corresponding to the contours at a selected longitudinal point on said barrels, means for shifting each of said carriers rectilinearly and differentially a predetermined distance in accordance with the aforesaid selected mathematical function, shiftable setting means for alternatively setting the calculator for multiplication or addition, means for returning the carriers to alternative positions such that, when the shiftable setting means is shifted to the multiplication position, all carriers will be moved to neutral position and, when the shiftable setting means is shifted to the addition position, all carriers will be moved to a multiplicand position corresponding to the digit 1, a primary key bank having a plurality of rows of keys, each key having associated with it a shiftable selector element and each row having individually associated with it a shiftable carrier, and all keys being simultaneously movable by the shiftable setting means to alternative positions for multiplication and addition, whereby in the multiplying position, manipulation of a key in a row will actuate the shifting means of the shiftable carrier associated with that row to a multiplicand position corresponding to the integer represented by the key actuated, and whereby in the adding position manipulation of a key in a row will actuate its associated shiftable stop-plate to interpose itself in position for engaging with the appropriate stops on the computing barrels, and concurrently cause the power means to actuate the totalizer through the said transmitting means to record a number corresponding to the key depressed, and a bank of multiplier keys simultaneously movable in conjunction with the primary bank to alternative positions, each key having associated with itself a shiftable selector element in each primary row corresponding to the number it represents and

whereby, in the multiplying position, manipulation of a key will operate its associated shiftable selector elements to select the appropriate contours on the computing barrels and concurrently cause the power means to actuate the totalizer through the said transmitting means to record a number corresponding to the product of the multiplier key depressed and the multiplicand set into the machine by prior manipulation of the primary keys and whereby in the addition position all said multiplier keys will be ineffective.

8. A calculator comprising a row of multiplier keys corresponding to each of the nine primary digits and zero, rows of multiplicand keys, the keys in each row corresponding to each of the nine primary digits and zero, power driving means, a carrier shiftably mounted beneath each row of multiplicand keys, shifting means actuable upon manipulation of a selected multiplicand key for moving each of said carriers rectilinearly and differentially out of its initial position by a distance proportional to the integer represented by such selected multiplicand key, a plurality of stop-plates each shiftably mounted adjacent to and in conjunction with one of the multiplicand keys, means actuable responsive to movement of a selected multiplier key to operate in each multiplicand row the stop-plate mounted adjacent to the multiplicand key having a notation corresponding to said selected multiplier key, a pair of computing elements mounted in each carrier having a plurality of stops so arranged as to permit different amounts of movement of the computing elements until arrested by the respective stop-plate brought into co-operating position upon manipulation of each of the multiplier keys, the amount of movement in each case representing a multiple of the integer represented by each multiplier key respectively, each of said carriers being adapted for movement by the shifting means upon manipulation of a selected multiplicand key to a unique position such as to bring into operative relation with each stop-plate in that row the stops representing that multiple which is the product of the two integers respectively corresponding to the selected multiplicand key and the multiplier key operating the respective stop-plate, means actuable responsive to movement of any one of the multiplier keys for connecting the driving means to the computing elements for moving said computing elements, and totalizer means actuated by the movement of the computing elements for accumulating a corresponding numerical value.

9. A calculator comprising a row of multiplier keys corresponding to each of the nine primary digits and zero, rows of multiplicand keys, the keys in each row corresponding to each of the nine primary digits and zero, power driving means, a carrier shiftably mounted beneath each row of multiplicand keys, shifting means actuable upon manipulation of a selected multiplicand key for moving each of said carriers rectilinearly and differentially out of its initial position by a distance proportional to the integer represented by such a selected multiplicand key, a plurality of stop mechanisms each shiftably mounted adjacent to and in conjunction with one of the multiplicand keys, means actuable responsive to movement of a selected multiplier key to operate in each multiplicand row the stop mechanism mounted adjacent to the multiplicand key having notation corresponding to said selected multiplier key, a pair of computing elements mounted in each carrier having a plurality of stops so arranged as to permit different amounts of movement of the computing elements until arrested by the respective stop mechanism brought into co-operating position upon manipulation of each of the multiplier key means, the amount of movement in each case representing a multiple of the integer represented by each multiplier key respectively, the stops on one of said computing elements representing the units integer of such multiple and the stops on the other of said computing elements representing the tens integer of such multiple, each of said carriers being adapted for movement by the shifting means responsive to manipulation of a selected multiplicand key to a unique position such as to bring into operative relation with each stop mechanism in the row the stops representing that multiple which is the product of the two integers respectively corresponding to the selected multiplicand key and the multiplier key operating the respective stop mechanism, means actuable responsive to movement of any one of the keys for connecting the driving means to the computing elements for moving said computing elements, and totalizer means actuated by the movement of the computing elements for accumulating a corresponding numerical value.

10. A calculator comprising, in combination, a totalizer, power means, a plurality of shiftable selector elements, carriers mounted for movement in a straight line, a pair of computing elements mounted on each shiftable carrier with their longitudinal axes parallel to the line of carrier shift, one of the elements of each pair having formed contours in its surface spaced along its length at predetermined intervals and representing, by their position with relation to a predetermined reference line on the element in terms of a selected unit of measurement, units components of the products of each of the nine primary digits with each other and with zero, the other element having similarly spaced and formed contours representative of the tens components of such products, means for transmitting to the appropriate orders of said totalizer differential movements corresponding to the contours at a selected longitudinal point on said elements, means for differentially shifting each of said carriers a predetermined distance, shiftable setting means for alternatively setting the calculator for multiplication or addition, means for returning the carriers to alternative positions such that, when the shiftable setting means is shifted to the multiplication position, all carriers will be moved to neutral position and, when the shiftable setting means is shifted to the addition position, all carriers will be moved to a multiplicand position corresponding to the digit 1, a primary key bank having a plurality of rows of keys, each key having associated with it a shiftable selector element, each row having keys corresponding to each of the nine primary digits and zero and each row having individually associated with it a shiftable carrier, a multiplier key bank consisting of a row of keys corresponding to each of the nine primary digits and zero, each key having associated with itself a shiftable selector element in each primary row corresponding to the number it represents, means actuable by the shiftable setting means for shifting all primary and multiplier keys to alternative positions for multiplication and addition whereby, when shifted to the multiplying position, all key means will be rotated such that manipulation of a key in a row in the primary bank will actuate the shifting means of

the shiftable carrier associated with that row to a multiplicand position corresponding to the integer represented by the key actuated and such that manipulation of a multiplier key will operate its associated shiftable selector elements to select the appropriate contours on the computing elements and concurrently cause the power means to actuate the totalizer through the said transmitting means to register a number corresponding to the product of the number represented by the multiplier key depressed and the multiplicand set into the machine by prior manipulation of the primary keys and whereby, when shifted to the adding position, all keys will be rotated so that manipulation of a key in a row in the primary bank will actuate its associated shiftable selector element to select the appropriate contour on its associated computing elements and concurrently cause the power means to actuate the corresponding order of said totalizer through the said transmitting means to register a number corresponding to the key depressed and such that all multiplier keys will be ineffective.

11. A calculator comprising, in combination, a totalizer, power means, carriers mounted for shifting movement in a selected line, stop plates, a pair of computing barrels mounted on each shiftable carrier with their longitudinal axes parallel to the line of carrier shift, one of the barrels of each pair having a plurality of stops in its surface spaced along its length at predetermined intervals each so arranged as to permit different amounts of rotary travel of the barrel depending upon which stop plate is moved to engage it and representing, by their position with relation to a predetermined reference line on the barrel in terms of a selected unit of measurement, units components of the products of each of the nine primary digits with each other and with zero and the other barrel having similarly spaced and formed stops representative of the tens components of such products, means for transmitting to the appropriate orders of said totalizer differential rotary movements of the barrels corresponding to the stops at a selected longitudinal point on said barrels, means for differentially shifting each of said carriers a predetermined distance, a primary key bank associated with each carrier, said key bank having a plurality of rows of keys, each row having keys corresponding to each of the nine primary digits and zero, each key in a row being associated with one stop plate, a multiplier key bank consisting of a row of keys corresponding to each of the nine primary digits and zero and means such that all stop plates of the several rows corresponding to a selected digit are operable by manipulation of the multiplier key corresponding to that selected digit, means for returning said carriers to predetermined position, shiftable setting means for alternatively setting the calculator for multiplication or addition whereby, when said setting means is shifted to its multiplying position, the returning means will be actuated to move all carriers to their neutral position and all key means will be moved to a position such that manipulation of a key in a row in the primary bank will actuate the shifting means of the shiftable carrier and computing barrels mounted thereon associated with that row to a multiplicand position corresponding to the integer represented by the key actuated and such that manipulation of a multiplier key will cause the stop plates operatively connected to it to move to a position to engage the stops on their associated computing barrels and engage the power means so as to rotate the barrels until the stops engage the stop plates and thus actuate the totalizer through the said transmitting means to register a number corresponding to the product of the number represented by the multiplier key depressed and the multiplicand set into the machine by prior manipulation of the primary keys and whereby, when said setting means is shifted to its adding position, the returning means will be actuated to move each carrier and computing barrels mounted thereon into multiplicand position corresponding to digit 1 and all key means will be moved to a position such that manipulation of a key in a row in the primary bank will cause the stop plate operatively connected to it to move to a position to engage the stops on its associated computing barrels and simultaneously engage the power means so as to rotate the barrels until the stops engage the stop plate and thus actuate the totalizer through the said transmitting means to register a number corresponding to the key depressed and such that all multiplier keys will be ineffective.

12. A calculator comprising, in combination, a totalizer, power means, carriers mounted for shifting movement in a straight line, a pair of computing elements mounted on each shiftable carrier with their longitudinal axes parallel to the line of carrier shift, one of the elements of each pair having formed contours in its surface spaced along its length at predetermined intervals, each contour representing, by its position with relation to a predetermined reference line on the element in terms of a selected unit of measurement, the unit component of the product of each of the nine primary digits with one other and with zero and the other element having similarly spaced and formed contours each representative of the tens component of such product, there being at least one contour on each element corresponding to each product of each of the nine primary digits with each other and with zero, means for transmitting to the appropriate orders of said totalizer differential movements corresponding to the contours at a selected longitudinal point on said elements, a primary key bank having a plurality of rows of keys, each row having keys corresponding to each of the nine primary digits and zero and each row having individually associated with one of said shiftable carriers, means actuable upon manipulation of a key in a row in the primary bank for positioning the shiftable carrier associated with that row to a multiplicand position corresponding to the integer represented by the key actuated, a multiplier key bank consisting of a row of keys corresponding to each of the nine primary digits and zero, a plurality of shiftable elements each mounted adjacent to and in conjunction with one of the primary keys, means actuable responsive to movement of a selected multiplier key to operate in each primary row a shiftable element mounted adjacent to the primary key having the same notation as said selected multiplier key to select that longitudinal point on the computing elements, movements corresponding to the contours at which point are to be transmitted to the totalizer by the transmitting means, and means such that manipulation of a multiplier key will cause the power means to actuate the totalizer through the said transmitting means to register a number corresponding to the product of the number represented by the multiplier key manipulated and the multiplicand set into the ma-

chine by prior manipulation of the primary keys.

13. A calculator comprising a plurality of rows of multiplicand key means and a row of multiplier key means, each key in a row corresponding to one of the nine primary digits and zero, respectively, power driving means, a shiftable carrier mounted in conjunction with each row of multiplicand keys and having a plurality of stop faces on its surface, means for rectilinearly and differentially shifting the carriers, trigger means for releasing the carriers so that they can be moved by the shifting means, a shiftable member operatively associated with each multiplicand key and with the trigger means, so arranged that manipulation of a selected multiplicand key will move the member into position to engage a corresponding stop face on the carrier and simultaneously release the trigger means, thus permitting the carrier shifting means to move the carrier a predetermined distance corresponding to the selected multiplicand key manipulated, a stop-plate mounted in conjunction with each multiplicand key and operatively associated with the multiplier key having the same notation as said multiplicand key, rotary calculating barrels mounted in the shiftable carriers, each having a plurality of stops so arranged as to permit different amounts of rotation of said barrels depending upon which stops have been moved into engaging position by travel of the carriers and upon which stop-plates have been moved into engaging position as a result of manipulation of a selected multiplier key, part-revolution clutches actuable responsive to movement of any of the stop-plates for connecting the driving means to the computing barrels and rotarily driving them until the respective barrels are stopped by engagement of their stops and the corresponding stop-plates, totalizer means actuated by rotation of the computing barrels for accumulating a corresponding total, means for automatically returning the computing barrels to rotational neutral position ready for performing another multiplying operation with the same multiplicand setting of the computing carriers, and means for returning the shiftable carriers to neutral position, locked by their respective trigger means, so that said carriers can be reset into new multiplicand positions.

14. A calculator comprising a plurality of banks of multiplicand keys and a bank of multiplier keys, each key of each bank respectively representing a successive integer, power driving means, a stop-plate mounted adjacent to and in conjunction with each multiplicand key and operatively connected to and associated with the multiplier key representing the same integer as said adjacent multiplicand key, a shiftable carrier associated with each bank of multiplicand keys having a plurality of stop recesses formed in its surface, each having a length between stop faces which, in terms of a selected unit of measure, is respectively a mathematical function of one of the successive integers represented by the said multiplicand keys, means for shifting the carrier rectilinearly and differentially in the direction of its length, trigger means for releasing the carrier so it can be moved by its shifting means, a vertically shiftable stop member associated with each multiplicand key and operatively connected to the said trigger means in such manner that manipulation of a selected multiplicand key will engage and shift the associated stop member into that stop recess in the carrier corresponding to the integer represented by the selected multiplicand key and simultaneously operate the trigger means to release the carrier so that the shifting means can move the carrier until the stop face of the stop recess engages the stop member, a pair of computing barrels mounted on each carrier, each provided with a plurality of stops respectively positioned along its length such that manipulation of a selected multiplier key will bring one of its associated stop-plates into position for engaging with one of the barrel stops, depending upon the previous movement of the carrier as a result of manipulation of a selected multiplicand key and on the selected multiplier key, said stops being circumferentially so arranged on one barrel as to represent the units components, and on the other barrel the tens components, of the products of all digits, whereby to permit different amounts of rotary travel of the computing barrels depending upon which selected multiplicand and multiplier keys are manipulated, a partial revolution clutch in conjunction with each carrier actuable responsive to operation of any stop-plate in its associated multiplicand bank for connecting the driving means to the computing barrels for rotating each barrel until the barrel is stopped by engagement of one of the barrel stops with said operated stop plate, and releasing the barrels upon completion of said predetermined partial revolution, means for returning the released barrels to rotational initial position, a totalizer, and means for transmitting the rotary movement of the barrels to appropriate orders of said totalizer.

15. A calculator comprising a plurality of banks of multiplicand keys and a bank of multiplier keys, each key of each bank respectively representing a successive integer, power driving means, a stop-plate mounted adjacent to and in conjunction with each multiplicand key and operatively connected to and associated with the multiplier key representing the same integer as said adjacent multiplicand key, a shiftable carrier associated with each bank of multiplicand keys having a plurality of stop recesses formed in its surface, each having a length between stop faces which in terms of a selected unit of measure is respectively a mathematical function of one of the successive integers represented by the said multiplicand keys, means for shifting the carrier rectilinearly and differentially in the direction of its length, trigger means for releasing the carrier so it can be moved by its shifting means, a vertically shiftable stop member associated with each multiplicand key and operatively connected to the said trigger means in such manner that manipulation of a selected multiplicand key will engage and shift the associated stop member into that stop recess in the carrier corresponding to the integer represented by the selected multiplicand key and simultaneously operate the trigger means to release the carrier so that the shifting means can move the carrier until the stop face of the stop recess engages the stop member, a pair of computing barrels mounted on each carrier, each provided with a plurality of stops respectively positioned along its length such that manipulation of a selected multiplier key will bring one of its associated stop-plates into position for engaging with one of the barrel stops, depending upon the previous movement of the carrier as a result of manipulation of a selected multiplicand key and on the selected multiplier key, said stops being circumferentially so arranged on one barrel as to represent the units components, and on the other barrel the tens

components, of the products of all digits, whereby to permit different amounts of rotary travel of the computing barrels depending upon which selected multiplicand and multiplier keys are manipulated, overrunning transmission means in conjunction with each carrier actuable responsive to operation of any stop-plate in its associated multiplicand bank for connecting the driving means to the computing barrels for rotating each barrel until the barrel is stopped by engagement of one of the barrel stops with said operated stop-plate, and releasing the barrels upon completion of rotary movement thereof, means for returning the released barrels to rotational initial position, a totalizer, means for transmitting the rotary movement of the barrels to appropriate orders of said totalizer, and means for returning each carrier to neutral position locked by its respective trigger means so that the computing barrels can be reset into new multiplicand positions.

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