

W. D. BEARD.
MULTIPLYING MACHINE.
APPLICATION FILED MAR. 11, 1916

1,289,610.

Patented Dec. 31, 1918.

15 SHEETS—SHEET 1.

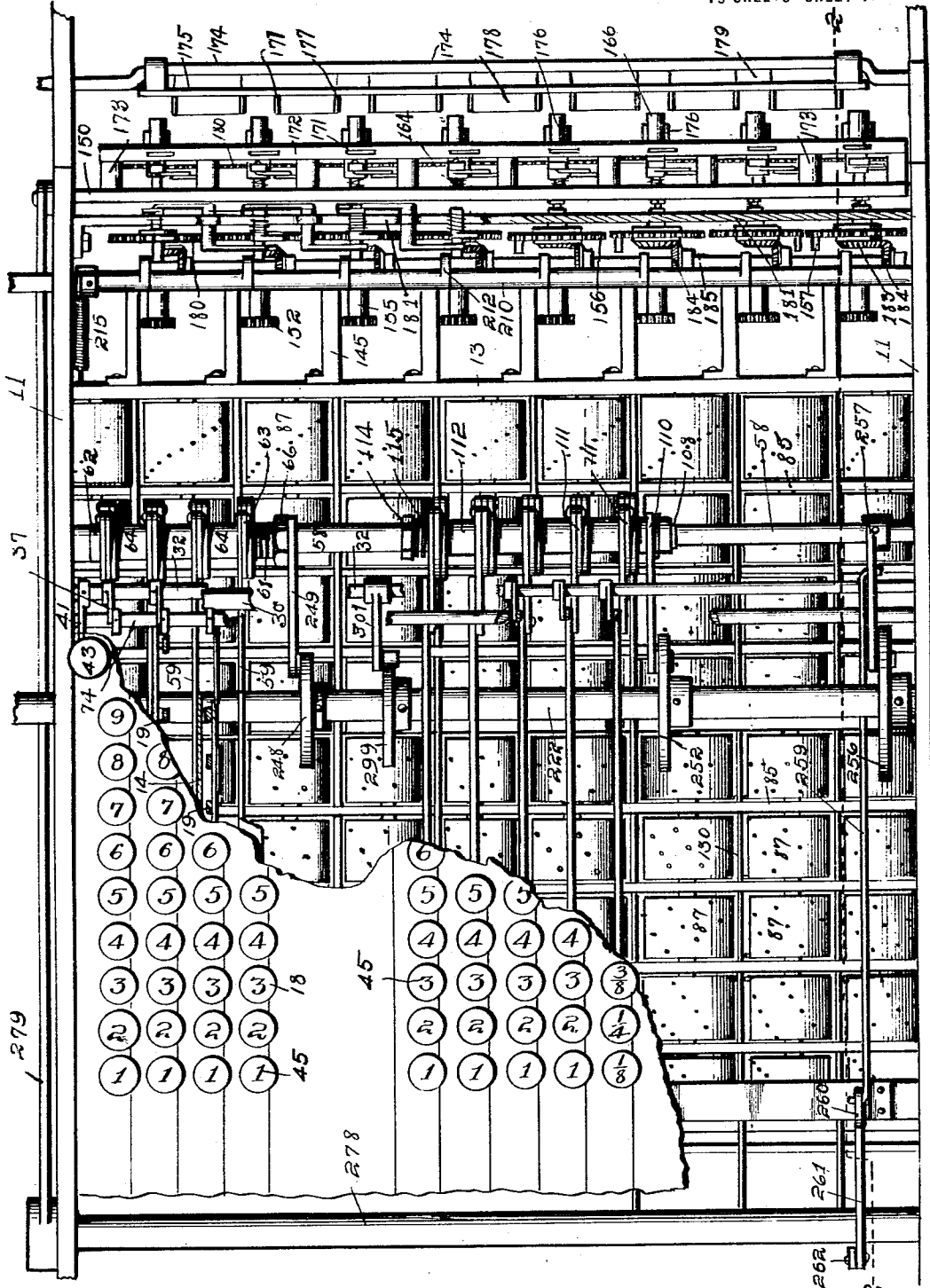
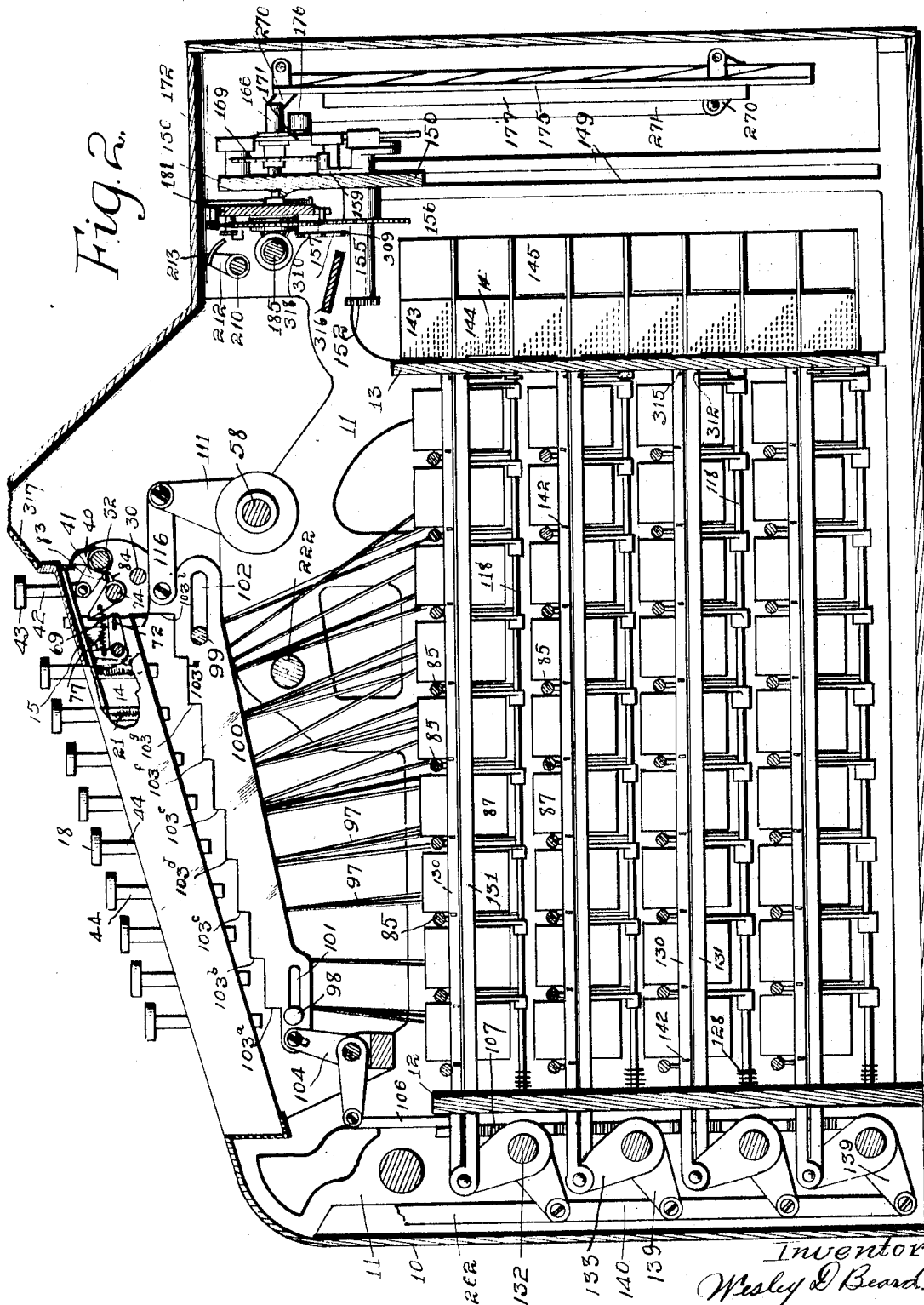


Fig. 1.

Inventor.
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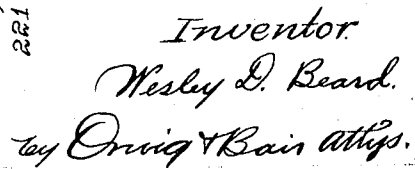
Fig. 2.



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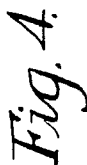
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Fig. 3.



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15 SHEETS—SHEET 4.

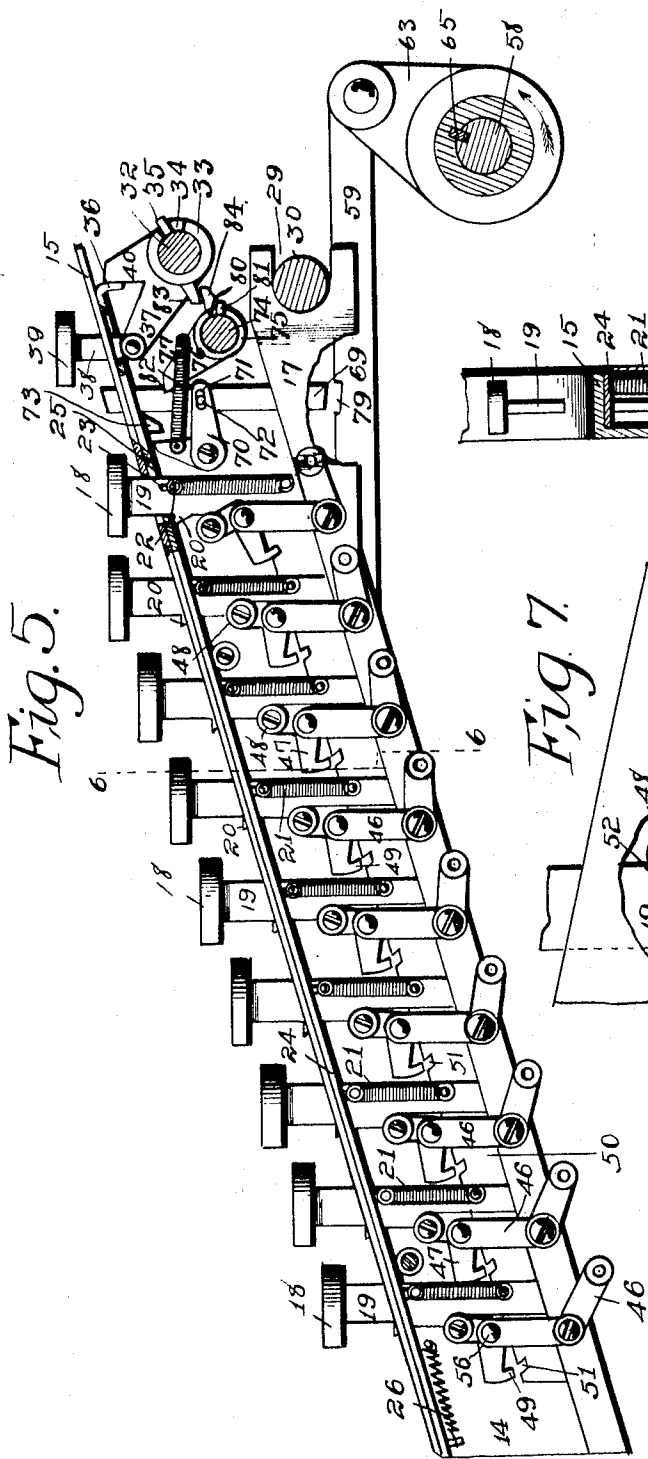
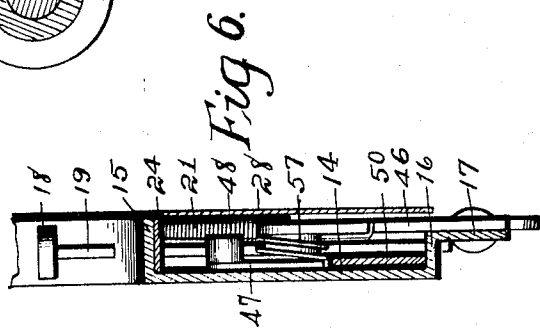
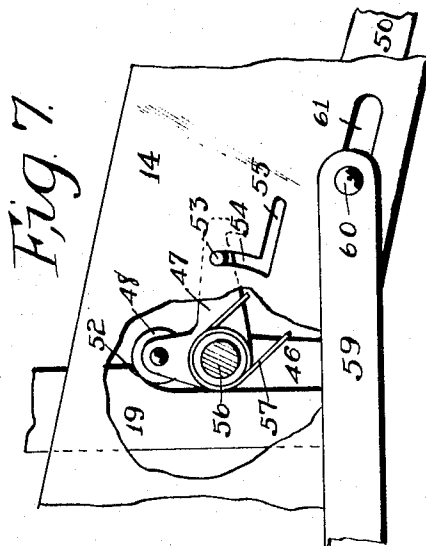


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MULTIPLYING MACHINE.
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15 SHEETS—SHEET 5.



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1,289,610.

Fig. 8.

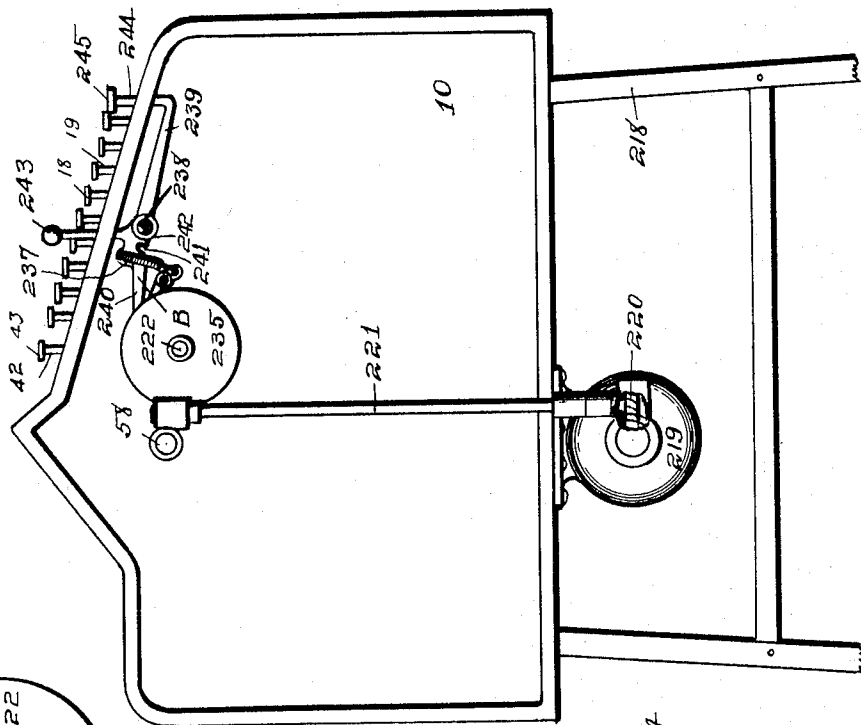


Fig. 11.

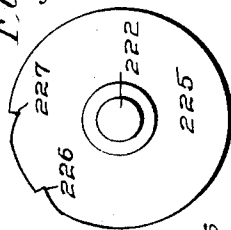


Fig. 9.

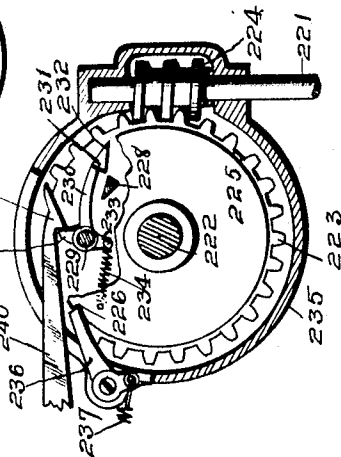
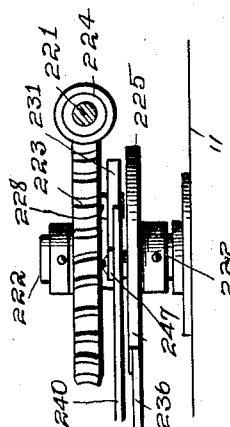


Fig. 10.



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G. A. JULIUS & F. A. WILKINSON.
MANUALLY CONTROLLED MACHINE FOR PRINTING AND ISSUING DIFFERENTIATED TICKETS
AND RECORDING THE ISSUE THEREOF.

APPLICATION FILED MAY 21, 1918.

Patented Dec. 24, 1918.

8 SHEETS—SHEET 7.

1,288,910.

Fig. 13

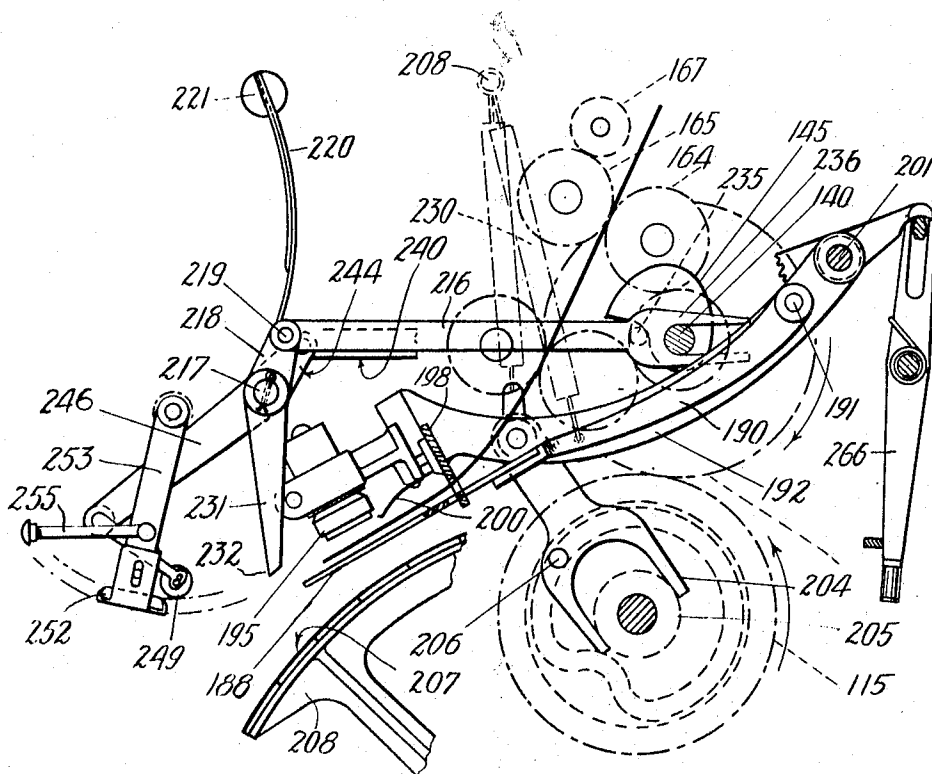
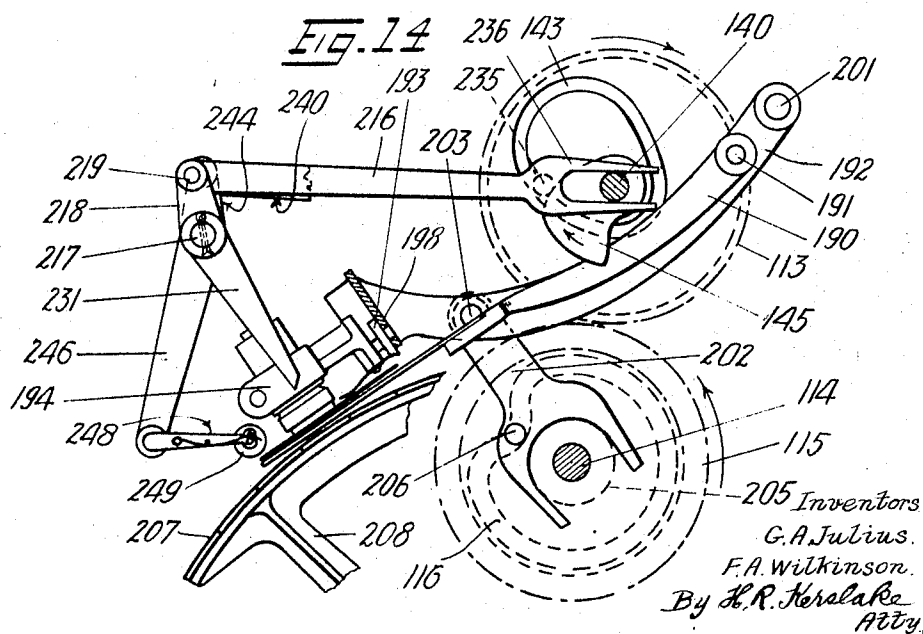
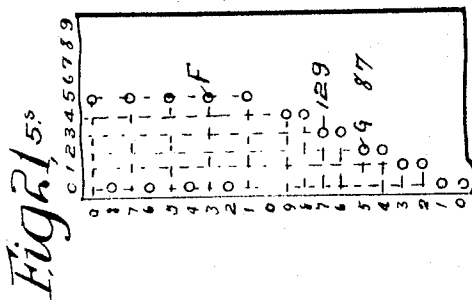
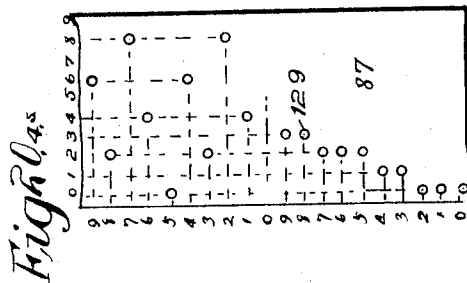
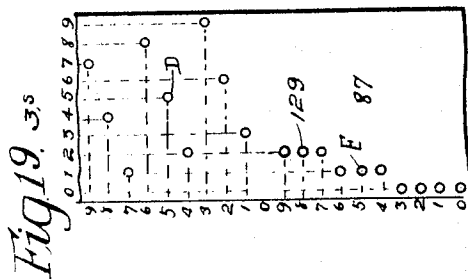
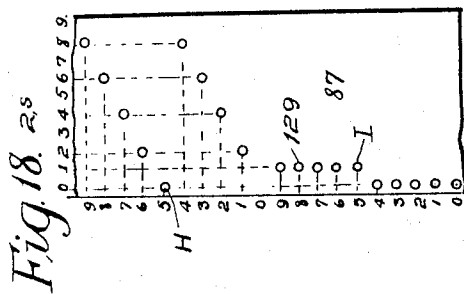
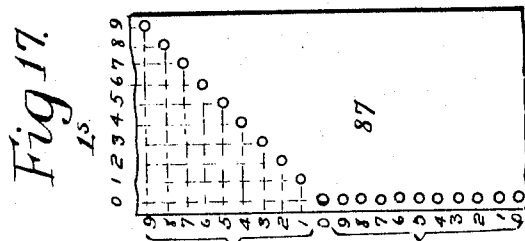
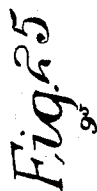
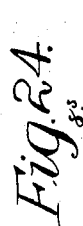
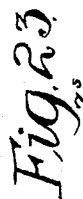
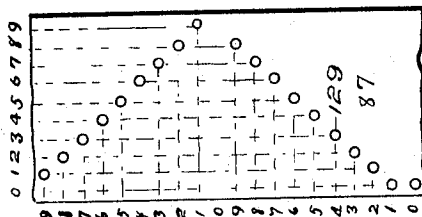
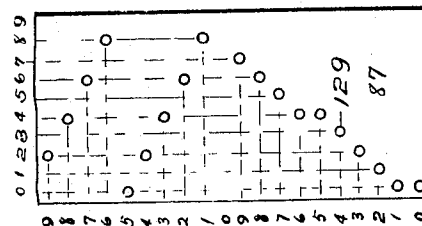
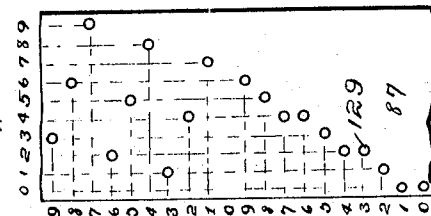
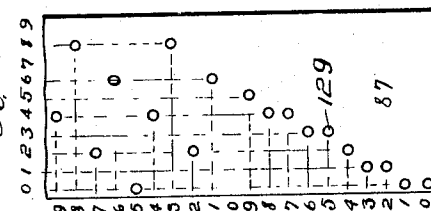


Fig. 14



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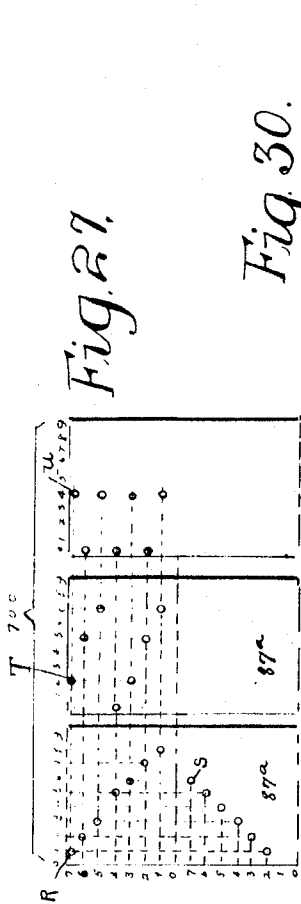


Fig. 27.

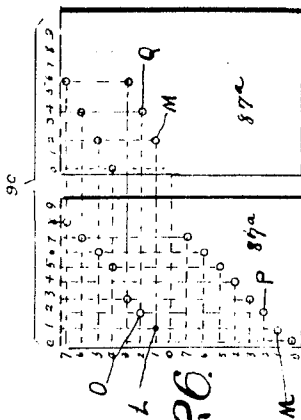


Fig. 26.

Fig. 30.

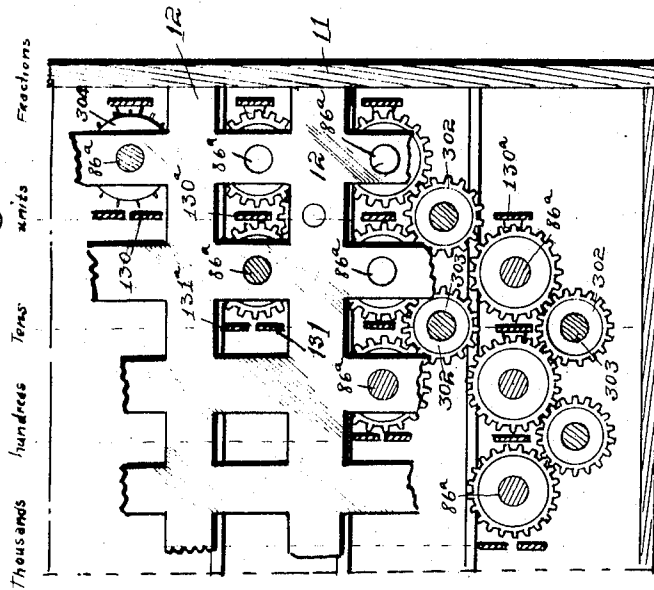


Fig. 31.

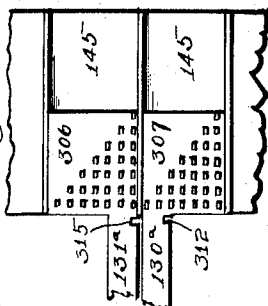


Fig. 28.

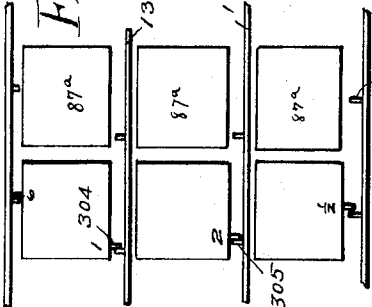
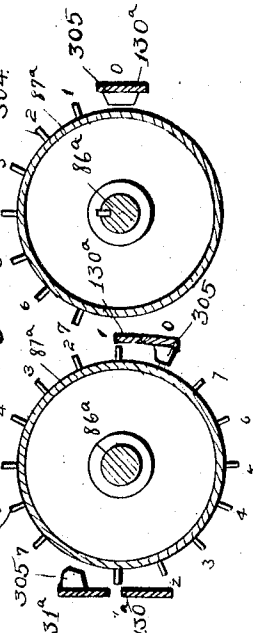


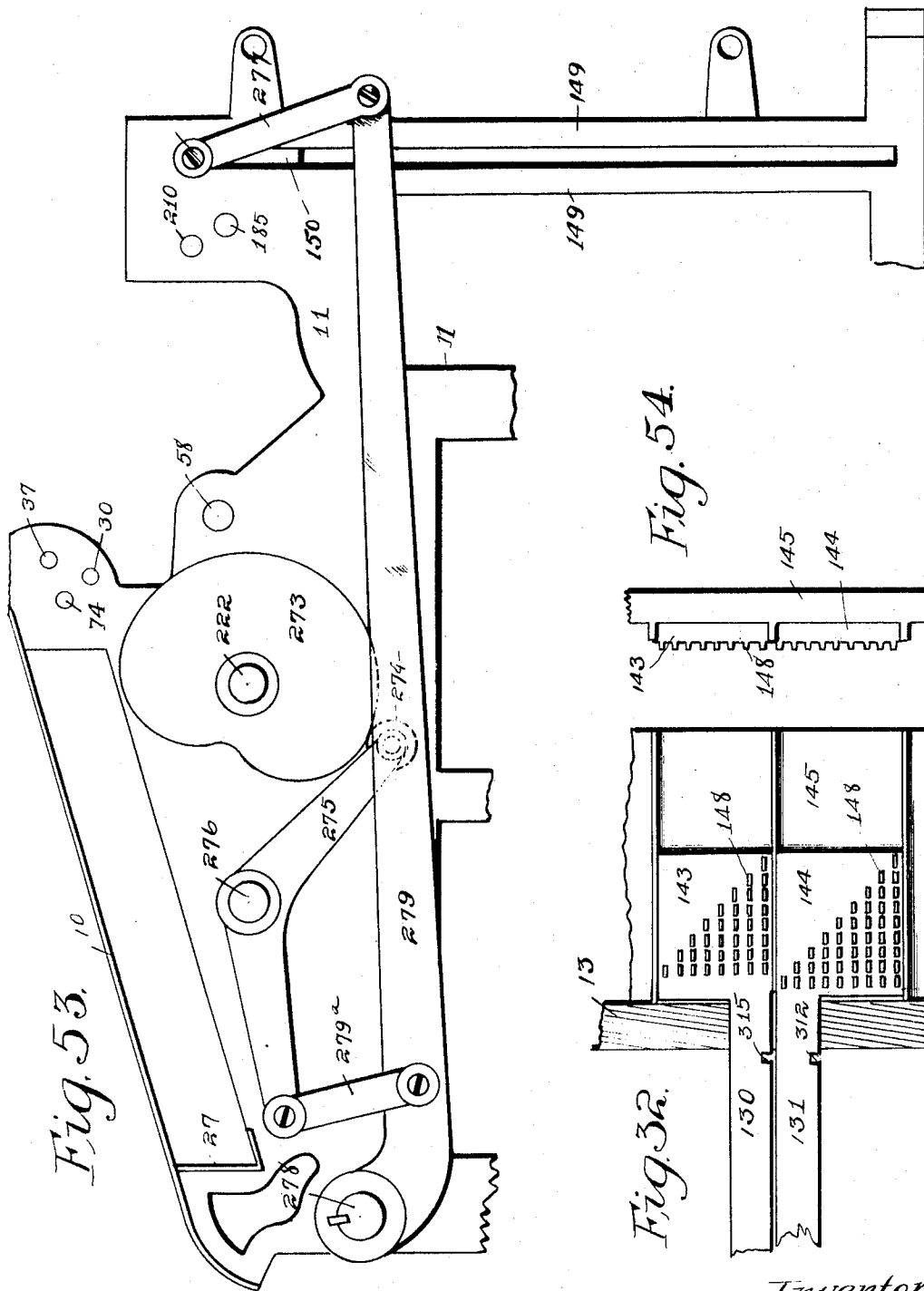
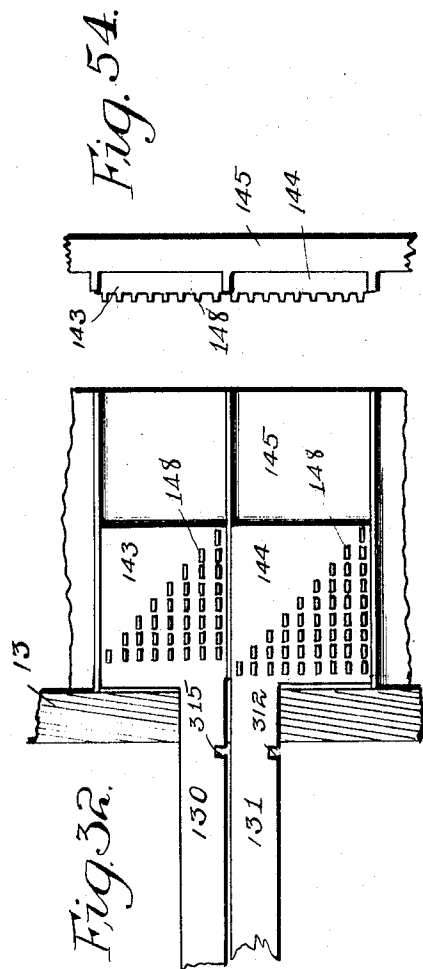
Fig. 29.



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15 SHEETS—SHEET 10.



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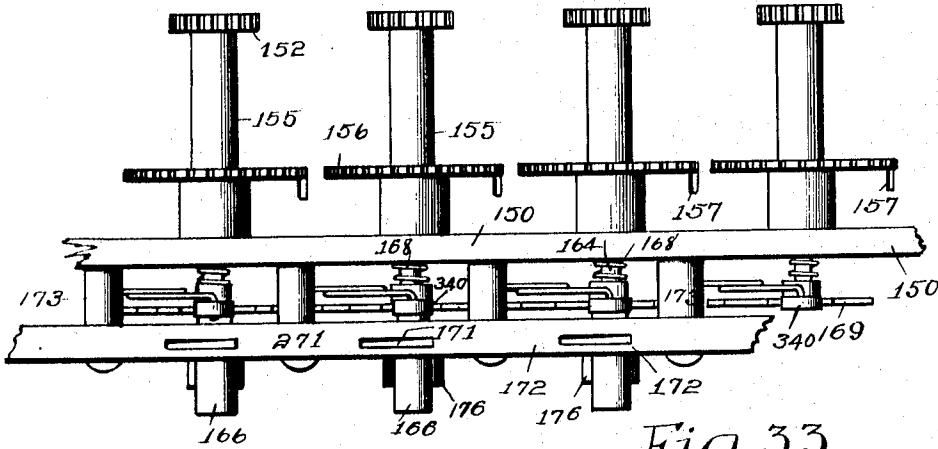


Fig. 33.

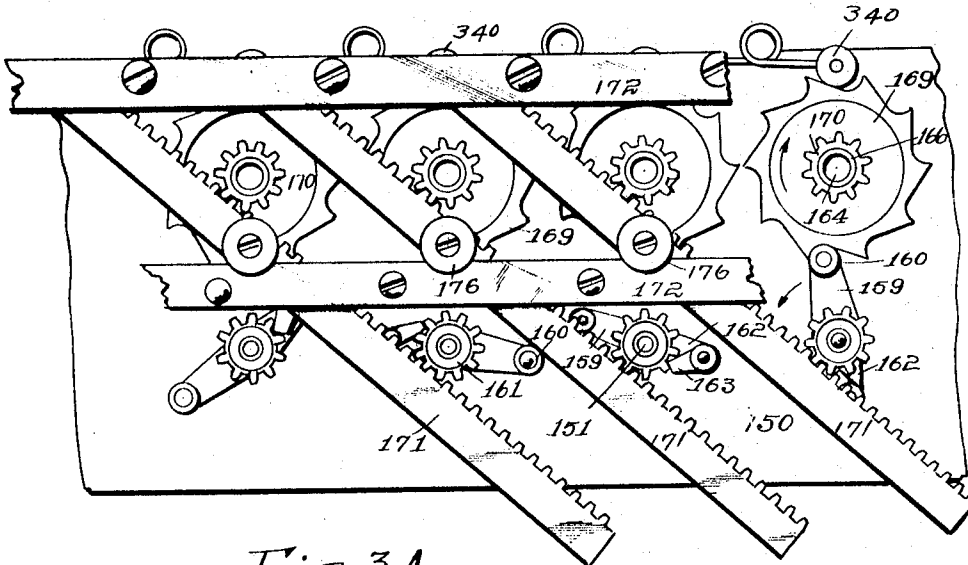
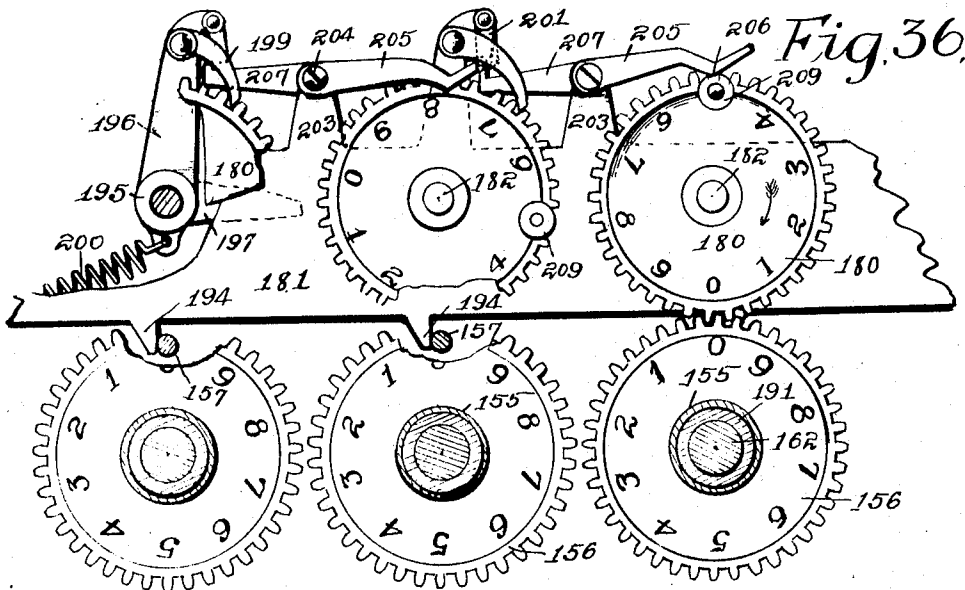
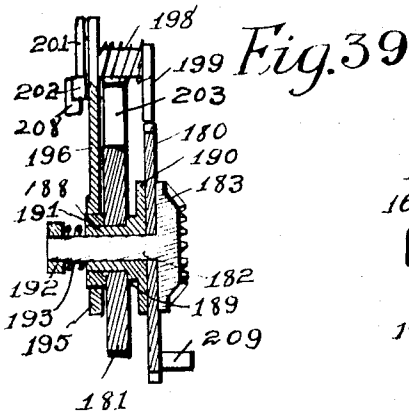
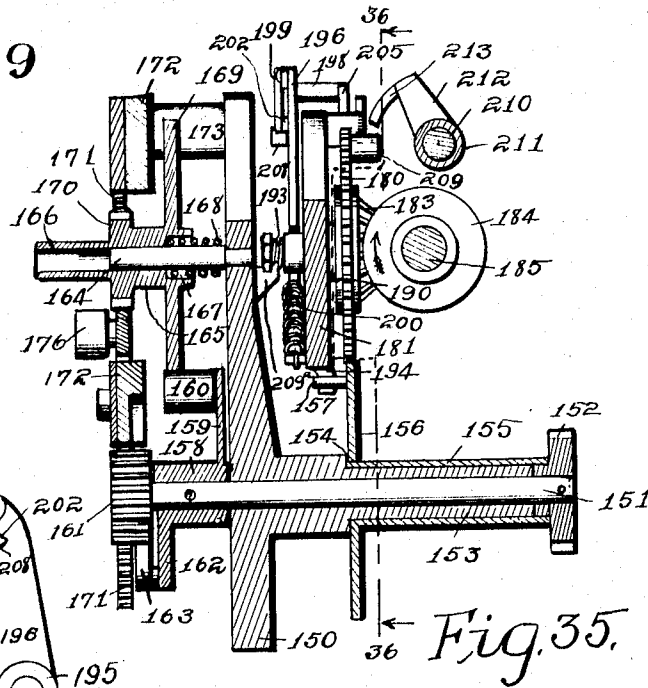
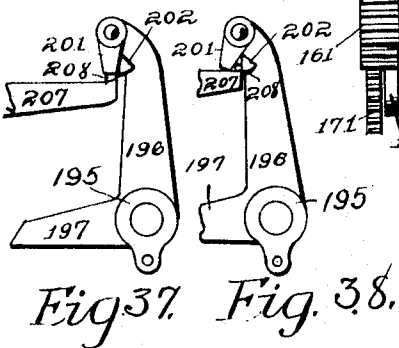


Fig. 34.

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Fig. 41.

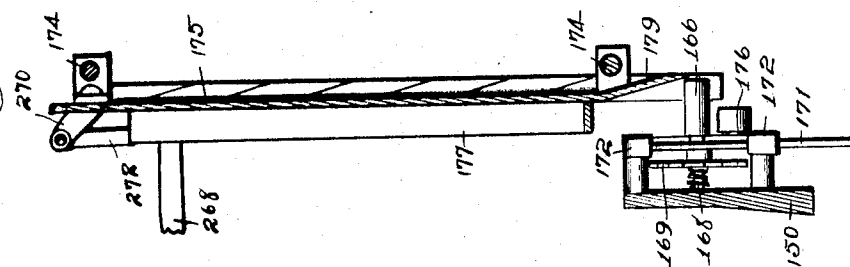
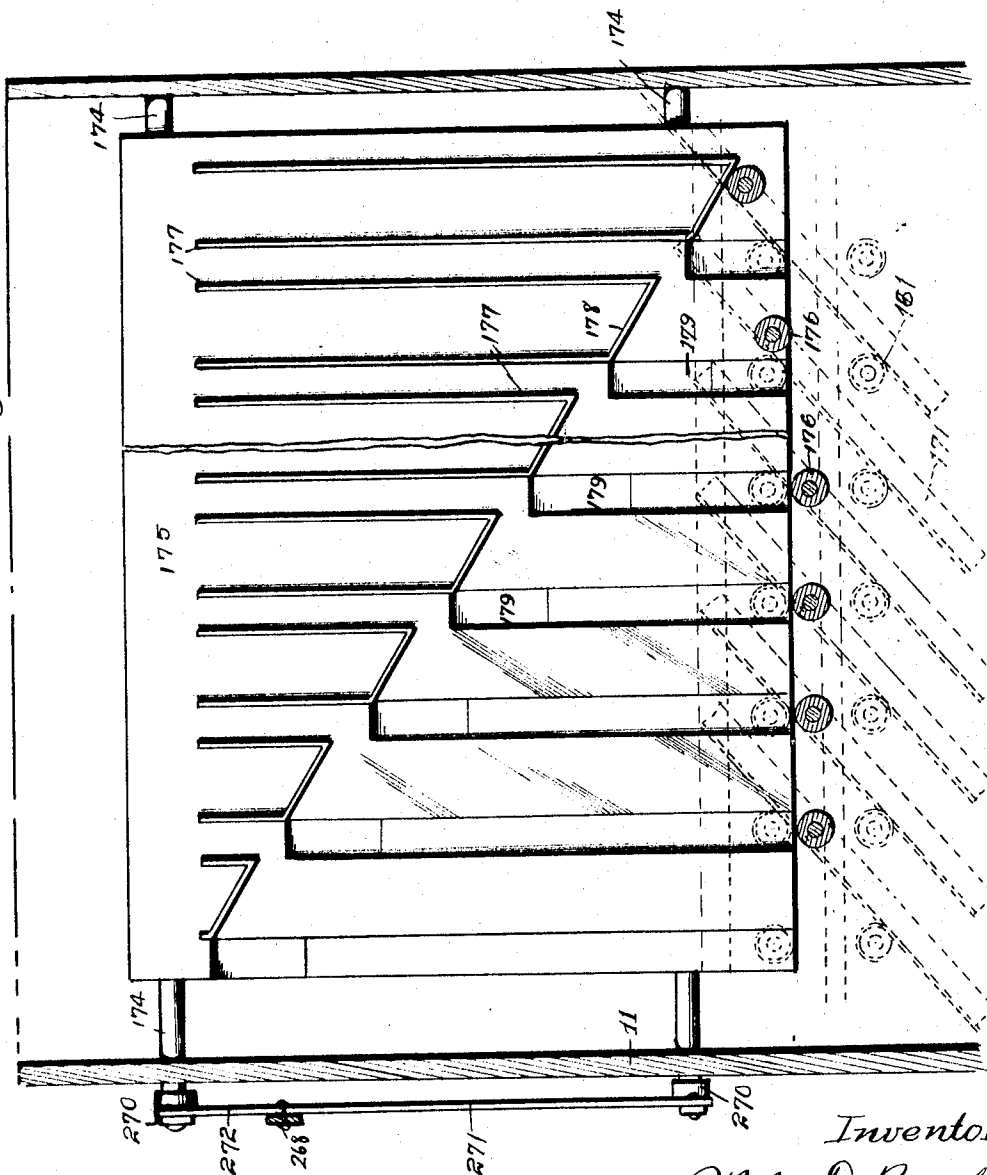


Fig. 40.



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Patented Dec. 31, 1918.

15 SHEETS—SHEET 14.

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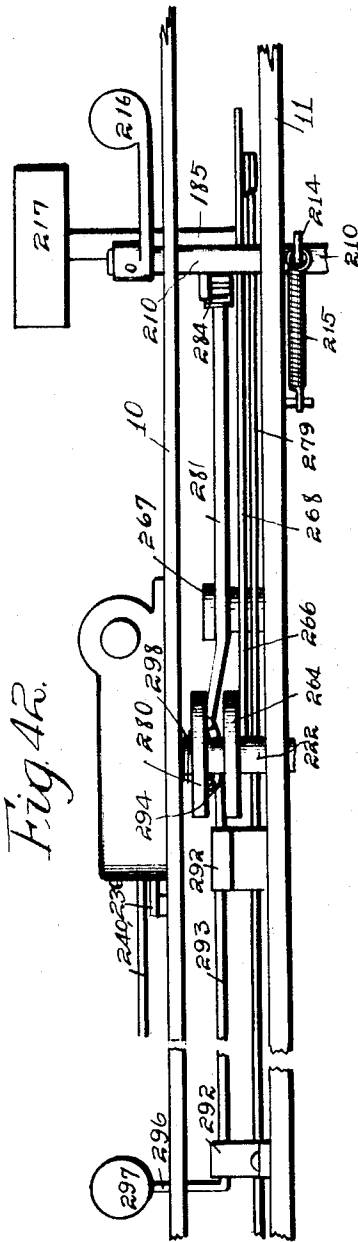


Fig. 44.

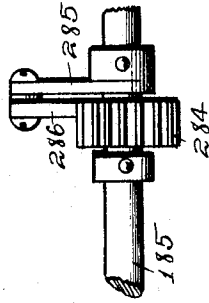


Fig. 43.

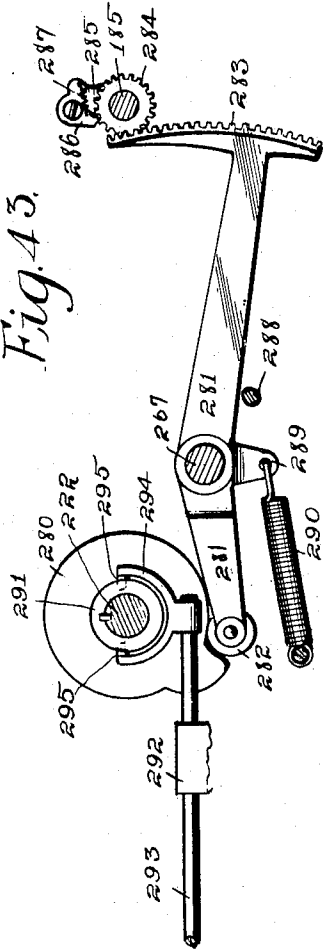
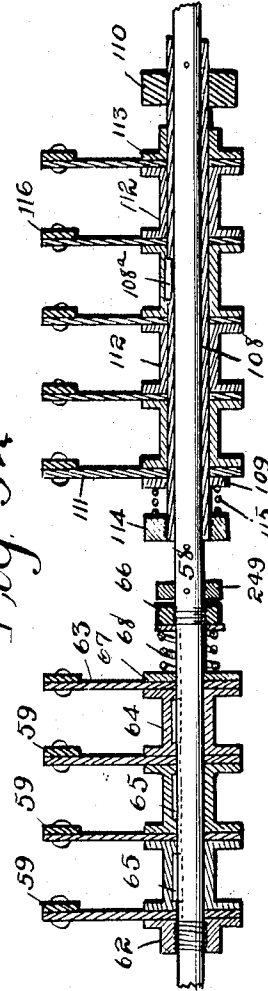


Fig. 52.



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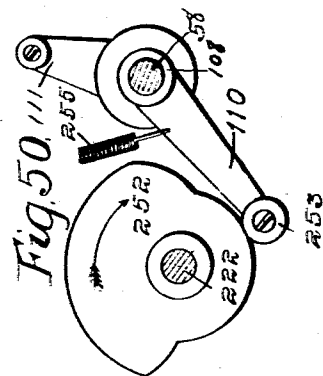


Fig. 51.

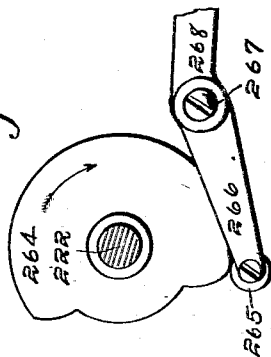
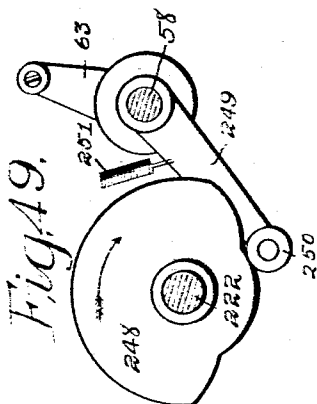


Fig. 48.

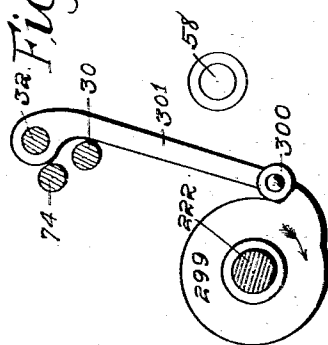


Fig. 47.

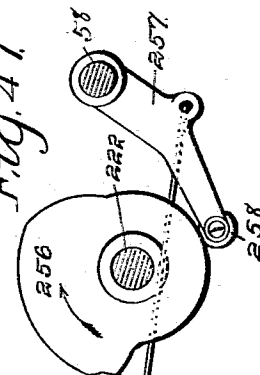


Fig. 45.

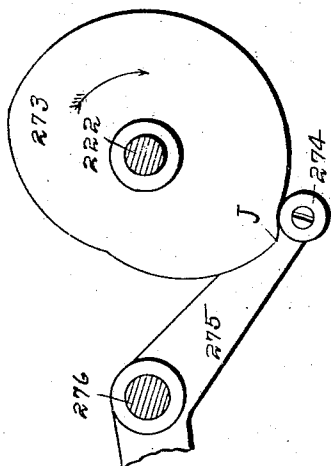
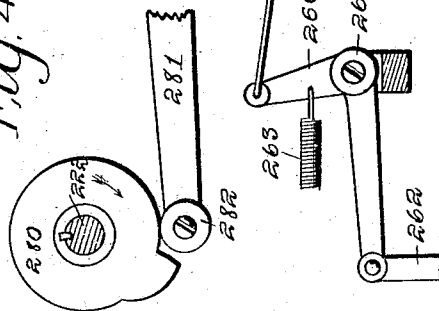


Fig. 46.



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UNITED STATES PATENT OFFICE.

WESLEY D. BEARD, OF DES MOINES, IOWA.

MULTIPLYING-MACHINE.

1,289,610.

Specification of Letters Patent.

Patented Dec. 31, 1918.

Application filed March 11, 1916. Serial No. 83,579.

To all whom it may concern:

Be it known that I, WESLEY D. BEARD, a citizen of the United States, and resident of Des Moines, in the county of Polk and State of Iowa, have invented a certain new and useful Multiplying-Machine, of which the following is a specification.

My invention relates to multiplying machines.

10 In general it is my object to provide a machine which will perform mathematical calculations, especially of multiplication, mechanically in a minimum time.

15 It is my purpose to make a machine of the type mentioned with a minimum number of parts, and capable of performing multiplication with a minimum number of mechanical operations.

20 A further object is to make such a machine which may be operated by the user with a minimum number of movements, and which is so constructed that the user need have in mind only a few operations at a time, so that the device may be operated 25 with minimum mental strain.

30 A further object is to make such a machine in which the only manual operations necessary are the pressing of the multiplicand and the multiplier keys and the pressing of a starting button.

35 A further object is to make such a machine in which all the keys in both the multiplicand and multiplier may be pressed simultaneously, or one at a time.

40 A further object is to provide such a machine in which the multiplicand and multiplier may be set up on the keyboard and the machine then automatically operated to perform a complete operation of multiplication, and set up the answer with a minimum 45 distance of movements of the mechanical parts, whereby the multiplication is accomplished with maximum speed of operation, of the machine, and in a minimum time.

50 A further object is to provide in such a machine, means whereby the partial product resulting from the multiplication of the multiplicand by the various digits of the multiplier are simultaneously obtained and set up in the machine, and automatically 55 added together and set up in a final product in a minimum time.

A further object is to provide in such a machine new and effective carrying mechanism.

Still an additional purpose of my invention is to provide such a machine capable of performing the operation of multiplication and setting up the product, which product may then be taken off and the machine 60 cleared.

A further object is to provide such a machine capable of performing the operation of multiplication, registering the final result of the completed problem, retaining 65 such result, performing another operation of multiplication and automatically adding the result of the second multiplication and registering the sum of both operations and continuing to add in the results of additional 70 multiplications independently.

A further object is to provide in such a machine simple mechanism for multiplying fractions without reducing the fractions to decimals, and which will multiply by a 75 fraction indicated on a multiplier key and produce the correct result including a whole number and a fraction.

A further object is to provide simple and effective means for selecting out and making 80 operative certain operating cylinders or means.

My invention consists in the construction, arrangement and combination of the various parts of the device whereby the objects 85 contemplated are attained, as hereinafter more fully set forth, pointed out in my claims, and illustrated in the accompanying drawings, in which:

Figure 1 shows a top or plan view of part 90 of the machine, illustrating the relative arrangements of the banks of keys, the multiplier set of keys and the multiplicand set of keys being shown in plan, the upper casing of the machine being partially broken 95 away to show the mechanism of the interior thereof.

Fig. 2 shows a vertical, longitudinal, sectional view taken on the line 2—2 of Fig. 1.

Fig. 3 shows a front elevation of the 100 mechanism of the machine, the casing thereof being shown in vertical section.

Fig. 4 shows a longitudinal, vertical, sectional view through the casing and the transverse frame members of the machine, 105 one side of the frame being shown in side elevation from the inside of the machine, parts of the mechanism being shown assembled on the frame.

Fig. 5 shows an enlarged, detail view of 110

one of the banks of keys of the multiplicand set, in side elevation.

Fig. 6 is a vertical, transverse, sectional view taken on the line 6—6 of Fig. 5.

5 Fig. 7 is a detail view in side elevation of part of the mechanism operatively connected with one of the key stems, taken from the side opposite that shown in Fig. 5.

10 Fig. 8 shows a side elevation of the completed machine, illustrating the manner of mounting a motor thereon.

Fig. 9 shows an enlarged, detail, view of the mechanism for transmitting power from the motor to the main shaft of the machine, the gear casing being shown in vertical section.

Fig. 10 shows a top or plan view of the mechanism shown in Fig. 9, the gear casing being removed.

20 Fig. 11 shows a side elevation, in detail, of the disk or the main shaft, being the disk shown in Fig. 9.

Fig. 12 shows a detail, sectional view of the computing devices, which are shown herein as cylinders.

25 Fig. 13 shows a transverse, sectional view of two of the cylinder shafts with cylinders thereon, illustrating certain other mechanism.

30 Fig. 14 shows a detail, sectional view of one of the cylinders and the slide bars adjacent thereto.

Fig. 15 shows a detail view partly in section of a part of the retaining devices for holding the cylinders against floating movement, and the means for unlocking the slide bars.

40 Fig. 16 shows a detail, vertical, sectional view of part of the mechanism for operating the slide bars.

Figs. 17 to 25 inclusive show the computing cylinders laid out in plan, and illustrate the arrangement of the stops on said cylinders.

45 Fig. 26 shows a detail view of two cylinders laid out in plan, illustrating the arrangement of the stops, the stops being shown in proper arrangement for multiplying 90 by any fraction of a unit having eight for its denominator.

50 Fig. 27 shows a similar view of three cylinders, the stops being illustrated for showing the arrangement thereof for multiplying seven hundred by some fraction, having eight for a denominator.

55 Fig. 28 shows a top view of some of the computing cylinders, illustrating the arrangement thereof with relation to the slide bars.

60 Fig. 29 shows a sectional view of two of said computing cylinders, the slide bars being shown adjacent thereto.

Fig. 30 shows a detail view, partly in section, showing the arrangement of the frame, the shafts, the computing cylinders for mul-

tiplying by fractions, and the gearing mechanism for connecting said cylinders.

Fig. 31 shows a detail view of part of two slide bars, and step plates thereon used in multiplying fractions.

Fig. 32 shows a detail view of the toothed plates for one set of digits.

Fig. 33 shows a detail view of part of the cumulator mechanism shown in plan.

75 Fig. 34 shows a detail view of part of the cumulator mechanism shown in rear elevation.

Fig. 35 shows a detail, sectional view of part of the mechanism shown in Fig. 33.

80 Fig. 36 shows a detail, sectional view taken on the line 36—36 of Fig. 35, illustrating the part of the mechanism for obtaining the totals of a series of multiplications, and part of the mechanism for clearing the machine.

85 Fig. 37 shows a detail view of part of the carrying mechanism, shown in Fig. 36.

Fig. 38 shows a detail view of the same mechanism in a different position.

90 Fig. 39 shows a vertical, sectional detail view of the friction device for forming part of the clearing mechanism.

Fig. 40 shows a detail view of the plate for operating the carrying device of the cumulator mechanism.

95 Fig. 41 shows a transverse, sectional view of said plate and part of the mechanism operatively connected therewith.

100 Fig. 42 shows a detail, plan view of part of the controlling levers, and parts of the operating mechanism on the left side of the machine.

Fig. 43 shows a detail, sectional view of part of the means for operating the clearing mechanism.

105 Fig. 44 shows a detail view of the ratchet mechanism shown in Fig. 43.

110 Figs. 45 to 51 inclusive, show detail views of cams for operating the various mechanisms of the machine.

Fig. 52 shows a longitudinal, sectional view of one of the operating shafts and the mechanism mounted thereon.

115 Fig. 53 shows a detail, side elevation of the sliding frame members and part of the controlling mechanism therefor.

Fig. 54 shows a rear end view of two of the toothed plates, and

120 Fig. 55 shows a detail view of part of the locking mechanism for the slide bars.

In the form of my invention illustrated in the accompanying drawings, I have used the reference numeral 10 to indicate generally the inclosing casing for the machine, which casing may be of any suitable shape, size and material, for protecting the mechanism from dust and the like, and to give it the proper appearance.

Suitably mounted within the casing 10 is a frame comprising at each side of the ma-

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chine the spaced side members 11, the spaced transverse members 12 at the front of the machine, the rear member 13 (Fig. 4) and other parts which will be hereinafter more particularly referred to.

The frame mentioned has in general the shape of a rectangular box with parts cut away to save weight and material, and with parts arranged to support the various shafts and other mechanism of the machine.

Mounted at the upper forward portion of the machine is a set of multiplicand keys and a set of multiplier keys. Each set of keys comprises a plurality of banks. Each key bank comprises nine keys arranged in succession fore-and-aft in the machine, and also arranged successively higher in the machine from front to rear. The arrangement just described is simply for convenience and might be varied if desired. In this connection it may be noted that I have shown in my drawings four banks of digit keys and in each set also one bank of fraction keys in the multiplier. Such an arrangement of keys would, of course, limit the capacity of the machine and it is my purpose to make such a showing only for illustration, it being understood that the capacity of the machine may be increased by increasing the number of banks of keys in the multiplicand and multiplier, and by duplicating the mechanisms operatively connected therewith.

For convenience in further discussion of the machine, we assume that the end of the machine shown at the left-hand portion of Fig. 1 is the front of the machine, and the other end is the back, and that the lower part of the machine, shown in Fig. 1, is the right-hand side, and the other side the left-side of the machine.

In Fig. 5, I have illustrated the arrangement of one bank of keys of the multiplicand set, which is the left-hand set of keys. For each bank there is provided a frame inclined from the forward upper end of the machine upwardly and rearwardly, each frame in each case comprising a vertical strip or plate 14 having at its upper edge a flange 15 extending at right angles away from the plate 14, and having at its lower edge a similar somewhat shorter parallel flange 16 (Fig. 6). Formed on the edge of the flange 16, opposite the plate 14, is a downward extension 17. Each key 18 has a stem 19 extended slidably downwardly through suitable slots in the flanges 15 and 16. Each stem is provided at its forward edge with a shoulder 20 projecting forwardly from the stem at a point near the flange 15. The slots in the flanges 15 are of sufficient length to permit the passage of the portions of the stems 19 having the shoulders 20.

Each key is normally held in its upper

position with the shoulder 20 just above the flange 15, by means of a spring 21 secured to the key stem 19, and secured to the plate 14 by means of a pin 22 extended through an elongated slot 23 in the key stem 19 (Fig. 5).

Mounted beneath each flange 15 is a locking bar 24, provided with elongated slots 25 adapted to permit the free sliding movement of the key stems 19, and to permit the passage of the shoulders 20 through said slots. Each bar 24 is normally held at the rearward upper position of its movement by means of a spring 26 secured to the plate 14 and to the locking bar.

It will be seen that when a key 18 is in its upper position and is pushed downwardly, as illustrated by the showing in Fig. 5, the shoulder 20 of the key thus depressed will engage the lock bar 24 and push said lock bar forwardly until the shoulder 20 passes below and clears the lock bar, whereupon the spring 26 will move the lock bar rearwardly to position where the shoulder 20 will engage the lock bar 24 and prevent the stem 19 and key 18 from being moved upwardly by the spring 21, until the lock bar is again moved forwardly in the machine to permit the shoulder 20 of the depressed key to clear the lock bar and pass upwardly through the slot 25.

The frame for each bank of keys is supported at its forward end by an angle iron 27, shown in Fig. 4.

Mounted on the frame for each bank of keys is a plate 28 spaced opposite the plate 14. The flange 17 is provided at its rearward end with a slot 29 in which is received a transverse rod 30 mounted in upward extensions 31 on the frame of the machine (Fig. 5).

Rotatably mounted in the upwardly extending members 31 (Fig. 4) preferably slightly above and rearward from the rod 30 is a transverse shaft 32. Rotatably mounted on the shaft 32 in line with each bank of keys, is a sleeve 33 (Fig. 5). Each sleeve 33 has formed in it a slot 34, elongated circumferentially of the shaft 32. A pin 35 extends outwardly from the shaft 32 into each slot 34, whereby rotation of the sleeve 33 with relation to the shaft 32 is limited.

Formed on the rear end of each lock bar 24 is a downwardly extending flange 36. Formed on each sleeve 33 is an upwardly and forwardly extending arm 37 pivoted at its forward end to a key stem 38 extended slidably upwardly through an elongated slot in the lock bar 24 and through a slot in the flange 15. The stem 38 has on its upper end a key 39.

Formed on each sleeve 33 is an upwardly extending arm 40, so arranged that when the key 39 is depressed, the arm 40 engages the

flange 36 and slides the lock bar 24 forwardly in the machine. On account of the arrangement of the parts, with the pin 35 extended into the slot 34, it will be seen that the key 5 39 of any particular bank of keys can be operated for releasing the lock bar of that bank without rotating the shaft 32. If, however, the shaft 32 is rotated a certain distance, the pin 35 will be engaged for moving 10 the sleeves 33 and the arms 40 for moving the slide bars of all the banks of keys in both sets. In this connection it may be noted that the shaft 32 is connected with the lock bar 24 of all the banks of keys of the 15 multiplicand, and also with all the banks of keys of the multiplier, which will now be described, in a way similar to that just described.

Near one end of the shaft 32 is fixed a laterally extending arm 41 pivoted to a key 20 stem 42 slidably mounted in the casing of the machine (Fig. 2). On the upper end of the key stem 42 is a key 43. By depressing the key 43 the locking bars of all the banks 25 of keys may be moved forwardly in the machine.

There is also provided mechanism, which will be hereinafter referred to, whereby the machine automatically operates the shaft 32 30 for operating the various lock bars for releasing all the keys of the multiplicand and multiplier sets.

The banks of keys of the multiplier, which are the banks shown in the right-hand set 35 of keys in Fig. 1, are constructed and arranged similar to the keys of the multiplicand, hereinbefore described, with the exception that the stems 44 of the keys 18 of the multiplier set are longer and extend 40 downwardly farther than the stems 19 of the multiplicand set, as illustrated in Fig. 2; that is to say the key banks of the multiplier set have the lock bars 24, the spring 21 and the mechanism for operating the lock bars, 45 arranged similarly to the same mechanism for the multiplicand set of keys.

The digit keys on the multiplier and multiplicand are provided on their upper faces with indicating characters 45. I preferably 50 place the numeral 1 on the lower forward horizontal row of keys of each set, the numeral 2 on the next rearward upper horizontal row of keys, and so on, and the arrangement of indicating characters on the keys 55 for multiplying by fractions is made as may be desired.

In Fig. 1, I have shown a part of one bank only of fraction keys for multiplying by 60 eighths. The lower forward key being the one-eighth key, the next key being the one-fourth key, that is to say the two-eighths key, the next rearward key, the three-eighths key and so on. It will, of course, be understood that other characters on the fraction 65 keys may be provided, as may be desired.

I will now describe the mechanism operated by the depression of the keys of the multiplicand set.

Pivotally supported upon the flange 14 adjacent to each stem 19 is a bell crank lever 70 46, which as shown has one upwardly extending arm and one rearwardly extending arm. The angles formed by the arms of the various bell crank levers 46 vary somewhat in order to properly operate the mechanism hereinafter described. 75

Pivoted on the upper end of the upwardly extending arm of each bell crank lever 46 is another bell crank lever 47, having an upwardly extending arm, on which is mounted 80 a small roller 48 and a forwardly extending arm having at its forward end a downwardly extending catch member 49.

Slidably mounted adjacent to each plate 14, preferably to slide on the flange 16 between the plate 14 and the key stem 19, is an operating bar 50 the upper edge of which is 85 formed with a plurality of notches 51 to receive the various catch members 49. The operating bar 50 is designed to normally stand in position with its various notches 90 51 just below the various catch members 49.

The key stems 19 are provided on their forward edges with curved shoulders 52 arranged adjacent to the rollers 48 when the 95 parts are in their normal position (Fig. 7).

On the forward end of each forwardly extending arm of each bell crank 47 is a laterally extending pin 53, which is extended through a slot 54 in the plate 14. 100 The slot 54 is curved on the arc of a circle having its center at the center of the pivot point of the bell crank 47 when the bell crank 46 is in its normal position. At the lower end of each slot 54 is formed a forwardly extending slot 55. 105

Mounted on the pivot pin 56 of each bell crank lever 47 is a spring 57, having its ends adapted to engage the lever 46 and the lever 47 for yieldingly holding the pin 53 at the 110 upper end of the slot 54.

The operating bar 50 moves longitudinally forwardly for the purpose of swinging the upwardly extending arms of the bell crank levers 46 forwardly and their rearwardly extending arms upwardly. Arranged transversely in the machine is a shaft 58 (Fig. 5). A vertical, sectional view of the shaft 58 and the parts mounted thereon is shown in Fig. 52. 120

I will now describe the mechanism on the shaft 58 for connecting said shaft with the various operating bars 50.

A link 59 is pivoted to each bar 50 by means of a pin 60 extended through an elongated slot 61 in the plate 14 (Fig. 7). 125 Mounted on the shaft 58 is a nut 62. (Fig. 52).

Slidably and rotatably mounted on the shaft 58 adjacent to the nut 62 is a plurality 130

of arms 63. The arms 63 are spaced from each other by means of sleeves 64, which are keyed to the shaft by means of keys 65 to permit said sleeves to slide but not to rotate on said shaft. The respective arms 63 are pivoted to the rear ends of the respective links 59.

Mounted on the shaft 58 is a nut 66 and spaced therefrom on the opposite side of all the arms 63 and sleeves 64 is the nut 62. Mounted on the shaft 58 between the nut 66 and the nearest adjacent arm 63 is a washer 67. Between the washer 67 and the nut 66 is a coil spring 68. By adjustment of the nut 66, the tension on said spring may be regulated as desired. It will be seen that all of the arms 63 are frictionally connected with the shaft 58 and normally tend to operate together when said shaft is rotated.

It will thus be seen that rotation of the shaft 58 would tend to operate the bars 50 of all the banks of keys of the multiplicand.

In order to prevent the operation of the operating bars 50 of the banks of keys of the multiplicand, wherein no key has been depressed, the following mechanism has been provided.

An upright locking bolt 69 is slidably mounted in the flanges 15 and 16 in a suitable elongated slot in the locking bar 24 of each bank of keys. (Fig. 5).

Pivotally mounted on the plate 14 adjacent to each bolt 69 is a bell crank lever 70, one arm of which extends rearwardly in the machine and is provided with an elongated slot 71 to receive a pin 72 extending laterally from the bolt 69. The other end of each bell crank 70 extends upwardly in the machine to position adjacent to the locking bar 24. Extending downwardly from each locking bar 24 is a lug 73 adapted to engage the upwardly extending arm of the bell crank 70 during certain movements of the parts of the machine.

Rotatably mounted in the machine is a transverse shaft 74 preferably mounted rearwardly in the machine from the bolts 69. Rotatably mounted on each shaft 74, adjacent to each bolt 69, is a short sleeve or collar 75. On each collar 75 is an upwardly extending arm 76 designed to engage a bolt 69. Secured to the arm 76 and to the upwardly extending arm of each bell crank 70 is a coil spring 77, adapted to hold the upwardly extending arm of the bell crank 70 at the forward limit of its movement and hold the arm 76 in engagement with the bolt 69. The bolt 69 is intended to normally stand at the lower position of its movement with its lower end received in the slot 79 in the upper surface of the adjacent link 59.

Each sleeve 75 is provided with a slot 80 elongated circumferentially of the shaft 74. Received in each slot 80 is a pin 81 on the shaft 74.

Each bolt 69 is provided with a notch 82 which is below the upper end of the arm 76 when the bolt 69 is in its lowered position. When one of the keys of the bank, under consideration, is depressed thereby moving the lock bar 24 forwardly in the machine, the lug 73 on said lock bar engages the upwardly extending arm of the bell crank lever 70, thereby operating the said bell crank lever for raising the bolt 69 out of the notch 79. The notch 82 then receives the end of the arm 76, whereby the bolt 69 is locked in its upper position. Each sleeve 33, hereinbefore referred to, is provided with a forwardly extending pin 83, and each sleeve 75 is provided with a rearwardly extending pin 84 arranged in the path of the pin 83. If, after a key has been depressed in one bank of keys, it should be desired to release said key without otherwise affecting the operation of the machine, the key 39 may be depressed, as hereinbefore described, for moving the bar 24 forwardly in the machine and permitting the stem 19 of the depressed key to move upwardly. The depression of the key 39 causes the pin 83 to engage the pin 84 for moving the sleeve 75 and the arm 76 for causing the arm 76 to move away from the slot 82 in the bolt 69, and permitting the spring 77 to operate the bell crank lever 70 for moving the bolt 69 downwardly until its lower end sits in the notch 79. The construction of the parts with the elongated slot 80 permits each sleeve 75 to have limited rotary movement on the shaft 74, for permitting the manual release and lowering of one bolt 69 independently of the automatic operation of the machine. Ordinarily the shaft 74 is operated by the automatic mechanism of the machine for releasing all the stems 69.

I will now describe the further mechanism operated by the depression of the keys of the multiplicand set.

Suitably mounted on the frame of the machine is a plurality of transverse shafts 85. The shafts 85 are arranged in rows in different horizontal planes, the shafts of the various rows being also preferably arranged in parallel vertical planes.

Suitably mounted on the frame of the machine is a plurality of horizontal shafts 86 arranged longitudinally in the machine. The shafts 86 are arranged in a series of rows, each row being in a different horizontal plane and each row preferably being arranged just below one of the rows of shafts 85. The shafts 86 in the different horizontal rows are also preferably arranged in parallel vertical planes.

Mounted upon each shaft 86 are nine computing cylinders 87, such as those shown in Fig. 12. The cylinders 87 are arranged in rows longitudinally of the machine on the shafts 86, and are also preferably arranged

in rows vertically and in rows horizontally and transversely of the machine.

Various forms of the computing devices may be used, but in the illustration of my invention shown in the accompanying drawings, I have for convenience sake shown the cylinders 87 (Fig. 12). Each cylinder 87 preferably comprises a hub 88 rotatably mounted on the shaft 88. On the hub 88 is a web 89, on the periphery of which is mounted the cylinder 87'. Screwed on to one end of the hub 88 is a cap 90 adapted to rotate with relation to the shaft 86. A pin 91 is extended through the shaft 86 and is received between the cap 90 and the hub 88 of each computing cylinder longitudinally of the shaft 86. Formed on the end of each hub 88, opposite the cap 90, is a clutch member 92. A clutch member 93 is keyed on the shaft 86 adjacent to each clutch member 92 to permit sliding but to prevent rotating movement of said clutch member 93 with relation to the shaft 86. Formed on each clutch member 93 are parallel spaced annular flanges 94. An arm 95 extends from one of the shafts 85 into a groove formed between the flanges 94, whereby when the shaft 85 is rotated, the clutch member 93 will be thrown into or out of engagement with the clutch member 92. It will, of course, be understood that there is one of the arms 95 for each clutch member 93.

On each shaft 85 is an arm 96 which may extend rearwardly in the machine, as shown in Fig. 4.

Pivoted to each arm 96 is a link 97 extending upwardly and pivoted to one of the rearwardly extending arms of one of the bell crank levers 46 of the multiplicand keys (Figs. 4 and 5).

As illustrated in the drawings, the right-hand bank of keys of the multiplicand is the unit bank; the next bank to the left the ten's bank; and so on. As shown in the drawings, the right-hand bank in the multiplier set of keys represents fractions; and the next bank to the left the unit's bank, the next bank to the left the ten's bank, and so on. The parts are preferably so arranged that the one key of each bank of keys of the multiplicand is connected with the forward shaft 85 of the upper horizontal row of series of said shafts. The unit key representing one is connected with the arm 96 on the upper forward shaft 85 at the right-hand end of said shaft. The ten key of the multiplicand set of keys is connected with the second arm 96 from the right-hand end of the upper forward shaft 85. The key representing the unit two is connected with the forward shaft of the second row of shafts 85 from the top of the machine, and with the arm 96 thereon at the right-hand end of said shaft. The twenty key of the

65 multiplicand set is connected with the second arm from the right-hand end on the forward shaft of the second row of shafts 85 from the top of the machine, etc. For instance, the key representing nine thousand, being the upper left-hand key in the multi- 70 plicand set, as shown on Fig. 1, is connected with the left-hand arm 96 of the rearward shaft 85 on the lower row of said shafts. The depression of any key in the multiplicand set rotates one of the shafts 85, and it follows that it throws into engagement all the clutches operated from that shaft. 75

Thus for illustration, if the one key is depressed, it will impart limited rotation to the upper forward shaft 86, thereby throwing 80 all of the clutches connected with that shaft into engagement, so that the forward computing cylinders 87 of all of the shafts 86 of the top row of said shafts will be operatively connected with said shafts. If then 85 the thirty key is depressed, the third shaft from the front in the second row from the top of the shafts 85 will be operated for throwing all of the clutches in connection therewith into engagement. 90

Slidably mounted on suitable supporting members 98 and 99 below the lower ends of the stems 44 of each bank of keys in the multiplier is a step bar 100 (Fig. 2). The step bars 100 are provided with slots 101 and 102 95 which are horizontally elongated and receive the members 98 and 99 for permitting the step bars to slide horizontally. The upper edges of the step bars 100 are provided with a series of shoulders 103^a, 103^b, 103^c, 103^d, 100 103^e, 103^f, 103^g, 103^h, 103ⁱ, as shown in Fig. 2. The shoulders on each step bar 100 are designed to coact with the respective keys of the bank above the step bar.

Adjacent to the forward end of each step bar 100 is centrally pivoted a bell crank 104, one arm of which is pivoted to the adjacent step bar 100. On the forward end of each shaft 86 is a gear 105, shown in Figs. 3 and 12. A rack bar 106, shown in Fig. 3, meshes 110 with each gear 105 and is inclined upwardly therefrom and laterally in the machine to one arm of one bell crank lever 104 to which said rack is pivoted. The gears 105 on the upper horizontal row of shafts 86 are of 115 sufficient width to mesh also with rack bars 107 which extend downwardly in the machine and in the form of the device shown in the drawings, are inclined from their upper ends laterally toward the left side of 120 the machine.

In a machine built as shown in the drawings, where the second bank of keys from the right in the multiplier set represents the unit digits, then the second rack bar 107 125 from the right meshes with the pinion 105 of the first shaft 86 at the right in the top row of said shafts 86, and with the pinion

105 on the next shaft to the left thereof, in the next lower row of shafts 86, and also with the next shaft to the left of said last described shaft in the third row of shafts 86 from the top, etc. In other words, the shafts 86 rotated from any key in a certain bank of the multiplier set are not arranged in vertical line, but are arranged in a plane inclined from its upper edge at the top of the machine downwardly and toward the left side of the machine at its lower end. It will thus be seen that when the step bar 100, below any bank of keys of the multiplier set is shoved forwardly in the machine it will, through the bell crank lever 104 connected with it, the rack 106, the gear 105, and the members connected therewith, operate all of the shafts which are operatively connected with one of the rack bars 107. It may also be mentioned that the number of shafts operated by each rack bar 107 is always equal to the number of banks of keys in the multiplicand set and I will now describe the mechanism for operating the step bars 100, shown in Fig. 2.

Mounted on the shaft 58, hereinbefore mentioned, rearwardly of the banks of keys of the multiplier set is a sleeve 108, on which, near one end, is a washer 109, and on the other end of which is an operating arm 110. (See Fig. 52).

Rotatably mounted on the sleeve 108 is a plurality of spaced arms 111. The arms 111 are spaced apart by sleeves 112 slidably but non-rotatably mounted on the sleeve 108 by means of keys 108^a. Mounted on the sleeve 108 near the end thereof, opposite the washer 109, is a collar 113. The arms 111 are all located between the washer and the collar 113. (Fig. 52).

Mounted on the sleeve 108 is an adjustable nut 114. Mounted on the sleeve 108 between the nut 114 and the washer 109 is a coil spring 115. The tension on the spring 115 may be varied by means of the nut 114.

Pivoted to each step bar 100 is a link 116 extending rearwardly and pivoted to one of the arms 111. It will be seen that when the sleeve 108 is rotated in one direction, the step bars 100 will be moved forwardly.

Arranged to normally stand in the path of each shoulder 103^a is a member 69, similar to that already described as coacting with the notch 79 and similarly actuated. On account of the use of the member 69, it is necessary to use the frictional device for connecting the arms 111 with the sleeve 108, so that when the sleeve 108 is rotated, the step bars 100 of those banks of keys wherein a key has been depressed, will be moved forwardly while the step bars on the other banks may be held against movement by the members 69, and the arms 111 connected with the step bars which are locked are held against rotation with the sleeve 108.

The shoulders of the step bars 100 are so arranged that when the lower forward key of a bank of keys of the multiplier is depressed and the step bar below that bank is moved forwardly, the lower end of the stem 44 of said key will stand in the path of the first shoulder 103^a and limit the forward movement of the step bar 100. The second shoulder, namely 103^b, will stand in the path of the key number two when said key is depressed. The shoulders are also so arranged that when key number one is depressed, the bar 100 will be permitted forward movement a sufficient distance to permit the parts to operate, for rotating the gear 105 connected therewith, one-twentieth of a revolution. When the two key is depressed, the bar 100 can move a sufficient distance forwardly to rotate the gear 105 and the shaft connected therewith, and the cylinders on said shaft two-twentieths of a revolution.

The ten key limits its step bar to a movement of sufficient distance to rotate the cylinders connected therewith one-twentieth of a revolution, etc., so that in multiplying, for instance, by 23, the unit 3 key would be depressed thereby rotating the cylinders operatively connected therewith, three-twentieths of a revolution, and the 20 key would be depressed, thereby rotating the cylinder connected therewith two-twentieths of a revolution.

Referring next more particularly to the computing cylinders and to the views shown thereof, in Figs. 12, 13, 14 and 15, it may be noted that in said figures are shown means for preventing any floating rotation of the computing cylinders on the shafts 86.

Extending inwardly from one edge of each cylinder 87 is a toothed flange 117. Mounted below each shaft 86 and preferably at one side thereof is a longitudinally arranged rock shaft 118. Pivotally mounted on each shaft 118 is an arm 119 having on its upper end a right-angled extension 120, on which is a roller 121 adapted to travel adjacent to the notched flange 117 and enter the notches thereon. The arm 119 is connected with the shaft 118 by means of a coil spring 122, whereby the roller 121 is yieldably held in engagement with the notched flange 117. It will be understood that similar means is provided for yieldably holding all of the cylinders 87 against rotation.

In the end of each cylinder, opposite the notched flange 117 is an annular inwardly extending flange 123 in which is one notch 124.

Fixed to the shaft 118 adjacent to each cylinder 87 is an arm 125 extending upwardly and having at its upper end a lateral extension 126, carrying a roller 127 adapted to engage the flange 123.

A spring 128, secured to each shaft 118 and to the frame member 12 of the machine, tends to hold the rollers 121 and 127 in engagement with the flanges 117 and 123. (See Fig. 2.)

Projecting radially outwardly from the surfaces of the cylinders 87 are pins 129. The arrangement of the pins 129 on the cylinders 87 will be hereinafter more particularly referred to. In some figures the pins 129 are omitted.

Arranged in the space between the cylinders 87 on each successive shaft 86 in the horizontal rows of said shaft are slide bars; the upper bar of each pair being indicated by the reference character 1301, and the lower bar by the reference character 131. The slide bars are arranged to slide horizontally in the machine, and are arranged substantially parallel with the shafts 86. The rear ends of the bars 130 and 131 are slidably mounted in the frame member 13.

At the forward end of the machine there is suitably mounted on the frame a plurality of transverse shafts 132. There is one shaft 132 for each horizontal row of slide bars 130 and 131 (Fig. 2).

Pivottally mounted on each shaft 132 is a plurality of spaced pairs of upwardly extending arms 133. The arms 133 of each pair are held apart from each other by means of spacing blocks 134 and the respective pairs are spaced apart by means of sleeves 135. On one end of each shaft 132 is a nut or collar, which may be similar to the nut 62. On the other end is an adjustable nut 136, similar to the nut 66.

On the shaft 132 near the nut 136 and between the nut 136 and the arms 133, is a washer 137. A coil spring 138 is mounted on each shaft 132 between the nut 136 and the washer 137 thereon. It will thus be seen that all of the arms 133 are locked on the shaft by the frictional devices just described, and normally tend to move with the shaft whenever the shaft is rotated, but if any of said arms should be held against movement, the shaft 132 may rotate without moving the arms which are thus being held. Fixed to each shaft 132 is an arm 139, which as shown extends downwardly and forwardly in the machine and is pivoted at its forward end to a substantially upright controller bar 140.

The upper ends of the respective arms 133 of each pair are secured to the forward ends of the respective members of one pair of bars 130 and 131. The bars are bent so that in the main portion of the machine they are arranged parallel one above the other, as shown in Figs. 13 and 16.

Projecting laterally from the upper bar 130 on each pair toward the right-hand cylinder 87, and near the forward end of each cylinder 87 is a lug 141. Projecting later-

ally from each lower bar 131, near the forward end of each cylinder toward the cylinder on the left of said bar is a lug 142 (Fig. 14).

Mounted on the rear end of each bar 130 is a toothed plate 143 (Fig. 32). Mounted on the rear end of each bar 131 is a toothed plate 144. The plates 143 and 144 on all the bars, which are arranged in the same vertical plane, are arranged to travel in suitable guides 145.

In the operation of the machine, after certain cylinders have been selected out and operatively connected with their shafts by the operation of the multiplicand keys, and have been rotated on their shafts by the operation of the multiplier keys, the bars 130 and 131 are moved rearwardly in the machine by mechanism which will be hereinafter more fully described. The pins 129 are arranged to serve as stops for lugs on the said slide bars. The pins 129 on the cylinders 87 are arranged so that in different positions of the rotation of the various cylinders they stop the bars 130 and 131 in different positions of the movement of said bars depending upon the numbers involved in the problem of multiplication.

In Figs. 17 to 25 inclusive, I have shown the cylinders 87 laid out for better illustrating the arrangement of said pins 129. It may be said that the surface of each cylinder is theoretically divided into two halves and each half is divided into twenty equal spaces. In the machine as shown in the drawings, the pins on the upper half of the cylinder are so located as to stop the bars at the proper points for indicating or permitting the mechanism to move to position for indicating the unit in the product of the multiplication of two figures, while the pins on the lower half of each cylinder serve as stops for the lower bars at the proper point for indicating or permitting the mechanism to move to proper position for indicating the ten of such product.

The parts are so arranged that when the cylinder is rotated to the proper position by means of the multiplier key, the pins which belong to the upper half of the cylinder serve as stops for the lower bar on the right-hand side, and the pins which belong to the lower half of the cylinder serve as stops for the upper bars on the left-hand side. The importance of this arrangement will hereinafter appear more clearly. Such an arrangement assists in carrying tens, as will hereinafter appear, and does away with the need of complicated carrying mechanism.

All of the cylinders in the front tier are "ones" cylinders, and have the pins thereon arranged as shown in Fig. 17. All of the cylinders in the second tier are "twos" cylinders and have their pins arranged as shown

in Fig. 18. All of the cylinders in the third tier have their pins arranged as shown in Fig. 19, and so on.

In order to illustrate the arrangement of the pins, I will describe the arrangement of the pins on the entire front tier of cylinders, with the exception of those used in multiplying by fractions.

In Fig. 17 one of said cylinders is shown laid out. On all of the laid out cylinders it may be said that the cylinder is divided into twenty spaces circumferentially of the cylinder, and ten equal spaces lengthwise of the cylinder. The cylinders in the first tier are only used in multiplying some number by 1, 10, 100, 1000, and so on. In any case the multiplication does not leave any figure to be carried. The pins 129" on the upper half of the cylinders, now being described, are arranged as follows:

Beginning at one of the dividing lines between the halves of the cylinder, I have for convenience, set opposite the twenty spaces in which the cylinder is divided, circumferentially adjacent to the upper half of Fig. 17, the characters 0123456789, and continued on the lower half the characters 0123456789. For convenience of illustration, I have indicated the spaces on the cylinders longitudinally thereof by the characters 0123456789 adjacent to the laid out cylinders. On all the cylinders there is no pin in the first zero space, being the first space circumferentially of the cylinder shown in Fig. 17. There is a pin located in the second space from the forward end of the cylinder, in the second space circumferentially thereof, so that if the cylinder has been selected out by the multiplicand for multiplying, and has been rotated by means of the multiplier key one for turning the cylinder one-twentieth of a rotation, then the pin 129, just mentioned, will stand in the path of the lug of the upper bar on the right of the cylinder, and will stop the movement of said bar after the bar has moved, what I will now for convenience call one space. In other words setting the machine to multiply one by one, sets it to permit the bar, just mentioned, to move one space.

In the third space circumferentially of the cylinder on the upper half thereof a pin is arranged in the third space from the front, and in the fourth space, circumferentially of the cylinder, so that if the one key should be struck on the multiplicand, or the ten key or the one hundred key for selecting out one of the rows of cylinders in the front tier thereof, and thereafter the three key on the multiplier is struck for rotating the proper cylinder in the upper row of the front tier, which would be the second cylinder from the right, then that cylinder will be rotated from its zero position three-

twentieths of a revolution, thereby bringing the pin in the fourth space circumferentially of the cylinder, and in the third space longitudinally of the cylinder, into the path of the lug on the upper bar on the right. When said bar is moved, it will be permitted to move three spaces and will then be stopped by the pin on the cylinder. Thus for multiplying one by one, the cylinder is moved to position for permitting the bar to move once; for multiplying one by three the cylinder is moved for permitting the bar to move three spaces, etc.

I will now describe the arrangement of pins on one of the cylinders in the third tier from the front. The pins on the upper half of the cylinders in the "threes" tier, are arranged as shown in Fig. 19 to represent the right-hand figures of the products of the multiplication of any digit by three, and the pins on the lower half are arranged to represent the left-hand figure of the product, where the product consists of two numbers.

For instance, if the numbers to be multiplied are seven times three, the product is twenty-one. By pushing down the three key of the multiplicand, the third shaft from the front in the top row of shafts 85 is operated to set the clutches of all the cylinders of the top transverse row in the third tier from the front. When the seven key of the multiplier is depressed, the second gear from the right in the upper row of shafts will be rotated seven points or distances, and the rack bar 107 will rotate every shaft operatively connected therewith, as illustrated in Fig. 3, the same distance.

It will be noted, however, in this connection, that when the gear 105, under consideration, is rotated, the cylinders on the shafts 86 below the top row are not operated, although certain of the shafts which carry such lower cylinders are rotated by the diagonally arranged rack bar 107 operatively connected with the upper shaft 86 which has been rotated, for the reason that no clutches have been set on said lower shafts. It will be seen that one cylinder has been selected out to be operated. The complete operation of the parts will be hereinafter more fully referred to.

The "threes" cylinders have the pins thereon arranged so that when one of them has been selected out by the operation of the keys, as just described, and rotated, a pin on the upper half of the selected cylinder, which pin stands in the seventh space in the upper half of the cylinder, circumferentially thereof, and the one space, which is the second space from the forward end longitudinally of the cylinder, will be in the path of the lug on the lower bar at the right of the cylinder, while the pin located in the seventh space circumferentially of the

cylinder in the lower half thereof and in the second space longitudinally of the cylinder, will stand in the path of the lug on the upper bar at the left of the cylinder, so that when said bars are operated, the lower right-hand bar, which may be for illustration called the unit bar, will move one space, and the upper bar at the left will move two spaces.

The lugs on the bars normally stand even with the first position from the front end of the cylinders. The pins of the cylinders of the various tiers are arranged so that they, by their positions, represent the products of the multiplications of the digit, which the cylinder represents, by any other digit.

Figs. 20 to 25 inclusive, show the arrangement of the pins on the cylinders in the fourth to ninth tiers inclusive.

The toothed plates 143 and 144 on the rear ends of the bars 130 and 131 are arranged in vertical tiers and also in transverse rows. Each plate has a plurality of laterally projecting teeth 148. The surfaces of the plates 143 and 144 from which the teeth 148 project may be said to be divided from front to rear into nine equal spaces, and also divided from top to bottom into nine equal spaces. The teeth 148 are arranged in rows. In the first vertical space from the front edge of each plate are nine teeth, one tooth being arranged in each horizontal space. In the second vertical space from the front are eight teeth, the upper horizontal space having no tooth. In the third vertical space from the front of the plate are seven teeth, the two upper horizontal spaces having no teeth, etc. The last vertical space nearest the rear edge of each plate has only one tooth in the lower horizontal space. The teeth on all the plates are similarly arranged.

The mechanism for multiplying by fractions will be hereinafter referred to.

Vertically slidable in suitable guides 149 at the rear of the machine is a sliding frame member 150 shown in Figs. 2, 33, and 35.

Rotatably mounted in the frame 150 is a plurality of shafts 151 projecting forwardly and rearwardly from the frame 150, the shafts 151 being arranged in the same horizontal plane and spaced from each other.

On the forward end of each shaft 151 is fixed a pinion 152. Extending forwardly from the frame 150 and preferably formed thereon is a bearing member 153 having formed thereon an annular shoulder 154. Mounted on the outer smaller part of the bearing member 153 is a sleeve 155, fixed to the pinion 152, and having at its rearward end a cumulator wheel 156 having gear teeth and provided near its periphery with a pin 157 extending rearwardly in the machine. The pinions 152 and the plates 143 and 144 are so arranged in the machine that when the bars 130 and 131 are moved rearwardly,

carrying with them the plates 143 and 144, and the frame 150 is moved downwardly, the pinions 152 will engage the pins 148 and be rotated thereby. The pinions 152 are rotated as many tenths of a revolution on the downward movement of the frame member 150 as there are teeth 148 in the path of said pinions.

I will now describe a part of the cumulating and carrying mechanism of my improved multiplying machine.

On the rear end of each shaft 151 is fixed a sleeve 158, having an arm 159. On the end of the arm 159 is a suitable roller 160.

On the rear end of each shaft 151 is loosely mounted a pinion 161. On the sleeve 158 is an outwardly extending arm 162 to which is pivoted a pawl 163 adapted to engage and coact with the pinion 161.

On the upper part of the frame 150 is mounted a plurality of stub shafts 164, which are preferably mounted above the respective shafts 151. Rotatably mounted on each stub shaft 164 is a hub 165 having an extension 166 extending beyond the free end of the shaft 164. In the end of the hub 165, opposite the extension 166 is a recess 167, which receives one end of a coil spring 168 mounted on the stub shaft 164 between the hub 165 and the frame 150. On each hub 165 is a notched wheel 169, designed when the parts are in normal position to be engaged and moved one notch by the roller 160 upon each revolution of the shaft 151 below the shaft 164. Slidably mounted in mesh with each pinion 161 is a rack bar 171 extending upwardly and inclined to the right in the machine so as to be in mesh with the pinion 170 on the hub 165 next to the right of the pinion 161 with which each rack is connected.

The racks 171 are slidably mounted in bearings in frame members 172 supported by studs 173 extending rearwardly from the upper portion of the frame member 150. The pinions 170 are normally held in mesh with the racks 171 by the springs 168, but it will be seen that by forcing the hubs 165 forwardly against the pressure of the springs 168, the pinions 170 may be moved out of mesh with their respective racks 171.

In the operation of the mechanism just described, it may be noted that each time a pinion 152 is rotated a complete revolution or past ten teeth, the roller 160 on the arm 159 on the shaft which carries the particular pinion 152, under consideration, will engage the notched wheel 169 above the shaft 151 and move it one notch in the direction indicated by the arrow on the right-hand wheel 169 in Fig. 34. The effect of the rotation of the wheel 169 is to rotate the hub 165 and the pinion 170 thereon. The pinion 170 has ten teeth and each wheel 169 has ten notches, so that when the wheel 169 is rotated one

notch or one-tenth of a revolution, the pinion 170 on the same hub is rotated one-tenth of a revolution or past one tooth, thereby moving the rack 171, which is in mesh with the pinion 170, upwardly one tooth and rotating the pinion 161 one tooth. The pinion 161 is of such width as to mesh with the rack 171 and also to be engaged by the appropriate pawl 163. The pawl 163 in each case is arranged to permit the pinion 161 to rotate freely when the rack 171 is moved upwardly.

All of the parts just described are carried by the frame member 150. It will thus be seen that when the frame member 150 is moved downwardly, each rack 171 will be moved upwardly a distance equal to the spaces between a certain number of teeth, corresponding with the number of revolutions of the shaft 151 below the shaft 164 with which the rack 171 is in mesh, whereby the pinions 161 on the next shaft 151 to the left, will be moved the same number of tenths of a revolution. The pinions 161 are arranged with ten teeth.

The numeral wheels 156, hereinbefore referred to, have on their forward surfaces ten indicating characters, preferably the zero and the Arabic numerals one to nine inclusive, arranged equi-distant from each other. It will be seen that, after the operation just described, when a rack is moved downwardly to its normal position it will rotate the pinion 161 with which it is in mesh as many tenths of a revolution corresponding to the number of teeth which the rack has been moved upwardly, and will thereby rotate the wheel 156 on the same shaft with the pinion 161 the same number of tenths of a revolution.

I will now describe how the racks are returned or moved downwardly to their normal positions after having been raised as hereinbefore referred to, without affecting the notched wheels 169, and at such times as to permit all the racks to be operated without interfering with each other.

Suitably supported rearwardly of the frame 150 is a pair of crank shafts 174 arranged one above the other. Suitably supported on the cranks of the crank shafts 174 is an upright plate 175. In Fig. 40, is shown a front view of said plate. On each rack bar 171 is a rearwardly extending roller 176. The extensions 166 of the hubs 165 extend rearwardly somewhat farther than the rollers 176. On the forward surface of the plate 175 is a plurality of bars or parallel guide flanges 177 adapted to receive between them the rollers 176, when the racks 171 are in their normal positions, when the plate 175 is in the forward position of its movement. It may be mentioned that by mechanism, which will be hereinafter referred to, the cranks 174 are so operated that during the downward stroke of the frame

member 150 and the parts mounted thereon, the plate 175 is held at or near its rearward position of movement where it will be out of the path entirely of the rollers 176 and the extensions 166.

By such mechanism the plate 175 is moved forwardly when the frame 150 reaches its lowermost position, so that the plate 175 is in operative position with relation to the rollers 176 and the extensions 166 during the upward stroke or movement of the frame 150.

The pairs of flanges 177 are arranged in spaced parallel relation and are graded in length. The pair on the right is the longest and the pair on the left is the shortest of said pairs. The right-hand flange of each pair is extended downwardly somewhat farther than the left-hand member of each pair. The lower end of the left-hand member of each pair of flanges 177 is connected with the lower end of the right-hand flange of the next pair of flanges 177 to the left by a forwardly extending flange 178, which is inclined from its lower end upwardly and toward the left, as clearly shown in Fig. 40. It will, of course, be noted that there are as many pairs of flanges 177 as there are rack bars 171 and rollers 176.

Below the path or groove, formed between each pair of flanges 177, a strip, or tongue portion of the plate 175 is inclined outwardly and rearwardly at 179, just below the lower ends of the flanges 177.

The operation of the plate 175 is as follows:

The frame member 150 and the parts carried thereby having been moved to their lower limit of movement by mechanism hereinafter referred to, the plate 175 is moved forwardly. On the upward movement of the frame member 150, the rearward extensions 166 on the hubs 165 engage the inclined portion 179 and move the pinions 170 forwardly in the machine, thereby throwing them out of gear with their racks. In this connection it will be noted that on account of the location of the portions 179 at different heights on the plate 175, the right-hand extension 166 engages the right-hand portion 179 for throwing the right-hand rack out of gear first, and that the next rack to the left is not thrown out of gear until the following operation has occurred.

If the right-hand rack has been raised upwardly during the downward stroke of the frame 150, then the roller 176 on the right-hand rack 171 will engage the lowermost flange 178, as shown in full lines in Fig. 40, and the rack 171 carrying said roller will be moved downwardly, thereby rotating the gear 161 in mesh with such rack, and by the action of the pawl 163 and the parts connected therewith, rotating the numeral wheel 156 on the shaft 151

which carries the pinion 161 just referred to. Wherever the rack 171 has not been moved upwardly, its roller will simply travel upwardly between the guide flanges 5 177 and will not be affected.

In Fig. 40, I have shown the roller to the right moved upwardly the greater distance; the second roller from the right moved upwardly somewhat less distance, 10 and the other rollers in their normal positions. The first roller to the right having been engaged by the lowermost flange 178 for lowering the right-hand rack, then during the continued movement of the frame 15 150, the second roller from the right will engage the second flange 178 from the right for lowering the rack connected with said second roller, and so on; the racks being successively operated, on account of the arrangement of the flanges 178. In this connection it should be noted that just before 20 it is so operated, each rack is thrown out of gear with its pinion 170 on account of the co-action of the extension 166 with the appropriate portion 179 of the plate 175. It is necessary that the racks be actuated successively from right to left in the machine, for the reason that the lowering of the first rack to the right operates the next numeral 30 wheel to the left (the second wheel from the right). Such operation, as is readily seen, may result in causing said second numeral wheel from the right to rotate its shaft 151 for causing the roller 160 connected 35 therewith to engage the second notched wheel 169 from the right for rotating it one-tenth of a revolution and moving the rack bar operatively connected with it. It will thus be seen that it would be mechanically impossible to simultaneously lower the 40 racks 171 to accomplish the carrying and cumulating operation desired.

The mechanism hereinbefore described, in connection with certain operative parts, hereinafter to be described, are employed for 45 completing the operation of multiplication and setting the result thereof on the numeral wheels 156.

Means are provided, which will be hereinafter described, for clearing the machine 50 after a product for each process of multiplication has been set up on the numeral wheels 156. An additional set of wheels or indicating devices 180 are provided on which 55 the sum of the products of a series of multiplications may be set up.

Just forwardly of the upper portion of the frame member 150 is a fixed frame 181 in which are rotatably mounted a plurality 60 of shafts 182, each being located preferably just above one of the shafts 151. On the forward end of each shaft 182 is a beveled gear 183 in mesh with the beveled gear 184 on a shaft 185 mounted transversely in the

machine. Loosely mounted on each shaft 61 182 between the beveled gear 183 and the frame member 181 is a wheel 180 carrying indicating characters similar to those on the numeral wheels 156, on its forward face, and having teeth which mesh with teeth on 70 the next lower numeral wheel 156 when the frame member 150 is in its upper position.

Rotatably mounted in the frame 181 and slidably receiving each shaft 182 is a sleeve 188 having a shoulder 189 for engaging one 75 side of the frame member 181, and having an annular disk 190 which frictionally engages the wheel 180. On the sleeve 188 is a nut or collar 191 for engaging the other side of the frame 181. On the rearward end of 80 the shaft 182 is screwed a nut 192, and between the nut 192 and the sleeve 188 is a coil spring 193, whereby the disk 190 and the beveled gear 183 are held in frictional engagement with the wheel 180. It will thus be 85 seen that ordinarily the wheel 180 will be rotated with the shaft 182, but that the shaft 182 and the wheel 180 may rotate independently of each other.

The frame member 181 has a series of 90 downwardly extending lugs 194 which stand in the path of the pins 157 on the numeral wheels 156 when the wheels are in their upper positions.

The mechanism just described may be operated for clearing the numeral wheels 156. 95 When the shaft 185 is operated by mechanism, hereinafter referred to, for rotating the beveled gears 184 in the direction indicated by the arrow thereon in Fig. 35, the 100 parts will be operated for rotating the numeral wheels 156 anti-clockwise until the pins 157 engage the respective lugs 194 at which time the zeros on the numeral wheels 156 will be up. 105

I will now describe the mechanism for adding together and setting up a series of products of multiplications.

It will be noted that when the product of multiplication is cleared out of the numeral 11 wheels 156 as hereinbefore described, the wheels 156 and 180 are so arranged and constructed that the wheel 180 above the wheel 156, which is being cleared out, will rotate as many tenths of a revolution as the wheel 156 11 is rotated for moving it to the zero position and the numerals on the wheels 180 are so arranged that if the wheels 180 start from the zero position, said wheels will be moved so as to indicate the same product as was carried by the wheel 156 before it was cleared 120 out. In other words, if the right-hand wheel 156 stands at nine, then it will take nine-tenths of a revolution to clear said wheel 156, and the wheel 180 in mesh with said wheel 125 156 will be moved nine-tenths of a revolution and will stand at nine when the clearing operation is complete. It is to be under-

stood, during such clearing operation, the upper wheels 180 rotate the lower wheels 156. The mechanism, hereinbefore described, is sufficient for setting up one product on the wheels 180, and I have provided additional means whereby another product may be added in and the total of the two products set up on said wheels. In order to accomplish this purpose, it is necessary to provide carrying mechanism in connection with the wheels 180.

Assuming that all of the wheels stand in zero position and that a problem in multiplication has been set up on the key board, and that the frame 150 has been lowered and raised, the product will be set up and shown on the wheels 156. If then the wheels 156 are cleared, such product will be carried into the wheels 180. If then another problem is set up on the key board, and the frame 150 lowered and then raised and the lower wheels are again cleared, in the manner hereinbefore described, the second problem will be added to the first and the total set up on the wheels 180, by means of the mechanism hereinbefore described, and the parts which will now be explained.

Rotatably mounted on the collar 191 on each shaft 182 is a hub or collar 195, formed on which is an upwardly extending arm 196 having a laterally extending arm 197. Secured to the frame of the machine and to a downward projection on the collar 195 is a coil spring 200 which tends to hold the upper end of the arm 196 at the limit of its movement toward the right. Pivoted to each arm 196 is a pawl 199 adapted to coact with the teeth of an adjacent numeral wheel 180.

Pivotally secured to the upper end of each of the arms 196 is a downwardly hanging blunt ended pawl 201. Projecting rearwardly from the side of the arm 196, adjacent to the pawl 201 is a lug 202. In Figs. 37 and 38, I have shown a rear view of one of the arms 196 with the pawl 201 in two different positions.

The upper edge of the frame member 181 is provided with upright members 203 between the successive shafts 182. Pivotally mounted in the upper front of each of the uprights 203 is a shaft 204. The forward end of each of the shafts 204 has an arm 205 secured thereto, said arm extending toward the right, as shown in Fig. 36, and being provided at its outer end with a cam portion 206, the cam portion 206 being located at a point vertically above the shaft 182 and a slight distance forward of the wheel 180. The rear end of each shaft 204 is provided with an arm 207 extending toward the left, as shown in Fig. 36, the end of which is provided with a forwardly and upwardly projecting portion 208. This portion 208 is de-

signed to lie normally adjacent at the side of the lug 202, as illustrated in Fig. 38 and in alinement with the pawl 201.

On the frame 150 are lugs 209^a (Fig. 35) extending forwardly and so located as to engage the lower edges of the arms 197 when the frame 150 is at its upper limit of movement. Thus it will be seen that when the frame 150 is at its upper limit of movement, the said lugs will engage the lower edges of the arms 197, and thereby cause the arms 196 to be held in the position shown in Fig. 36, and cause a tension on the springs 200. The lugs 208 will engage the lugs 202 and hold the arms 196 from movement toward the right (see Figs. 37 and 38). When the frame 150 moves down and the lugs 209^a disengage the arms 197, the springs 200 tend to move the arms 196 to the right.

When the arms 196 are moved to the left, the lugs 208 of the arms 207 will engage the pawls 201, swinging them slightly to one side as the arms 196 are moved, permitting the arms 207 to rise till the lugs 208 stand in position to engage the sides of the lugs 202, as shown in Fig. 38.

Assuming that a product of multiplication has been carried out of the wheels 156 and into the wheels 180 and that some of the wheels 180 have made more than a complete revolution or moved through more than ten spaces, the rollers 209 on the front face of the wheels 180 which have thus revolved will have engaged the portions 206 of the adjacent arms 205 which will cause the right-hand ends of said arms to be elevated, and the left-hand ends of the arms 207 to be lowered, thereby causing the lugs 208 to disengage the lugs 202 and allow the pawls 201 to swing to a vertical position immediately above the lugs 208, as illustrated in Fig. 37. The levers 196 will be operated to swing to the right, carrying with them the adjacent wheels 180 through the medium of the pawls 199. The limit of movement of each arm 196 is such that on its movement to the right the adjacent wheel 180 is moved one-tenth of a revolution. However, this movement is not permitted until the frame 150 has moved downwardly a slight distance to allow the lugs 209 to disengage the arm 197. It will thus be seen that if the wheels 180 are rotated to such position that the nines are readable thereon, and an additional rotation of one-tenth is imparted to the right-hand wheel, the tens will be automatically carried across to the wheel to the left, by the action of the springs 200 and the mechanism just described.

A suitable mechanism has been provided for clearing the wheels 180.

Mounted in the frame just forwardly of the upper portions of the wheels 180 is a suitable transverse shaft 210, on which is a

plurality of collars 211, on which are upwardly extending arms 212 having laterally extending curved flanges 213 which are longer than the width of the arms 212, as clearly shown in Fig. 35.

Secured to the arm 214 on the shaft 210 is a spring 215, shown in Fig. 42, which is also secured to the fixed frame of the machine. On the outer end of the shaft 210 is a handle 216, which may be depressed for rotating the shaft in the direction indicated by the arrow adjacent thereto, shown in Fig. 35, for moving the projecting ends of the curved flanges 213 into the paths of the respective rollers 209. The shaft 185 may be rotated manually by grasping the knob or handle 217 on the outer end of the said shaft 185, and the shaft 185 is thus operated in the opposite direction from that in which it is rotated to clear the wheel 156, whereupon the wheels 180 are moved anti-clockwise until the rollers 209 engage the flanges 213 when the wheels 180 will stand in zero position. It will be understood that during the last operation, the frame 150 is lowered a short distance, so that the wheels 156 are not in mesh with the wheels 180.

The entire machine is preferably mounted upon a suitable supporting frame 218. Suitably mounted on the machine is a motor or other prime mover 219, the shaft of which is operatively connected by a worm gear mechanism 220 with an upright shaft 221.

Mounted transversely in the upper central portion of the machine is a main cam shaft 222. The various operating mechanisms of my multiplying machine are actuated from cams on the shaft 222 in such a way that one complete rotation of the shaft 222 will operate all of said mechanisms for completing the operation of multiplying one number by another and setting the product up on the wheels 156 and transferring such product into the wheels 180. A single rotation of the shaft 222 also, when the parts are operatively connected as hereinafter described, clears the numeral wheels 156.

Loosely mounted on one end of the shaft 222 is a gear 223 in mesh with a worm 224 on the upper end of the shaft 221. Fixed on the shaft 222 is a disk 225 having in its periphery spaced notches 226 and 227. The disk 225 is mounted on the shaft 222 between the gear 223 and the main body of the machine. On the gear 223 is a lug 228 extending toward the disk 225.

Pivotaly mounted on a pin 229 on the disk 225 is a pawl 230 having near its end a hook member 231 adapted to engage the lug 228, and having a beveled edge 232 adapted to engage the lug 228 for permitting the lug 228 to pass under the outer end of the pawl 231 in one direction of the rotation of the disk 225. The pawl 229 has a downwardly projecting arm 233 to which is secured a

spring 234. One end of the spring 234 is secured to the disk 225 for normally holding the hook member 231 of the pawl 230 in position for engaging the lug 228.

Pivoted on the gear casing 235, which incloses the gearing mechanism just described, is a pawl 236 which is yieldingly held by a spring 237 in engagement with the periphery of the disk 225.

Mounted on the same side of the machine as the shaft 221 is a stud 238. Resting upon the stud 238 is a lever having a forwardly projecting arm 239, and a rearwardly projecting arm 240. The lever, just described, has two notches 241 and 242 thereon which are adapted to rest upon the stud 238 for supporting said lever on the stud. I have indicated the lever generally in Fig. 8 by the reference character "B."

Extending upwardly from the lever B is a handle 243, whereby the lever may be lifted and moved to position for selectively mounting the lever on the stud 238 in either of the notches 241 or 242.

On the forward end of the arm 239 is an upwardly extending member 244, on the upper end of which is a key 245. On the rear end of the arm 240 is a hook 246, adapted to engage and coast with an upwardly extending lug 247 on the pawl 230. The spring 237, above referred to, is secured to the arm 240 somewhat forwardly in the machine from the pawl 236, and serves to hold the arm 240 downwardly in proper position for engaging the hook 247 and also holding the pawl 236 in engagement with the periphery of the disk 225.

It will be seen that when the arm 240 is in position in engagement with the hook 247, thereby holding the hook member 231 of the pawl 230 out of engagement with the hook 238, the motor may be started and will continue to rotate the gear 223. When the key 245 is depressed, thereby raising the inclined end of the arm 240, the hook member 231 will drop into the path of the lug 228 on the gear 223 which will then impart to the disk 225 and the shaft 222 one complete revolution.

At the end of one revolution, the hook member 246 will engage the hook 247 and draw the pawl 230 out of engagement with the lug 228, so that the gear 223 will continue to rotate freely without affecting the operative mechanism of the machine until the key 245 is again depressed.

Anti-clockwise movement of the disk 225 is prevented by the pawl 236.

In this connection it may be noted that when the arms 239 and 240 are in the position on the stud 230, shown in Fig. 8, then the hook member 246 will stand in the position shown in Fig. 9 and will disconnect the disk 225 and gear 223 at such a point that the pawl 236 will enter the notch 221

on the disk. If, however, the members 240 and 239 should be raised by means of the handle 243 and moved forwardly in the machine causing the notch 241 to rest on the stud 238, then the hook member 246 will be moved forwardly in the machine and will engage the hook 247 at such a time in the revolution of the disk 225, that when said disk is thrown out of gear with the gear 223 the pawl 236 will drop into the notch 227. It thus follows that the shaft 222 will be stopped in different positions, depending upon the position of the arms 239 and 240, with relation to the stud 238.

On the shaft 222 is a plurality of cams which are shown in Fig. 1 and in Figs. 45 to 51 inclusive.

In Fig. 49 I have shown a cam 248, which serves to operate the shaft 58. On the shaft 58 is an arm 249 on the free end of which is a roller 250 in engagement with the cam 248. The arm 249 is yieldingly held in proper position for causing the roller 250 to engage the cam 248 by means of a spring 251.

In Fig. 50 is shown a cam 252 on the shaft 222 in engagement with the roller 253 on an arm 110 on the sleeve 108 of the shaft 58. A spring 255 holds the arm 110 in position for yieldingly pressing the roller 253 against the face of the cam 252.

In Fig. 47 is shown a cam 256 on the shaft 222. Pivottally supported on the shaft 58 near the cam 256 is an arm 257, on which is a roller 258 in engagement with the cam 256. Pivoted to the arm 257 is a link 259 extending forwardly in the machine. The link 259 is pivoted at its forward end to an upwardly extending arm of a bell crank lever 260, which bell crank lever is suitably pivoted at 261 on the frame of the machine. The bell crank lever 260 has a forwardly extending arm pivoted at its forward end to a downwardly extending link 262. The lower end of the arm 262 is pivoted to the upper end of the bar 140. A spring 263 secured to the upwardly extending arm of the bell crank lever 260 and to a stationary member on the machine tends to hold the roller 258 in engagement with the cam 256.

In Fig. 51 there is shown on the shaft 222 a cam 264, the face of which is engaged by a roller 265 on an arm 266, pivoted on a stud 267. The arm 266 has a rearwardly extending portion 268. The crank shafts 174, hereinbefore described, are mounted in bearings 269 at the rear part of the machine.

On one end of each crank shaft 174 is an upwardly and forwardly extending arm 270. The upper ends of the arms 270 are pivoted to the opposite ends of a substantially vertical link 271. The rear end of the arm 268 preferably stands below the pivotal point of the upper arm 270 and the upper end of the link 271. A short link 272 is pivoted to the

rear end of the arm 268 and the upper end of the link 271, (see Figs. 1, 4, 41 and 42.)

In Fig. 45 there is shown on the shaft 222 the cam 273, the face of which engages a roller 274 on one arm of a bell crank lever 275, which is pivotally mounted on the stud 276 on the frame of the machine. The cam 273 is provided for raising and lowering the frame member 150. The frame member 150 travels between the guide members 149, hereinbefore referred to.

Pivoted at the upper part of each end of the frame member 150 at each side of the machine is a depending link 277. In the forward part of the machine near the upper portion thereof is a transverse shaft 278 extending across the machine. Fixed on the shaft near the opposite ends thereof (Fig. 53) are parallel arms 279 extending rearwardly through the machine and pivoted at their rear ends to the lower ends of the respective links 277. The bell crank lever 275 has a forwardly extending arm pivoted to a downwardly extending link 279^a. At its lower end the link 279^a is pivoted to one of the arms 275 at a point rearwardly of the shaft 278 in the machine.

On the shaft 222 is a cam 280, shown in Figs. 42, 43 and 46. The cam 280 is slidably but non-rotatably mounted on the shaft 222. The cam serves to operate the clearing mechanism of the machine. Pivoted on the stud 267 is an arm 281 having a forwardly extending portion on which is a roller 282 designed to engage the face of the cam 280. The arm 281 has a rearwardly extending portion on which is a curved rack 283 in mesh with a pinion 284, loosely mounted on the shaft 185, shown in Figs. 43 and 44. On the shaft 185 is fixed an arm 285, to which is pivoted a pawl 286 which is held in engagement with the pinion 284 by means of a spring 287. It will be seen that the rearwardly extending portion of the arm 281 may move downwardly carrying with it the rack 283 thereby rotating the pinion 284 without affecting the shaft 185. When, however, the cam 280 engages the roller 282 for raising the rack 283, the pinion 284 will be rotated, and through the pawl 286 and the arm 285 will rotate the shaft 185. The parts are so arranged that said rotation will be a little over a complete revolution. Below the rearwardly extending part of the arm 281 is a suitable stop 288 for limiting the downward movement of the rack 283.

Formed on the arm 281 is an arm 289 to which is secured a spring 290. The spring 290 is also secured to some fixed part of the machine for yieldingly holding the rack 283 in its lowered position.

When it is desired to operate the machine without working the clearing mechanism, such purpose can be accomplished by manipulating the following mechanism. The cam

280 is provided with a hub 291. Mounted in suitable bearings 242 is a longitudinally arranged rock shaft 293, the rear end of which carries a yoke 294.

5 On the arms of the yoke 294 are pins 295, which engage the hub 291.

At the forward end of the rock shaft 293 is a laterally extending arm or handle 296 having a key 297 at its upper end. By depressing the key 297 the pins 295 may be made to engage the hub 291 for sliding the cam 280, longitudinally on the shaft 222, out of engagement with the roller 282, and against the pressure of a spring 298 on the shaft 222. The spring 298 normally yieldingly holds the cam 280 in engagement with the roller 282.

On the shaft 222 is a cam 299, shown in Fig. 48, which operates the key releasing mechanism. The cam 299 engages a roller 300 on an arm 301, which arm 301 is fixed on the shaft 32, hereinbefore referred to.

I have provided suitable mechanism quite similar to that hereinbefore described, for multiplying by fractions. I have shown in the drawings only one bank of fraction keys, being the right-hand bank of keys of the multiplier set, shown in Fig. 3 and Fig. 1.

With the mechanism here shown, multiplication by fractions may be done directly without reducing the fractions to decimals. It will, of course, be seen that by reducing any fraction to a decimal the machine can be used for multiplying the fractions without the use of the fraction multiplying mechanism here shown.

I have shown in Fig. 3 a right-hand bank of keys in the multiplier set, which keys represent fractions having eight for their denominator. That is to say the lowest key in the bank represents one-eighth, and the second key two-eighths, etc.

I have, in my present drawings, shown the mechanism for multiplying by fractions having eight for a denominator only. It will be seen, however, that by duplicating and adding parts, a machine could be constructed for multiplying by other fractions.

For multiplying by fractions, I employ shafts 86^a (Fig. 29) similar to the shafts 86, already described, arranged in vertical rows longitudinally of the machine, and also arranged in horizontal rows, except that there is only one upper shaft 86^a used for multiplying by fractions. In the second horizontal row of shafts from the top, the two right-hand shafts are employed in multiplying by fractions. In the third and lower rows from the top, three shafts are employed.

The shafts in each horizontal row are geared together successively by intermediate gears 302, mounted on shafts 303, so that the shafts in each horizontal row rotate together, and so on. On the fraction shafts 86^a are

mounted cylinders 87^a similar in their general construction to the cylinders 87 already described, except that the pins 304 thereon are properly located for representing partial products of multiplications by eighths. The upper shaft 87^a is connected with the second shaft from the right in the next lower horizontal row of shafts 86^a and with the third shaft 86^a in the third horizontal row of shafts from the top, and so on, by a rack 107 similar to those hereinbefore described. The shafts 86^a which carry the fraction cylinders have clutch devices similar to those already described similarly connected with the keys of the multiplicand.

It will be seen that by operating the keys of the multiplicand, the clutches of the proper cylinders of the fraction shafts are connected in the same way as the clutches on what may be called the digit shafts. The proper clutches having been thrown into gear, then by operating the one-eighth key, the upper right-hand shaft 86^a will be rotated one-sixteenth of a revolution. It will be noted that the rack device and the gearing device are located slightly differently from those for rotating the digit cylinders. That is to say the cylinders 87^a, are divided into two halves, as are the cylinders 87, and the teeth of the racks 106 connected with the fraction keys and the teeth on the gears 105 of the fraction shafts 86^a, and the teeth of the racks 107 connected with the said last described gears, are so arranged that the operation of the one-eighth fraction key rotates the proper shafts one-sixteenth of a revolution. The operation of the two-eighths key operates the proper shaft two-sixteenths of a revolution, etc.

At the right of each shaft 86^a is a bar 130^a, similar to the bar 130 hereinbefore described, and at the left of the left-hand shaft 86^a in each horizontal row is a bar 131^a similar to the bar 131, already described. The said bars 130^a and 131^a adjacent to the shafts 86^a have lugs 305 engaging pins on the upper and lower halves respectively, of the fraction cylinders 87^a, when said cylinders are rotated by the operation of the multiplier keys, and when said bars are moved rearwardly in the machine. The bars 130^a and 131^a are operatively connected with the members 140, and with operative mechanism such as has been hereinbefore described.

At the rear ends of the bars 130^a and 131^a are plates 306 and 307, shown in Fig. 31, mounted in guides 145, similar to those already described.

The teeth 308 are arranged on the plates 306 and 307 in a manner similar to those on the plates 143 and 144, the only difference being in the number of teeth. The plates 306 and 307 have seven vertical rows of teeth. The forward row contains seven

teeth, the second one from the front six teeth, the third one five teeth, the fourth one four teeth, the fifth one three teeth, the sixth row two teeth, and the seventh one one tooth.

The fraction plates 306 and 307 are designed to cooperate with numeral wheels 156 similar to those already described, with the exception that the fraction wheels are divided into eight equal spaces instead of into ten. The fraction numeral wheels may be arranged to carry into the upper wheels 180 in the same way in which such carrying is done from the digit wheels already described.

Mounted in front of the upper portions of the wheels 156 and the lower portions of the wheels 180 is a suitable plate 309 having openings 310.

I will now describe somewhat in detail the practical operation of my multiplying machine.

Assuming that the parts are assembled and in proper normal position, the motor 219 is set in operation, whereby continuous rotary movement is imparted to the shaft 221 and the gear 223. The pawl 236 will hold the disk 225 against rotation in one direction and the hook on the member 240 will hold the pawl 230 out of engagement with the lug 228, and thereby prevent the gear 223 from rotating the disk 225.

Assume that the problem to be worked out is the multiplication of 253×25 . In the multiplicand bank of keys, the operator pushes down the three key in the unit bank, the five key in the ten's bank, and the two key in the hundredth's bank. The depression of the three key in the unit's bank forces the slide bar 24 forwardly in the machine, until the shoulder 20 passes downwardly through the openings in the frame, and the slide bar 24 to position below the slide bar 24.

The lug 73 on the slide bar 24 of the unit's bank of keys in the multiplicand, engages the upwardly extending arm of the bell crank lever 70 moving it forwardly in the machine, and causing the other arm of said bell crank lever 70 to engage the pin 72 and raise the bar 69 out of the notch 79 in the link 59, leaving the link 59 free to be operated at the proper time.

When the bar 69 is raised, the notch 82 therein will be engaged by the pawl 76 which holds the bar 69 in its raised position, until the shaft 74 is operated to release the pawl 76.

The downward movement of the stem 19 of the three key, moves the roller 48 forwardly, when said roller engages the shoulder 52, thereby moving the pin 53 downwardly in the slot 54 against the pressure of the spring 57, until said pin 52 reaches

the slot 55 in which position the parts are held until further operated.

The depression of the other keys of the multiplicand affects the parts connected therewith in the same way as explained in the description of the operation of the three key in the unit bank of the multiplicand set.

The operator then depresses the five key in the unit bank of the multiplier set, and the two key in the ten's bank of the multiplier set. The depression of the multiplier keys, operates the corresponding slide bars 24 in the same way as the depression of the multiplicand keys. The depression of the five key in the unit bank of the multiplier moves the lower end of the stem thereon downwardly to position above the step plate or bar 100 adjacent to the shoulder 103^a.

When the two key in the ten's bank of the multiplier set is depressed, the slide bar 24 is operated the same way as hereinbefore described, and the stem of the key is moved downwardly to position adjacent to the shoulder 103^b of the slide bar 100, below the ten's bank in the multiplier set of keys.

The button 245 is depressed thereby raising the arm 240 and releasing the pawl 230, which is drawn by the spring 234 to position where, as the gear 223 rotates, the lug 228 thereon will engage the hook member 231 on the pawl 230 and carry the disk 222 around with the gear 223, thereby rotating the main operating shaft 222.

Before the shaft 222 begins its rotation, the cam 248 stands substantially in the position shown in Fig. 49, and the cams 273, 280, 256, 299, 252, and 264 stand substantially in the positions shown in Figs. 45, 46, 47, 48, 50 and 51.

The first movement of the shaft 222 rotates the cam 248 for moving the arm 249 on the shaft 58 downwardly, thereby imparting a limited degree of rotation to the shaft 58. It has already been shown that the arms 63 are all held in position on the shaft 58 by the frictional engagement of the parts 62, 64, and the washer adjacent to the spring 68. When the shaft 58 rotates in the direction indicated by the arrow in Fig. 5, all of the arms 63 tend to be moved forwardly in the machine for thereby moving the links 59 and the slide bars or plates 50.

As a matter of fact, however, only those links 59 can be operated which have been released from the members 69 by the raising of said members 69 by the depression of certain keys of the multiplicand. In other words, when the shaft 58 is operated by the operation of the cam 248, those links 59 which have been released will be moved forwardly in the machine carrying with them the upwardly extending arms of the bell crank levers 46 operatively connected with the depressed keys. The lower arms

of said bell crank levers will be raised, thereby operating the links 97, the arms 96, and the particular shafts 85 connected therewith. That is to say, when the three key in the unit bank of the multiplicand set has been depressed, and the shaft 58 is operated, the link 59 connected with the unit bank will be moved for operating the proper bell crank lever 46 connected with the three key, and the third shaft 85 from the front in the top horizontal row of shafts will be given a limited degree of rotation, whereby the arms 95 will be actuated for throwing into engagement all the clutches of all the cylinders 87 in the top row on the third tier of cylinders from the front. The depression of the five key in the ten's bank in the same way will rotate the fifth shaft 85 from the front in the second horizontal row of shafts from the top, or in other words will rotate the second shaft from the top in the fifth tier of shafts 85 from the front, thereby throwing into operative position all the clutches connected with the cylinders 87 in the fifth tier from the front in the second row from the top.

The depression of the two key in the hundredth's bank of the multiplicand will set the clutches of all the cylinders in the third row from the top in the second tier from the front.

The cams 248 and 252 are so arranged on the shaft 222, and so shaped that immediately after the clutches have been set, by the operation of the cam 248, the cam 252 will move the arm 110, fixed on the sleeve 108, for imparting a limited rotation to said sleeve. The rotation of the sleeve 108 tends to move all the links 116 forwardly in the machine, thereby tending to move all of the step plates 100 forwardly in the machine. However, only those plates 100, which have been released from the upright members 69 by the depression of the five key in the unit bank, and the two key in the ten's bank of the multiplier set are operated, and the other plates 100 and the links 116, and arms 111 connected therewith, will be held against movement by the engagement of the members 69 with the shoulder 103'. The forward movement of the plate 100 of the unit bank of keys in the multiplier set, will be limited by the downwardly extending stem of the five key, which has been depressed. The forward movement of said plate will operate the member 104 and the rack 106, for rotating the gear or pinion 105 on the right-hand shaft 86 in the upper row, five-twentieths of a revolution.

It will be remembered that the right-hand shaft in the top row is the fraction shaft 86^a. The rotation of the shaft 86, just described, will operate the rack 107 connected therewith for rotating the next shaft 86 in the next vertical row to the left, and operate

all the other shafts operatively connected with the rack bar 107 in the same way; all of said shafts being rotated five-twentieths of a revolution.

At the same time, the forward movement of the step plate 100 of the ten's bank of keys in the multiplier set, will rotate the gear or pinion 105 on the second shaft 86 from the right in the top row of said shafts two-twentieths of a revolution, thereby moving the rack 107 connected with said last described gear for rotating the next lower shaft 86 to the left, etc.

It will be understood that only one cylinder 87 is rotated on each shaft, that being the cylinder the clutch of which has been set by the depression of the multiplicand key. Thus, by the operation hereinbefore described, the cylinders have been rotated as follows:—

The third cylinder from the front on the right-hand shaft 86 in the upper row has been rotated five-twentieths of a revolution. The operation of the rack 107, operatively connected with the gear 105 on the upper right-hand shaft 86, will rotate the next lower shaft 86 to the left thereby rotating the fifth cylinder thereon, the clutch of which has been set by the depression of the five key in the ten's bank of the multiplicand, five-twentieths of a revolution, thereby also operating the next shaft 86 to the left in the third horizontal row of shafts from the top for rotating the second cylinder 87 thereon from the front five-twentieths of a revolution.

By the operation of the two key in the ten's bank of the multiplier set, the gear 105 on the second shaft 86 from the right in the top row has been rotated two-twentieths of a revolution, thereby rotating the third cylinder from the front on said shaft two-twentieths of a revolution. The same operation moves the rack 107 connected with the second shaft 86 from the right in the top row for rotating the next shaft below and to the left, and rotating the fifth cylinder from the front thereon two-twentieths of a revolution, and also for rotating the shaft 86 to the left in the next lower row for rotating the second cylinder from the front thereon two-twentieths of a revolution.

The result is, that the third cylinder from the front on the upper right-hand shaft 86, which is the three cylinder, will have been rotated five-twentieths of a revolution for bringing the pin on the upper half of said cylinder into the path of the lug 142 on the bar 131 at the right of said cylinder, and bringing another pin on the lower half of said cylinder into the path of the lug 142 on the bar 130 at the left of said cylinder.

It will be remembered that the pins on the three's cylinder are so arranged that

when the three cylinder has been rotated five-twentieths of a revolution, the pin which will stand in the path of the lug on the bar 131 will permit said bar to move rearwardly what may be called five spaces, which will be a sufficient distance for bringing the plate 144 at the rear end of said bar 131 to position where there will be on the plate 144, under consideration, in the path of the proper gear 152, a vertical row of five teeth 144.

The clutches of the proper cylinders 87 having been set, and the proper cylinders having been rotated the proper distances by the depression of the keys of the multiplier and multiplicand, as hereinbefore described, and the operation of the cams 248 and 252, and parts connected therewith, the operation of the machine has reached a proper stage for moving the bars 130 and 131 rearwardly. The bars 130 and 131 are operated from the cam 256 on the shaft 22. After the cam 248 has been operated for setting the clutches, and the cam 252 has been operated for rotating the cylinders 87, the cam 256 reaches such a point in its rotation that it then moves the arm 257, pivoted on the shaft 58 (see Fig. 47) for moving the link 259 rearwardly in the machine and moving the bell crank lever 260 against the tension of the spring 263 for raising the bar 140 and the arms 139 connected therewith for imparting limited rotation to the various shafts 132. The rotation of the shafts tends to move the sleeves 135 and all of the arms 133 and to carry rearwardly the bars 130 and 131.

I have provided means for holding the bars 130 and 131 against rearward movement, except in the instance of those bars adjacent to the cylinders which have been rotated, following the depression of the keys.

Mounted on the shafts 118 are arms 311, which normally project upwardly into notches 312 in the next lower bar 131 to the right of the shaft 118 (Figs. 31 and 55).

Pivoted to each arm 311 is an arm 313, projecting laterally and upwardly and having at its end, an upwardly projecting lug 314, normally received in a notch 315 in the next upper bar 130 to the left (Figs. 31 and 55). The upper ends of the arms 313 may slidably rest on the bars 131 below the bars 130 which are locked by the lugs 314.

It will be remembered that each cylinder 87 is provided with an internal flange 123 having a notch which normally receives the roller 127 on the arm 125 on the shaft 118. When the cylinders 87 are rotated, in the manner hereinbefore described, the roller 127 is forced out of the notch in the flange 123, thereby imparting limited rotation to the shaft 118 in the direction indicated by the arrow in Fig. 55, whereby the upper

end of the arm 311 and the lug 314 on the arm 313 are moved out of the notches in the bar 131 on the right, and the bar 130 on the left of the cylinder 87 which has been rotated.

It may be mentioned, in this connection, as hereinbefore referred to, that the rollers 121 engaging the notched flanges 117 of the cylinders 87 hold all of the cylinders against floating movement.

When the shaft 132 is rotated, in the manner hereinbefore described, the bars 130 and 131, which have been released by the operation of the shaft 118, are moved rearwardly until their lugs engage the projecting pins 129 on the adjacent cylinders 87.

On the assumption that the problem to be worked out is 253×25 , then in the illustration now being made of the operation of the machine, the lower bar 131 at the right of the cylinders on the upper right-hand shaft 86, will be moved rearwardly until it engages the projecting pin of the third cylinder from the front on said shaft. The cylinder in question is one of the "threes" cylinders, illustrated in flat form in Fig. 9.

The cylinder, in question, was moved by the operation hereinbefore described, five spaces or five-twentieths of a revolution, thereby bringing the pin "D" in the fifth circumferential space (see Fig. 19) into the path of the lug on the bar 131. The pin "D" stands in such position that the bar 131, under consideration, moves rearwardly five spaces thereby moving the plate 144 connected with said bar rearwardly. The said plate 144 then stands in position where there will be in line, below one of the gears 152, a row of five teeth. At the same time, the bar 130 at the left of the cylinder under consideration, which is the third cylinder from the front in the upper right-hand row of digit cylinders, moves to position where the pin "E" on said cylinder stands in the path of the lug on said bar 130. The bar 130, under consideration, therefore will move rearwardly carrying with it its plate 143, which will be moved to position where one tooth only will be in line below the proper gear 152. It will, of course, be understood that all the bars move simultaneously.

Continuing the explanation of the problem being worked out, the bar 131 at the right of the cylinders in the second row from the right in the second horizontal row of cylinders from the top of the digit cylinders, will be moved rearwardly, until one of its lugs engages the pin "F", the fifth cylinder from the front shown in Fig. 21. The bar 130 at the left of said cylinder will be moved rearwardly until its lug engages the pin "G" on said cylinder, shown in Fig. 21.

The bar on the right of the second cylinder from the front in the third row of cylinders

ders from the top on the third digit shaft 86 from the right, will not be moved, inso-
much as the pin "H", which may be called
the zero pin on the cylinder in question,
5 which is shown in Fig. 18, will engage the
lug on said bar 131. The next bar 130 to
the left of said cylinder will move rear-
wardly until its lug engages the pin "I" on
the cylinder, under consideration, shown in
10 Fig. 18.

The plate 144 on the last bar 131 men-
tioned above, will not be moved, but the
plate 143 on the last plate 130, described
above will be moved rearwardly until one
15 pin thereon will stand below the proper
gear 152.

In the same way, the other bars adjacent
to the cylinders 87, which have been rotated,
will be moved rearwardly for bringing the
20 plates 143 and 144 into proper position.

The positions and movements of the var-
ious bars 130 and 131 may be somewhat
illustrated by setting out in diagram, the
problem being used for illustration, as fol-
25 lows:—

	2 5 3
	2 5
	<hr/>
	1
30	6 5
	1 2
	0 5
	1
	4 0
35	<hr/>
	6 3 2 5

Thus, in the figures shown above, the five
in the unit column represents the number of
40 teeth on the plate 144 on the first bar 131,
which was operated, that stands in the path
of the proper gear 152. The five, just men-
tioned, stands in the path of what may be
called the unit gear 152.

45 In the second column, one represents the
number of teeth on one of the plates 143,
five represents the number of teeth on one
of the plates 144 and six the teeth on another
plate 144 in the path of the ten's gear
50 152, etc.

It will be noted from the illustration of
the performance of a problem in multipli-
cation, as described up to this point, that
55 the partial products of multiplication are
obtained simultaneously. By partial prod-
ucts, I means the product of multiplication
of any one digit of the multiplicand by a
digit of the multiplier. That is to say in
the foregoing problem, the product of mul-
60 tiplication of three by five is fifteen, a par-
tial product. The product of the multipli-
cation of five by five is twenty-five, and the
product of five by two is ten, and so on; all
of these partial products are obtained simul-

taneously and set up in the machine on the
plates 143 and 144 in proper position with
relation to the units, tens, and so on, gears
152.

The advantage of obtaining and setting
these products up simultaneously in the ma-
70 chine rather than by obtaining and setting
them up by successive operations of the ma-
chine, and the saving of time, are obvious.

When the parts of the machine have been
operated, and moved to the positions as de-
75 sired in the illustration now being made, the
cam 273 will have reached the position where
the arms 279 will be operated to lower the
frame member 150, causing the gears 152 to
engage the teeth on the tooth plates and to
80 be rotated as many tenths of a revolution as
there are teeth in their paths. The unit gear
152 will engage five teeth and be moved five-
tenths of a revolution. The ten's gear 152 will
engage one tooth on one plate 143 and be
85 moved one-tenth of a revolution, and will
engage five teeth on one plate 144 and be
moved five-tenths of a revolution and will
engage six teeth on another plate 144 and
be moved six-tenths of a revolution. The
90 hundred's gear 152 will engage two teeth
on one plate 143. The thousand's gear 152
will engage one tooth on one plate 143 and
be moved one-tenth of a revolution and will
engage four teeth on one plate 144 and be
95 moved four-tenths of a revolution. It will
be understood in this connection that the
right-hand gear 152 is the fraction gear, the
next gear to the left the unit's gear, the sec-
ond gear to the left the ten's gear and so on.
100

The further rotation of the shaft 273,
shown in Figs. 45 and 53, will start the
frame member 150 on its upward move-
ment.

Continuing the illustration of the opera-
105 tion of the machine, it will be seen that the
unit gear 152 will be rotated twelve spaces,
and so on. The rotation of the gears 152
imparts rotation to the numeral wheels 156.
It is assumed that all of the numeral wheels
110 start from the zero position. The rotation
of the gears 152 also rotates the sleeves 158
and the arms 159 thereon. When the ten's
gear 152 has rotated ten spaces, the roller
160 on the arm 159 operatively connected
115 with the shaft 151, which carries the ten's-
gear 152, will engage a notch in the notched
wheel 169, imparting to said notched wheel
one-tenth of a revolution (see Figs. 34 and
35). Rotation of the wheel 169 imparts ro-
120 tation to the sleeve or hub 165 and the gear
170 thereon, thereby raising the rack 171,
connected with the gear 170, one tooth or
space. The movement of the rack 171 ro-
tates the gear 161 next below and to the left
125 of the gear 170 which moved the rack 171.
The gear 161, in question, moves freely on
the shaft 151, and has no effect thereon

when the rack 171 is moved upwardly. Thus it will be seen that the numbers which are carried, are simply as it were, carried into the racks 171 and held there during the further downward movement of the frame member 150.

Just before the upward movement of the frame member 150, the cam 264 will have reached the position to permit the arm 266 to move upwardly whereby the arm 268 moves downwardly, thereby operating the members 270 for rotating the shaft 174 and causing the crank thereon to be moved to position for carrying the plate 175 slightly forwardly in the machine until the flanges 178 lie in the paths of those rollers 176, which have been moved out of their normal positions by the raising of the rack bars 171, and the members 179 lie in the paths of the rollers 166. The further rotation of the cam 273 causes the upward movement of the frame member 150. During said upward movement, the rollers 166 successively engage the inclined faces 179, and thereby move the sleeves 165 and wheels 169 forwardly in the machine until the gears 170 are out of mesh with the racks 171. It may be noted here that the gears 170 are not all thrown out of gear with the racks at the same time, but that the right-hand gear 170 is first thrown out and before the next gear 170, to the left, is thrown out, the roller 176 on the right-hand rack 171 will have entered the space between the proper guides 177.

In the performance of the problem, now under consideration, the right-hand rack 171 will not have been moved during the downward movement of the frame member 150, and hence the roller 176 thereon will be directly below said guides 177 and pass between them on the upward movement of the frame member 150.

I am describing the operation, at present, without reference to the fraction mechanism of the machine.

The second rack 171 from the right will have been raised one notch, so that immediately after the second member 166 from the right has been operated, for throwing the second gear 170 from the right out of mesh with its rack, the roller 176 on said rack will engage the inclined flange 178, thereby forcing said rack 171 downwardly and imparting one-tenth of a revolution to the gear 161, which is the third from the right in the machine, and thereby through the proper pawl 163, arm 162, shaft 151 and sleeve 155, impart one-tenth of a revolution to the hundred's wheel 156. The downward movement of the rack 171, under consideration, will bring the roller 176 thereon to position between the proper guide flanges 177 as the upward movement of the frame

member 150 continues. It will be noted that the gear 170 connected with the hundred's shaft will not be thrown out of mesh with its rack until after the roller 176, on the second rack 171 from the right, has performed its function, as above described. It thus appears that if, in the illustration under consideration, a number had been set up on the numeral wheels 156 before starting the operation of the machine, and if the number on the hundred's wheel had been nine, the carrying of another number into the hundred's wheel, during the upward movement of the frame 150 would cause the roller 160 connected with the hundred's wheel to carry one number into the proper wheel 169, before the pinion 170 connected therewith would be thrown out of gear with its rack 171, which rack would not be thrown out of gear until after the number had been so carried. The spring controlled rollers 340 engage the notches of the wheels 169, and prevent their floating movement, and prevent the rack bars 171 from moving downwardly until properly actuated.

The further revolution of the shaft will bring the frame member 150 to its upper position, and when it reaches such position the result of the problem in multiplication under consideration will be set up on the numeral wheels 156.

The unit wheel 156 will show through the opening 310, the character 5, the ten's wheel will show the character 2, the hundredth's wheel will show the character 3, and the thousand's wheel will show the character 6.

In one position of the cam 263, the gear teeth on the wheels 156 are in mesh with the teeth on the wheels 180, this being at the time when the point J of the face of the cam 273 engages the roller 274 (see Figs. 45 and 36). Just before and just after the cam 273 reaches the position just described, the teeth on the wheels 156 will stand just below and out of mesh with the teeth on the wheels 180.

When the frame member 150 reaches its lower position, the cam 252 moves to position for operating the arms 110, the sleeve 108, and the arms 111 for returning the step plates 100 to their original rearward or normal positions. The return of the step plates 100 to their original positions, returns the cylinders 87, which have been moved during the operation of the machine, to their original or zero, or starting positions. While the frame member 150 is still at the lower limit of its movement, and immediately after the last described movement of the cam 252, the cam 248 moves to position for operating the arm 249, the shaft 58 and the arm 63 for returning the links 59 and the bars 50 to their original starting positions. The rearward movement of

the bars 50 carries the members 47 and bell crank levers 46 for releasing those clutches which have been set. When the bars 50 reach their rearward position, the pins 53 stand at the lower end of the slot 54. It will, of course, be understood that we are now referring only to the parts which have been moved during the operation of the machine.

- 10 At a proper time, preferably during the upward movement of the frame member 150, the cam 299 is operated for moving the arms 301, and imparting slight rotation to the shaft 32, causing the arms 40 thereon to engage the downward portions 36 of the slide-bars 24 for moving the slide-bars 24 forwardly in the machine until they clear the shoulders 20 on the keys which have been depressed for permitting the keys to be moved upwardly by the springs 21. The rotation of the shaft 32 causes the lugs 83 to engage the lugs 84, thereby moving the pawls 76 out of engagement with the notches 82 of the bolts 69, whereupon the springs 82 will operate the bell crank levers 70 for dropping the members 69 downwardly into the notches 79 in the links 59. A slight further movement of the cam 299 will return the shaft 32 to its original position and permit the springs 26 to return the slide bars 24 to their upward rearward positions. The parts just described are so arranged as to work in proper sequence.

- In this connection it may be noted that if, during the first part of the operation of the machine, a mistake should be made in depressing keys of the multiplicand, the keys may be released and the clutches thrown out by depressing the key 39, thereby operating the members 40 and 83 of the bank of keys in which the key has been improperly depressed.

- The operation of the shaft 32, by means of the cam 299 also operates the members 40 and 83 adjacent to the multiplier keys for properly operating the slide-bars thereof and for raising the bolts which have been depressed in the multiplier set to drop to position in the paths of the shoulders 103¹. It will be understood that one key 39 is provided for each bank of keys in both the multiplier and multiplicand set. The key 43 operates the shaft 32 in a way similar to its operation by the cam 299 for releasing and returning all the keys which may have been depressed after a problem has been set up. In this connection it may be noted that the keys 39 operate the collars or sleeves 33 which are allowed some play on the shaft 32, on account of the slots 34 while the key 43 operates the member 41, which is fixed on the shaft 32 and thereby serves to operate the shaft 32.

The machine may be adjusted to stop just

before the point "J" of the cam 273 reaches the position where the point J will engage the roller 275 in which case, the numeral wheels 156 will stand just below and out of mesh with the wheels 180. In order to have the machine stop at the point just mentioned, the handle 243 is manipulated before the machine is originally started to cause the pin 238 to rest in the notch 241 or rearward notch, thereby moving the member 240 to the forward position of its movement, and causing the hook member 246 to engage the upwardly extending lug 247 on the pawl 230, thereby disengaging the hook member 231 on the pawl 230 from the lug 228 at such a time in the revolution of the shaft 222 that the cam 273 stops its movement before the roller 274 reaches the point J on said cam.

The operator may then take notice of the numbers on the upper portions of the numeral wheels, which are visible through the openings 310, shown in Fig. 2, as reflected on the mirror 316. The mirror 316 can be observed through the transparent member 317, shown in Fig. 2.

After the operator has taken off the numbers on the wheels, another problem can be worked out on the machine. After the keys have been depressed and the automatic operation of the parts commenced, and when the point J on the cam 273 reaches the roller 274, the wheels 156 will mesh with the wheels 180. The wheels 156 will be rotated anticlockwise from the cam 280 on the shaft 222. The cam 280 moves the arm 281 for operating the rack 283, thereby rotating the gear 284, which, through the arm 285 and pawl 286 will rotate the shaft 185.

The shaft 185 will rotate all of the gears 184, which in turn will rotate all of the gears 183. The numeral wheels 180, which are in mesh with those wheels 156 which have not been moved by the operation of the machine will remain stationary for the reason that the wheels 156 which have not been moved will be held against movement by the engagement of the pins 157 thereon with the lugs 194.

The wheels 180 which move at all, will be rotated to carry with them the wheels 156 in mesh with them, until the pins 157 on the wheels 156 engage the lugs 194. Thus the first or unit wheel 156, which was moved five-tenths of a revolution will be moved anti-clockwise five-tenths of a revolution, and the wheels 180 in mesh with said wheels 156 will be moved five-tenths of a revolution bringing the numeral five thereon opposite the proper opening 318 in the plate 309 (Fig. 2). The ten's wheel which will have been moved two-tenths of a revolution, to work out the problem used herein for illustration, will be returned two tenths of a

revolution, thereby rotating the wheel 180, in mesh with the ten's wheel 156, to bring the numeral 2 opposite the opening 318. The hundredth's wheel 156, which was moved three-tenths of a revolution by the operation of the machine, in the illustration, will be returned three-tenths of a revolution thereby moving the wheel 180, in mesh therewith, to position where the numeral three is opposite the opening 318. The thousand's wheel 156, which was moved six-tenths of a revolution, will be moved back permitting the wheel 180, in mesh therewith, to move six tenths of a revolution for bringing the numeral six thereon opposite the opening 318. Thus where the product of the problem in multiplication is worked out on the machine and the machine is set to stop before carrying the product of the second multiplication into the wheels 180, the product of the first multiplication will be set up on the upper wheels 180 and can be seen and the product of the second multiplication will be visible on the lower wheels 156 after the second multiplication.

It will be seen that the operation above described, whereby the problem of multiplication is set up in the wheels 180, results in clearing the wheels 156 and leaving them stand in their normal or zero position.

In the illustration so far described, it has been assumed that all the numeral wheels have started from their zero position. In case a problem is worked out on the machine, when there is already a product set up in the wheels 180, or in some instances when the second product is added into the first product on the wheels 180, it is necessary to carry the numbers on the wheels 180 successively to the wheels 180 to the left. This carrying is accomplished by the mechanism hereinbefore described.

Assuming that in clearing the wheels 156, the right-hand numeral wheel 180, shown in Fig. 36, is moved clockwise, from its nine position to its zero position. The roller 209 on the wheel 180 will raise the arm 205, thereby lowering the arm 207, and permitting the pawl 201 to drop downwardly to the position shown in Fig. 37, and the lug 208 will be moved downwardly out of the path of the lug 202 on the arm 196 adjacent to the second numeral wheel 180 from the right, shown in Fig. 36.

The arm 197, however, is held against movement by the lug 209^a on the frame 150. Thus the arm which is carried by it is held until the frame member 150 begins another downward movement, whereupon the spring 200, connected with the arm 196, under consideration, will move said arm, carrying with it the pawl 199 a sufficient distance for moving the second wheel 180 from the right—shown in Fig. 36, one-tenth of a rev-

olution, whereby the carrying of the number 65 from the unit wheel 180 to the ten's wheel 180 is completed. Thus it will be seen that by manipulating the handle 243 for lifting the lever connected therewith and placing the notch 241 over the pin 238, the arm 240 may be placed in position for stopping the operation of the machine just before the point J on the cam 273 rotates the roller 274, and the operation of the machine will be stopped when the product of the multiplication is set up in the wheels 156 before said product is carried into the wheels 180. If, however, it is desired to carry the product of the multiplication into the wheels 180, before stopping the machine, the handle 243 may be used for moving the lever connected therewith for setting the notch 242 over the point 238, thereby moving the arm 240 rearwardly in the machine and permitting a little further rotation of the shaft 222 before the machine is stopped, whereby the cam 45 moves to position where the point J engages the roller 274, whereupon the machine may be operated for carrying the problem from the wheels 156 into the wheels 180, and will permit the cam 273 to move a little farther, permitting the frame member 150 to move slightly downwardly from its upper limit of movement.

It is desirable to permit a slight downward movement of the frame member 150 in order to allow for the operation of the arms 196 and pawl 199 for completing the carrying operation from one wheel 180 to another wheel, so that when the machine stops, the complete and proper product of the multiplication will appear on said wheels.

When it is desired to leave the product of one multiplication set up on the wheels 180, and to perform further multiplications without adding the sums of the products into the wheels 180, the mechanism for adding the product set up on the wheels 156 into the product already set up on the wheels 180, may be thrown out of gear and made inoperative by depressing the button 297 and moving the cam 280 outwardly from the body of the machine on the shaft 222 and out of contact with the roller 282.

At any time when it is desired to add the product of a multiplication, which has been set up on the wheels 156, and a product already set up on the wheels 180, the button 297 may be raised for throwing the cam 280 into contact with the roller 282.

It will be seen that by depressing the button 297, the product may be left set up on the wheels 180 and several multiplications may be performed on the machine without clearing the wheels 156, and that the sums of the several products will be set up on the wheels 156, and that the sum of the several products thus set up in the wheels 156 may

finally be added to the number already set up on the wheels 180.

A number set up on the wheels 180 may be cleared out by depressing the button or handle 216 and moving the members 213 into the paths of the rollers 209 on the numeral wheels 180, and thereafter manually rotating the shaft 185 by means of the handle 217 at a time when the wheels 156 are out of mesh with the wheels 180 in a direction opposite that of the rotation of the shaft 185 by the rack 283. When the shaft 185 has thus been manually rotated until all of the rollers 209 are stopped by the members 213, the wheels 180 will be in their normal or zero positions.

The operation of the multiplication by fractions is very similar to that already described. Using for illustration the numbers heretofore used, and adding to the multiplier the fraction $\frac{3}{8}$, the problem to be worked out is

$$\begin{array}{r} 2 \ 5 \ 3 \\ 2 \ 5 \frac{3}{8} \end{array}$$

The operation in completing the multiplication, except as to the fractions, has already been described.

In carrying out the multiplication, by fractions, the multiplicand is set up and the multiplier is set up.

It will be remembered that as hereinbefore described, the fraction cylinders are divided into nine spaces longitudinally and sixteen spaces circumferentially. The depression of the two-eighths key in the fraction bank of the multiplier set rotates the third cylinder from the front on the upper fraction shaft 86^a two-sixteenths of a revolution. The rack bar 107, connected with the pinion on the upper shaft 86^a rotates the next lower shaft 86^a to the left.

The rotation of the left-hand or second fraction shaft 86^a in the second row of shafts from the top serves to rotate the fifth cylinder from the front thereon, the clutch of which was set by the depression of the 50 key of the multiplicand set, two-sixteenths of a revolution.

The fact that all of the shafts 86^a in the second row from the top are connected by the gears 302, results in the rotation of the other shafts in said second row from the top, which are not directly connected with the rack 107, each being rotated two-sixteenths of a revolution.

It will be seen that the other shafts 86^a in the same way are each rotated two-sixteenths of a revolution. The fifth cylinder from the front end of each of the shafts 86^a in the second row from the top is rotated with the shaft, and the second cylinder from the front on each shaft 86^a in the third row from the top is rotated two-sixteenths of a

revolution. Owing to the fact that none of the clutches have been set on the lower row of shafts 86^a, none of the cylinders thereon will be moved.

The pins on the cylinders are so arranged that when the upper right-hand shaft 86^a is rotated for moving the third cylinder thereon two-sixteenths of a revolution for moving it to position where a pin on the upper half of said cylinder in the sixth space from the front end thereof stands in the path of the lug 305 on the bar 130^a at the right of said cylinder, and when the bar 130^a is moved rearwardly, the plate 307 at the rear end thereof, will be moved to position where six teeth thereon will stand in the path of the fraction gear 152.

The pins on the fifth cylinder from the front on the left-hand shaft 86^a in the second row of said shafts from the top, are so arranged that when said cylinder is rotated two-sixteenths of a revolution, there will stand in the path of the lug on the bar 130^a on the right of said cylinder, a pin which will permit said bar 130^a to move two spaces thereby carrying the plate 307 on said bar 130^a a sufficient distance rearwardly to bring a row of two teeth thereon into the path of the unit gear 152.

Such rotation of the cylinder, under consideration, will bring a pin on the lower half thereof into the path of the lug 305 on the bar 131^a at the left of said cylinder at such a point as to permit said bar 131^a to move rearwardly one space, for bringing the plate 306 on said bar to position where one tooth thereon stands in the path of the ten's gear 152.

When the cylinder now under consideration is rotated two-fifths of a revolution, the cylinder to the right thereof on the fraction shaft 86^a is rotated two-sixteenths of a revolution, and the pins on the latter cylinder are so arranged that the rotation of said cylinder two-sixteenths of a revolution brings a pin on the upper half of said cylinder into the path of the lug 305 on the bar 130^a at such a point as to permit the rearward movement of said bar four spaces for moving the plate 307 on said bar rearwardly in the machine for bringing a row of four teeth thereon into the path of the fraction gear 152.

The rotation of the left-hand shaft 86^a in the third of said shafts from the top, in performing the problem, under consideration, rotates the second cylinder from the front thereof two-sixteenths of a revolution, bringing a tooth on the upper half thereof into the path of the lug 305 on the right-hand bar 130^a, at such a point as to permit the rearward movement of said bar five spaces for carrying the plate 307 thereon, rearwardly, to position where a row of five

teeth on said plate stand in the path of the ten's gear 152.

The said cylinder, now under consideration, has a zero pin in its lower half which, when said cylinder is rotated two-sixteenths of a revolution, stands in the path of the lug 305 on the left-hand bar 131^a and prevents the rearward movement thereof.

Before proceeding with the illustration of the problem, now under consideration, I will digress slightly for the purpose of further explaining the arrangement of the pins on the cylinders of the fraction shafts 86^a.

In Fig. 26, I have shown for purposes of illustration, the ninth cylinders from the front on the second row of fraction shafts 86^a from the top, which I may call the 90 cylinders.

It may be stated generally that the arrangement of the pins on the cylinders on the right-hand shafts 86^a represent in all cases fractional results, with the exception, that the top row of cylinders 87^a have the pins so arranged that the pins on the upper half thereof represent fractional results which are whole numbers.

Referring to the 90 cylinders laid out in Fig. 26, it will be seen that the pins thereon are so arranged that when the one-eighth key is depressed, for rotating said cylinders one-sixteenth of a revolution, a pin on the upper half of the left-hand 90 cylinder will stand in position to permit the rearward movement of the proper bar 130^a, one space, as shown at L in Fig. 26. In the same way the pin at M in said figure on the lower half of the cylinder will move to position where it will permit the rearward movement of the proper bar 131^a one space. Each of the bars 130^a and 131^a, just referred to, will carry the plate 306 thereon rearwardly for bringing one tooth into the path of the fraction unit gear 152, and the ten's gear 152 respectively.

The same operation will move the right-hand 90 cylinder one-sixteenth of a revolution, thereby bringing the pin N thereon into the path of the bar 130^a at the right of said cylinder, at such a point as to permit the rearward movement of said bar 130^a two spaces for bringing the plate 307 thereon to position where a row of two teeth stand in the path of the fraction gear 152. If the two-eighth's multiplier key has been depressed, the 90 cylinders will be rotated two-sixteenths of a revolution, whereby a pin on the upper half of the left-hand 90 cylinder, indicated in Fig. 9, by the character 0, will be moved into the path of the lug 305 on the right-hand bar 130^a at such a point as to permit the rearward movement of said bar two spaces.

At the same time the pin P, in the lower half of said cylinder will be moved to po-

sition in the path of the lug 305 on the left-hand bar 131^a at such a point as to permit the rearward movement of that bar two spaces. At the same time, the right-hand 90 cylinder will be moved two-sixteenths of a revolution, thereby bringing a pin P thereon into the path of the lug 305 on the right-hand bar 130^a at such a point as to permit the rearward movement of said bar four spaces.

The further arrangement of the pins on the 90 cylinders will readily be seen from the foregoing description.

In Fig. 27, I have shown the arrangement of the pins on the seventh cylinders from the front on the third row of shafts from the top, these being what may be called the seven hundred cylinders.

In Fig. 28 I have shown the seven hundred cylinders arranged in the position in which they will stand after the depression of the seventh key in the hundred's bank of the multiplicand, and the seven-eighth's key in the fraction bank of the multiplier.

When said keys, as above mentioned, are depressed, the left-hand seven hundred cylinder will be rotated seven-sixteenths of a revolution, thereby bringing the cylinder to position where the pin R in the upper half thereof stands in the path of the lug 305 on the right-hand bar 130^a at such a point as to permit the rearward movement of said bar one space. The pin S on the lower half of said cylinder stands in the path of the lug 305 on the left-hand bar 131^a at such a point as to permit the rearward movement of said bar six spaces. The second seven hundred cylinder from the left will be moved, bringing a pin on the upper half thereof into the path of the lug 305 on the right-hand bar 130^a, at such a point as to permit the rearward movement thereof two spaces. The third from the left or fraction cylinder will be moved to position where the pin U on the upper half thereof will stand in the path of the lug on the right-hand bar 130^a, at such a point as to permit the rearward movement of such bar four spaces.

In Fig. 28, I have shown the cylinders 87^a in their position, with the pins thereon moved to positions for coacting with the lugs on the bars in working out the multiplication of seven hundred by seven-eighths.

In this connection it will be noted that that in multiplying by fractions, the left-hand cylinder in each horizontal row of cylinders on the shafts 86^a has pins arranged for coacting with a bar 130^a on the right, and pins for coacting with a bar 131^a on the left, while the other cylinders in each horizontal row have pins only on their upper halves for coacting with the lugs on the bars 130^a at the right of the cylinders.

Continuing now the illustration of the

problem of the multiplication of 253 by 25 and two eighths, it should be noted that the operation of the machine as hereinbefore described, has moved the plates 307 and 306 rearwardly in the machine, until they stand in the following positions. I am omitting here all mention of the plates 143 and 144, the operation of which has been hereinbefore described.

- 10 The plate 307 on the bar 130^a, opposite the upper fraction cylinder, stands in position with a row of six teeth below the fraction gear 152. The next lower plate 307 stands in position with four teeth in the path of
15 said gear. The plates 306 and 307 below the unit gear 152 have been moved to position as follows:—

- The plate 307 on the bar 130^a on the right of the second row of fraction cylinders from the right in the second row of cylinders from the top will stand in position with two teeth in the path of the unit gear 152.

- 20 The plate 306 on the bar 131^a at the left of the left-hand shaft 86^a in the second row of fraction shafts from the top will stand in position with one tooth below the ten's gear 152.

- 25 The plate 307 on the bar 130^a at the right of the left-hand shaft 86^a in the third row of said shafts from the top, stands in position with a row of five teeth below the ten's gear 152, being the third row from the front of the plate shown in Fig. 31.

- The mechanism for setting up numbers on the unit's, ten's and hundredth's wheels
35 156 and 180 has already been described. The mechanism for setting up the fractions represented on plates 307 in the right-hand vertical row of said plates is the same as has already been described in the case of
40 multiplication of whole numbers, with the exception that the fraction gear 152 has eight teeth instead of ten, and the fraction numeral wheel 156, connected therewith, has on its face the zero and seven numbers. The
45 fraction numeral wheel 180 in mesh with the wheel 156 has on its face the zero and seven numbers.

- It will, of course, be understood that the characters on the fraction wheels 156 and
50 180 may be the numerals one, two, three, etc., or may be the fractions one-eighth, two-eighths, three-eighths, etc., or might be the fractions one-eighth, one-fourth, three-eighths, one-half, etc. It will be noted, therefore, that the only difference in the
55 mechanism shown in Fig. 35 between the mechanism used for multiplying whole numbers and the mechanism used for multiplying by fractions lies in the number of teeth on the fraction gear 152, and in the indicating characters on the faces of the fraction numeral wheels.

- 60 There is given here the arrangement of the numerals which may be said to show in a

schematic way the arrangement of teeth on the various plates 143, 144, 306, and 307 in working out the problem in multiplication herein used for illustration.

2	5	3	
2	5	$\frac{3}{8}$	
<hr/>			
	1		
	6	5	6
1	2	1	
	0	5	2
1			
4	0	5	
<hr/>			
6	3	8	$8\frac{3}{8}$

In the above schematic arrangement, the right-hand numeral 6 represents the result of the multiplication of $3 \times \frac{3}{8}$. In the operation in performing such multiplication, the plate 307, at the upper right-hand row of cylinders 304, is moved rearwardly until the vertical row of six teeth thereon stand in position below the fraction's gear 152. The right-hand numeral 4 represents the fractional result of the multiplication of $50 \times \frac{3}{8}$. The result of such multiplication is $12\frac{3}{8}$, and in the operation of the machine, the plate 307 on the bar 130^a at the right-hand row of cylinders 304 in the second row from the top, is moved rearwardly in the machine, until a vertical row of four teeth thereon stand in the path of the fraction's gear 152. The right-hand number 2 in such schematic results represents the unit result in the multiplication of $50 \times \frac{3}{8}$. In the operation of the machine, the plate 307 on the bar 130^a at the right of the second row of cylinders 304 from the right in the second row of said cylinders from the top, is moved rearwardly two spaces for bringing a vertical row of two teeth to position below the unit's gear 152. The numeral I in the third row from the top, third column from the top of the partial results, shown in schematic arrangement above, represents 10, forming part of the result of $50 \times \frac{3}{8}$, and is represented on the machine by the plate 306 on the bar 131^a, at the left of the last described row of cylinders 304, which has been moved rearwardly one space for bringing one tooth into the path of the ten's gear 152.

In the same way the other plates 306 and 307 and 143 and 144, which have been operated in performing the entire problem above mentioned, have been moved rearwardly, so that they stand in such relative positions with relation to the other operative plates, that the teeth on all of said plates in line with the various gears 152 are represented by the various numbers shown by the partial results in the above schematic arrangement.

In my claims where I use the word "frac-

tion", I mean the use of fractions other than the use of decimals. I believe that I have devised a mechanism which has great advantages over a machine multiplying by decimals for various reasons.

In multiplying by some fractional numbers it is practically impossible to work out the result in decimals, because of the limited capacity of a machine of this kind.

By the use of actual fractions, for instance, seven-eighths the result is obtained in whole numbers with one fraction at the end thereof, whereas if decimals were used the fractional result would take three places and would involve the use of at least three cumulator wheels, where I obtain the same result with one cumulator wheel with the fractions thereon.

I do not intend to claim or cover a machine for multiplying fractions when reduced to decimals or secure results reduced to decimals, but have devised and intend to claim a machine using actual fractional numbers.

Many of the advantages of the construction herein described may be seen from the foregoing description. It will be noted that the mechanism of the machine is comparatively simple, and inexpensive to manufacture.

All of the working parts are operated from the cams, on a single main power shaft, whereby the proper timing of the operation of the various parts may be accomplished for securing proper sequence of operations.

Attention is particularly called to the speed with which a machine of this type can be operated for securing and setting up the results of problems of multiplication, on account of the manner in which "tens" are carried. Reference is here had particularly to the manner in which the "tens" are taken off the cumulator wheels, and, as it were, held in suspension during the main operation of the machine, while the sums of the products of multiplication are being simultaneously obtained and are then added in.

Another important advantage lies in the construction of the cylinders 87 and 87^a, whereby they are divided into two halves with the pins properly arranged on both halves as hereinbefore referred to.

Another advantage is found in the arrangement of the keys, and the parts connected therewith, whereby a very slight amount of physical labor will set the machine in position for operation, and all the heavy work is done by the motor.

Another advantage is believed to lie in the arrangement of the computing cylinders, and the bars which coact therewith, in connection with the means for setting the clutches on the proper cylinders for rotating them by means of the diagonally arranged rack bars,

Another advantage of my improvement, is believed to lie in the frictional mounting of the arms 63, 111, 133, whereby the selective operation of said arms is readily permitted.

A number of the advantages of my machine may be found by referring to the objects thereof, hereinbefore described.

It will be understood that some changes may be made in the construction, and arrangement of the various parts of my improved multiplying machine without departing from its essential features, and purposes, and it is my intention to cover by this application any such changes which may be included within the scope of my claims.

I claim as my invention:

1. In a multiplying machine, means for setting up a multiplicand, means for setting up a multiplier, cumulating devices, means for setting up partial products on the machine, means for carrying said partial products into said cumulating devices, means for cumulating and holding "tens" during the operation of said last means and for thereafter adding said "tens" into the sums set up on said cumulating means, a second set of cumulative means, means for clearing a number set up on said first cumulating means into said second cumulating means, said last means including means for cumulating and holding "tens" during part of the operation of said last cumulating means, and for thereafter adding them in on said cumulating means.

2. In a multiplying machine, means for setting up a multiplicand including banks of keys, a plurality of shafts, a plurality of computing devices on each shaft capable of movement with relation thereto, clutch devices formed on said computing devices, a coacting clutch member on each shaft adjacent to each computing device, means selectively controlled by said keys for setting said clutches.

3. In a multiplying machine, means for setting up a multiplier including banks of keys, a plurality of shafts, said shafts being arranged in rows parallel with each other in parallel planes, computing devices arranged on said shafts, the computing devices on the different rows of shafts being arranged in parallel rows and being loosely mounted on the shafts, clutches on said computing devices, a coacting clutch member slidably but non-rotatably mounted on each shaft adjacent to each computing device, means for operatively connecting the keys with said last clutch members whereby the depression of any key sets the clutches on one row of cylinders of the different shafts.

4. In a multiplying machine, means for setting up a multiplier including banks of keys, a plurality of shafts, said shafts being arranged in rows parallel with each other in

parallel planes, computing devices arranged on said shafts, the computing devices on the different rows of shafts being arranged in parallel rows and being loosely mounted on the shafts, clutches on said computing devices, a coacting clutch member slidably but non-rotatably mounted on each shaft adjacent to each computing device for operatively connecting the keys with said last clutch member, means whereby the depression of any key sets the clutches on one row of cylinders on different shafts, said means in each case including a shaft arranged transversely of said first rows of shafts operatively connected with a key, and having means operatively connected with a row of clutch members.

5. In a multiplying machine, means for setting up a multiplicand, said means including banks of keys, a plurality of computing devices, a slide bar adjacent to each bank of keys, means whereby the depression of any key in the bank operatively connects the slide bar adjacent to said bank with a certain computing device, a shaft, a plurality of arms thereon, means for frictionally holding said arms against movement with relation to said shaft, links connecting the respective arms with the respective slide bars, means for locking said links against movement, means whereby the said locking means is moved to inoperative position when a key is depressed, the parts being so arranged that when the shaft is rotated all of the slide bars adjacent to the banks in which a key has been depressed will be operated.

6. In a multiplying machine, means for setting up a multiplier, said means including banks of keys, a plurality of computing devices, a slide bar adjacent to each bank of keys, means whereby the depression of a key in any bank operatively connects the slide bar adjacent thereto selectively with said computing devices, a shaft, means for operatively connecting said shaft with all of said slide bars, whereby when the shaft is rotated those slide bars only which are adjacent to the banks in which a key has been depressed, are actuated, said means including arms pivotally mounted on said shaft, means for limiting the pivotal movement of said arms, means for normally, frictionally holding said arms against movement with relation to said shaft, said arms being operatively connected with the respective slide bars.

7. In a multiplying machine, a multiplicand set of keys arranged in banks of nine, the keys of each bank representing the digits, a plurality of shafts arranged in a plurality of rows, cylinders rotatably mounted on said shafts, having projecting members arranged to represent the results of multiplications of digits, means controlled from said keys for selectively operatively connecting

the cylinders with the shafts, against rotation thereon.

8. In a multiplying machine, a frame, a multiplicand set of keys, a multiplier set of keys each set comprising a plurality of banks of keys representing numbers, a row of parallel shafts for each bank of keys in the multiplicand set, rotatably mounted in said frame, the number of shafts in each row being equal to the number of banks of keys in the multiplier set, a computing cylinder rotatably mounted on each shaft in each row, corresponding to one key in each bank of the multiplicand set, a clutch device for each cylinder on each shaft, means controlled by the actuation of the keys of the multiplicand whereby all the clutches of its corresponding cylinders are set, means controlled by the actuation of the multiplier keys whereby for each multiplier key depressed one shaft of each row is rotated, a predetermined distance corresponding to the number represented by the key depressed.

9. In a multiplying machine, a frame, a multiplicand set of keys, a multiplier set of keys each set comprising a plurality of banks of keys representing numbers, a row of parallel shafts for each bank of keys in the multiplicand set, rotatably mounted in said frame, the number of shafts in each row being equal to the number of banks of keys in the multiplier set, a computing cylinder rotatably mounted on each shaft in each row, corresponding to a key in each bank of the multiplicand set, a clutch device for each cylinder on each shaft, means whereby the actuation of any multiplicand key sets all the clutches of its corresponding cylinders, means whereby the actuation of one key in each bank of the multiplier set simultaneously rotates one shaft of each row a predetermined distance corresponding to the number represented by the key, said cylinders each having stop devices located to represent the result of the multiplication of digits, slide bars located adjacent to each cylinder, coacting engaging devices on said slide bars adapted to engage said stop device, and means carried by said sliding bars having rows of teeth arranged to represent the results of multiplications, and cumulating devices adapted to coact with said last teeth for performing multiplication.

10. In a multiplying machine, a computing cylinder having on one portion stop devices arranged to represent the right-hand figure of the result of the multiplication of a certain digit by any other digit, and on another portion means arranged to indicate the left-hand figure of the result of the multiplication of said first digit by any other digit, a slide bar adjacent to each cylinder having an engaging member adapted to engage the stop devices on one portion of said

cylinders, a similar slide bar adjacent to each cylinder having a device adapted to engage the stop devices on the other portion of said cylinder; means for moving said cylinders to predetermined positions, means for moving said slide bars to positions where their engaging members engage the coacting stop devices on the cylinders, computing device members on said slide bars, and cumulating devices adapted to coact therewith.

11. In a multiplying machine, a frame, a set of multiplicand keys, a set of multiplier keys, each set comprising a plurality of banks of keys, representing numbers, a row of parallel shafts for each bank of keys in one set, rotatably mounted in said frame, the number of shafts in each row being equal to the number of banks of keys in the other set, a computing cylinder rotatably mounted on each shaft in each row corresponding to a key in each bank of said first set, a clutch device for each cylinder on each shaft, means whereby when a key in one bank of the first set has been actuated all the clutches on its corresponding cylinders are set, means whereby when one key in each bank of the other set has been actuated one shaft of each row is rotated a predetermined distance corresponding to the number represented by the last mentioned key, means on each cylinder representing the multiplication of digits, cumulating wheels, means whereby when certain of said cylinders have been rotated, said wheels are rotated to position for indicating the product of the multiplication of the number indicated by the depressed keys of the multiplicand set, by the number indicated by the depressed key of the multiplier set.

12. In a multiplying machine, a frame, a set of multiplicand keys, a set of multiplier keys, each set comprising a plurality of banks of keys, representing numbers, a row of parallel shafts for each bank of keys in one set, rotatably mounted in said frame, the number of shafts in each row being equal to the number of banks of keys in the other set, a computing cylinder rotatably mounted on each shaft in each row corresponding to a key in each bank of said first set, a clutch device for each cylinder on each shaft, means whereby when a key in one bank of the first set has been actuated all the clutches of its corresponding cylinders are set, means whereby when a key in any bank of the other set has been actuated one shaft of each row is rotated a predetermined distance corresponding to the number represented by the last mentioned key, and means on each cylinder for representing the multiplication by digits.

13. In a multiplying machine, a plurality of computing devices, each having on one portion engaging means, relatively located

for indicating the right-hand figures of the result of the multiplication of one digit by any other digit, and having on another portion engaging means for indicating the left-hand figure of the result of the multiplication of the first digit by any other digit, means for selectively moving said computing devices to position where the engaging means on each of the computing devices so moved, stands in position for representing the partial product of the multiplication of one digit of the multiplicand by one digit of the multiplier, movable members adapted to coact with said engaging means, toothed plates carried by said movable members, means whereby said movable members are selectively actuated and moved distances corresponding to the positions of the engaging means which represent partial products on the computing devices which have been actuated, whereby each plate actuated is moved to position with a row of teeth in a certain path, equal in number to the number represented by one engaging means on a computing device theretofore actuated, cumulator wheels, means operatively connected therewith for traveling across said plates and rotating said cumulator wheels, to position for indicating the sum of said partial products.

14. In a multiplying machine, a plurality of computing devices each having on one portion stops positioned to represent the right-hand figures of the results of multiplications of one digit by other digits, and on another portion stops positioned to represent the left-hand figures of the results of said multiplications, means for selectively moving said devices to operative positions where their stops represent partial products, a plurality of series of toothed plates, means for operatively connecting said toothed plates with said computing devices, whereby when the toothed plates are actuated, one plate in one series is moved to position where teeth thereon represent one of the figures in a partial product on one computing device, and another plate in another series moves to position where the teeth thereon are positioned to represent the other figure in said partial product, and cumulating means for taking up and adding all of the partial products thus set up on said plates.

15. In a multiplying machine, a plurality of computing devices each having on one portion stops positioned to represent the right-hand figures of the results of multiplications of one digit by other digits, and on another portion stops positioned to represent the left-hand figures of the results of said multiplications, means for selectively moving said devices to operative positions where their stops represent partial products,

a plurality of series of toothed plates, means for operatively connecting said toothed plates with said computing devices, whereby when the toothed plates are actuated, one
 5 plate in one series is moved to position where teeth thereon represent one figure of the partial product on one computing device and another plate in another series moves to position where the teeth thereon are positioned
 10 to represent the other figure in said product, and cumulating means for taking up and adding all of the partial products thus set up on said plates, said means including carrying mechanism adapted to cumulate and
 15 hold "tens" to be carried during part of the operation of said cumulating means, and to subsequently add in "tens" and set up the total product.

16. In a multiplying machine, a plurality
 20 of series of members, having stop devices thereon, means for setting up a multiplicand, means for setting up a multiplier, means for automatically simultaneously actuating said
 25 members for moving them so that the position of the stops thereon represent the partial products of the multiplication of the various digits of the multiplicand by the various digits of the multiplier, a carriage,
 30 cumulating mechanism carried thereby, means for moving said carriage across said members for adding said partial products together, said cumulating means including
 35 carrying mechanism, whereby "tens" are cumulated and held in inoperative relation during the return of said carriage, said carrying mechanism being adapted to add in
 said "tens" during the return movement of said carriage.

17. In a multiplying machine, means for
 40 setting up a multiplicand, means for setting up a multiplier, members having stop devices, means for automatically and simultaneously actuating said members for moving
 45 them so that the position of the stop devices thereon represent partial products, a movable frame member, cumulating mechanism mounted thereon, means for automatically
 50 carrying said frame past said members in operative position with relation thereto for adding said partial products together, and for returning said movable member,
 55 means for holding said cumulating mechanism and said members in inoperative position with relation to each other during the return movement of said movable member,
 60 said cumulating mechanism including carrying means whereby "tens" are cumulated and held during the movement of the movable member in one direction, and are added in
 during the return of said movable member.

18. In a multiplying machine, means for
 65 setting up a multiplicand, means for setting up a multiplier, members having stop devices, means for automatically and simulta-

neously actuating said members for moving them so that the position of stop devices thereon represent partial products, a movable frame member, cumulating mechanism
 7 mounted thereon, means for automatically carrying said frame past said members in operative position with relation thereto for adding said partial products together, and
 8 for returning said movable member, means for holding said cumulating mechanism and said members in inoperative position with relation to each other, during the return
 9 movement of said movable member, said cumulating mechanism including carrying means whereby "tens" are cumulated and
 10 held during the movement of the movable member in one direction, and are added in during the return of said movable member, a second cumulating device, means for auto-
 11 matically clearing a product in the first cumulating device into the second cumulating device.

19. In a multiplying machine means for
 9 setting up a multiplicand, means for setting up a multiplier, members having stop devices, means for automatically and simulta-
 10 neously actuating said members for moving them so that the position of the stop devices thereon represent partial products, a movable frame member, cumulating mechanism
 11 mounted thereon, means for automatically carrying said frame past said members in operative position with relation thereto for adding said partial products together, and
 12 for returning said movable member, means for holding said cumulating mechanism and said members in inoperative position with relation to each other during the return
 13 movement of said movable member, said cumulating mechanism including carrying means whereby "tens" are cumulated and
 14 held during the movement of the movable member in one direction, and are added in during the return of said movable member, and means for automatically clearing said
 15 cumulating devices.

20. In a multiplying machine, means for
 16 setting up a multiplicand, means for setting up a multiplier, members having stop devices, means for automatically and simulta-
 17 neously actuating said members for moving them so that the position of the stop devices thereon represent partial products, a movable frame member, cumulating mechanism
 18 mounted thereon, means for automatically carrying said frame past said members in operative position with relation thereto for adding said partial products together, and
 19 for returning said movable member, means for holding said cumulating mechanism and said members in inoperative position with relation to each other, during the return
 20 movement of said movable member, said cumulating mechanism including carrying means whereby "tens" are cumulated and held during the movement of the movable member in one direction, and are added in during the return of said movable member.

are cumulated and held during the movement of the movable member in one direction, and are added in during the return of said movable member, a second cumulating mechanism, means for automatically clearing a product in the first cumulating mechanism, and means for clearing the second cumulating mechanism.

21. In a multiplying machine, means for setting up a multiplicand, means for setting up a multiplier, cumulating mechanism, means for automatically performing the problem of multiplication and setting the result thereof up on said cumulating means, a second cumulating mechanism, and means for automatically clearing the product set up on the first cumulating mechanism into the second cumulating mechanism, means for automatically stopping said machine after a complete operation, said means being adjustable for stopping the machine either before or after said clearing operation, at the option of the operator.

22. In a multiplying machine, means for setting up a multiplicand, means for setting up a multiplier, cumulating mechanism, means for automatically performing multiplication and setting the result thereof up on said cumulating mechanism, said means including a prime mover, a power shaft, a plurality of means on said power shaft operatively connected with the mechanism of the machine, each having members representing the results of multiplications, a second cumulating mechanism operatively connected with said first cumulating mechanism and with said shaft, whereby a product set up on the first cumulating mechanism is cleared out and set up on the second cumulating mechanism, means for operatively connecting said prime mover with said shaft and adapted to automatically disengage when the shaft has made a complete revolution.

23. In a multiplying machine, means for setting up a multiplicand, means for setting up a multiplier, cumulating mechanism, means for automatically performing multiplication and setting the result thereof upon said cumulating mechanism said means including a prime mover, a power shaft, a plurality of means on said power shaft operatively connected with the mechanism of the machine, each having members representing the results of multiplications, a second cumulating mechanism operatively connected with said first cumulating mechanism and with said shaft, whereby a product set up on the first cumulating mechanism is cleared out and set up on the second cumulating mechanism, means for operatively connecting said prime mover with said shaft and adapted to automatically disengage when the shaft has made a complete revolution, means for adjusting said last means

for stopping the shaft before or after said clearing operation, at the option of the operator.

24. In a multiplying machine, a set of keys comprising a series of banks, a plurality of shafts, a plurality of computing devices rotatably mounted on each shaft, means for selectively operatively connecting the computing devices with the shafts, means arranged in operative relation with each bank of keys for imparting rotation to a plurality of said shafts, the operation of said means being controlled in each case by the key which has been depressed in the particular bank.

25. In a multiplying machine, a frame, a multiplicand set of keys mounted thereon, arranged in banks, a multiplier set of keys arranged in banks, the keys of each bank representing digits, the keys of the different banks representing units, tens, hundreds and so on, a plurality of shafts, said shafts being arranged in vertical rows, and in horizontal rows, a plurality of computing devices, mounted on each shaft having stops positioned to represent the partial products of the multiplication of one digit by any other digit, means for selectively operatively connecting the computing devices with the shafts on which they are mounted, said means being arranged to be controlled by the keys actuated in the one set whereby when a key in said set is actuated, said means may be actuated for connecting one computing device on each shaft in one horizontal row of shafts with its shaft, a plurality of means for selectively rotating said shafts, said last means being so arranged that a series of shafts is rotated by each of said means which last means are selectively controlled by the actuation of the keys in the other set.

26. In a multiplying machine a plurality of computing devices rotatably mounted, a plurality of means for selectively operating different series of computing devices, a set of keys, the selective actuation of said last means being determined by the operation of the said keys.

27. In a multiplying machine, keys for setting up a multiplicand, keys for setting up a multiplier, a plurality of shafts, a plurality of computing devices rotatably mounted on said shafts, a plurality of means for selectively operatively connecting said computing devices with said shafts, the selective operation of said last means being determined by the operation of the keys in one of said sets, a plurality of means for rotating a series of said shafts, the selective operation of said last means being determined by the operation of the keys in the other set.

28. In a multiplying machine, keys for setting up a multiplicand, keys for setting

up a multiplier, a plurality of shafts, a plurality of computing devices rotatably mounted on said shafts, a plurality of means for selectively operatively connecting
 5 said computing devices with said shafts, the selective operation of said last means being determined by the operation of the keys in one of said sets, a plurality of means for rotating a series of said shafts, the selective
 10 operation of said last means being determined by the operation of the keys in the other set, a plurality of series of toothed plates, a movable frame member, a cumulating mechanism carried thereby, means
 15 for actuating said plates for moving their teeth into the path of said cumulating mechanism, and means operatively connected with said plates and with said computing device whereby the degree of movement of
 20 said plates is determined by the position of the cumulating devices which have been actuated.

29. In a multiplying machine, keys for setting up a multiplicand, keys for setting
 25 up a multiplier, a plurality of shafts, a plurality of computing devices rotatably mounted on said shafts, a plurality of means for selectively operatively connecting said computing devices with said shafts, the
 30 selective operation of said last means being determined by the operation of the keys in one of said sets, a plurality of means for rotating a series of said shafts, the selective operation of said last means being deter-
 35 mined by the operation of the keys in the other set, said computing devices having stops positioned to represent partial products, a cumulating mechanism operatively connected with said computing devices,
 40 whereby the partial products represented by the position of the stops on the computing devices which have been actuated are added together and set up in the machine.

30. In a multiplying machine, a set of
 45 keys, for setting up a multiplicand, a set of keys for setting up a multiplier, a plurality of shafts, a plurality of computing devices rotatably mounted on said shafts, a plurality of means for selectively opera-
 50 tively connecting said computing devices with said shafts, the selective operation of said last means being determined by the operation of the keys in one of said sets, a plurality of means for rotating a series of
 55 said shafts, the selective operation of said last means being determined by the operation of the keys in the other set, said computing devices having stops positioned to represent partial products, cumulating
 60 mechanism operatively connected with said computing devices, whereby the partial products represented by the position of the stops on the computing devices which have been actuated are added together and set

up in the machine, said cumulating mechanism including carrying mechanism whereby
 "tens" are accumulated and held during part of the operation of said cumulating mechanism, and are added in during another part of said operation.

31. In a multiplying machine, a plurality of series of toothed plates, a movable frame member, a cumulating mechanism carried thereby including a plurality of gears designed to travel across the respective series
 75 of toothed plates, means for setting up a multiplicand, means for setting up a multiplier, means for automatically selectively moving said plates for bringing into the paths of said gears teeth on said plates, rep-
 80 resenting the partial products of the multiplications of the digits of the multiplicand by the digits of the multiplier, means for reciprocating said movable frame member, means whereby when the movable frame
 85 member has completed its movement in one direction, said plates are withdrawn from the path of said gears.

32. In a multiplying machine, a plurality of series of toothed plates, a movable frame
 90 member, a cumulating mechanism carried thereby including a plurality of gears designed to travel across the respective series of toothed plates, means for setting up a multiplicand, means for setting up a multi-
 95 plier, means for automatically selectively moving said plates for bringing into the paths of said gears teeth on said plates, representing the partial products of the multiplications of the digits of the multiplicand
 100 by the digits of the multiplier, means for reciprocating said movable frame member, means whereby when the movable frame member has completed its movement in one direction, said plates are withdrawn from
 105 the path of said gears, said cumulating mechanism including carrying means, whereby during the movement of said frame member in one direction, the "tens" are taken up and held, and whereby, during the return
 110 movement of said frame member, said "tens" are added in and the total product set up on the machine.

33. In a device of the class described, computing devices comprising a plurality of
 115 shafts, a plurality of cylinders mounted on said shafts, stops positioned on said cylinders to represent partial products, means for selectively operatively connecting said cylinders with said shafts, means for con-
 120 necting said shafts in series, means for setting up a multiplicand, means for setting up a multiplier, means for automatically actuating said first means, and means for automatically rotating the shafts for rotating
 125 the cylinders which have been operatively connected therewith to position with the stop devices on the opposite sides thereof

representing the right and left-hand figures respectively of the multiplication of one digit by another digit.

34. In a multiplying machine, a multiplicand set of depressible keys, a multiplier set of depressible keys, movable toothed plates, computing devices controlled by the keys, and arranged to control the operation of said plates, actuating mechanism for communicating the requisite movement of the computing devices, according to the keys depressed, a carriage movable for traversing the toothed plates, having gears to engage the teeth thereon, cumulator devices actuated by said gears, means for gathering and retaining the "tens" as the carriage is moved in one direction and adapted to carry them to the cumulator devices as the carriage is moved in the opposite direction.

35. In a multiplying machine, a frame, a multiplicand set of keys, a multiplier set of keys, each set comprising banks of keys representing numbers, a row of rotatable parallel shafts for each bank in the multiplicand set, the number of shafts in each row corresponding to the number of banks of the multiplier keys, a computing device corresponding to each key in one bank of the multiplicand set, loosely mounted on each shaft, a clutch device on each shaft for each computing device, means controlled by the actuation of the multiplicand keys for selectively setting one clutch of each shaft for each key so actuated, means controlled by the actuation of the multiplier keys whereby for each multiplier key actuated, one shaft of each row is rotated a predetermined distance, stops on one portion of each computing device, representing one figure of the multiplication of one digit by any other digit, stops on another portion of each computing device representing the other figure, if any, of such multiplication, a slide bar on each side of each shaft having means adapted to coast with the stops of the computing devices, toothed plates operated by said slide bar, means for actuating said slide bar to position for coasting with said stops, whereby said toothed plates are selectively actuated for moving them to position where the teeth thereon represent partial products and cumulating devices for coasting with said toothed plates, for setting up the result of a multiplication.

36. In a multiplying machine, a frame, a multiplicand set of keys, a multiplier set of keys, each set comprising banks of keys representing numbers, a row of rotatable parallel shafts for each bank in the multiplicand set, the number of shafts in each row corresponding to the number of banks of the multiplier keys, and computing devices corresponding to each key in one bank of the multiplicand set, loosely mounted on each shaft,

a clutch device on each shaft for each computing device, means controlled by the actuation of the multiplicand keys for selectively setting one clutch of each shaft for each key so actuated, means controlled by the actuation of the multiplier keys whereby for each multiplier key actuated, one shaft of each row is rotated a predetermined distance, stops on one portion of each computing device, representing one figure of the multiplication of one digit by any other digit, stops on another portion of each computing device representing the other figure, if any, of such multiplication, a slide bar on each side of each shaft having means adapted to coast with the stops of the computing devices, toothed plates operated by said slide bars, means for actuating said slide bars to position for coasting with said stops, whereby said toothed plates are selectively actuated for moving them to position where the teeth thereon represent partial products, a movable frame, and cumulating mechanism thereon having gears adapted to traverse said toothed plates, said cumulating mechanism including means for causing "tens" to be taken up and carried during the movement of the movable frame in one direction and to add said "tens" into said cumulating mechanism during the reverse movement of said frame.

37. In a multiplying machine, means for setting up a multiplicand, means for setting up a multiplier, a plurality of series of movable toothed plates, means for actuating said plates, according to the problem set up in the multiplicand and multiplier for moving them to position where in one series the aligned teeth represent all the units of the multiplications of the digits of the multiplicand by the digits of the multiplier, in another series the aligned teeth represent the tens and cumulating mechanism operatively connected with said toothed plates for setting up in the machine the result of a multiplication.

38. In a multiplying machine, a set of keys for setting up a multiplicand, a set of keys for setting up a multiplier, a plurality of shafts, a plurality of computing devices, a plurality of means for selecting out certain of said computing devices according to the keys actuated in one set, a plurality of means for operating said computing devices according to the keys actuated in another set, said computing devices having stops positioned to represent partial products, a cumulating mechanism operatively connected with said computing devices, whereby the partial products represented by the position of the stops on the computing devices which have been actuated are added together and set up in the machine, said cumulating mechanism including carrying mechanism where-

by "tens" are accumulated and held during part of the operation for said cumulating mechanism, and are added in during another part of said operation.

39. A multiplying machine comprising a multiplicand set of keys, a multiplier set of keys, computing devices, mechanism for controlling the requisite movement of the computing devices according to the keys operated, toothed plates, slide bars controlled by said computing devices for actuating said toothed plates, friction devices for actuating said slide bars, a frame movable to traverse the toothed plates, carrying gears adapted to engage the teeth on said plates which have been positioned according to the devices actuated and cumulator mechanism actuated by said gears.

40. A multiplying machine comprising a multiplicand set of keys, a multiplier set of keys, computing devices, mechanism for controlling the requisite movement of the computing devices according to the keys operated, toothed plates, slide bars controlled by said computing devices for actuating said toothed plates, friction devices for actuating said slide bars, a frame movable to traverse the toothed plates, carrying gears adapted to engage the teeth on said plates which have been positioned according to the devices actuated, cumulator mechanism actuated by said gears, and means for actuating said friction devices.

41. A multiplying machine comprising a multiplicand set of keys, a multiplier set of keys, computing devices controlled by said keys, toothed plates, slide bars, controlled by said computing devices, for actuating said toothed plates, mechanism for controlling the requisite movement of the computing devices according to the keys operated, a frame movable to traverse the toothed plates, carrying gears adapted to engage the teeth on said plates which have been positioned according to the devices actuated, cumulator mechanism actuated by said gears, friction devices for actuating said slide bars, including a rock shaft, a plurality of arms rotatably mounted on said shafts, means for operatively connecting said arms with the respective slide bars, and means including tension devices for causing said arms to be frictionally held against rotation relative to said shaft.

42. A multiplying machine, comprising a multiplicand set of keys, a multiplier set of keys, computing devices controlled by said keys, toothed plates, slide bars controlled by said computing devices for actuating said toothed plates, mechanism for imparting the requisite movement of the computing devices according to the keys depressed, a frame movable to traverse the toothed plates, carrying gears adapted to engage the teeth on

said plates, which have been positioned according to the devices actuated, cumulator mechanism actuated by said gears, friction devices for actuating said slide bars, including a rock shaft, a plurality of arms rotatably mounted on said shaft, means for operatively connecting said arms with the respective slide bars, means including tension devices for causing said arms to be frictionally held against movement relative to said shaft, and means including a shaft and a cam thereon for actuating said rock-shaft.

43. A multiplying machine comprising a multiplicand set of keys, a multiplier set of keys, computing devices controlled by said keys, toothed plates, slide bars controlled by said computing devices for actuating said toothed plates, mechanism for controlling the requisite movement of the computing devices according to the keys depressed, a frame, movable to traverse the toothed plates, carrying gears adapted to engage the teeth on said plates which have been positioned according to the devices actuated, cumulator mechanism actuated by said gears, including means for gathering and retaining "tens" while said movable frame is being moved in one direction, and for adding them in and setting them up on cumulator wheels when said movable frame is moved in the opposite direction.

44. In a multiplying machine, a frame, a multiplicand set of keys, a multiplier set of keys, computing devices operatively connected with said keys, means for actuating said computing devices according to the keys depressed in the multiplicand, a plurality of slide bars, arranged to coact with said computing devices, toothed plates actuated by said slide bars, means for actuating said slide bars adjacent to the computing devices which have been operated, said means comprising frictionally actuated arms operatively connected with the respective slide bars and cumulating devices, adapted to coact with said toothed plates for performing the operation of multiplication.

45. In a multiplying machine, a frame, a multiplicand set of keys, a multiplier set of keys, computing devices operatively connected with said keys, means for actuating said computing devices according to the keys depressed in the multiplicand, a plurality of slide bars arranged to coact with said computing devices, toothed plates actuated by said slide bars, means for actuating said slide bars adjacent to the computing devices which have been operated, said means comprising frictionally actuated arms operatively connected with the respective slide bars, means actuated for locking said slide bars against movement, and means actuated by the computing devices for releasing the proper slide bars.

46. In a multiplying machine, a frame,
means for setting up a multiplier, means for
setting a multiplicand, means for perform-
ing the operation of multiplication and set-
ting up the result thereof on the machine,
said means including cumulator wheels, said
means including also a power shaft opera-
tively connected with the means for per-
forming multiplication, a second set of cu-
mulator wheels operatively connected with
the first set, whereby the problem set up on
the first wheels may be carried into the sec-
ond wheels, a prime mover, means for oper-
atively connecting said prime mover with
said power shaft, means for operatively dis-
connecting said prime mover with said
power shaft, when the operation of multipli-
cation has been completed, said last named
means being adjustable for disconnecting
the prime mover and the power shaft before
or after the problem is carried from the first

wheels into the second wheels at the option
of the operator.

47. In a multiplying machine, means for
setting up a multiplicand, means for setting
up a multiplier, a set of cumulator wheels,
a second set of cumulator wheels, means for
automatically performing the problem of
multiplication and setting the result thereof
upon the first set of cumulator wheels, means
for actuating said second set of cumulator
wheels for clearing said problem into said
second set of wheels, said first means having
an adjustable device whereby the machine
can be stopped in position with the first
set of wheels out of operative relation with
the second set of wheels, and means for man-
ually clearing out the second set of cumula-
tor wheels.

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WESLEY D. BEARD.