Aug. 1, 1939. H. L. CLARY 2,167,827

ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

Filed Sept. 27, 1928 11 Sheets-Sheet 1

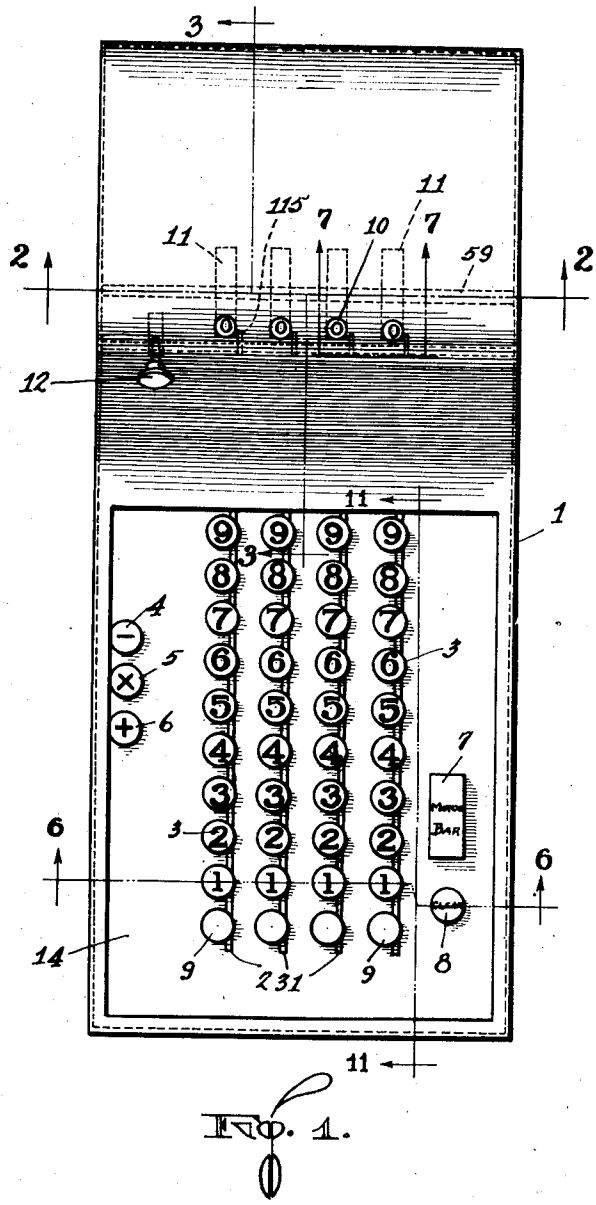



Fig. 1.

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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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FIG. 2.

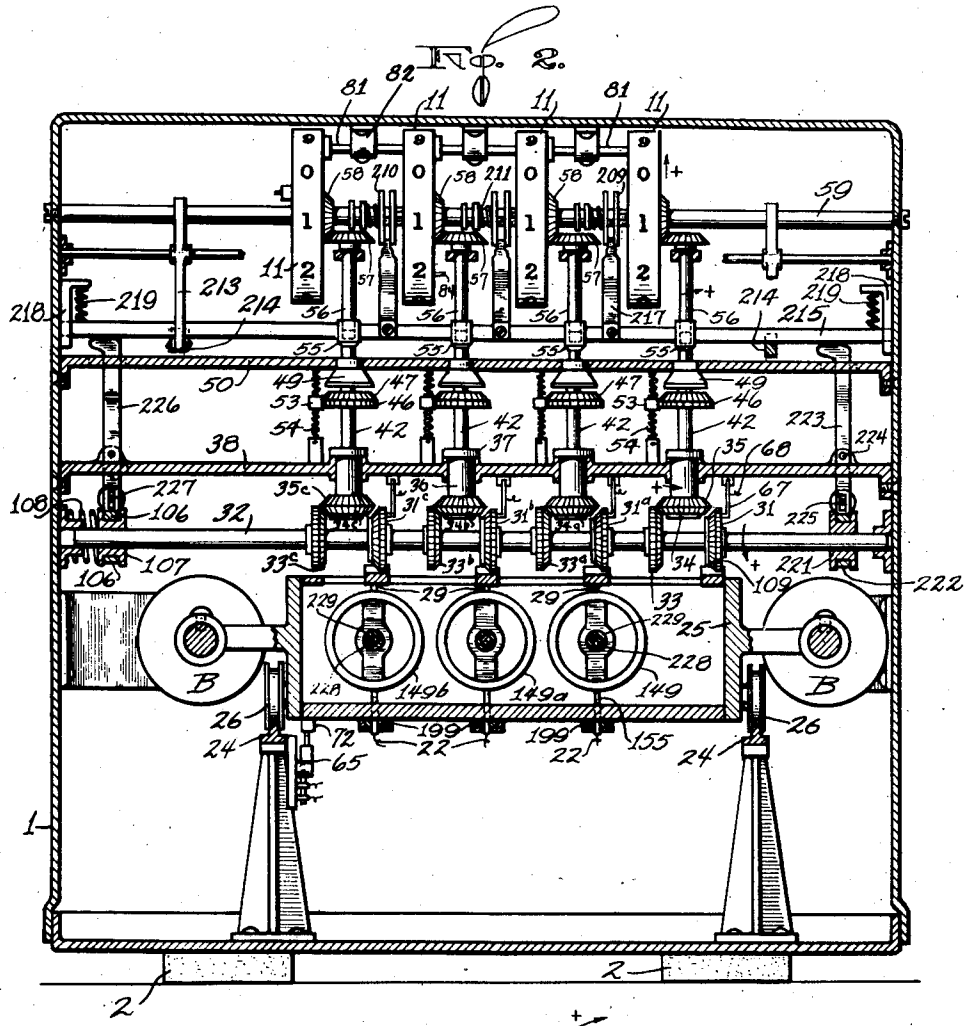


FIG. 9.

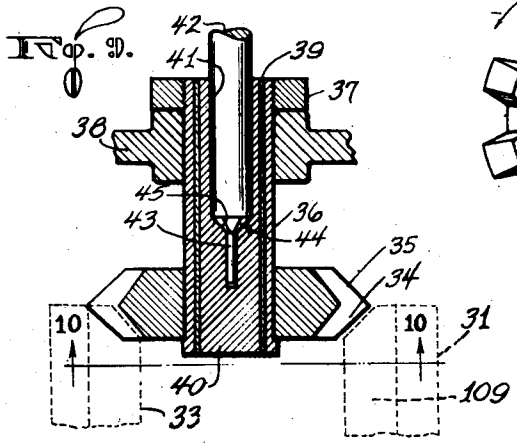
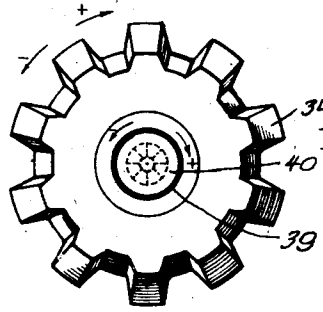


FIG. 10.



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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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Fig. 3.

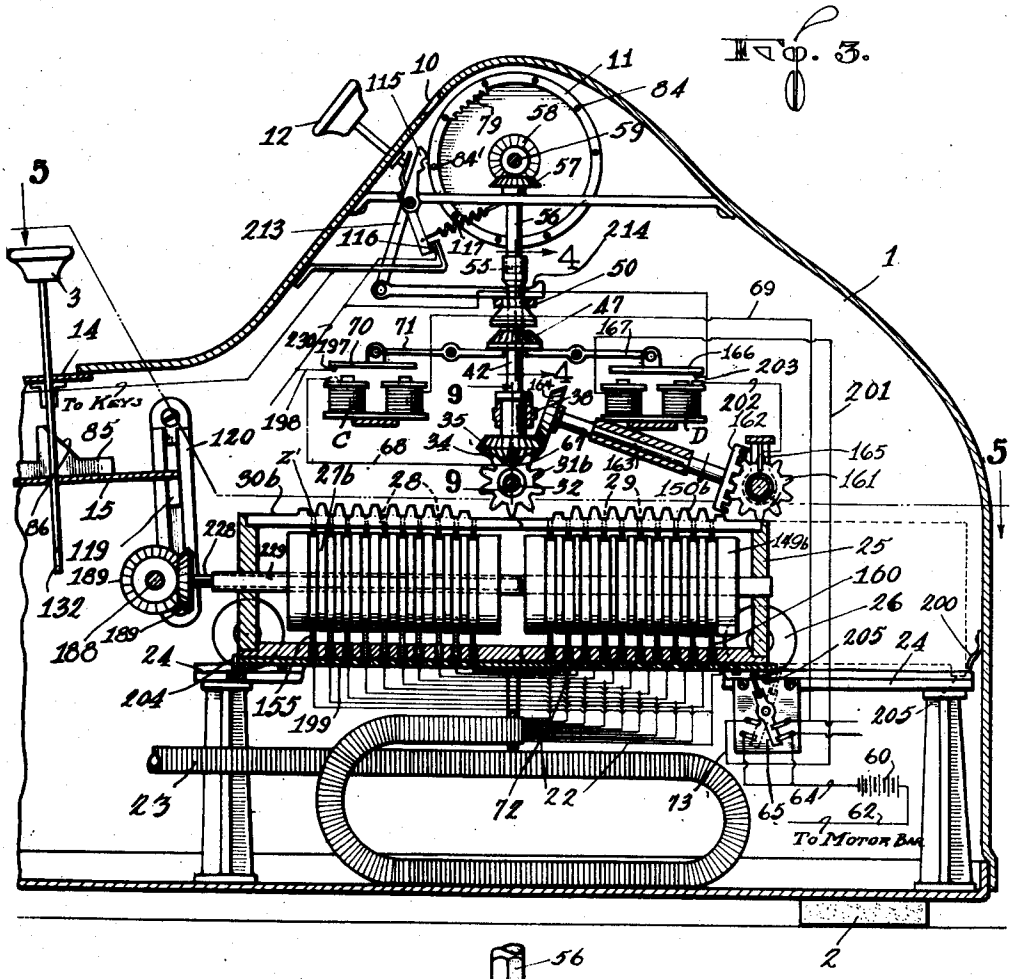
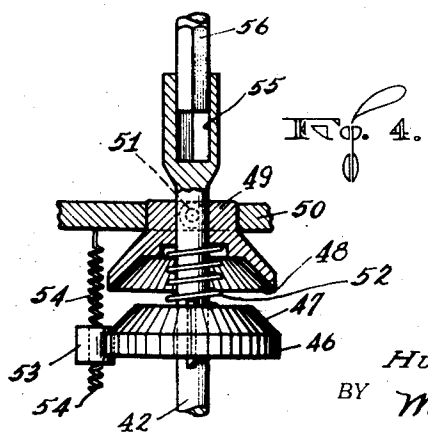



Fig. 4.



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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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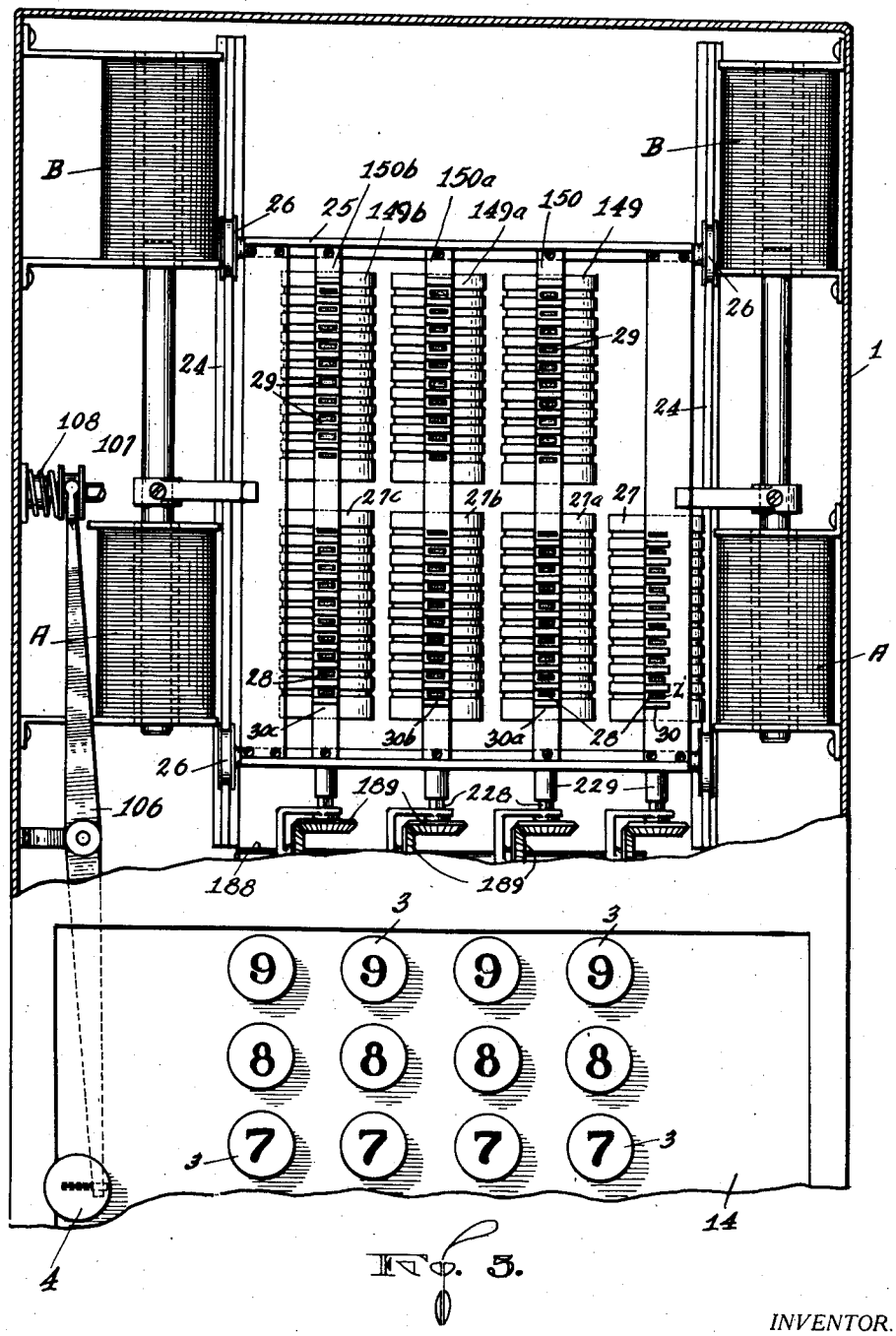



Fig. 3.

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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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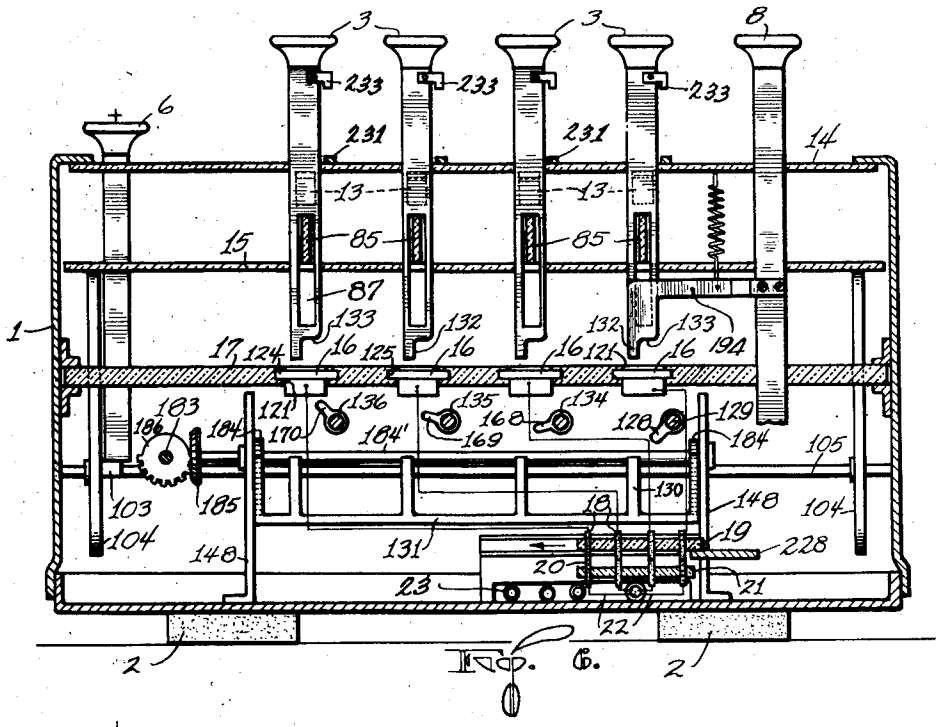


Fig. 6.

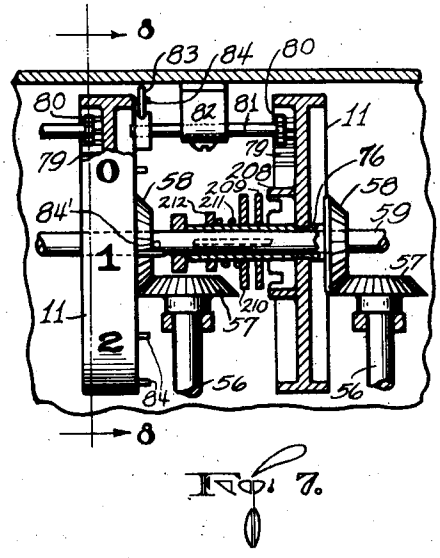


Fig. 7.

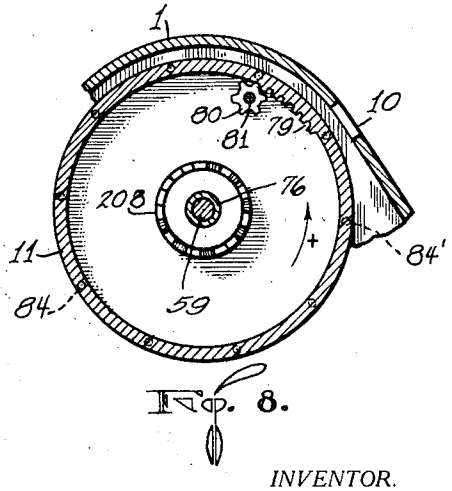


Fig. 8.

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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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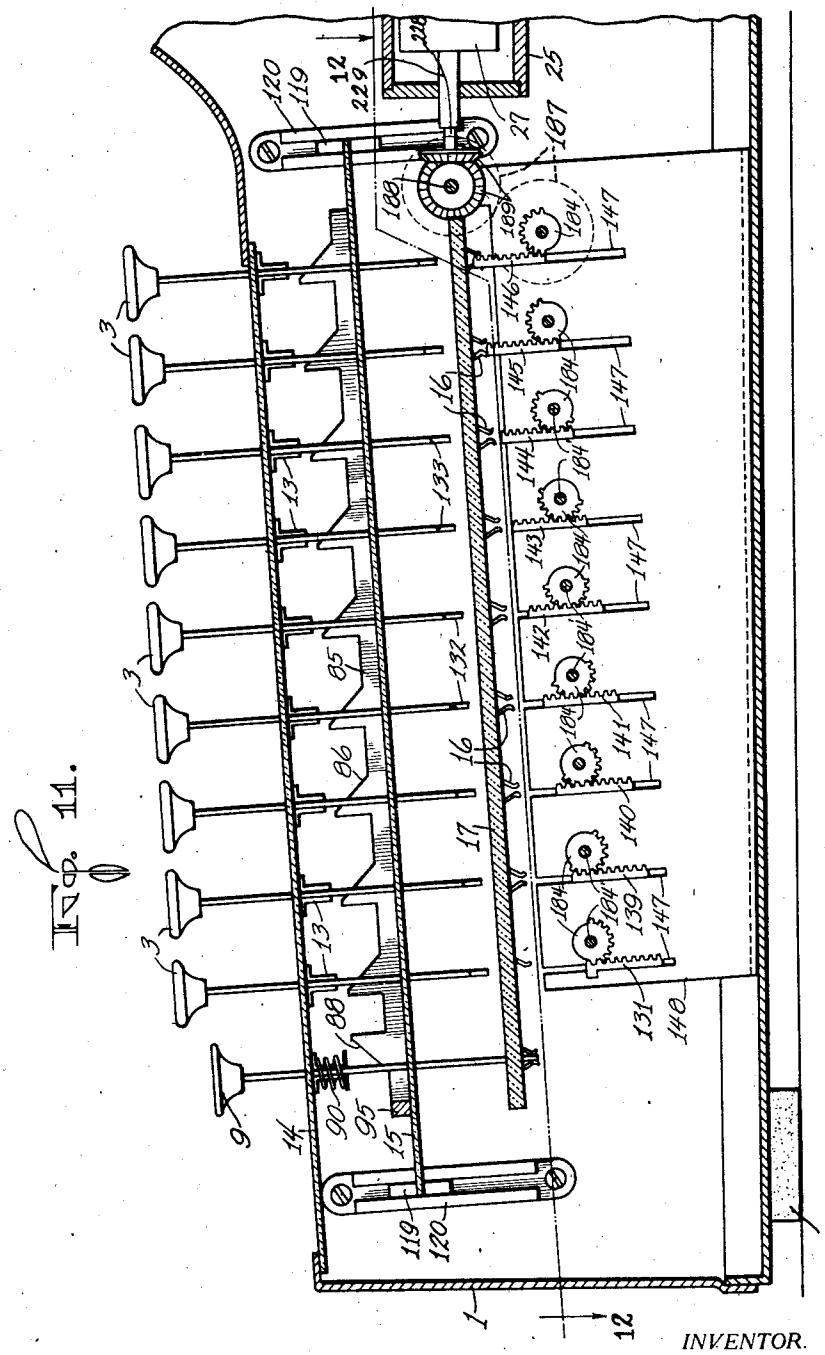



Fig. 11.

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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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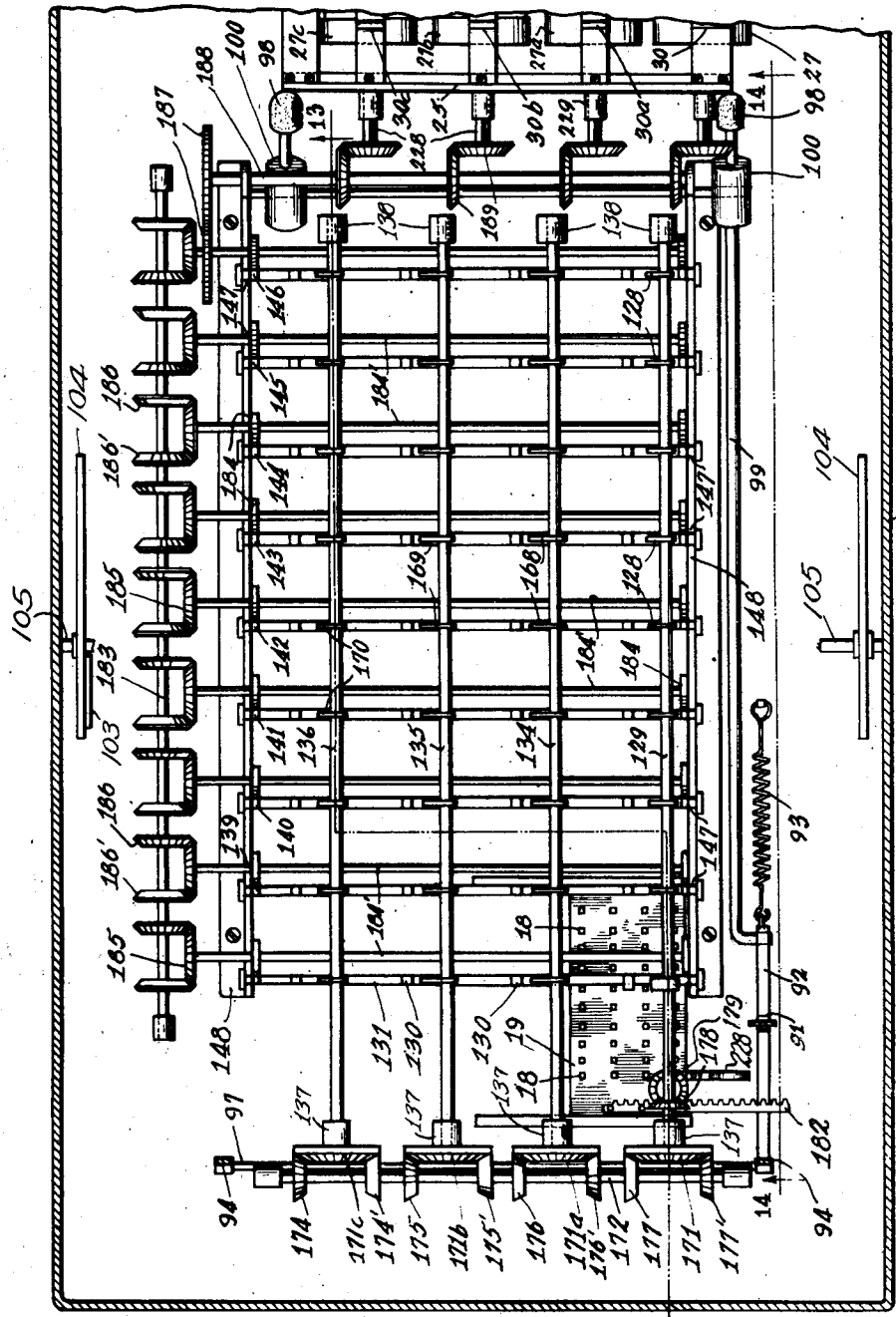


Fig. 12.

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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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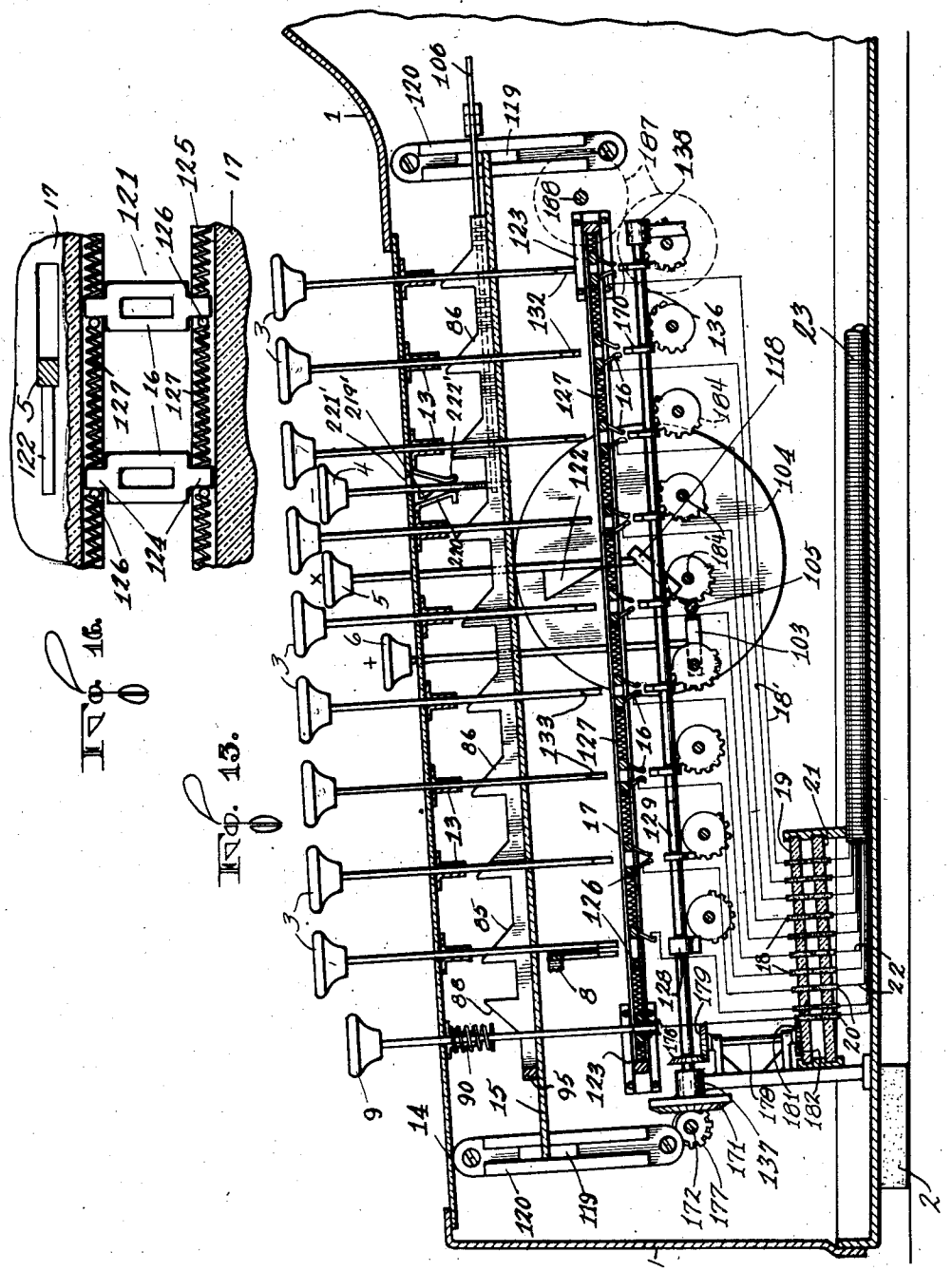


Fig. 16.



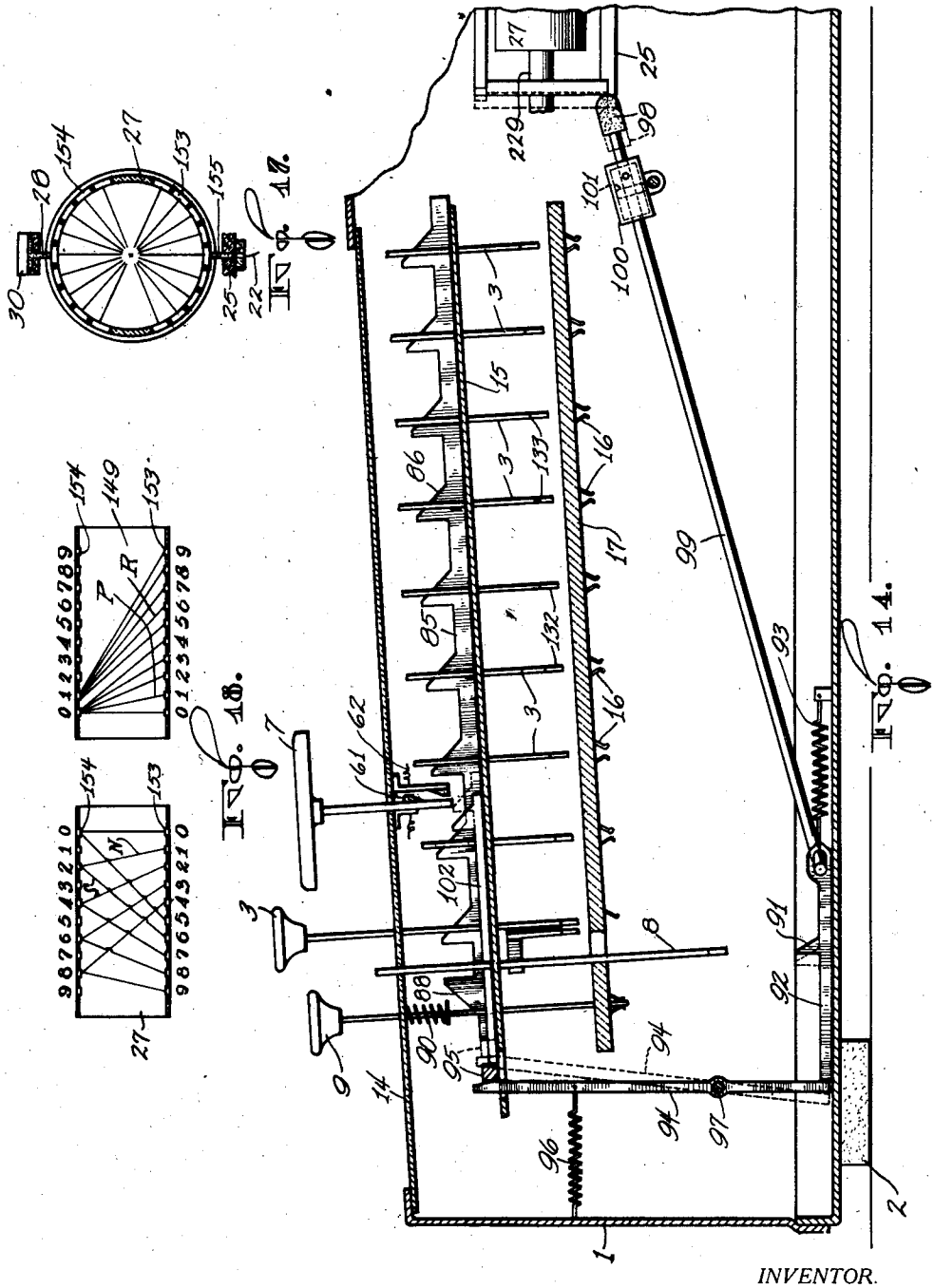
Fig. 13.

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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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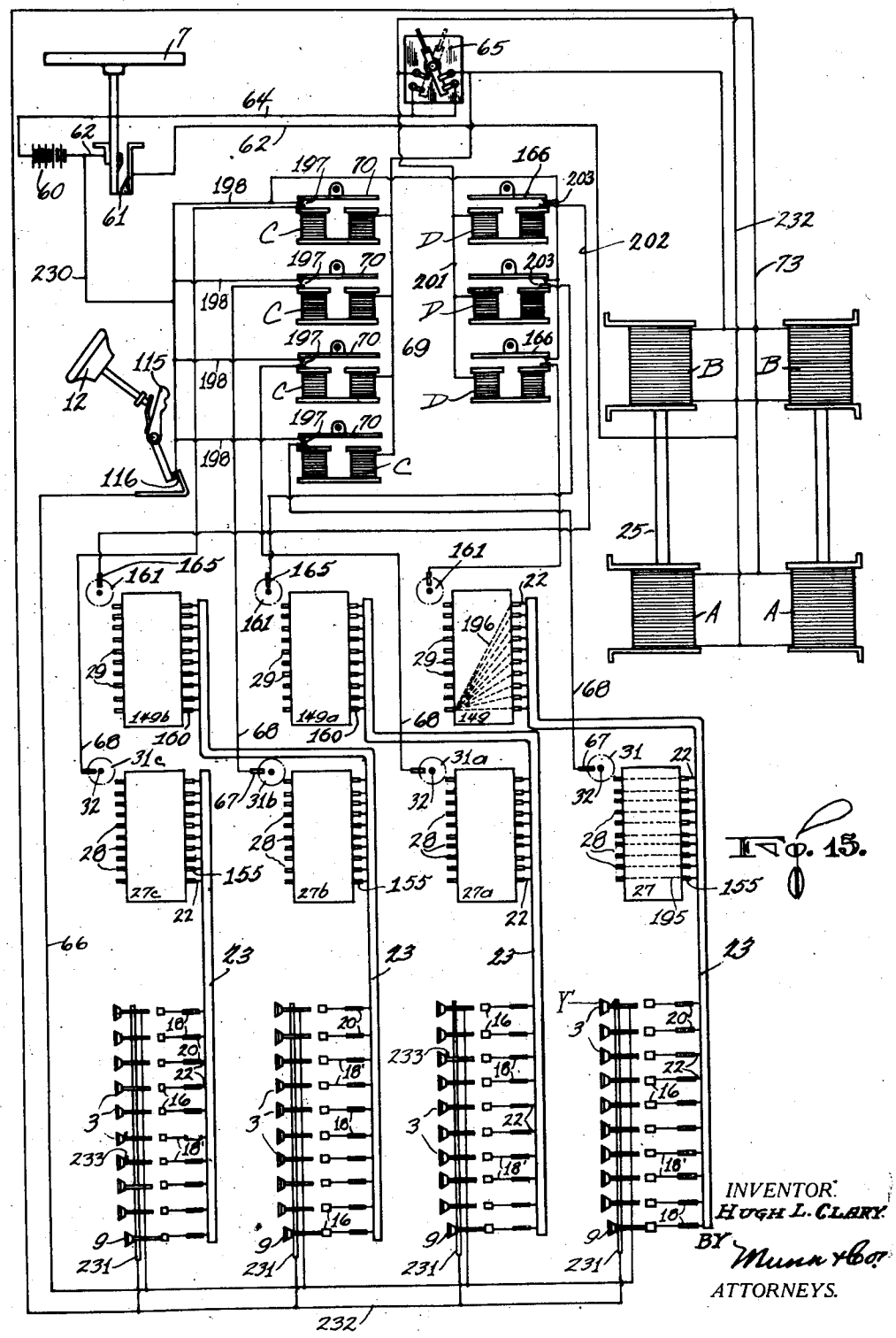



FIG. 15.

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ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

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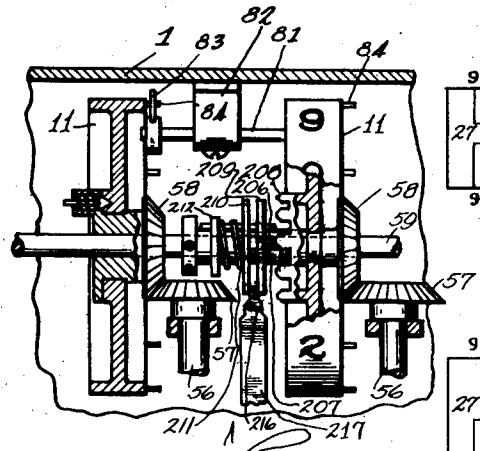



Fig. 19.

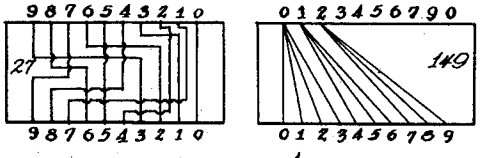



Fig. 20.

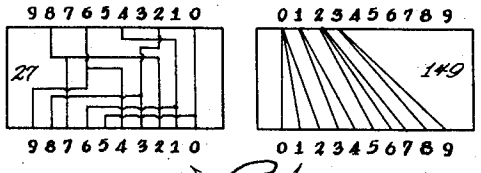



Fig. 21.

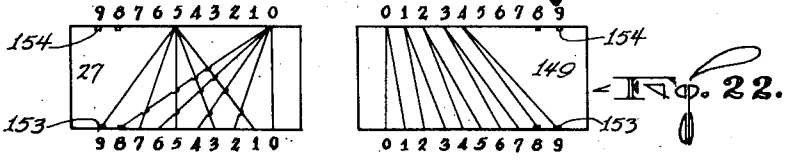



Fig. 22.

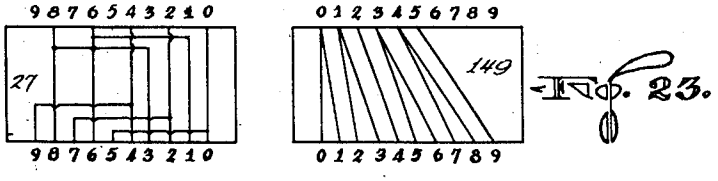



Fig. 23.

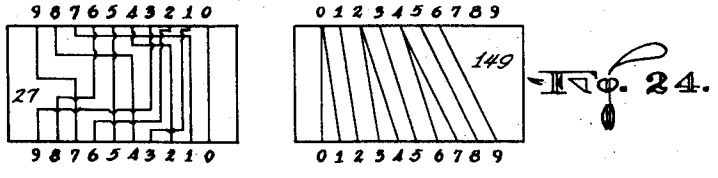



Fig. 24.

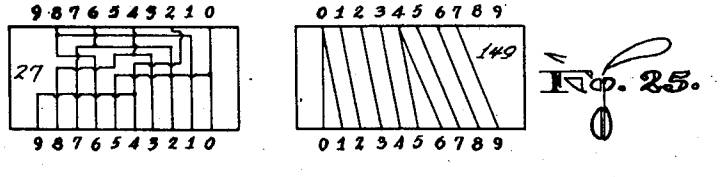



Fig. 25.

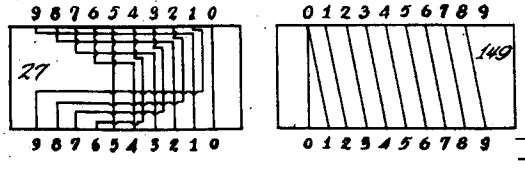



Fig. 26.

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Patented Aug. 1, 1939 2,167,827

# UNITED STATES PATENT OFFICE

2,167,827

## ADDING, SUBTRACTING, AND MULTIPLYING MACHINE

Hugh L. Clary, San Mateo, Calif., assignor to Clary Multiplier Corporation, Los Angeles, Calif., a corporation of California

Application September 27, 1928, Serial No. 308,797

48 Claims. (Cl. 235—61)

My invention relates to improvements in adding, subtracting, and multiplying machines, and it consists in the combinations, constructions and arrangements hereinafter described and claimed.

The principal object of my invention is to provide a machine on which an operator can accomplish multiplication by setting up the two factors of a product consecutively on the same keyboard and using, if necessary, the same key or keys for each factor of the product. This reduces multiplication insofar as operation of the machine is concerned to the simplicity of addition as accomplished now on standard adding machines.

Another object of the present invention is to provide an electrical machine in which there is an electrical connection between each key and number wheels. The depressing of a key or keys closes a circuit or circuits which causes an electrically driven wheel-turning member to rotate the wheels to the appropriate sum, product or difference in accordance with the electrical connections set up by the depression of the key or keys.

In my device, it is not necessary to add in the multiplicand the appropriate number of times, nor to manually shift places, nor to depress other than significant figures, nor to depress the figures in any definite order, nor to allow two revolutions of the machine for multiplication as against one for addition, nor to perform the multiplication by each digit as a separate operation; but it is merely necessary to depress the significant figures of the multiplicand in the keyboard, and after the depression of a multiplication key, depress the significant figures of the multiplier one at a time in the same keyboard. The product will then have appeared on the numbered wheels.

Other objects and advantages will appear as the specification proceeds, and the novel features will be particularly pointed out in the appended claims.

My invention is illustrated in the accompanying drawings forming a part of this application, in which—

Figure 1 is a top plan view of the device;

Figure 2 is a section along the line 2—2 of Figure 1;

Figure 3 is a section along the line 3—3 of Figure 1;

Figure 4 is a section along the line 4—4 of Figure 3;

Figure 5 is a section along the line 5—5 of Figure 3;

Figure 6 is a section along the line 6—6 of Figure 1;

Figure 7 is a section along the line 7—7 of Figure 1;

Figure 8 is a section along the line 8—8 of Figure 7;

Figure 9 is a section along the line 9—9 of Figure 3;

Figure 10 is a section along the line 10—10 of Figure 9;

Figure 11 is a section along the line 11—11 of Figure 1;

Figure 12 is a section along the line 12—12 of Figure 11;

Figure 13 is a section along the line 13—13 of Figure 12;

Figure 14 is a section along the line 14—14 of Figure 12;

Figure 15 is a wiring diagram;

Figure 16 is a fragmentary view of a portion of the device;

Figure 17 is a schematic sectional view of a drum used in the device;

Figure 18 is a longitudinal view of two of the drums;

Figure 19 is a view of another portion of the device; and

Figures 20 to 26 inclusive are wiring diagrams of the drums.

In carrying out my invention, I provide a casing 1 which is best shown in Figures 1 and 2. Figure 1 shows the top plan view of the casing, and Figure 2 shows a section through its greatest height. The casing is mounted upon pads 2 or other suitable supports. Figures 3 and 11, if taken together, show how the front part of the casing is designed to carry a number of banks of keys, while the back part carries the operating mechanism.

Referring to Figure 1, I show to the left of the banks of keys 3 a subtraction key 4, a multiplication key 5, and an adding key 6. To the right of the keys 3 I show a motor bar 7, and beneath this I show a clearing key 8 which clears any depressed key 3. I also show clearing keys 9 for each row of keys 3.

Openings 10 are provided in the casing 1 for permitting the numbers on the wheels 11 to be viewed. The openings 10 are large enough to expose only one number at a time. A clearing key 12 is used for bringing all of the numbered wheels 11 back to zero.

I will first take up the simple addition, and then will follow this by setting forth the subtracting mechanism, and will then set forth the multiplication mechanism.

*Adding mechanism*

When the machine is used for addition, certain portions of the machine which are used exclusively for multiplication do not come into play, and hence will not be described here. Without this multiplying mechanism, the machine would constitute a simple adding machine. A consideration of Figures 3 and 13 will show that when any key 3 is depressed, the current will flow from the conductor clips 13 (all of which are connected to the source of current 60 by wires 230 and 66, see Figure 15) through the depressed key shaft to the corresponding socket 16 and then through the intervening wires, 18' and 22, through drums 27 and 149 to contacts 28 in a rack 30. The drums are used solely for multiplying, and, therefore, need not be described at the present time. The rack 30 is made of insulating material, and the contacts 28 are disposed between the teeth. There is always one potentially alive contact on the rack 30 that is in electrical connection with one terminal of the battery 60. If no key 3 is depressed, the live contact 28 is the one connected with the zero key, i. e., key number 9 (see Figure 1). If any key 3 is depressed, key 9 is raised and the live contact 28 is shifted to one corresponding to the number of the key depressed.

The live contact point for zero is the first one at the right of rack 30 in Figure 3. When a significant key is depressed, a contact 28 corresponding to this key becomes alive and the zero contact is disconnected by the raising of the number 9 key. It will thus be seen that when the key numbered 1 is depressed, the live point is moved over one tooth to the left on rack 30. When key numbered 2 is depressed, it is moved over two teeth on rack 30. When key numbered 3 is depressed, the live point is moved over three teeth to the left, and so on. In other words, the number of teeth between zero contact point and the live contact point will equal the number of the key depressed.

The rack 30 is mounted upon a carrier 25, and the carrier in turn is supported by wheels 26 which ride upon a track 24.

On carrier 25 is also shown rack 150, also of insulating material, with contact points 29. These are utilized for entry of left-hand components of partial products in multiplication, as described later. As there is no such carry-over in simple addition, the connections are for a zero carry-over; that is, in adding position every wire entering the drum 149 is wired to zero contact point 29, see wires 196 in drum 149 in Fig. 15. The wiring through the drums 27 and 149 for simple addition is shown by the dotted lines 195 and 196, see Figure 15.

Having explained how the current is led by the depression of a numbered key 3 to appropriate contact points 28 and 29 on racks 30 and 150, the further action of the machine may be explained. The depression of the motor bar 7 energizes solenoids B—B (Figure 5) causing the carrier 25 to move to the right. This movement (see Figure 3) causes the racks 30, there is one for each bank of keys 3, to engage with pinions 31 and at the same time racks 150, there is one for each bank with the exception of the units bank of keys, to engage with pinions 161.

Associated with each pinion 31, is a ratchet bevel gear 33 (see Fig. 2), which moves with pinion 31 through the rotation of the shaft 32 and meshes with the bevel gear 34 (see enlarged detail in Figures 9 and 10). Bevel gear 34 is double, having teeth 35 on the top thereof.

Each pinion 161 meshes with a crown gear 162 turning a shaft 163 in the direction shown by the arrow (see Fig. 3). Shaft 163 rides freely in a ratchet gear 164, imparting no motion thereto when turned in this direction. It is therefore evident that during the motion of carrier 25 from left to right in Figure 3 the rotation of pinion 31 imparts motion to bevel gear 34 through the action of its companion gear 33, and that the similar motion of pinion 161 has no effect thereon.

It should be stated that pinions 31 and gear 33, as shown in Figure 2, are mounted in a fixed position on the shaft 32, and that the whole shaft 32 rotates with the pinions. Ratchet gear 33 does not rotate with the shaft when the shaft reverses.

It is best now to describe in some detail the mechanism which is being turned by the rotation of the gear 33, and how this turns the number wheels.

The gear 34 (see Figures 9 and 10) is mounted upon a bushing 36, and the latter is secured in a collar 37 that in turn rests upon a partition 38 (see Figure 2). The gear 34 is connected to the bushing 36 by a key or other suitable means of attaching the gear solidly to the sleeve. The bushing 36 has an insulating sleeve 39 that electrically insulates the bushing from a central core 40. The core 40 has a bore 41 for receiving a shaft 42. The lower end of the shaft 42 is reduced at 43 (see Figure 9) and carries splines 44. The shaft is shown operatively connected to the core 40, but when it is raised by a means hereinafter described, the splines 44 disengage themselves from slots 45 and permit relative rotation between the core and the shaft. The splines reengage as the pinions 31 leave the racks and before there is any material overthrow. Four shafts 42 are provided as shown in Figure 2.

Figure 4 shows the top of each shaft 42. A toothed wheel 46 is feathered to the shaft and carries an integral toothed cone 47. A raising of the shaft 42 disconnects it from the gear 34 and at the same time moves the toothed cone 47 into a toothed conical recess 48 which prevents further rotation of the shaft because the recess 48 is formed in a brake shoe 49 that is rigidly secured to a partition 50 by means of a pin 51 or other suitable fastening device. A spring 52 urges the cone member 47 from the brake shoe 49.

A roller 53 (see Figure 4) rides in the teeth 46 and is yieldingly held against the teeth by springs 54, the latter being secured to the partitions 38 and 50 (see Figure 2), the roller is for the purpose of preventing number wheel 11 from stopping at any other position than that in which a number is visible through the opening 10, and also to hold pinions 31 and 161 with one tooth extending vertically down from the center just prior to engagement with the racks 30 and 150, as shown in Figure 13.

The shaft 42 has a square socket 55 which permits it to move longitudinally with respect to a shaft 56 yet at the same time be operatively connected thereto. Again referring to Figure 2, it will be noted that there are four shafts 56, and each carries a bevel gear 57 which drives the number wheel of the counter mechanism. Applicant's invention is not dependent upon any particular counter, register, or recording mechanism. The input into the counter or registering device is determined by the number of $\frac{1}{10}$ revolutions which are imparted to the gear 57. Any

counter or register device which can be controlled by the differential motion of driving gears can be used in this machine. Such counter devices may be of either the simultaneous or subsequent carry type such, for example, as are illustrated in the patents to Chase, No. 1,329,262, Chase, No. 1,011,156, Gooch, No. 1,246,087, Horton, No. 1,016,501, or Hollerith, No. 974,272. These counter mechanisms also contain means for clearing so as to bring the counter back to a zero reading.

Returning now to bevel gear 34 which is being rotated by bevel gear 33 turning with shaft 32 that is driven by rack 30 and pinion 31, we find that pinion 31 is in contact with a brush 67 that is mounted on partition 38 (Figure 2). A wire 68 leads from the brush 67 to coil C which is a U-shaped electromagnet. When the rack 30 moves underneath pinion 31, the pinion makes successive contacts with the contact points 28 disposed between the teeth of the rack.

As previously stated, zero contact point is a live one if no key 3 in a bank of keys 1–9 has been previously depressed. Pinion 31 will strike this contact point before engaging with any of the teeth in rack 29. When no key 3 is depressed, the source of current is in direct connection with zero point, and the pinion 31 upon striking this point will close the circuit, allowing the current to pass from the live point through the pinion 31, brush 67 and wire 68 to coil C. From here the current will flow through wire 69 (see Fig. 15), switch 65, wire 64, and back to the source. This will energize coil C, which will pull down the keeper 70. This rocks a lever 71 (see Fig. 3) which raises the tooth wheel 46 and disengages shaft 42 from gear 34 shown in Figure 9, and brings it into engagement with brake shoe 49.

When keeper 70 is pulled down, it forms a contact at contact point 197 through wire 198 which leads to the source of current. This forms a locked circuit and causes coil C to remain energized until the completion of the forward stroke of the carrier 25. When the moving rack 30 engages with the pinion 31, it will cause the pinion 31 to rotate, which will rotate the gear 34. No motion, however, will be imparted to the shaft 42 or the numbered wheels 11 since the shaft 42 is disengaged from driving contact with gear 34. It is evident, therefore, that when no key in any bank of keys is depressed, the forward movement of the rack has no effect on the numbered wheels 11.

Now when a key is depressed, let us say the key numbered 7, zero ceases to be a live point through the action of the clearing bar 85, and the current now flows from the source of current through the conductor clip 13, associated with the key, through the key shaft, through socket 16, and through the wire, sockets and drums (used only for multiplication, and which are described later), to the contact point 28 on rack 30, which is spaced seven teeth to the left of zero contact point. Now when the rack 29 in its forward movement engages the pinion 31, it will cause the shafts 42 and 56 (see Fig. 2) to turn, and through bevel gears 57 and 58 will cause wheel 11 to turn. The gearing is such that as each tooth of the rack 30 passes beneath the pinion 31, the numbers 1, 2, 3, etc., will appear consecutively to the operator through the openings 10 provided therefor. When seven teeth shall have passed beneath, the number 7 will be opposite the opening.

As previously stated, the contact point immediately following the seventh tooth in the rack 30 is directly connected with the source of current, and it is therefore a live point. As soon as the number 7 has appeared, a contact will be made between the live point and the wheel 31, and the current will flow through pinion 31, brush 67, and wire 68, to coil C, and the action of the coil will disengage the shaft 42 from driving connection with the gear 34. This will engage the toothed wheel 46 with the brake shoe 49, and will stop the wheel 11 from further rotation beyond position 7, i. e., the position at which number 7 is visible to the operator. Since in the other banks no key has been depressed, the other racks 30*a*, *b* and *c* will have no effect on the numbered wheels, as previously explained.

There is a clearing bar 85 for each bank of keys. These bars slide on a partition 15 (see Fig. 11), and have cams 86, one for each key. A cam 88 cooperates with key 9. A depressing of any key 3 will raise key 9 and vice versa.

The carrier 25 upon reaching the extreme right-hand position (as shown by the dotted lines in Figure 3) does two things:

(*a*) Causes contact rod 199, slidably secured to the carrier, to hit a spring stop 200 carried by the rear wall of casing 1. This pushes the rod to the left, breaking the connections from the wires 21 to contact points 155 on carrier 25, and making the connections from wires 21 to contact points 160. The contact points 155 are electrically connected with points 28 by drums 27, and contact points 160 are electrically connected with points 29 by drums 149. For simple addition, the two sets of contact points 28 and 155 can be considered directly connected together, and all of contact points 160 as being connected to the zero point 29.

(*b*) Swings the knife switch 65 into the dotted-line position (see Fig. 3). A projection 72 carried by the carrier 25 engages with the knife switch 65 at the proper time and throws it. The projection 72 is also shown in Figure 2. The throwing of the switch 65 connects the coils A—A with the source of current through the wires 73 and 64. This causes the carrier to move back toward its starting position. It also connects one wire of coils D to the source of current through the wires 201, switch 65, and wire 64 (see Fig. 15).

From the switch 65 runs the wire 69 to the coil C. The wire 68 and the wire 198 are from the other terminal of coil C. When the switch 65 is thrown, the current no longer flows to coil C. This deenergizes coil C and allows spring 52 (see Fig. 4) to force shaft 42 into engagement with gear 34. It will be noted that this reengagement of gears takes place at the moment the carrier reaches its extreme right position, between its forward and backward movement, and when the carrier is practically stationary. It also takes place at a time when the pinions are not in mesh with the racks.

The throwing of the switch also cuts off the current through the coils B—B.

It will not be seen that at the beginning of the backward stroke of the carrier 25, the rack 150 is in the same position with respect to the pinion 161 as characterized the position of the rack 30 and the pinion 31 at the beginning of the forward stroke. Coils A—A are pulling the carrier 25 back in the same manner as the coils B—B pulled it forward, and coils D are ready to life rods 42 when properly energized in the same manner as coils C lifted them on the forward stroke. The use of solenoids to provide full strokes in both directions is shown in Hoyt No.

1,005,774 and the structure therein shown may be used as an actuating mechanism. Also, a motor and a one revolution clutch of any standard type would be equally satisfactory as a means of causing the reciprocating motion of the racks and could be used.

It will be remembered that on the forward stroke shaft 163 idled in ratchet gear 164 through the operation of the ratchet (not shown) in the gear 164. On the backward stroke, the ratchet gear 164 is operatively connected to the shaft 163, engages with the teeth, and the gear 164 therefore drives the gear 34 through the action on the teeth 35. It will be noted that the gear 164 is driving the gear 34 in the same direction on the back stroke as it was driven by the gear 33 on the forward stroke, that is, in the positive direction. During the back stroke, the pinion 31 rotates in the reverse direction through the return action of rack 30 meshing with it. This imparts a similar motion to the shaft 32. When the shaft 32 rotates in the reverse direction, it moves freely in the ratchet gear 33 through the action of ratchet (not shown), and imparts no motion thereto.

It will be seen from the foregoing decription that the machine provides two complete adding machines both actuating the same numbered wheels in the same way. One operates on the forward stroke and uses the back stroke merely to return to its normal position. The other operates on the back stroke, and uses the forward stroke merely to return to its normal position.

This second adding machine that operates on the return stroke is used solely for adding in the multiplying carry-over in multiplication. By multiplying carry-over, I mean the figure 8 in the product $9\times9=81$, for example. In simple addition the multiplying carry-over is always zero, and this portion of the machine could be entirely dispensed with were the machine built for addition only.

As has been said before, when the machine is set for addition, as shown in Figure 3, all of the wires 21 make connections through the drums 149, as shown by the dotted lines in Fig. 15, direct to the zero contact point 29 at the extreme left of the rack 150. In other words, all of the sockets in the appropriate bank are wired to this point so that this point is always a live one on the return stroke when using the machine for simple addition.

Therefore, on the return stroke, the pinions 161 (see Fig. 3), strike the live zero contact points 29 on the rack 150, making a connection through the pinions to the brushes 165 and wires 202 direct to the coils D which, now becoming energized, pull down keepers 166. This rocks levers 167, raises the rods 42, and prevents them from imparting motion to the number wheels 11 in the manner already described for zero contact points on the racks 30. When the keeper 166 is pulled down, it forms a contact at contact point 203 through the wire 66 to the source of current (see Fig. 15). This contact causes the coil D to remain energized throughout the completion of the stroke.

Upon the completion of the back stroke, three things are brought about:

(a) Contact rod 199 hits a spring stop 204 carried by the rails 24. This pushes the rod to the right, breaking the connections from the wires 21 to contact points 160, and making the connections from wires 21 to contact points 155. This is, the contact rod 199 is brought back to the original position shown on Figure 3. There are three contact rods for the four bank machine illustrated, one each for the tens, hundreds and thousands rows.

(b) Projection 205 on carrier 25 hits the knife switch 65 and swings it back into its original position shown in Figure 3.

(c) The keyboard is cleared. That is, all of the depressed keys are raised and the zero keys are returned to their normal depressed position. The motor bar is raised from its socket so as to open the switch 61 and break the current through the machine. This is brought about as follows:

In Figure 14 I have shown the carrier 25 as contacting with a snubber 98. This snubber is mounted upon a rod 99 that engages with a bar 92. The rod 99 passes through a cylinder 100 and carries a piston 101 that slides in this cylinder. The piston and cylinder are so constructed as to retard the return movement of the carrier 25 as it reaches the end of its stroke and to bring it to a quiet stop. At the same time the rod 99 is moved by the carrier and actuates a transverse bar 95 through the medium of levers 94 mounted on a shaft 97. The bar 95 actuates the bars 85 which move all of the keys into upright position, with the exception of keys 9. These are moved down by springs 90.

It will also be noted from Figure 14 that a special clearing bar 102 is used for raising the motor bar key 7. This construction causes the key 7 to be raised with the keys 3.

It should further be noted that the plus key or addition key 6 is depressed before any addition is started. This key engages with a plate 103 carried by a disc 104 (see Fig. 13) eccentrically mounted upon a shaft 105. The movement of the key 6 downwardly swings the disc 104 and its associate disc. This raises the partition 15 into a position which limits the downward movement of the keys 3.

Thus far I have described how the number 7 can be brought to view in the machine during simple adding. Suppose now the number 9 is added. The key Y' (shown in Figure 15) will be depressed and then the motor bar 7 will be depressed. The terminal Z' in the right-hand rack 30 (shown in Fig. 5), will constitute a live point, and the carrier 25 moving toward the top of the sheet in Figure 5 will cause the pinion 31 to move the right-hand wheel 11 in Figure 2 through 9 numbers which will bring the number 6 into view. A number 1 will have to be carried over into the next number wheel. This particular carry-over mechanism is shown in Figures 7, 8 and 19. The type of carry over used in my device is known as the simultaneous carry over. This carry over will add an additional number to the second wheel of two numbered wheels while both are being rotated simultaneously by a prime mover. Although I have illustrated one particular type of simultaneous carry over, this is done merely to make a more complete disclosure of the entire invention, as any standard construction can be used just as efficiently.

Each wheel 11 is mounted on a sleeve 76. Figure 19 shows the wheels as having a double ratchet 208 in which pawls 206 and 207 ride. The pawls are carried by rings 209 and 210 respectively feathered on the sleeve 76. The wheels 11 when in adding position have the pawls 206 and 207 yieldingly engaged with the ratchets 208. Springs 211 bear against the rings 209 and 210, and collars 212 for holding the pawls in engagement as shown in Fig. 19 springs 211 bear

on a shoulder 212 which is part of the sleeve 76. This spring also bears on the ring 210. The ring 210 bears on ring 209 through spreader arm 217, which spreader arm 217 is pivotally mounted on bar 215 (Fig. 2). The spring therefore serves to press both pawls 206 and 207 against the teeth 208. Sleeve 76 bears against a collar which is fastened to shaft 59 so as to hold the assembly in place. The sleeve 76 is journaled on the shaft 59 and is driven by gear 57 through bevel gear 58. Wheel 11 is operatively connected to the sleeve by the double ratchet mechanism previously described.

Each wheel 11 has teeth 78 covering a portion of the inner surface of the rim, these teeth being disposed between the numbers 9 and 0. A pinion 80 meshes with the teeth and turns a finger 83 through one complete revolution. The finger contacts with a pin 84, carried by the adjacent wheel 11 and moves it through one-tenth of a circle. The pawl 207 prevents the first wheel 11 from turning backwards, and the pawl 207 on the next wheel permits it to be advanced one tooth of the ratchet 208.

The pinion 80 and finger 83 are mounted on a shaft 81 carried by a bearing 82. There are ten pins 84 on each wheel 11, and an extra long pin 84' used in connection with clearing the wheels 11 as will hereinafter be set forth. When the wheel 11 is advanced with respect to the sleeve 76 through the action of the finger 83 on a pin 84 for the purpose of imparting a carry in addition the pawl 207 is pushed aside by the action of the teeth 208. This moves the ring 210 to the left and contracts the spring 211. This relieves the spring pressure on ring 209 and its associated pawl 206, and since there is no force pushing pawls 206 into teeth 208, it is idly cammed aside. Furthermore, the friction between the pawls 206 and 207 when combined with the camming action of the teeth tend to make the whole ring and pawl assembly move as a unit over the teeth 208. It should be understood that the pawls 206 and 207 are tapered so as to be thicker at their tips, thus allowing them to engage teeth 208 and also clear the spreader arm 217. It is immaterial whether the adjacent wheel is stationary or movable as the relatively greater speed of the finger 83 will advance the wheel 11 with respect to the shaft 76 even though the shaft itself be moving. The relative positioning of the pins 84 and the finger 83 is such that as both move their arcs coincide and contact is maintained long enough for the carry to be imparted. Where it is desired that the mechanism carry for both addition and subtraction the finger 83 should normally extend radially inward and a pin 84, when the counter was at rest, should extend radially outward from it. For a carry when the next higher order wheel was at rest the motion would be imported to a pin 84 during the last half of a revolution of the finger 83. The finger 83 is long enough and its arc is such that the contact between 83 and 84 is not released until nearly a full carry has been imparted—the balance of the carry being due to the centering action of the spring 211 and the pawls 206 and 207. Should the wheel 11 be moving then the finger 83 will meet the adjacent pin 84 as that pin moves forward to intersect the arc in which the finger 83 travels. It is obvious that if the finger 83 can impart a carry to a stationary pin 84 during the last half of its stroke, it can do so to any carry pin 84 which is picks up sooner than this. Since finger 83 is extending radially inward when at rest and is equidistant from the pin 84 on either side of it, and since there is a pin 84 directly above it, the finger 83 will operate as effectively when turned in a negative direction as in a positive one.

I have described how the keyboard is automatically cleared at the end of each operation. If the operator wishes to clear the number wheel 11, he depresses the wheel clearing key 12 and then presses the motor bar 7. Figure 3 shows how a pressing of key 12 swings a catch 115 into the path of the pin 84' carried by the wheel 11 which, as already stated, is longer than the other pins 84 (see Figure 7). Figure 15 shows how the pressing of the key 12 opens a switch 116 which breaks all key circuits to their respective contacts 28 in the racks 30 and contacts 29 in racks 150, whereby the normally closed zero key contacts will not serve to interrupt the driving action to the wheels 11 from the racks 30 and 150. The depressing of the motor bar causes the carrier 25 to oscillate and to tend to move all of the number wheels 11 through a complete revolution. The catches 115 (see Fig. 1) are so positioned as to only engage with the pins 84'. Each wheel 11 will be rotated until its pin 84' comes into contact with a catch 115 associated therewith, whereupon the wheel 11 will be prevented from further rotation although the sleeve hub 76 will continue to rotate throughout the remainder of the stroke. In this way all of the wheels 11 are brought to zero reading.

The releasing of the key 12 permits a spring 117 to return the catches 115 back into normal position and to close the switch 116. It will be noted that the clearing key 12 through arms 213 and cams 214 (see Fig. 3) raises bar 215 (see Fig. 2) just sufficient to make the enlarged portions 216 of arms 217 spread the rings 209 and 210 apart. This makes the ends of the pawls 206 and 207 coincide. In this position the pawls will act as one and will ride over the teeth 208 in either direction. The bar 215 slides in guides 218 and is returned to normal position by springs 219.

If an error has been made and it is desired to press some other key in the particular bank, the proper error key 9 may be depressed and will move its clearing bar 85 to the right for raising the depressed key 3 and for permitting another key to be depressed. The key 9 is urged downwardly by a spring 90. It will be seen, therefore, that the key 9 not only acts as a circuit closer but also as a means for actuating the clearing bar 85.

A master clearing key (shown at 8 in Figure 1) is also used, and this may be depressed if it is desired to simultaneously raise all of the keys 3 that have been depressed. The construction which accomplishes this is shown in Figure 14. The key 8 engages with a cam edge 91 which moves the bar 92 to the left against the tension of a spring 93. The bar 92 engages with the levers 94, transverse bar 95, and the clearing bars 85, and moves them simultaneously, for raising all of the depressed keys. A spring 96 urges the lever 94 back into the full-line position.

*Subtraction mechanism*

Subtraction may be accomplished in this machine by providing means for reversing the mechanism operated by the rotation of the pinion 31. A reversible counter is required, such as shown in Gooch, No. 1,246,087, previously referred to, or such as is described herein.

In subtraction the device operates in exactly

the same way as for addition except that the wheels 11 are rotated in the reverse direction. The subtraction key 4 is depressed, and Figures 2 and 5 show how this key swings a lever 106 so as to force a collar 107 against a spring 108. Figure 2 shows how the collar 107 is fixed to the shaft 32. A movement of the collar to the left in Figure 2 will therefore bring bevel gears 109 ratchet mounted on pinion 31, into engagement with the bevel gears 34 and will move bevel gears 33 out of mesh. The racks are wide enough to always lie in the path of the pinions 31, whether the gears 109 are in mesh with the gears 34 or the gears 33, gears 109 are journaled on shaft 32 and are operatively connected to pinion 31 by a ratchet mechanism which allows it to drive on the forward stroke and idle on the return stroke.

Figure 13 shows the subtraction key 4 as having a projection 219' that rides under a catch 220 when the key is depressed. To release the key, it is moved in a slot 221' in the casing 1, against a spring 222'. The spring 108 causes the lever 106 to return the key to normal position.

It should be noted that the pinion 31 riding on the rack 30 and the pinion 161 riding on the rack 150 are moving in unison, and both are driving the gear 34 in a positive direction. On the return stroke, this imparts no motion to the numbered wheels 11, because of the ratcheting action of the gear 109 on the pinion 31.

Assume the number 74 has been added in the machine and that the number 3 is to be subtracted. As already stated, the subtraction key 4 is depressed, and then this can be followed by pressing the key numbered 3 in the units row. The subsequent depressing of the motor bar key 7 causes the carrier 25 to oscillate and the units number wheel 11 to be rotated in a reverse direction through three points before the circuit is closed, which frees the shaft 42 from the gear 34 and stops further rotation, as previously described. The result is a showing of the number 71 in the openings 10.

In case a higher number than 3 is subtracted from 74, such as the number 9, the units wheel 11 would be rotated in a reverse direction through nine points, and there would be a carry-over into the tens wheel which would cause this one to rotate in a reverse direction through one point. The difference would thus be 65.

When the minus key 4 is depressed, it moves the collar 107 (see Fig. 2) to the left and also a collar 221. A ring 222 rides in the collar 221, and a lever 223, fulcrumed at 224, has its lower end pivoted to the ring 222 at 225. In like manner, a lever 226 has its lower end pivoted to the lever 106 at 227. The tops of the levers 223 and 226 have cam edges which lift the bar 215 a distance sufficient to move the broadest portions of arms 217 between the rings 209 and 210. This will withdraw the pawls 207 and cause the pawls 206 to engage with the double ratchet 208. The wheels 11 can now be rotated in a reverse direction and will be prevented from rotating in the adding direction.

In all other respects the subtracting device is the same as the adding device and therefore needs no further explanation.

*Multiplying mechanism*

The adding mechanism previously described becomes adapted to direct multiplication by the incorporation of the following features which have not been mentioned heretofore.

1. A sliding contact plate for "placing over" or shifting the places of the multiplicand to correspond with the place of each digit of the multiplier;

2. Rotatable drums which shift the live contact points 28 and 29 on racks 30 and 150 from contact points representing merely the number of the key, to contacts representing the product of the number of the key and the given multiplier;

3. Devices for shifting the contact plate and rotating the drums to the position required by any given figure of a multiplier.

Reference to the various figures will make clear the operation and purpose of these portions of the mechanism. On Figure 13 is shown a plate 19 bearing ten contact points 18 which are connected to sockets 16 by wires 18'. These contact points allow the current to pass to the ten contact points 20 on plate 21 which lie immediately beneath. These contact points connect in turn to wires 22 which lead through the conduit 23 to the drums, which are described later, to the contact points on the rack 30 and 150.

Fig. 12 shows how plate 19 carries four rows of ten contact points 18 (one for each socket 16), and how this can be made to slide to the left over plate 21 by the action of a gear 181 (see Fig. 13) on rack 182, is described later. Now I have already described that when a key is depressed in any given bank of keys, for example the units bank, it forms live contact points on racks 30 and 150 in the same bank, and how, as a result, the key numbered 7, for instance, when pressed in the units column will cause a 7 to appear on the units wheel of the numbered wheels 11.

Reference to Fig. 6 will show that when plate 19 is slid to the left one space, the wire from socket 16 in the units place is making the same contact with the contact points 20 on plate 21 that was previously made by socket 16 in the tens place. Therefore, after the plate has been slid to the left one place, the key numbered 7, for example, when depressed in the units place, would make a connection to the racks 30 and 150 in the tens place, and through the action of the machine, as previously described, would cause seven to appear in the tens place on the numbered wheels. Thus, what has been punched on the keyboard as 7, appears on the numbered wheels as 70, that is, it has been set over one place and multiplied by 10. Had the plate 19 been slid over two places, 7 on the keyboard would appear as 700 on the numbered wheel 11; and, had it been slid over three places, it would have appeared as 7000 on the numbered wheels. On the plate 19 is a bar 228 adapted to make contact with the zero contacts 20 on the plate 21. The bar is connected to the source of current the same as conductor clips 13. When the plate is slid over one space, this bar makes contact with the zero contact 20 on the plate 21 in the units place, causing zero to remain in view on units wheel 11. When slid over two places, it makes zero contacts in the units and tens places, and so on. It should be understood that the machine disclosed is designed for the multiplication of a two digit multiplicand by a two digit multiplier, or a three digit multiplicand by a one digit multiplier. However, it will be obvious that the capacity of the machine can be easily increased merely by adding additional banks.

Referring now to drums 27 and drums 149 shown in Fig. 3, it will be seen that they are made of insulating material. On the lower half of the drums are nine rows of ten contact points 153 (see Fig. 17) adapted to make nine different con-

tacts with the ten contacts 155 and 160 (see Fig. 3). On the upper half, the drums have nine rows of ten contact points 154, each row being adapted to make contacts with the contacts 28 and 29. Between each set of contact points 153 on the lower half of the drums are wires to the set of contact points 154 on the opposite side of the drums, so that there are nine different sets of connections between the contacts 155 and 160 and the contacts 28 and 29 (note the wires in Fig. 17).

Each of the nine sets of connections corresponds to a different multiplier from 1 to 9 inclusive. The connections across the drum for simple addition are shown by the dotted lines on Fig. 15. These are also the connections for multiplication by 1. The connections for multiplication by 2 are shown on Fig. 18. Now the current flowing from the contacts 155 and 160 always represents a multiplicand key. The position into which the drums 27 and 149 have been rotated always represents a multiplier key, and the live contacts 154 on the other side of the drums to brushes 28 and 29 always represents the product of the two keys.

Thus in multiplication by 2, the connection from a multiplicand key numbered 1 would be through contact 153 numbered 1 (Fig. 18) and the wire N to contact 154 numbered 2 and to contact 28 numbered 2 in rack 30, since the product of $2\times1$ is 2. The connection on drum 149 is from contact 153 numbered 1 through wire P to contact 154 numbered 0, which connects with contact 29 numbered 0 on the rack 150, since the product of these numbers consists of one digit and there is no carry-over to the tens place.

It will be noted that the product $6\times2$ has wiring identical with the above, insofar as its terminal or rack 30 is concerned, the current flowing through wire S, but that the current is led to contact point 154 numbered 1 by wire R. This contact connects with contact 29 numbered 1 on the rack 150, representing a carry-over of 1 to give the product 12. As has been stated, connection through the drums for multiplication by 1 (simple addition) is shown on Fig. 15, and for multiplication by 2 on Fig. 18. Wiring for multiplication by digits 3–9 inclusive is shown by the tables in Figs. 20 to 26 inclusive.

On Fig. 5, I show the disposition of the drums in relation to each bank of keys 0–9 and in relation to the racks. Wires from the unit keys lead to drums 27 and 149, as stated, and it will be noted that drum 27 makes contacts with rack 30, which is in the units place, and actuates a units number wheel, and that drum 149 makes contacts with the rack 150, which is in the tens place, and actuates the "tens" number wheel. Connection from the keys in the tens bank are to drums $27^a$ and $149^a$ and so on.

From the above, it will be seen how shifting over the contacts of the sliding plate 19 enables one to multiply by 10, 100, 1000, etc., and how shifting the drums enables me to multiply by any digit from 1 to 9. It is now necessary to explain how these two members are shifted simultaneously, and to illustrate how this accomplishes direct multiplication.

Figure 13 shows a multiplication key 5 as resting upon a plate 118 carried by the left-hand disc 104. The key 5 swings the disc 104 about its shaft 105 and permits the partition 15 to lower. It will be noted from Figure 13 that the front and back of the partition 15 are secured to slides 119 that travel in guides 120. The guides are secured to the side walls of the casing 1, and hold the partition 15 in parallel relation, although permitting it to be raised and lowered by the discs 104. Figure 6 shows the slots 87 in the keys 3 as being long enough to permit the partition 15 to be lowered. The partition 15 is lowered sufficiently so that the levers 94 do not actuate the transverse bar 95. The actuation of the transverse bar 95 as previously described is for addition only.

The sockets 16 (see Figures 6 and 16) are slidable in slots 121 in a partition 17. As already stated, there is one socket 16 for each key 3, and the sockets are normally disposed in alignment with the keys. In multiplying, a multiplicand is first set in the machine, as, for example, 45, by depressing the keys numbered 4 and 5 in the tens and units rows. The shanks of these keys will enter their respective sockets 16. If, now, the multiplication key 5 is depressed, it will move a cam-shaped member 122 through a slot in the partition 17, which will cause a movement of the partition to the left in Figure 13. The partition is slidably mounted in guides 123 for this purpose. All of the sockets will move with the partition except those that have received the key shanks of numbered keys 4 and 5. These sockets will be held against movement.

In Figure 16 I show how any of the sockets 16 can be held against movement by receiving key shanks, while permitting the others to move with the partition. Each socket has trunnions 124 that are slidably mounted in grooves 125 in the side walls of the slots 121. Pins or other suitable stops 126 prevent the movement of the sockets 16 to the left with respect to the partition 17, but permit their movement to the right. Springs 127 are compressed when a socket is held against movement while the partition is moved to the left and return the socket to its original position should the key be removed before the partition 17 is again moved back into place. The springs 127 to the left of the zero sockets bear on some suitable stop independent of the plate 17 and serve to return the plate 17 to its original or normal position when the multiplication key 5 is raised.

It will be seen, therefore, that a depressing of the key 5 will permit the sockets connected to keys numbered 4 and 5 to remain fixed, while the other sockets move with the partition as a unit. The purpose for moving the sockets not receiving keys, out of alignment with the keys, is to permit the keys now acting as multipliers to pass between the sockets without closing any electrical connection through the sockets. As soon as the multiplication key has ben depressed, all of the keys 3, including the keys numbered 4 and 5, constitute multipliers. The keys used in setting up the multiplicand remain depressed throughout the entire operation even though they are not used as multipliers.

Assume that the number 45, already depressed on the keyboard, is to be multiplied by the number 36. The multiplication key is depressed. The key numbered 6 in the units row can be pressed downwardly and will ride clear of the socket 16 associated therewith because the socket has been previously moved. The key will continue on down in its movement and will strike a finger 128 carried by a shaft 129 (see Fig. 6) and a finger 130 carried by a rack 131. The key 3 is provided with a projection 132 for contacting with the finger 130 and with a shoulder 133 for contacting with the finger 128. The projection and shoulder are so arranged as to simultaneously contact with both fingers 128 and 130.

It should be noted at this point that there are four shafts similar to the shaft 129, these being numbered 134, 135 and 136. The shaft 129 is placed beneath the row of units keys 3, while the shafts 134–136 inclusive are placed beneath the rows of tens, hundreds, and thousands keys. The shafts extend from the front to the back of the casing 1 and are supported by front bearings 137 and by rear bearings 138 (see Fig. 12).

Now when any key 3 in the units row is depressed as a multiplier, it will push the finger 128 (Fig. 6) into the position shown. With the finger 128 in this position, the plates 19 and 21 are in the position shown in Fig. 6. When any key 3 in the tens' column is pressed, it will push down a finger 168 on the shaft 134 associated with the key, which will move the plate 19 over one place with respect to plate 21. This is accomplished through gear 171*a* (Fig. 12), gear 176, shaft 172, gear 177', gear 171, shaft 129, gears 178, 179 (Fig. 13) shaft 180, pinion 181, and rack 182. The finger 168 is now completely depressed, and fingers 169 and 170 on shafts 135 and 136 have moved down through one-third of the ninety degree arc through which they are designed to travel. The fingers 128 have moved up one-third of a ninety degree arc.

When a hundreds key is depressed, it slides plate 19 over one additional space, moves fingers 136 down with it and fingers 168 and 128 up. When a thousands key is depressed, the plate 19 is moved over there spaces, and fingers 136 are at the bottom of their arcs. The finger 128 is then at the top of its arc, and the position of the four sets of fingers is just the reverse of that shown in Fig. 6.

This action (see Fig. 12), is brought about through the train of mutilated gears 174, 174', 175, 175', 176, 176', 177 and 177', which are mounted on the shaft 172. Each gear of a pair of gears, as for example gears 174 and 174', is a half gear with teeth on opposing sides so as to be continually in mesh with one side or the other of gear 171*c*. The reversing motion is accomplished by the fact that one gear of the pair of gears 174 and 174', or mutilated gears, meshes first with one side of gear 171 and then the other gear meshes with the other side. The relative size of gears 174 and 171 (ratio ½ to 1) determines the ninety degree arc through which fingers 128, 168, 169 and 170 are designed to move. The positioning of each pair of gears 174—174', 175—175', 176—176', and 177—177' with respect to their common axis determines the order in which these gears reverse their associated gears 171, 171*a*, 171*b*, and 171*c*, and brings about the action of the arms already described.

It should be noted that all of the fingers in any one bank are at the same angle, and that a key in a given bank has, therefore, the same action on plate 19 as any other key in the same bank. It will also be noted that in whatever position the plate 19 may be, the depression of a key will move it, if the plate needs moving, to the appropriate position for a multiplier corresponding to the bank of keys depressed.

Now the drums 27*a*, *b* and *c*, and 149*a* and *b* are turned in a manner almost identical with that which moves the fingers, and which has just been described. As has been stated, when a key is depressed as a multiplier it passes below the sockets 16, and the key projection 132 hits the finger 130 carried on the rack 131. The rack 131 extends laterally across the four rows of keys. These racks are clearly shown in Figure 11, and I have numbered them 131 and 139–146 inclusive. The rack 131, for example, is adapted to be actuated by any one of the four keys numbered 1. The rack 146 is positioned beneath all of the keys 3 numbered 9, and is adapted to be actuated by any one of these keys after the multiplication key has been depressed. Each rack is slidably mounted in slots 147 formed in side members 148 (see Fig. 11).

These racks mesh with mutilated gears 184 shown on Fig. 11 and also Fig. 12. Fig. 12 shows how a train of mutilated gears 186 and 186' mounted on a shaft 183 connects all of the shafts 184' by means of gears 185 mounted on the shafts 184', so that a motion imparted to any rack 131 and 139 to 146 inclusive imparts movement to all. This train of gears and their actions is identical with that already described, for the gears 171 and 174 to 177' inclusive, except that there are nine positions instead of four as in the place shifting mechanism, and the gears 184 associated with racks 131 and 139 to 146 inclusive move through an arc of one hundred and eighty degrees before reversing, instead of through an arc of ninety degrees.

This reversing movement through one hundred and eighty degrees is imparted to drums 27, 27*a*, 27*b*, 27*c*, 149, 149*a*, and 149*b* by gears 187 (see Fig. 12) which turn a rod 188. Through bevel gears 189, shafts 228 are connected to the shaft 188. The shafts 228 are square, and are slidably received in hollow shafts 229 upon which the drums are mounted. The square shafts 228 permit the movement of carrier 25.

As has been previously said there are nine different sets of contact connections through the drums to racks 30 and 150, according to whether the multiplier is 1, 2, 3, 4, 5, 6, 7, 8 or 9. The action of the keys 3 in pressing down the racks 131 and 139–147 inclusive turns the drums. When the racks are in the position shown in Fig. 11, the drums are set for multiplication by one, which is also simple addition. When in this position the depression of a key 3 numbered 1 for multiplying would have no effect since rack 131 is already completely depressed. The depression of a key 3 numbered 2, however, would hit rack 139 and completely depress it. This would move the drums through one-ninth of a semi-circumference to the set of contacts for multiplication by two, see Fig. 18. As rack 139 goes down, rack 131 goes up the same distance, so that a subsequent depression of any key numbered 1 would bring it back to its original position. Had any key 3 numbered 9 been depressed, the key would have hit rack 146, which would move down into completely depressed position, and would move the drums through eight-ninths of a semi-circumference to the set of contacts for multiplication by nine. It will be noted that while there are nine different positions on the lower half of the drums, it is only necessary to move them through eight-ninths of a semi-circumference to cover the nine positions on the upper half.

It will be noted that only one set of fingers, either 128, 168, 169, or 170, can be down at any one time, and that only one rack, either 131 or one of rack 139 to 146 inclusive, can be down at any one time. This means that only one key can be depressed as a multiplier at any one time. In other words, the mechanism permits only one digit of a multiplier to be depressed at one time.

Since only one digit of the multiplier can be depressed at any one time, it is desirable that this depression automatically actuate the carrier 25 without the use of the motor bar 7, so that after

depressing a digit of the multiplier the multiplying action will be automatically completed. A three digit multiplier requires depressing three different keys once. This is accomplished in the following manner.

On the wiring diagram Fig. 15, it will be seen that all of the keys 3 are connected directly with one terminal of the source of current 60 by wires 66 and 230. The motor bar 7 when depressed closes the circuit from this same terminal to coils A and B, which move the carrier forward and back, establishing during the movement of the carrier the appropriate connections to the C and D coils, as already described. It is evident, therefore, that in lieu of closing the circuit to the A and B coils through the motor bar, it could be closed through the keys 3 themselves which are connected to the same terminal of the source of current 60.

Four conductor rods 231 are provided for this purpose, and they rest upon the keyboard 14 (see Fig. 1) and are disposed immediately beneath the keys 3, but not in contact with the key shafts. The rods are connected to A and B coils by wires 232, as shown in the wiring diagram Fig. 15. The rods 231 are carried slightly above the plate 14, and are flat with a thin rounded edge, (see Fig. 6). On the shafts of the keys 3 are spring clips 233 positioned so as to slide over the rounded edge of the conductor rods 231 when the keys reach the limit of their downward movement in multiplication, i. e., when the drums and place shifting plate are in position. The spring clips press downwardly against the rods making a firm connection with the source of current during the action of the carrier.

I am no ready to illustrate by an example how the machine operates for multiplication. Let us take the problem of multiplying 45×36.

| | | |
|---|---|---|
| | 4 5 | Placed in machine at start |
| | × | Multiplication key 5 depressed |
| | 3 | Key 3 numbered 3 in tens row, depressed |
| Forward stroke | 2 5 0 ← | In drum 27 because of placing over |
| | ↑ ↑ | In drum 27a |
| | └ | In drum 27b |
| Backward stroke | 1 1 0 ← | In drum 149 because of placing over |
| | ↑ ↑ └ | In drum 149a |
| | └ | In drum 149b |
| First product | 1 3 5 0 | |
| | 6 | Key 3 numbered 6 in units row, depressed |
| Forward stroke | 4 0 ← | In drum 27 |
| | ↑ | In drum 27a |
| Backward stroke | 2 3 ← | In drum 149 |
| | ↑ | In drum 149a |
| Final product | 1 6 2 0 | |

I provide means for returning the contacts 18 into the position shown in Figure 6, and for returning the drums 27 and 149 back into number 1 position after the operator has finished with the device. This is accomplished by depressing the addition key 6 which causes the projection 183 in Figure 13 to rotate the eccentrics 184 and raise the plate 15 and then depressing the clearing key 8, which not only raises all of the keys 3 as already set forth, but also moves the contacts 18 back into the position shown in Figure 6 and returns the drums to number 1 position. In Figure 6 I show an arm 194 as extending from the key 8, this arm having a projection and shoulder similar to the projection and shoulder 132 and 133 carried by the bottom of each key 3. This arm slides along the shank of number 1 key in the units row, and when the key 8 is depressed the arm engages with the finger 128 and the finger 130 for returning the member 19 and the drums back into normal position. The machine is now ready to be used as a multiplying, subtracting or adding device.

As previously stated, a key once used to represent a digit of the multiplicand may be subsequently used to represent a digit of the multiplier without returning the key to its original position. This is best explained by illustration of the multiplication of 36×36. As has just been stated, the normal position of the keyboard is with the addition key 6 down. The machine is then ready for either addition or multiplication. The first step is therefore to depress the key 36 in the keyboard. The keys slide down the incline surface 86 of the member 85 until the limit of their downward motion is reached. They have then entered the appropriate sockets 16. The members 85 rest on the plate 15. When the multiplication key 5 is depressed this lowers the plate 15 and the members 85 and permits further downward motion of these keys. This is because the sockets 16 are open and permit the keys to pass through them while still maintaining contact with them. The depression of the multiplication key 5 moves aside the socket bearing plate 17 but it can not however move aside the sockets 16 in which the key shanks have already entered. As to these sockets, the movement of the plate 17 merely compresses the springs 127. The multiplicand 36 has thus been set up and the same keys are ready to act as multipliers if and when they are further depressed. If the 3 key in the tens row is now depressed, it acts on the mechanism below the key sockets so as to turn the drums to the position for multiplication by three and to shift the placing over plate for multiplication by 10. As previously explained, the downward movement of any key in the tens row will hit a finger 168 (see Fig. 6) which will turn shaft 134—the gearing being such that plate 19 will be moved one space to the left (see Fig. 6) and also through the train of gears previously described the finger 128 will be raised the equivalent of one space, thus permitting the plate 19 to be returned to its original position when the finger 128 is depressed through the action of a multiplier key operated in the units place. Subsequent depression of 6 in the units place will move the drums to the position for multiplication by 6 and the plate 19 back to the units position. It is obvious therefore that the fact that a key may already have been used to set up a multiplying contact does does not in any way disable it from being subsequently used to operate the multiplying drums and the placing over mechanism because the multiplicand is set up during the first stage of the downward stroke and the balance of the work is done during the second stage. The plate 15 acts as a differential latch to determine the exact amount of movement for each stage. The key is first depressed as far as plate 15 in its upper position will allow and then as far as plate 15 in its lower position will allow.

The machine can also be used as a divider in the same manner as standard machines are now used. In the claims I have therefore referred to the entire machine as an electric calculator.

I claim:

1. An electric calculating machine comprising a plurality of numbered wheels, movable members for rotating said wheels, electrically controlled means for disconnecting said wheels from said members, a plurality of contacts successively closed by said moving members, a plurality of keys wired to the contacts, and contact selecting

means positioned mechanically by said keys so as to cause said contacts to indicate the product of the keys depressed.

2. An electric calculating machine comprising a plurality of keys, a plurality of numbered wheels, members for rotating said wheels, electrically controlled means for disconnecting said wheels from said members, selective, key controlled means for causing said disconnecting means to free said wheels when they have turned up the product of the keys depressed.

3. An electric calculating machine comprising a plurality of numbered wheels, members for actuating said wheels, electrical means for moving said members, electrically controlled means for disconnecting said wheels from said members, selective, key controlled means for causing said disconnecting means to free said wheels when the product of the numbers on the depressed keys is turned up, said members being operated only once to turn up the proper product.

4. An electric calculating machine comprising a plurality of numbered wheels, means for rotating them in either direction, a plurality of contacts, a plurality of keys for selectively connecting any contact with a source of current, and electrically actuated means for disconnecting said wheels from said rotating means when the wheel rotating means strikes a live contact.

5. An electric calculating machine comprising a plurality of numbered wheels, means for rotating said wheels, electrically actuated means for disconnecting said wheels from said wheel rotating means, a plurality of contacts for each wheel, the contacts of each set being successively closed as the wheels rotate, a plurality of keys in electrical connection with said contacts through a multiplying member, any of said keys when depressed closing an electric circuit to said wheel disconnecting means when the wheels have turned to the product of the keys depressed.

6. An electric calculating machine comprising a plurality of numbered wheels, means for rotating said wheels, a plurality of contacts corresponding in number with the number of characters on the wheels, associated with each wheel, a plurality of banks of keys, means operatively connected with said wheel rotating means for selectively connecting said contacts with said keys through a multiplying member, electrically actuated means for freeing the wheels from the rotating means, said keys when depressed closing an electric circuit to said wheel freeing means when the wheels have turned to the product of the keys depressed.

7. An electric calculating machine comprising a plurality of numbered wheels, means for rotating said wheels, a plurality of contacts associated with said means and adapted to be successively closed as said wheel rotating means moves, a bank of keys for each set of contacts electrically connected through a multiplying member to the contacts when the keys are depressed, and electrically actuated means for disconnecting said wheels from said wheel rotating means when the wheels have turned to the product of the keys depressed.

8. An electric calculating machine comprising a plurality of numbered wheels, means for rotating said wheels, a set of contacts associated with said means and being successively closed by the movement of said wheel rotating means, a bank of keys for each set of contacts in electrical connection therewith, electrically controlled means actuated by the closing of a contact for disconnecting said wheels from said wheel rotating means, and key actuated means for changing the electrical connections between said keys and contacts for causing the wheels to turn up the product of the keys depressed.

9. An electric calculating machine comprising a plurality of numbered wheels, a pair of racks for rotating each wheel, a plurality of contacts associated with each rack, means for successively closing the contacts, a drum for each rack and having pre-arranged contacts thereon for electrically connecting with the first contact, key actuated means for rotating the drums in accordance with the key depressed, electrical connections between the keys and the contacts on the drums, key actuated means for changing the denominational relation of the electrical connections between the keys and the drums, and electrically controlled means for disconnecting said wheels from said wheel rotating means when said electrically controlled means is connected with a source of current by the closing of the contacts electrically connected with the depressed keys.

10. In a multiplying machine of the character described, an electrical circuit having a series of branches and a gap in each branch and a drum revolvable within the gaps having means for connecting the terminal of one branch with any one of a plurality of opposing terminals of the other branch circuits.

11. In a multiplying machine of the character described, an electrical circuit having a series of branches and a gap in each branch, a member movable in the gaps, a keyboard having a plurality of keys adapted to connect any one of the terminals on one side of the gap to a source of current and a plurality of leads in the member adapted to connect any one of the said terminals to any one of the opposing terminals according to the position of the movable member.

12. In a multiplying machine of the character described, an electrical circuit having a series of branches and a gap in each branch, a member movable in the gaps, a keyboard having a plurality of keys adapted to connect any one of the terminals on one side of the gap to a source of current, a plurality of leads in the movable member adapted to connect any one of the said terminals to any one of the opposing terminals according to the position of the member and means operable by the keys for positioning the member.

13. In a multiplying machine of the character described, a circuit having a series of branches and a gap in each branch to present two sets of terminals, means for causing each set of terminals to represent a set of figures, a member movable in the gaps having means for connecting any one terminal of one set with a terminal of the other set representing a desired multiple of the former, said first-named means including means for rendering any terminal of the first set active and means associated with said first-named means for operating the movable member.

14. In a multiplying machine of the character described, a circuit having a series of branches and a gap in each branch to present two sets of terminals, means for causing each set of terminals to represent a set of figures, a member movable in the gaps having means for connecting any one terminal of one set with a terminal of the other set representing a desired multiple of the former and a common keyboard for rendering any one of the first set of terminals active and for operating the movable member.

15. In a multiplying machine of the character described, a circuit having a series of branches

and a gap in each branch to present two sets of terminals, means for causing each set of terminals to represent a set of figures, a member movable in the gaps having means for connecting any one terminal of one set with a terminal of the other set representing a desired multiple of the former, said first-named means including individual keys for rendering the terminals of one set active by depression of the keys having means for limiting the key movement associated therewith, means for rendering the keys inactive relative to terminals not affected having means associated therewith for removing the limiting means and means operable by further depression of the keys for operating the movable member.

16. In a multiplying machine of the character described, a circuit having a series of branches and a gap in each branch to present two sets of terminals, means for causing each set of terminals to represent a set of figures, a member movable in the gaps having means for connecting any one terminal of one set with a terminal of the other set representing a desired multiple of the former, said first-named means including individual keys for rendering the terminals of one set active by depression of the keys having means for limiting the key movement associated therewith, means for rendering the keys inactive relative to terminals not affected having means associated therewith for removing the limiting means, and mechanical means operable by further depression of the keys for operating the movable member.

17. In a multiplying machine of the character described, a keyboard representing a number of figures, an electrical circuit having a plurality of terminals associated with the respective keys, a multiplying member associated with the terminals, a plate having a contact for each key for rendering a corresponding terminal active upon depression of a key, and a multiplying key having means associated therewith for moving the plate into an inactive position, the plate being constructed to leave contacts already engaged unaffected.

18. In a multiplying machine of the character described, a keyboard representing a number of figures, an electrical circuit having a plurality of terminals associated with the respective keys, a multiplying member associated with the terminals, an element normally limiting the key movement and a multiplying key having means associated therewith for moving the element for freeing the keys for further action.

19. In a multiplying machine of the character described, a keyboard representing a number of figures, an electrical circuit having a plurality of terminals associated with the respective keys, a multiplying member associated with the terminals, a cam bar normally limiting the key movement, a plate having a contact for each key for rendering a corresponding terminal active upon depression of a key, a multiplying key, means associated therewith for moving the cam bar for freeing the keys for further action, and means associated with the multiplying key for moving the plate into an active position, the plate being constructed to leave contacts already engaged unaffected.

20. In a multiplying machine of the character described, a keyboard representing a number of figures, an electrical circuit having a plurality of terminals associated with the respective keys, a multiplying member associated with the terminals, a member normally limiting the key movement, an eccentric supporting the member, and a multiplying key active on the eccentric for lowering the member and for freeing the keys for further action.

21. A calculating device comprising a single keyboard consisting of depressible keys, a totalizer, means for producing in the totalizer the mathematical result of the keys depressed and including a multiplicand circuit, a multiplying member and a decimal shifter, said multiplicand circuit being closed by the depression of the keys, and said multiplying member and decimal shifter being operated by a further depression of the keys.

22. In a calculating device, a single keyboard consisting of depressible keys, a totalizer, means for connecting the keyboard with the totalizer for causing numbers corresponding with the key depressed to be accumulated in the totalizer, and multiplying means adapted to be made effective in said first named means and to be actuated by the further depression of the keys, whereby the products of the numbered keys depressed will be transmitted to the totalizer.

23. In an electrical calculating device, a totalizer for turning up a mathematical result, key controlled means for actuating said totalizers, and a decimal shifter consisting of a movable contact bearing member actuated by said keys.

24. An electric calculating machine comprising a plurality of numbered wheels, cyclically operable means normally effective when actuated for rotating the wheels through an entire revolution, a plurality of keys, means for disconnecting said wheels from said wheel rotating means, electrical means for controlling said wheel disconnecting means, and mechanical means for controlling said electrical means so as to show the product of the keys depressed.

25. In a calculating device, a totalizer, means for adding numbers into the totalizer including keys, a multiplicand setting up means adapted to be made effective by the same keys, a multiplying member adapted to be actuated by the same keys, and a decimal shifter actuated by said keys, the multiplicand setting up means, multiplying member, and decimal shifter being operatively connected to the totalizer.

26. In an electrical calculator, a plurality of keys for setting up electrical circuits, a totalizer for receiving mathematical results set up by the keys, multiplicand setting up means made effective by the keys, multiplying members, and means for causing the same keys to act on the multiplying members, said electrical circuits impressing on the totalizer the product of the keys depressed.

27. In a multiplying machine, an electrical circuit having a series of branches and two gaps in each branch, a member movable within one set of gaps and having means for connecting the terminal of one branch with any one of a plurality of opposing terminals of the other branch circuits for the purpose of multiplication, and a movable member disposed in the second set of gaps and having means for connecting the terminal of one branch with any one of a plurality of opposing terminals of the other branches for the purpose of changing the denominational order.

28. An electric calculating machine comprising a product indicating means, members for actuating said means, a plurality of contacts successively closed by the moving members, a plurality of keys wired to said contacts in a prod-

uct indicating manner for connecting contacts with an electric source when the keys associated with the contacts are depressed, and electrically actuated means for disconnecting said product indicating means from said members, and being connected to said contacts, said means being energized when said members close the contacts in electrical connection with the source of current.

29. An electric calculating machine comprising a product indicating means, a member operatively connected to said means, electrically controlled means for disconnecting said product-indicating means from said member, and key controlled product selecting means for energizing said electrically controlled disconnecting means for stopping the operation of said product indicating means in the position to indicate a product.

30. In a multiplying machine, a plurality of contacts, a key for each contact, each key and its associate contact being movable for closing an electric circuit, means for rendering contacts not already closed electrically inoperative with respect to their associate keys, whereby any key may be further operated without affecting the contacts already closed.

31. An electric calculating device comprising product indicating means, movable members for actuating said means, electrically controlled means for disconnecting said members from said means, a plurality of contacts successively closed by said members, a plurality of keys wired to the contacts, and contact selecting means positioned mechanically by said keys for causing said contacts to indicate the product of the keys depressed.

32. In a multiplying machine, a series of contacts for forming electrical connections for actuating the machine, means for causing one or more contacts to become electrically alive, and means for keeping all of the other contacts out of electrical connection while permitting further operation of said first named means.

33. In a multiplying machine of the character described, a keyboard composed of a number of banks of keys to represent digits of different decimal orders, an electrical circuit having a set of terminals normally associated with each bank of keys, said circuit being closed by the depression of the keys to cause the sets of terminals to represent digits of the same order as the keys depressed, a complementary set of terminals associated with each of the first sets of terminals, and means actuated by a further depression of the keys for shifting any set of terminals normally associated with the keys of a given decimal order over to any set of terminals normally associated with the keys of a higher or a lower decimal order.

34. In a multiplying machine of the character described, a keyboard consisting of a number of banks of keys to represent digits of different decimal orders, an electrical circuit having several sets of terminals, each set adapted for association with a bank of keys when the keys are depressed, means for shifting one set of terminals over to another, said means comprising a contact bearing member having several sets of contacts electrically connected with the terminal sets, a second contact bearing member having several sets of contacts and being movable with respect to the first contact bearing member, and means actuated by a further depression of the keys for moving the second contact bearing member with respect to the first so that its sets of contacts will move into engagement with the desired sets of contacts on the first contact bearing member.

35. In a multiplying machine of the character described, a keyboard representing a number of banks of keys to represent digits of different decimal orders, an electrical circuit having several sets of terminals, each set adapted for association with a bank of keys, complementary sets of terminals associated with the first sets, and means operable by the keys for shifting one group of terminal sets with respect to the other.

36. In a multiplying machine, a keyboard representing a number of banks of keys to represent digits of different decimal orders, an electric circuit having several sets of terminals, each set adapted for association with a bank of keys, a multiplying member mounted for cooperation with the terminals, complementary sets of terminals associated with the first sets, means for shifting the groups of terminal sets with respect to each other for changing the denominational relation between the keys and the complementary sets of terminals, and means also operable by the keys for operating the multiplying member.

37. In a multiplying machine of the character described, a keyboard representing a number of figures, an electric circuit having several sets of terminals adapted for association with the keys, means operable by the keys for connecting desired terminals to a source of current, complementary sets of terminals associated with the first sets and means operable by any of said keys for shifting one group of terminal sets with respect to the other.

38. In a multiplying machine of the character described, a keyboard consisting of a number of banks of keys to represent digits of different decimal orders, an electric circuit having several sets of terminals, each set adapted for association with a bank of keys, means operable by the keys for connecting desired terminals to a source of current, a multiplying member mounted for cooperation with the terminals, complementary sets of terminals associated with the first sets, means operable by further key movement for shifting one group of sets of terminals with respect to the other group of sets and means also operable by the further key movement for operating the multiplying member.

39. In a multiplying machine of the character described, a keyboard consisting of a number of banks of keys to represent digits of different decimal orders, an electrical circuit having several sets of terminals, each set adapted for association with a bank of keys, means operable by the keys for connecting desired terminals to a source of current, a multiplying member mounted for cooperation with the terminals, complementary sets of terminals associated with the first sets, means operable by further key movement for shifting one group of sets of terminals with respect to the other group of sets, and for operating the multiplying member, a multiplication key, and means operable thereby for rendering the first-mentioned keys inoperative as means for connecting terminals to the source of current.

40. A multiplying machine comprising a keyboard having banks of numbered keys, the banks, reading from left to right, representing digits of descending decimal order, means for indicating a product, means actuated by the keys for setting up a multiplicand, and means for changing the same keys into multiplying keys, whereby an actuation of any of the same keys will set up in said product indicating means the product appropriate to both the digit and decimal order of the keys actuated.

41. A multiplying machine comprising a keyboard having a plurality of banks of numbered keys, means for setting up a multiplicand, means for setting up a multiplier, and a decimal shifter, said multiplicand and multiplier setting up means and said decimal shifter being controlled by any of the numbered keys.

42. A multiplying machine comprising a keyboard having a plurality of banks of numbered keys, the banks, reading from left to right, representing units of descending decimal order, means actuated by the keys for setting up a multiplicand, means for changing all of the same keys into multiplying keys, multiplying means actuated by the same keys, and an automatic decimal shifter operated by the keys when functioning as multiplying keys, said decimal shifter automatically causing said multiplying means to multiply by the same decimal order as the decimal order of the row of keys in which the key, acting as a multiplying key, is depressed.

43. In a multiplying machine of the character described, a keyboard consisting of a number of banks of keys to represent digits of different decimal orders, an electrical circuit having several sets of terminals, each set adapted for association with a bank of keys when the keys are depressed, means for shifting one set of terminals over to another, said means comprising a contact bearing member having several sets of contacts electrically connected with the terminal sets, a second contact bearing member having several sets of contacts and being movable with respect to the first contact bearing member, and means actuated by the keys for moving the second contact bearing member with respect to the first so that its sets of contacts will move into engagement with the desired sets of contacts on the first contact bearing member.

44. In a multiplying machine of the character described, a keyboard representing a number of figures, an electrical circuit having a plurality of terminals associated with the respective keys, said keys being movable into electrical connection with their terminals, a multiplying member associated with the terminals, and terminal moving means permitting each key on movement thereof to clear its terminal unless previously connected thereto and to actuate the multiplying member.

45. In a machine of the class described, an accumulator for accumulating a product, electromechanical means for entering partial products in said accumulator, said means including mechanical devices settable in accordance with the digits of the multiplier for selecting circuits representing partial products, further circuit selecting means settable in accordance with the digits of a multiplicand, a keyboard comprising a plurality of banks of keys, said key when depressed normally conditioning said further circuit selecting means in accordance with a multiplicand value, and a manipulative means for enabling said keyboard to control entry of a multiplier value in said mechanical devices upon depression of the keys thereof.

46. In a multiplying machine of the character described, a keyboard consisting of a plurality of banks of keys for controlling entry of digits of different decimal orders, first factor entry receiving devices normally controlled by said keys upon depression thereof, second factor receiving members settable in accordance with a second factor, and mechanical means for enabling said keyboard to introduce the second factor whereby the keys thereof when depressed control the positioning of said second factor receiving members.

47. In a multiplying machine of the character described, a keyboard consisting of numbered keys, first factor entry devices normally controlled by said keys upon depression thereof, revolvably mounted members settable to receive a second factor, and manipulative means for conditioning said keyboard whereby the keys thereof, when depressed, position said revolvable members in accordance with a second factor.

48. In a multiplying machine of the character described, a keyboard consisting of a plurality of banks of keys for controlling entry of digits of different decimal orders, first factor entry receiving devices normally controlled by said keys upon depression thereof, electrical transposing members representing multiplication tables settable in accordance with a second factor, and mechanical means for enabling said keyboard to introduce a second factor whereby the keys thereof when depressed control the positioning of said transposing members.

HUGH L. CLARY.