PATENT SPECIFICATION

Application Date Sept. 11, 1920. No. 26,158/20. **150,970**

Complete Accepted: Jan. 11, 1922.

COMPLETE SPECIFICATION.

Improvements in or relating to Calculating Machines.

[illegible] Ernst Kuhrt, of Friedrichsruher [illegible], Germany.

ERRATUM.

SPECIFICATION No. 150,970.

Page 3, line 118, *for* "accurate" *read* "arcuate"

PATENT OFFICE,

February 11th, 1929.

teeth of the setting [illegible] that the units and tens come to be successively transmitted to the setting wheels. Now in contra-distinction to this arrangement it is a special feature of my invention, that there are arranged for each bank of the machine disposed below the keyboard for the multiplicands a group of nine multiplication-plates corresponding to the multipliers from 1—9 which multiplication-plates, by being shifted in the lateral direction, may be so moved that their raised portions, representing the units and tens may be alternately brought in contact with their own or the preceding lower order of keys, each set of multiplication-plates being surrounded by a slide which is periodically brought into engagement with the multiplication-plates and which [illegible] operative position by the [illegible] of the slides, so that if, after the numeral drums have been set, these latter come to be locked in their position, say, for instance by the fact of their being provided with notches in the manner of a maltese cross, there will be no possibility of the said drums subsequently moving beyond their correct position the liability of errors in computation arising therefrom being thus obviated.

The periodical coupling of the slides with the multiplication-plates disposed below the multiplicand keyboard is effected by means of lips adapted to be displaced in the vertical direction and which displacement is in turn carried out by the multiplier-keys in accordance

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I, ERNST KUHRT, of Friedrichsruher Strasse, 25, Steglitz, Berlin, Germany, a citizen of the German Republic, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to calculating machines of the type wherein setting wheels are provided carrying a variable number of teeth, which teeth are acted upon by multiplication-members any one member having raised portions showing the product of the digits 1—9 multiplied by one of the digits 1—9, the action of the said multiplication-members on the teeth of the setting wheels being such that the units and tens come to be successively transmitted to the setting wheels. Now in contra-distinction to this arrangement it is a special feature of my invention, that there are arranged for each bank of the machine disposed below the keyboard for the multiplicands a group of nine multiplication-plates corresponding to the multipliers from 1—9 which multiplication-plates, by being shifted in the lateral direction, may be so moved that their raised portions, representing the units and tens may be alternately brought in contact with their own or the preceding lower order of keys, each set of multiplication-plates being surrounded by a slide which is periodically brought into engagement with the multiplication-plates and which in its turn acts upon the teeth of the setting wheels in suchwise that a transmission of the products on to the numeral drums of the totalizing mechanism may be effected. To this particular end, the said slides are provided each with two slide members the length of which corresponds to the sum total of the widths of the outer ends or points of the teeth of the tooth-setting wheels, while they are so spaced apart that when the slide member is at rest and the setting wheels in rotation, all the teeth thereof will be forced into the operative position. The direction in which the setting wheels are to be turned is at the same time so chosen for the particular arithmetical operation to be carried out, that, in the course of each such said operation, always the last teeth of the setting wheels will come to be moved into the operative position by the slide members of the slides, so that if, after the numeral drums have been set, these latter come to be locked in their position, say, for instance by the fact of their being provided with notches in the manner of a maltese cross, there will be no possibility of the said drums subsequently moving beyond their correct position the liability of errors in computation arising therefrom being thus obviated.

The periodical coupling of the slides with the multiplication-plates disposed below the multiplicand keyboard is effected by means of lips adapted to be displaced in the vertical direction and which displacement is in turn carried out by the multiplier-keys in accordance with the multiplier entering into con-

sideration for the time being, so that the slides come to be coupled by these lips to the very multiplication-plates corresponding to the multiplier key operated at the time.

An embodiment of my invention is shown by way of example in the drawings annexed to this specification and forming part thereof. In the drawings :—

Figure 1 is a side elevation of the calculating machine showing the drive mechanism.

Figure 2 is a vertical section.

Figure 3 a plan view thereof, the upper portions of the machine removed and the printing mechanism and the quotient indicating drums omitted.

Figures 4 and 5 are plan views of two different types of multiplication-plates.

Figures 6 and 7 are side elevations of the setting wheels along with the total indicating wheels acted upon by them, the dogs thereon being shown in two different positions.

Figure 8 is a front elevation of the parts shown in Figures 6 and 7, respectively.

Figures 9, 10, and 11 are a side elevation, plan view and end view, respectively, of the locking and indicating mechanism of the multiplicand keyboard.

Figure 12 is a part view similar to Figure 9 but showing one key depressed.

Figure 13 is a front elevation of the multiplier keyboard.

Figure 14 is a plan view of the rear end of the machine after the cover has been removed, showing in particular the printing mechanism and its drive.

Figure 15 is a detailed front elevation of the printing mechanism.

Figure 16 is a plan view of the total indicating and quotient indicating wheels, partially in horizontal section, and

Figure 17 is a side elevation of the parts shown in Figure 16, partially in section.

In the following description I will endeavour to describe the details of construction of the several parts of my machine, arranging the same under appropriate headings.

Referring to the driving mechanism (Figures 1 and 3) ; for each calculating operation there are required, besides a single to and fro motion of the crank, two rotations of the setting wheels in one and the same direction ; notwithstanding, it is understood that the direction of said rotation must be changed according to the particular arithmetical operation required to be performed.

The cast-metal part 1, screwed tight to the base-plate of the machine, is provided with an indenture 2 in the centre of which there is arranged a pivot 3. On this pivot there is mounted to rotate a lip of approximately rhombic form which is so dimensioned that a pin or roller 5 may, in any position which it will assume, freely travel through a slot remaining intermediate the side face of the indenture 2 and the periphery of the lip 4. The pin 5 is mounted on the end of a connecting rod 6 and is moreover adapted, by passing through a radial slot 7 of a spur wheel 8 likewise lodged to rotate on the said pivot 3, to engage the groove 2 formed by the cast-metal part 1 and the lip 4. The opposite end of the connecting rod 6 is either fixed to turn about a hand lever or crank 9, oscillating about an axis 10, or else this end of the tension rod is as shown in Figure 1, secured at 9^1 to an arm 10^1, adapted to oscillate conjointly with the axis 10 rotated by the crank 9. The spur wheel 9 meshes with another spur wheel 12 rigidly fixed to the main driving shaft 14. The gear ratio between spur wheels 8 and 12 is as 1 : 2.

When the crank 9 is in its initial position, the pin 5 is disposed at the extreme right-hand end of the groove 2. In this contingency, the lip 4 assumes the position shown in the drawing and in which it is retained by the action of a spring 13 operating on said lip by intervention of a displaceable arm 13^1. As soon as the crank 9 is moved in the direction indicated by an arrow in Figure 1, this said movement is transmitted by the crank upon the pin 5 through the connecting rod 6, and simultaneously also on to the spur wheel 8. During this operation the pin 5 travels along the upper portion of groove 2 and this primarily until it attains the position shown in Figure 1. The spur wheel 8 participates in this movement by effecting a rotation around the axis 3. As the movement of the crank continues, pin 5 comes to bear against the spring acted lip 4 and thus automatically clears for itself a path to the opposite left-hand extremity of the groove 2. As soon as this position has been reached, the spring 13 depresses the lip into its original position dis-

closed by Figure 1. During this first phase of the motion effected by the crank, the spur wheel 8 has completed a half-revolution, and, by virtue of the gear ratio indicated, brought about a complete revolution of the spur wheel 12 and of the main driving shaft 14 respectively.

The crank 9 now travels back along the same path but in the opposite direction, in the course of which the pin 5, the path it has just traversed being now barred by the lip 4, glides through the lower open portion of the groove 2. As this movement proceeds, the lip 4 is forced out of the path of the pin 5 and counter to the action of spring 13, so that finally the said pin is enabled to return again into its initial position at the right-hand end of the groove 2, while lip 4 likewise acting under the influence of spring 13, returns into the position shown in Figure 1. This, the second phase of the movement executed by the crank, likewise causes a semi-revolution of the spur wheel 8 and a complete revolution of the spur wheel 12 and of the main driving shaft 14.

Let it now be assumed that the motion just described has caused the main driving shaft to be rotated in a direction which will allow a sum either in addition or in multiplication to be performed. In that case, if it be then desired to carry out a sum in subtraction or in division it will obviously be necessary to cause the main driving shaft 14 to be turned in the opposite direction. To enable this to be done, the arm 13^1 which is under the influence of the spring 13 and in turn acts upon the lip 4, is so lodged as to be capable of displacement. By these means, the point where this said arm comes to engage the lip 4 may also be shifted to the opposite side of the axis of rotation 3. For while in the arrangement according to Figure 1 the right-hand section of the lip 4 must be forced downwards by the arm 13^1 and the left-hand section thereof upwards, the operation must now be reversed on the arm 13^1 having been shifted to the left by the aid of the stud 13^{11}, so that the left-hand section of the lip will be depressed and the right-hand section raised. The result is that the pin 5 is forced to travel along the lower portion of groove 2 during the first phase of the movement executed by the crank, whereas it has to travel along the upper portion of said groove during the second phase of said movement, so that consequently there will be effected a rotation of the spur wheel 8 and therewith of the main driving shaft 14 in the opposite direction.

Reference will now be made to the calculating mechanism (Figures, 2, 3, 6, 7 and 8). On the main driving shaft 14, which is rotated twice each time the crank is operated, there is provided for each place in the machine a setting wheel 15. This setting wheel possesses the shape of a disc which is rigidly mounted on the shaft 14 and in the lateral face of which there are formed nine slots adapted to accommodate dogs 16 for their part lodged close to the centre of the disc and capable of being oscillated in the axial direction, and provided with lateral projections 17. As shown to good advantage, particularly in Figures 2 and 8, these said dogs and projections are not uniformly distributed across the whole lateral face of the disc 15, but are disposed comparatively closely to each other so that they actually take up only a part of the entire circumference. The said dogs move within their slots under the action of friction, to which end a small spring (not shown) is preferably brought to bear against the side of each dog, with the result that these dogs are automatically retained in the position in which they have once been set.

The projections 17 forming a part of the dogs 16 are disposed at varying distances from the circumference, or from the centre of the disc, respectively, the said projections being so arranged that on each setting wheel beginning at the periphery thereof, they successively and with uniform distances gradually approach the centre of the axis. The setting of the dogs will be found to correspond to the spacing of the projection arranged on the multiplication-plates to be more fully described hereinafter. At the point where the dogs 16 are arranged on the setting wheels 15, each of the discs 15 is provided on its circumference with an opening 15^b.

Directly above these discs or setting wheels 15 there is arranged free to rotate on an axis 18 a numeral drum 19. These numeral drums, the number of which corresponds to that of the setting wheels, are provided along their circumference after the manner of a maltese cross with ten accurate openings 20 corresponding to the conformation of the periphery of the setting wheels 15. By means of these

openings 20 the numeral drums dispose themselves on the periphery of the setting wheels 15, so that they are secured against any independent rotation even when the setting wheel 15 is revolving. As a matter of fact, the rotation of the numeral drums 19 will only then take place when they have come within reach of the opening 15^b formed in each of the setting wheels 15. On its one face, each numeral drum is provided with a disc 21 containing nine radially disposed slots 22. These slots 22 are of various depths, the difference in depth existing among these slots again corresponding to the spacing of the projections of the multiplication-plates still to be described. Besides this, there are arranged on the face of the disc 21, ten teeth or studs 23 with which the dogs 16 of the setting wheels 15 are adapted to engage or else bear up against when such dogs are in their operative position. In addition there is provided a stationary return bar 44 (Figures 6 and 8) which, on the dogs 16 being in the said operative position, will serve to return them into the inoperative position after they have completed the arithmetical operation *i.e.* accomplished the displacement of the numeral drum(s) 19.

Under normal conditions, the dogs 16 are always rocked outward, that is, in the inoperative position. When in this position they are so disposed (see particularly Figure 6) that when the setting wheels 15 come to be turned they may freely travel past the discs 21 and the teeth or studs 23 fixed to the numeral drum 19 without in any way effecting the position of these members. These latter are for this reason normally secured in their position, primarily by the openings 20 engaging the periphery of the setting wheels 15, and this will likewise be the case when the openings 20 come to be disposed opposite the opening 15^b formed in the circumference of each of the setting wheels, because also in that contingency none of the teeth are able to enter into engagement with the teeth or studs 23 of the numeral drums 19, and because the said numeral drums are moreover, as already said, secured against any accidental displacement by means of small springs, not shown in the drawings. However, as soon as a set of dogs 16 has been rocked inward by means of a device to be described more in detail hereinafter then the said dogs 16 assume their operative position (see the upper portion of Figure 7) and enter into engagement with the teeth or studs 23 of the numeral drums 19 as the setting wheels continue to rotate, with the obvious result that the numeral drums 19 are fed forward by as many teeth as dogs 16 were rocked into the operative position. Directly this rotation has been effected by the numeral drums 19, which is now possible because in the course of this forward feed action the openings 20 have come to be disposed within reach of the openings 15^b of the setting wheels 15, the numeral drums 19 along with their openings 20 are arrested and secured or locked in their new position, and this by the unbroken section of the circumference of the setting wheels 15, which section has now entered into action again immediately to the rear of the dogs 16 : for, as stated in the preamble and as will be set forth more fully hereinafter, always the last of the series of dogs 16 are rocked into the operative position. This is a very important point for the reason that it prevents the dials from being jerked beyond their predetermined position, which in turn obviates the possibility of any errors being committed in computation.

The multiplication mechanism (Figures 2 to 5) will now be described. This mechanism substantially comprises two main parts namely, on the one hand, nine multiplication-plates 25 for each place in the machine and which are shifted sideways to and fro, once during each calculating operation, and, on the other hand, a slide 27, adapted to be shifted in the longitudinal direction, one always being provided for each place in the machine, and for its part adapted to be periodically coupled to the appropriate multiplication-plates.

All the multiplication-plates of all the nine places of the machine are arranged within a frame 24 disposed below the multiplicand keyboard, and in such a manner that each single plate may be freely shifted in the longitudinal direction of the machine. The spacing of the several sets of multiplication-plates corresponds to the spacing of the multiplicand keys. The said multiplication-plates 25 consist of flat metal strips, one such plate or strip being required for each multiplier 1—9 and for each place of the machine, so that always nine such plates belong to one place. These multiplication-plates are provided at their edges with projections or raised portions 26 (Figures

4 and 5). The raised portions, which are arranged on the one side of the plates, represent by virtue of the distance at which they are spaced apart the value of units, while the raised portions arranged on the opposite edge of the plates represent by reason again of the distance at which they are spaced apart the tens of the simple arithmetical products. Figure 4 illustrates, by way of example, a multiplication-plate for the multiplier " 1 " while the plate shown in Figure 5 represents the multiplier " 7." As will be observed, the plate for the multiplier " 1 " is provided with raised portions 26 only on its one side, because the highest figures contained in the product of any prime number multiplied by one will be the digit nine. On the other hand, the plate representing the product of the prime numbers multiplied by seven is provided with raised portions on either of its sides, those on the left hand and denoted 26^1 being arranged for the units of the products 7, 14, 21, 28, 35, 42, 49, 56 and 63, while the raised portions 26^{11} on the right hand represent the respective tens. The plates of each set are so lodged that each plate may be shifted in the longitudinal direction independently of the others.

Each set of multiplication-plates is surrounded by a slide 27, adapted to be moved in the longitudinal direction of the machine; from which fact it will be understood that there are arranged as many slides 27 as there are places and sets, respectively. These slides obtain their movement each from a compression spring 27^1 which constantly tends to move the respective slide 27 in the direction indicated by the arrow in Figure 2. The said slides are, however, prevented from carrying out such a movement by arms 28 which are provided one for each slide 27 and arranged on a common shaft 28^1 passing right through the machine in the transverse direction. These arms bear against a lateral abutment 29 of the slides. In addition, there is mounted on the shaft 28^1 an arm 30^1 which by a spring (not shown) is pressed against the periphery of a cam 30 arranged on the main driving shaft 14 (Figures 2 and 8). On the crank 9 being rotated the cam 30 begins to act on the arm 30^1 and, influenced by the compression spring 27^1 acting on the slide 27, causes the arm 28 to rock forward, while the shaft 28^1 effects a rocking movement. At the end of the stroke which is produced by spring pressure, the movement of the slide 27 comes to be reversed because under the action of the rotating cam 30 through arm 30^1 the shaft 28^1 is again rocked and brings arm 28 and the slide 27 back to their initial position. The slide is therefore shifted in a direction contrary to that indicated by the arrow in Figure 2.

As already stated, the slides are temporarily coupled to their respective multiplication-plates. This coupling action is effected by the intervention of lips 31. For this purpose all the slides 27 are bridged by a beam 32 provided with a lip 31 for each slide; said lips being each disposed in slots formed in the beam. The beam 32 is adapted to be raised by the multiplier keys 33 by intervention of a two-armed frame-shaped lever 35 oscillating about a pivot 34. After being released by the multiplier key, the said beam 32 returns into its position of rest under the influence of a spring 36.

The displacement of the two-armed lever 35 and hence the raising of the beam 32 along with the lips 31 attached thereto may vary, this depending upon the particular multiplier key which for the time being has been actuated. If, for example, the key representing the multiplier " 7 " comes to be depressed, then the beam 32 along with all the lips 31 will be raised for the space of seven units, the result being that the lips 31 will come to be disposed opposite the multiplication-plates corresponding to this particular multiplier " 7." Now, the normal position of the lips 31 is such that in the event of the slide 27 being displaced this latter will come to be moved to and fro below the multiplication-plates. However, should all the multiplication-plates in the different places of the machine and all the multiplier keys 33 happen to be in their position of rest, *i.e.*, not depressed, and should now the slides 27 come to be moved in the direction indicated by the arrow in Figure 2 then this will in no way effect the position of the multiplication-plates, since in that event, as already mentioned, the lips 31, which form the linking means, glide past below the multiplication-plates. If, on the other hand, one of the multiplier keys 33, say, the one for the multiplier " 3," comes to be depressed without, however, one of the multiplicand keys having been at the

same time operated, then, in the event of the slides 27 being now moved, all the multiplication-plates corresponding to multiplier " 3 " would be displaced, since by actuating the finger-key 33 for multiplier " 3 " the beam 32 and the lips 31 would be raised for the space of three units. But, on the other hand, even in this case all the slides and along with them all the respective multiplication-plates would be able to freely complete the stroke caused by the action of the cam 30 without the entire mechanism being in any other way affected thereby. But if, to assume a third possibility, besides the key 33 for the multiplier " 3," multiplicand keys have come to be depressed in addition in the different places of the machine, then on the slides 27 being now set in motion, the multiplication-plates for the multiplier " 3 " will primarily be taken along by means of the lips 31, still in that case those plates, located within reach of the multiplicand keys which happen to be depressed at this moment, will come to abut with their laterally raised portions or projections 26 against these very keys. For this reason the slides will, in such a contingency, be enabled to travel only across a definite path within the places in which multiplicand keys have been depressed, the greater or less extent of this path being in fact determined by the very character of these last-mentioned keys whereas all the remaining slides, *i.e.*, those in the places of the machine in which no multiplicand keys have come to be depressed, are free to complete their course as defined by the action of the cam 30. The multiplication-plates which have been shifted by the lips 31 are returned into their normal position by each slide 27 being provided in front with a perpendicularly disposed projection 27^{11}, adapted to position itself in front of the plates 25 so that, as the slides return into their initial position the multiplication-plates come to be likewise taken along by the intervention of the projections 27^{11}.

It has already been mentioned, that each calculating operation is divided into two phases determined in their nature by the to and fro motion of the crank 9. During these two phases, the frame 24, serving to accomodate all the multiplication-plates of all the places, is once shifted to and fro, *i.e.*, first to the right and then to the left. In order to bring about this lateral movement of the frame, the arm 10^1 operated by the crank 9 (of Figures 1 and 3) is provided with projections 37, 38 into which conically headed screws 39, 40 are screwed which serve to act as stops for the said projections, while the frame 24 of the multiplication-plates supports a slide member 41 disposed at an incline to the direction in which the said frame 24 moves. The result of this arrangement is that in the course of the to and fro motion executed by the crank 9 and owing to the fact that alternately the one and then again the other stop on the arm 10^1 will enter into contact with the slide member 41, this latter and with it the frame 24 will be laterally displaced. As will be quite obvious, this lateral displacement of the frame 24 will always be effected only when the crank 9 in the course of its motion comes to approach either the one or the other of its terminal positions.

At the commencement of the calculating operation, the crank 9 assumes the rearward position disclosed in Figure 2. At this moment the left hand sides of the multiplication-plates are within reach of their respective rows of keys (see Figure 3.) If now however shortly before the forward motion of the crank 9 comes to terminate, the frame 24 along with all the multiplication-plates be shifted sideways, and that to the right in consequence of the action exerted by the stops on the arm 10^1 on the slide member 41, then the right-hand sides of the multiplication-plates will come within reach of the preceding lower series of keys, and will remain there for so long until in the course of the return motion of the crank 9 and as it approaches its initial position, the slide member 41 and therewith the frame 24 are moved back into their initial position by the intervention of one of the said abutments or stops of arm 10^1. Thereupon, the multiplication-plates will, of course, be disposed with their left-hand sides within reach of the first appropriate row of keys.

The calculating operation is now performed by the slides 27 in full accordance with the multiplication-plates 25 set by aid of the multiplier keys 33 and of the setting wheels 15 hereinbefore described. To this particular end, the slides 27, which are so disposed as to pass sideways between the setting wheels, are provided on the one of their sides facing the said setting wheels, with two

slide members 42 and 42¹, of which the one, namely 42, is employed for adding and multiplying, and the other, namely 42¹, (the setting wheels now revolving in the opposite direction) for subtraction and division. The width of the said members 42, 42¹ corresponds to the total breadth of the part 17 of the dogs 16 of the tooth-setting wheels. The distance at which the two members 42, 42¹ are disposed the one from the other, on the other hand, corresponds to double the distance of the parts or points 17 from the centre of the shaft 14.

In the event of no multiplier key being depressed and the slide 27 being consequently enabled in accordance with the action of the cam 30 to carry out a full forward and backward stroke, then, regardless of the direction in which the shaft 14 or the tooth-setting wheels 15, respectively, happen to revolve, the slide members 42, 42¹ along with their appropriate slides 27 are primarily shifted for such a distance toward the left, as shown in Figure 2, as to prevent them from exerting any influence whatsoever upon the tooth-setting wheels, and this for the simple reason that in that case all the points 17 of the dogs 16 will be enabled to freely glide past the said slide members during the rotation of the setting-wheels 15. And moreover, as already stated, the dogs 16 are normally rocked out, *i.e.* in the inoperative position, therefore no transmission to the numeral drums 19 will be effected for the simple reason that no engagement of any kind whatsoever with these drums has taken place. If, on the other hand, some of the slides 27 are now suddenly arrested before completing their full stroke by one of the multiplier keys 33 and one of the multiplicand keys being depressed, then the slide members 42, are accordingly set in a certain particular manner which will permit contact with a definite number of points 17 of the dogs 16, and consequently the said dogs will be rocked inward into the position disclosed by the upper portion of Figure 7. These dogs when oscillated inward in the manner described will then come within reach of the studs or teeth 23 of the drums 19, thereby feeding the same forward for a corresponding space. The said dogs are subsequently rocked outward, that is returned into their inoperative position, in the well known manner by the return bar 44.

It will be understood, that the operation of rocking the points 17 and therewith the dogs 16 of the setting wheels 15 inward depends upon the position assumed for the time being by the slide member 42 or 42¹, respectively, and the position of these latter again depends, on the one hand, upon the depression of one of the multiplier keys 33 and, on the other hand, upon the depression of the multiplicand keys, in order to provide by means of these latter an abutment for the multiplication-plates.

A fact of essential importance in connection with the arrangement hereinbefore described is, as has already been said, that the direction in which the setting wheels are caused to rotate in dependency upon the particular arithmetical operation to be performed is selected in suchwise that always the last of the set of dogs 16 of the setting wheels 15 is acted upon by the slide member 42 or 42¹ respectively of the slides 27. Assuming, in connection with the position shown in Figures 2 and 8, that the setting wheels are rotating clockwise and are being acted upon, say for the purpose of performing a sum in addition, by the slide members 42, then it will be the dogs 16 the projections 17 of which are disposed at the greatest radial distance from the centre of the shaft, which will be acted upon by the said slide members 42. If, on the contrary, it be assumed that the setting wheels are moving counter-clockwise, and presuming further that for the purpose of carrying out, say, for instance, a sum in subtraction, the dogs 16 are being acted upon by the slide members 42¹, then those particular dogs will be influenced the projections 17 of which are disposed at the least radial distance from the centre of the shaft. This fact is of special importance for the reason that by these means, in combination with the provision of the openings 20 on the drums 19 and the peculiar formation of the periphery of the setting wheels 15, the drums will come to be locked directly they have been rotated the desired amount, and that hence any chance of excessive displacement of these drums, such as might arise in consequence of the quick speed at which the machine works, and which in the case of the hitherto known types of machines it was found possible to avoid only by the aid of means of a most intricate nature, is

entirely obviated. This, of course, at the same time excludes the possibility of the improved machine performing any wrong calculation.

The keyboard (Figures 9 to 13) will now be described: As will already have been noted, the keyboard consists of two different kinds of keys, the multiplier keys 33 and the multiplicand keys 46. The multiplier keys 33 (Figure 13) are arranged in a suitable number, for example, in machines having nine digits, there will be nine such keys disposed transversely to the machine, which when depressed are secured by means of a locking-bar 51 of the type generally used in the art. These multiplier keys are as regards their length so stepped or graduated that they are capable at one and the same stroke of raising the two-armed frame-shaped lever 35 and therewith the beam 32 along with the lips 31 to a greater or less extent in suchwise that in accordance with the particular multiplier key depressed, the lips 31 will come to be disposed opposite the corresponding multiplication-plates 25.

For each place in the machine there are arranged nine multiplicand keys 46. They are acted upon by a spring (shown in Figure 11) and provided with lateral projections 45. For the purpose of locking these multiplicand keys when depressed, there are arranged edgewise above the frame 24 for the multiplication-plates 25, a series of nine locking plates 48, being one for each key. The plates 48 for one and the same place are always arranged in juxtaposition (see Figures 10 and 11), each plate containing at the place provided for its own appropriate key, an oblique slot 47 into which the lateral projection 45 of the said key is adapted to project. The lower portion of the oblique slot 47 terminates in a notch 47^1 (Figure 9) in which the extension 45 comes to be locked. The result of this arrangement is that when a key is being depressed there takes place during this depression, and owing to the action of the lateral projection 45 moving within the oblique slot 47, a longitudinal displacement of the respective locking plate 48 until the said projection comes to a stop within the notch 47^1 so that thereby a key once depressed is now locked and thus prevented from rising again. Besides being provided with an oblique slot 47, each of the locking plates is in addition provided with a number of openings 50 for the remaining keys of the bank. These openings, which are of a substantially triangular form, are so disposed that the lateral projections 45 of the remaining keys of the same bank will likewise extend therethrough (Figure 11). The openings 50 are at the same time also provided with bevelled edges 50^1, though the inclination of these edges is oppositely disposed to that of the slots 47. The locking plates 48 are moreover provided with upwardly extending extensions 49 on the horizontal portion of which is indicated the figure of the respective key. As a result of the longitudinal displacement of a plate through the depression of a key, the extension 49 along with the figure denoted thereon is shifted within the area of a sight opening 49^1, so that by these means the figure represented by the key depressed is at once displayed, and that consequently the multiplicand depressed at the various places may be immediately read at a glance.

It will therefore be seen that when any particular key is depressed, say, the key for the multiplicand 9 (indicated by the numeral 46^a in Figures 9 and 12), the respective upwardly extending plate 48 will consequently be shifted by the projection 45 so far to the left as the extent of the slot 47 will permit. Directly, the figure 9 of the appropriate extension 49 will now become visible in the sight-opening 49^1. At the same time, as Figure 12 shows, the openings 50 belonging to this particular locking plate have altered their position relatively to the remaining keys of the place the result being that only one of the keys can be held in the depressed position. If now, however, another key be depressed, while the key 46^a is still in a depressed position, then owing to the action of the projection 45 of this second key on the inclined edge 50^1, the locking plate 48 of the key 46^a, which had been first depressed, will be again shifted to the right so that the projection 45 of this last-mentioned key will be released from the notch 47^1 and this key will consequently move upward under the influence exerted by its spring. This peculiar feature of the improved construction affords the advantage that only one key of a place may at one time be in a depressed state and that

furthermore the numerical value of the particular key which has been depressed for the time being is displayed by the extension 49 in the sight-opening 49[1], with the result that the entire multiplicand may be read at a single glance.

For the rest, the multiplicand keys extend below the plates 48 for such a distance that when they come to be depressed they will readily come within reach of the multiplication-plates 25, and may thus serve as an abutment for the laterally raised portions 26 of the plates 25 when these latter are to be displaced in the longitudinal direction by the slides 27, or by the lips 31, respectively.

An important advantage of the mechanism herein described is the fact that the slides 27 which are required for carrying out the calculation may also simultaneously serve to set a printing mechanism which latter does not belong to the invention. For this purpose the slides 27 may be provided on their rear ends with racks 77 which, as shown in Figure 15, are arranged on cranked bars or plates 78, so that the racks 77 of all the slides lie in close proximity to each other. These racks 77 are adapted to gear with lateral teeth or pins 76 provided on the type wheels 52, and these wheels are therefore correspondingly set when the slides 27 are moved longitudinally. The slides 27 are also provided with lateral lugs 82 and 85 (see Figures 2 and 14) which enable the numerical values, which have been set on the numeral drums 19 or on the quotient wheels 83, to be transmitted to the type wheels. In order to enable this operation to be carried out the numeral drums 19 are provided, as already mentioned, with lateral discs 21, which have incisions 22 in them of different depths, and the quotient wheels 83 also have similar lateral discs 84, which are provided with similar incisions of different depths. The numeral drums 19 with the discs 21 and also the quotient wheels 83 with the discs 84 are each arranged as shown in Figures 16 and 17 in a frame 74 which can be moved sideways in the corresponding casing against the action of springs 74[1] by means of a handle 75. Normally both the numeral drums 19 and also the quotient wheels 83 are so situated with respect to the slides 27 that when these latter are moved longitudinally the lugs 82, 85 do not come into contact with the discs 21, 84. If however the numeral drums 19 are moved sideways by means of the handle 75, the discs 21 on these drums move into the path of movement of the lugs 82. The longitudinal movement of each slide 27 can now only take place in accordance with the depth of the particular incision 22 opposite the lug thereon and consequently by this means the numerical value registered by the drums can, by means of the rack 77, be transmitted to the type wheels 52 and set there. In this way the result registered on the numeral drums 19 can be transmitted to the printing mechanism which may be of any desired construction.

The same effect can be secured if the quotient wheels 83 are so moved sideways by means of the corresponding handle 75 that the discs 84 provided with the incisions are brought in to the path of movement of the lugs 85 on the slides 27. By this means also the value registered on the quotient wheels will be transmitted by the slides 27 and the racks 77 to the type wheels 52. If the multiplier be transmitted to the quotient wheels 83 by means not belonging to this invention, the multiplier can be transmitted in this manner to the printing mechanism and printed off.

THE MANNER OF OPERATION.

To enable the manner of operation of the machine to be fully understood, let it be assumed that the number "764" is to be multiplied by "7." The multiplicand "764" is suitably set up by depressing the corresponding multiplicand keys 46 and the multiplier "7" by depressing the corresponding multiplier key 33. By the depression of the multiplier key the lips 31 (Figures 3 and 4) have been raised to such an extent that they will now be disposed opposite the multiplication-plates 25 corresponding to the multiplier "7." The multiplication-plates are now with their left-hand projections 26[1] (corresponding to the units of the partial product) within reach of the depressed multiplicand keys. Hereupon the crank 9 is operated. As it executes its motion, it rotates the main driving shaft 14, and therewith the setting wheels 15 and the cam 30. By means of arms 28, the said cam releases the slides 27 and the multiplication-plates 25 are taken along by them (these being obviously only those corre-

sponding to the multiplier " 7 ") until the same come to abut with their projections 26^1 against the depressed multiplicand keys. As a result the slide members 42 and 42^1, respectively, will now be so disposed that in the first set of keys, counting from the right and as the rotation of the setting wheels 15 progresses, there will have been rocked inward eight of the dogs 16, seeing that $7 \times 4 = 28$, hence eight units will have to be transmitted on to the respective numeral drum 19. In the second set of keys, the slide 27 is so disposed that, since $7 \times 6 = 42$, two of the said dogs 16 have to be rocked inward and that the second numeral drum will be so rotated as to indicate the figure " 2." In the third set as $7 \times 7 = 49$, nine of said dogs 16 will have to be rocked inward so that now the figure nine will be indicated by the third numeral drum. The sight openings will therefore now display the figure " 928." In the meanwhile, the crank 9 has completed its first stroke toward the left, and consequently the setting wheels 15 their first revolution. The frame 24 has been shifted to the right by the crank 9 shortly before the completion of the crank motion. As a result, the right hand projections 26 of the multiplication-plates 25 have now come within reach of the depressed multiplicand keys. If now the crank 9 be moved backward and as the setting wheels 15 commence their second revolution, the slides 27 again move for such a distance until their path from the depressed multiplicand keys comes to be barred by the " tens " projections 26^{11} on the multiplication plates 25. There therefore now takes place the transmission of the tens of the single products resulting from the multiplication of the sum " 764 " by " 7 " no transport taking place in the first set since there are now no more keys to the right of the first set of multiplication elements and consequently the slide members 42 and 42^1 of the slide 27 been entirely withdrawn out of reach of the dogs 16, so that the first numeral drum will remain set up to the figure 8. In the second set of keys, the second set of multiplication elements with its " tens " projections being now within reach of the first row of multiplicand keys, the figure " 2 " derived from the product of the multiplication of 7×4 namely 28, is transported on to the second numeral drum, and the figure " 4 " will be displayed in the second place. In the third place, as the third set of multiplication elements with its " tens " projections is disposed within reach of the second row of multiplicand keys, there will now be added to the figure " 9 " already contained on the third numeral drum, a " 4 " derived from the single product of $7 \times 6 = 42$. 4 plus 9 being 13, the third numeral drum will now display a " 3." The transfer of the ten on to the next-following higher place, *i.e.* on to the fourth numeral drum is hereupon effected by some well-known " tens " carrying device arranged in the totalising mechanism.

The fourth numeral drum will consequently now display the figure " 1." To the figure " 1 " there are now added (since the fourth set of multiplication elements with its " tens " projections is likewise within reach of the third row of multiplicand keys) the four tens resulting from the partial product of the multiplication of $7 \times 7 = 49$. The fourth numeral drum will therefore now display a " 5," the third a " 3," the second a " 4," and the first an " 8 " the total *i.e.* 5348 being equal to the product obtained when multiplying 764 by 7.

It is obvious that multiplications can be carried out by means of the above described mechanism in which the multiplier is a figure of several places. In this case it is necessary, after the calculation with the first multiplier has been completed, to move the entire counting mechanism one place towards the right the result of which is, calculating from the right, that the first numeral drum will be brought out of the path of the setting wheels 15 and will now no longer take any part in the calculation. This produces an operation which corresponds exactly with the method of calculation by hand in which the result of the calculation with the second multiplier is likewise shifted one place towards the left. Assuming that the multiplicand 764 already above mentioned is to be multiplied by the number 77 the operation will be best made clear if an example be given of the way in which, in the ordinary method of calculation by hand, the two separate results stand to each other namely

5348
5348

The result of the second calculating operation is now added by the machine to the result of the first calculating operating and the result is that in the extreme right hand numeral drum 19 the number " 8 " from the first calculating operation remains and is not altered. In the second numeral drum which indicated a " 4 " from the first calculating operation, an " 8 " will now be added on from the second calculating operation. There will accordingly appear upon this numeral drum a " 2 " while the tens place " 1 " will be carried on to the next numeral drum by a suitable tens transmitting mechanism. As there was a " 3 " here and as by the addition of the " 1 " from the second numeral drum a " 4 " now appears, this " 4 " will also be added on to the second calculating operation and an " 8 " will consequently appear. In the fourth numeral drum there will be added on to the " 5 " arising from the first calculation the " 3 " of the second calculating operation and an " 8 " appears accordingly; in the fifth numeral drum there is only the " 5 " from the second calculating operation which also appears in this form. After the calculation is completed the numeral drums 19 consequently show the desired product which is the number " 58828." It must however be mentioned that this method of multiplication with multipliers of several places by shifting totalising mechanism sideways one place has long been known and does not therefore belong to the subject matter of the invention.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is :—

1. Calculating machine with a variable number of teeth in the setting wheels and with multiplying devices which transmit the product by means of suitable projections indicating units and tens, characterised in that for each section of the machine underneath the multiplicand keys, there is arranged a group of nine multiplication plates, corresponding to the multipliers from 1 to 9, which multiplying plates by being moved laterally can be brought with their units and tens projections alternately into the path of their own or the preceding lower row of keys, and that each group of multiplying plates is surrounded by a slide, which is periodically coupled to the multiplying plates and which in its turn acts on the teeth of the setting wheels by which the numeral drums are set.

2. Calculating machine according to Claim 1, characterised by the fact that each slide to which the multiplying plates are coupled is adapted to transmit the unit or tens value to the teeth of its particular setting wheel, and for this purpose the slide carries two sliding surfaces adapted to correspond in length to the sum of the widths of lugs on said teeth and the distance between each other is so proportioned that when the slide is stationary and the setting wheels are rotated all the teeth therein are forced into the same operative position.

3. Calculating machine according to Claim 1, characterised in that a vertically adjustable tongue mounted upon each slide acts as a connecting or coupling member between the said slide and the multiplying plates, and that the adjustment of the height of which tongue is effected by multiplying keys according to the multiplier in use at the particular moment, the adjustment being effected in such a way that the slide is coupled by means of this tongue to that particular multiplying plate which corresponds to the particular multiplying key operated.

4. Calculating machine according to any of the preceding claims wherein the teeth of the setting wheels are provided with lateral projections or lugs which are so arranged that they approach from tooth to tooth the axial middle point of the setting wheels at equal distances.

5. Calculating machine according to any of the preceding claims and wherein the numeral drums are provided with recesses resembling a maltese cross by which they periodically engage the periphery of the setting wheels, characterised in that the recess provided for the setting of the numeral drums in the well known way, is so situated on the periphery of the setting wheels and is of such dimensions that it closes with two outer teeth of the setting wheels for the purpose of immediately producing the engagement of the setting wheels with the periphery thereof after the numeral drums have been rotated by the setting wheels, thereby preventing any overrunning of the numeral drums.

6. Calculating machine according to Claim 4, characterised by the fact that the direction of approach of the said lugs to the axial point is so selected in proportion to the direction of rotation of the setting wheels for the calculation desired at the moment, that at each calculating operation the last teeth of the setting wheels are brought into the operative position by the sliding faces of the said slide for the purpose of rendering any over-running of the numeral drums, and therefore any wrong calculation impossible, by the simultaneous locking of the numeral drums which acts on the setting of these latter.

7. Calculating machine according to Claim 1 characterised by the fact that it is operated by a pin or a roller which is so positively guided in a fixed recess, by means of an adjustable lozenge-shaped tongue, that a gear wheel driven by the said pin is set in two definitely separated half revolutions by the to and fro movement of a hand crank.

8. Calculating machine according to any of the preceding claims characterised by the fact that each multiplicand key is guided by a lateral lug in an inclined slot of a locking plate set up on its edge and a recess adjoining the slot is adapted to hold fast the depressed key, while in order to permit depression of only one key in any section, each plate has, at the points for the remaining keys, recesses having oblique edges oppositely disposed to the said inclined slot.

9. Calculating machine according to Claim 8, wherein each of the locking plates for the multiplicand keys is provided with a projection having a number corresponding to the corresponding multiplicand key, the arrangement being such that when the corresponding locking plate is moved in a longitudinal direction, the said number appears at a window and thereby renders visible the multiplicands depressed at the various points of the machine.

10. Calculating machine according to Claim 1, characterised by the fact that the multiplying plates of all sections are enclosed by a common frame which is provided with an inclined face which lies in the path of the movement of two stops attached to a hand crank in such a way that when the hand crank is moved forward and backward the said frame with all the multiplying plates is moved transversely to and fro the arrangement being such that the multiplying plates with their lateral raised portions are brought firstly under the influence of the depressed multiplicand keys at the one point and secondly into the path of the multiplicand keys of the next lower point.

11. Calculating machine according to any of the preceding claims characterised by the fact that the slides which surround the multiplying plates are provided, in addition to a rack for the setting of the type wheels, with two lugs which, after the sideway adjustment of the numeral wheels or the quotient wheels which are provided with deep incisions corresponding to the particular numerical value, can be brought into engagement therewith in such a way that according to the numerical values set on the numeral wheels or the quotient wheels the slides are set in such a manner that a transmission of the sum or quotient to the printing mechanism can be effected.

Dated this 11th day of September, 1920.

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55, Liberty Street, New York, N.Y., U.S.A.,
Agents for the Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1922.

FIG.1.

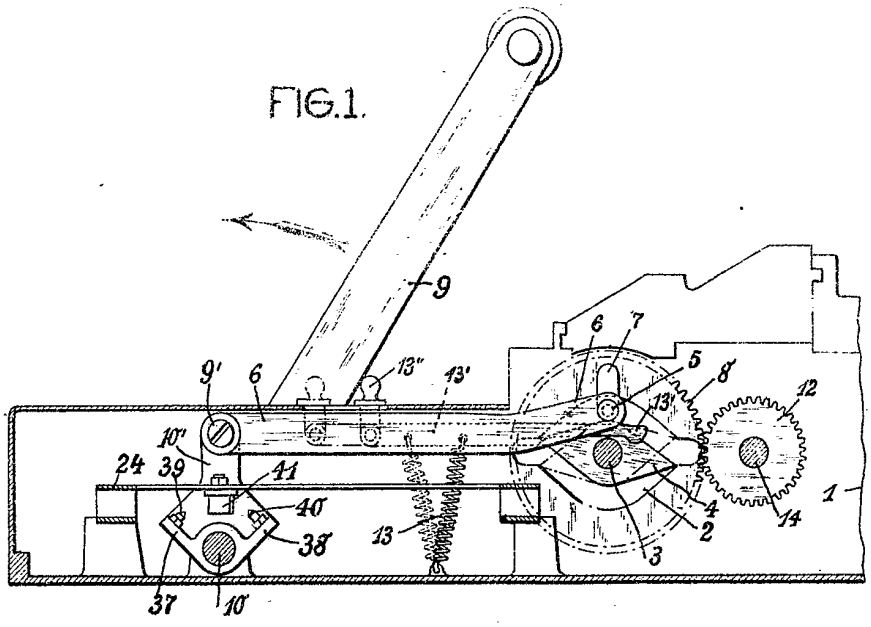

FIG.4.

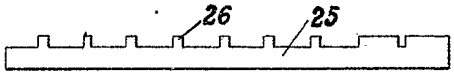

FIG.5.

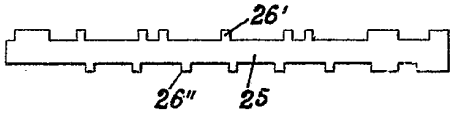

FIG.6.

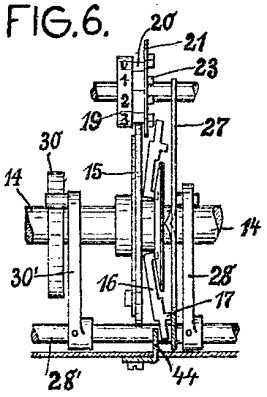

FIG.7.

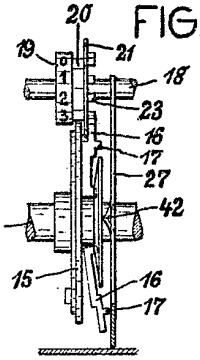

FIG.8.

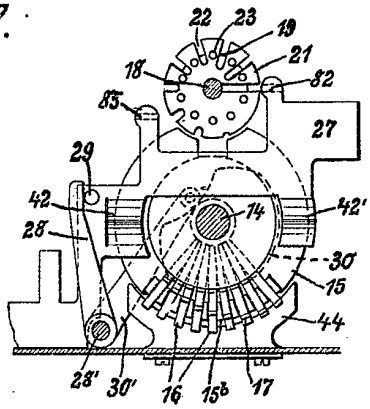

FIG. 2.

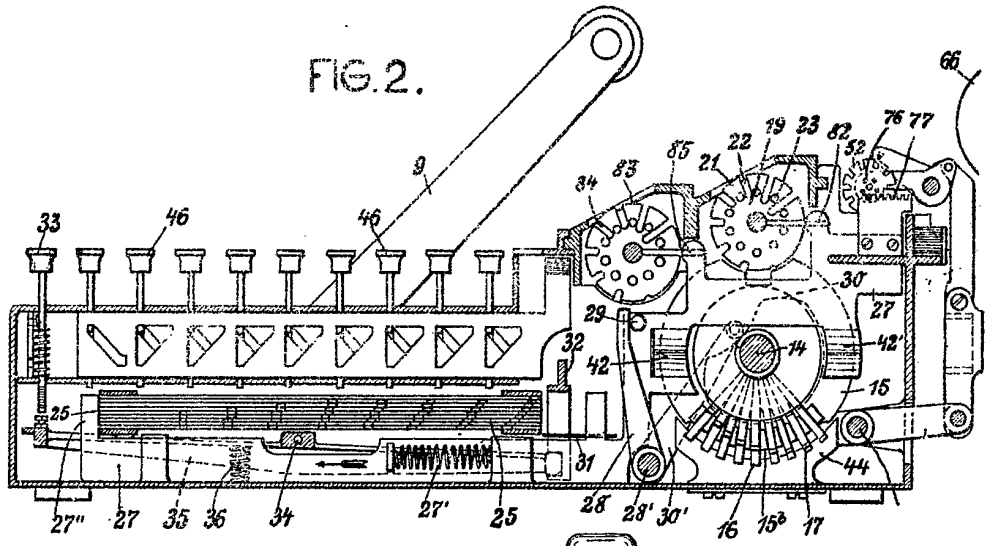

FIG. 3.

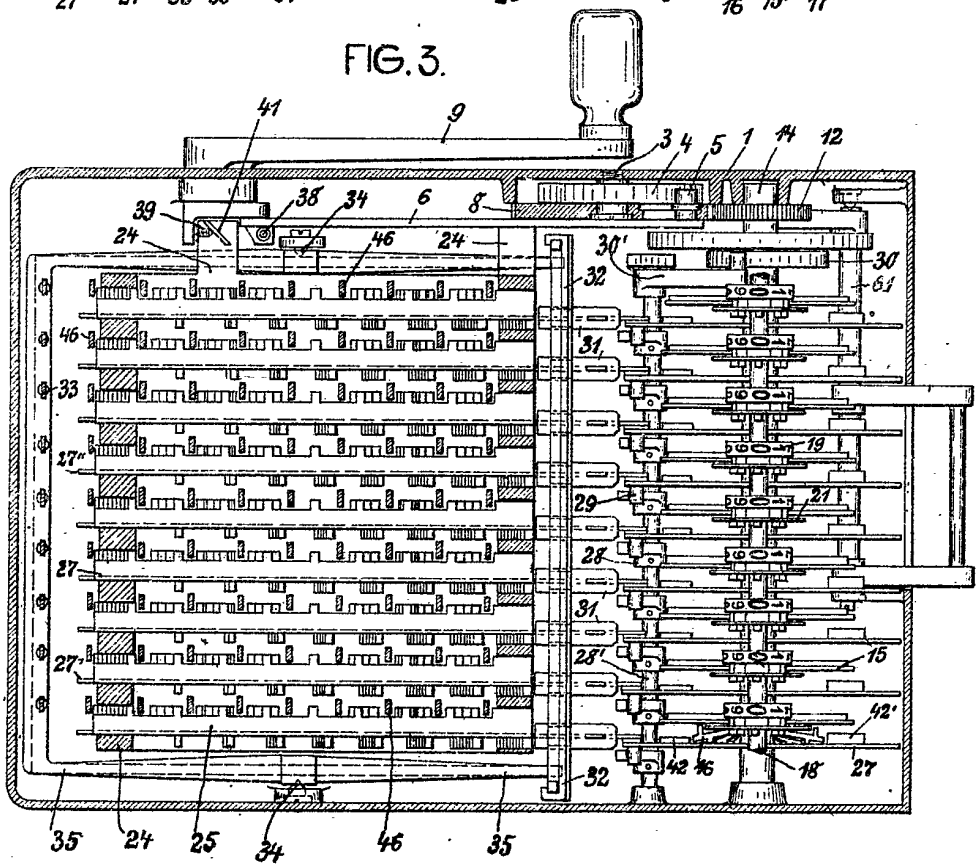

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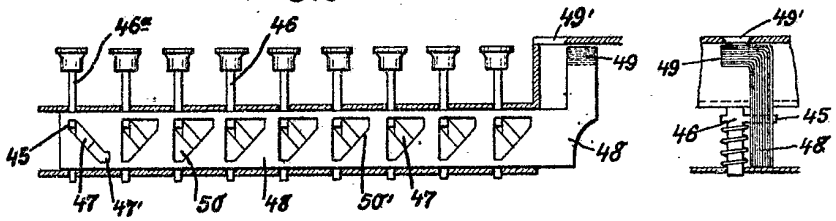
FIG.9.



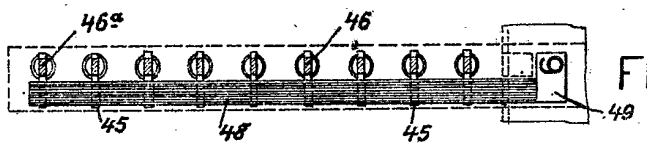


FIG.10.

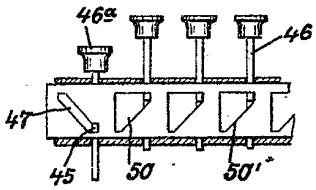


FIG.12.

FIG.17.

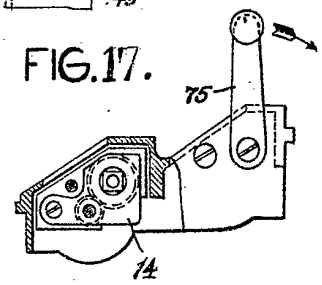


FIG.13.

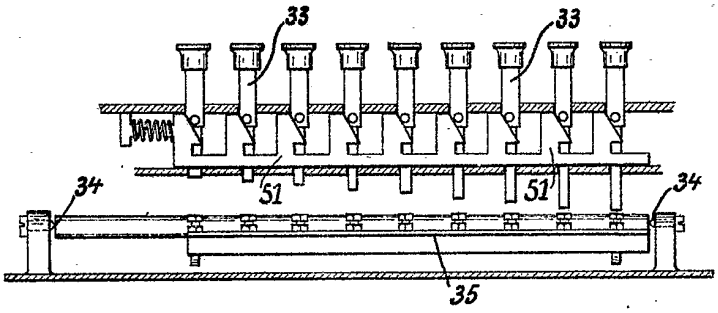


FIG.16.

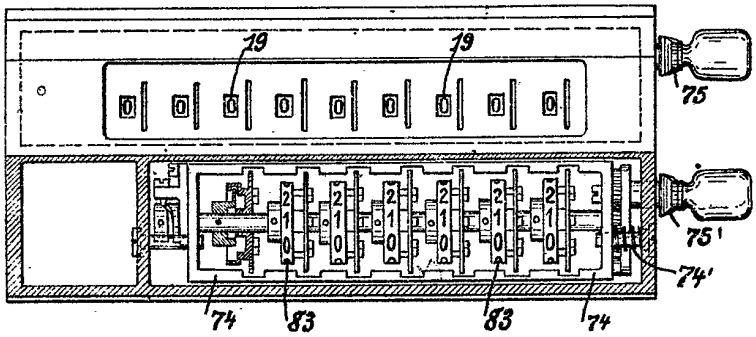


FIG. 14.

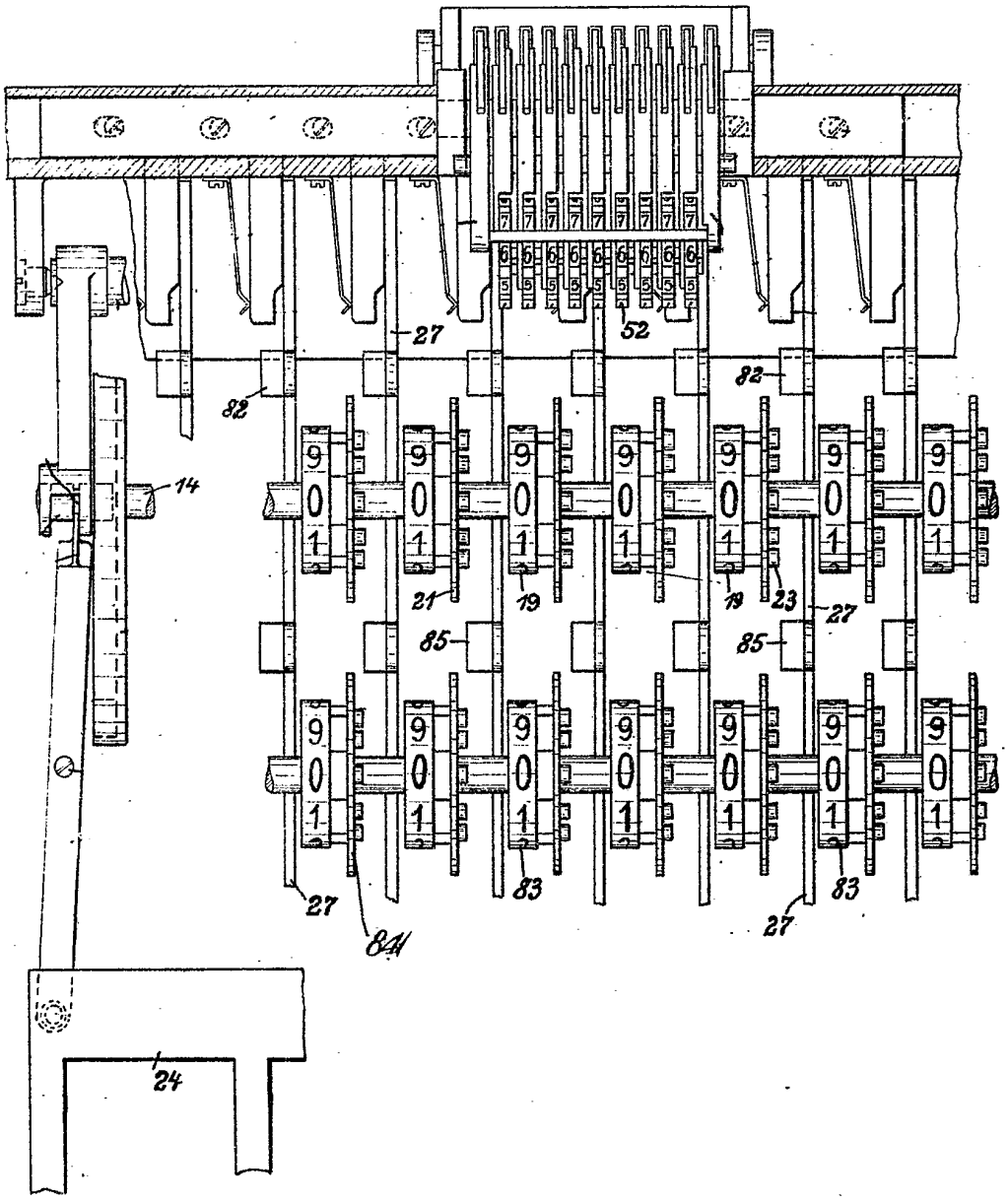


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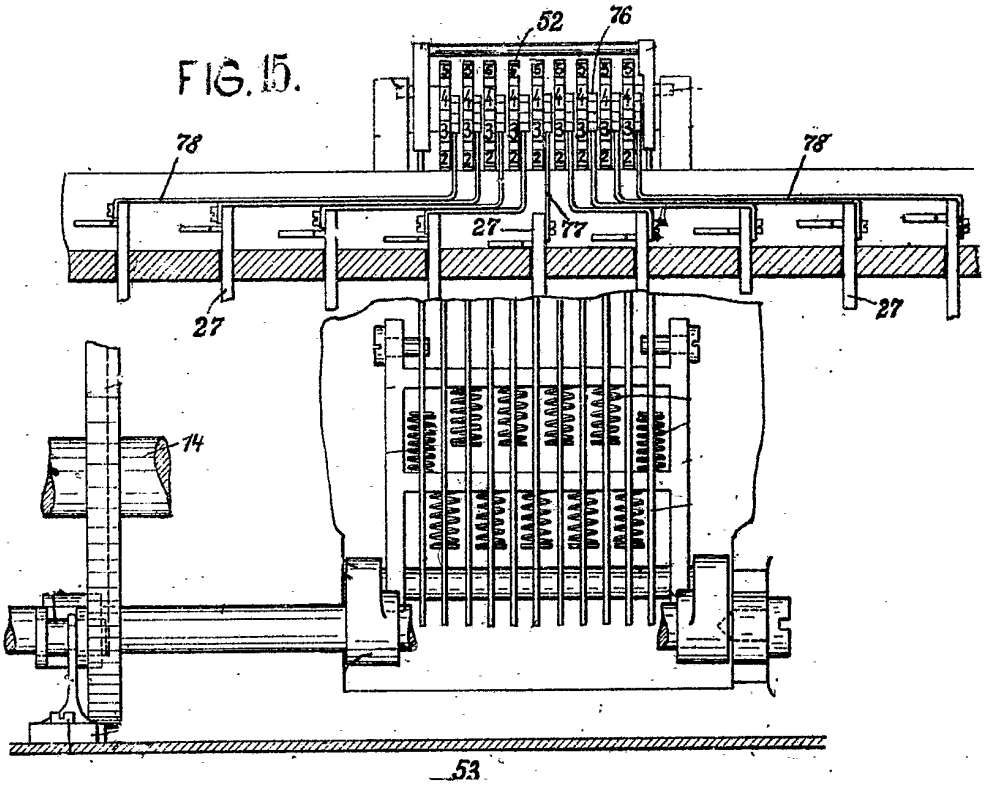
FIG. 15.



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