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MAY 25, 1943.
BY A. P. C.

F. PAPPÉ
CALCULATING MACHINE
Filed Feb. 1, 1940

Serial No.
316,824
11 Sheets-Sheet 1

Fig. 1

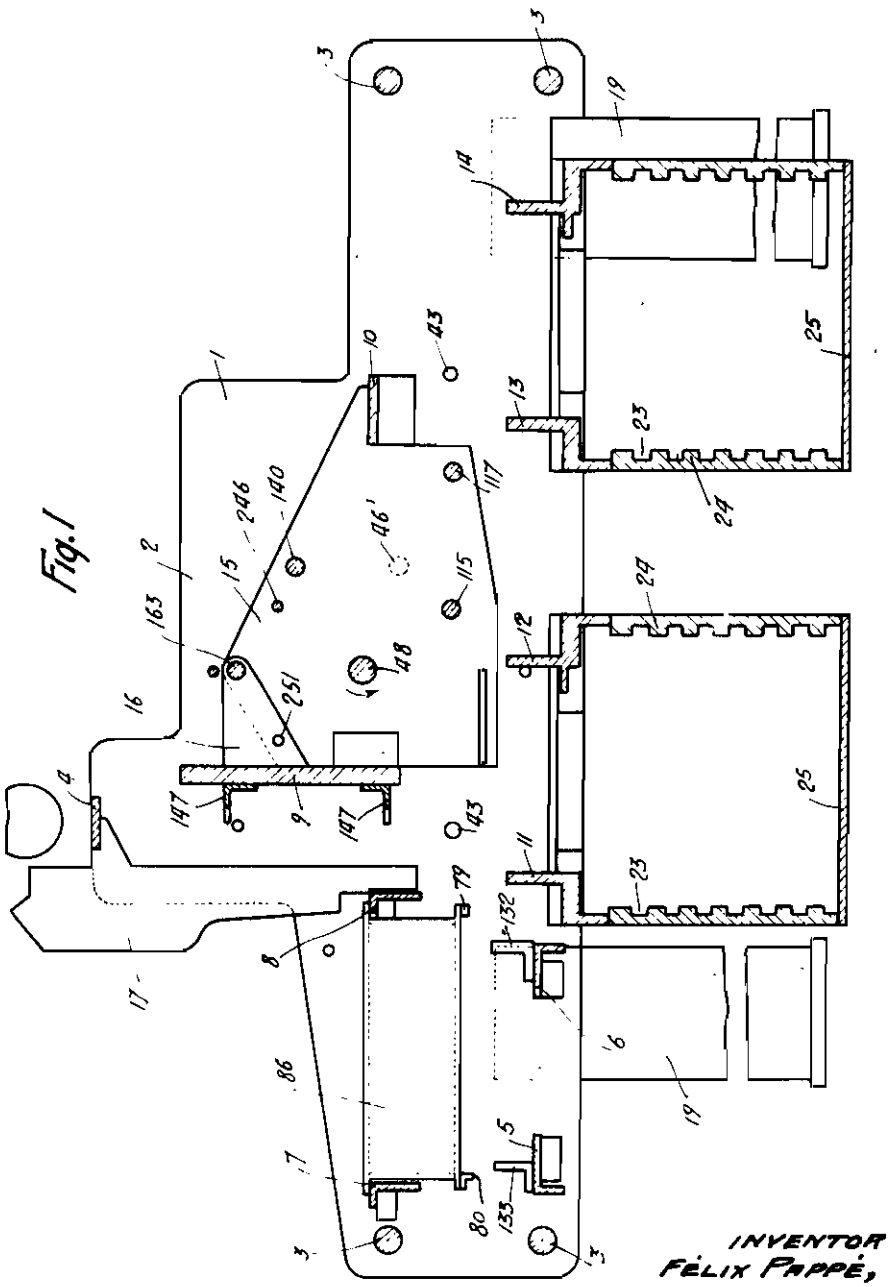

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Fig. 2

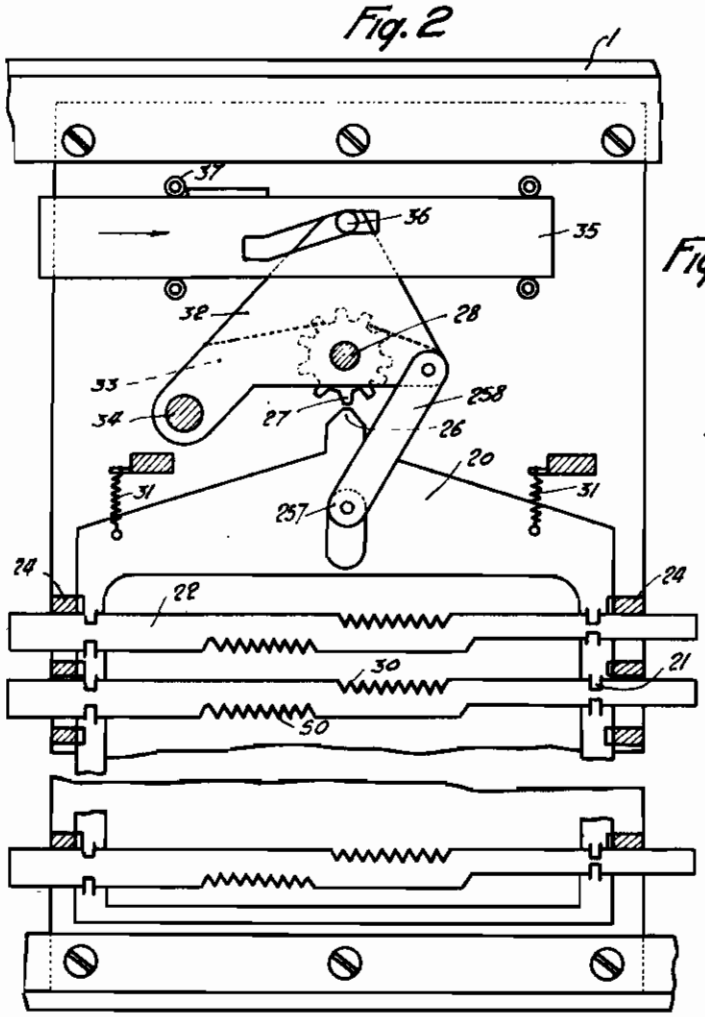

Fig. 4

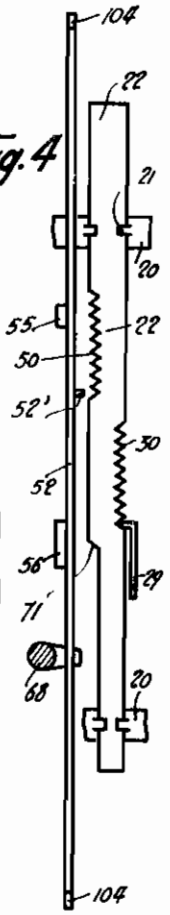

Fig. 3

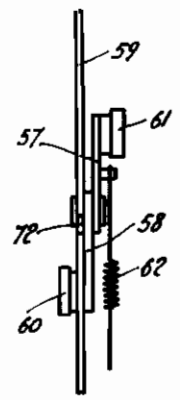

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Fig. 5

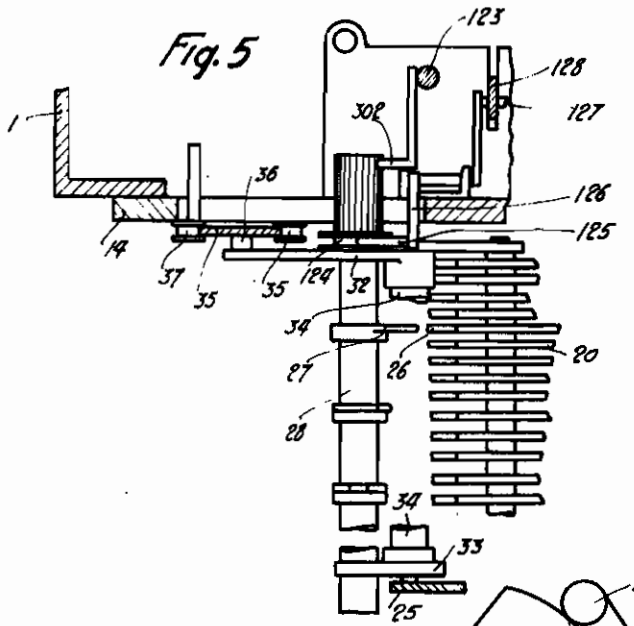

Fig. 6

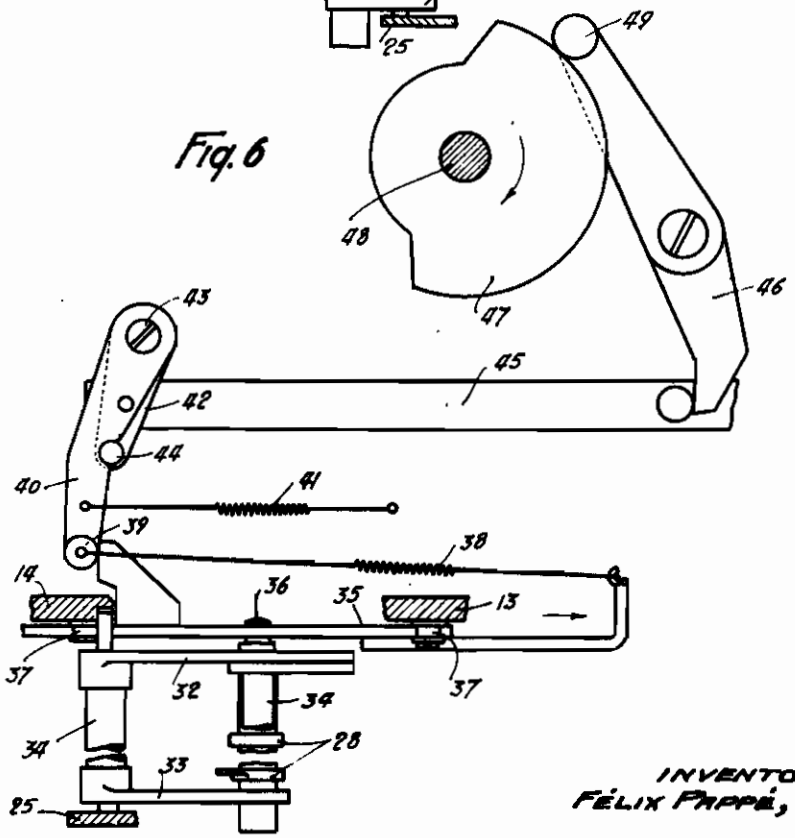

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Fig. 7.

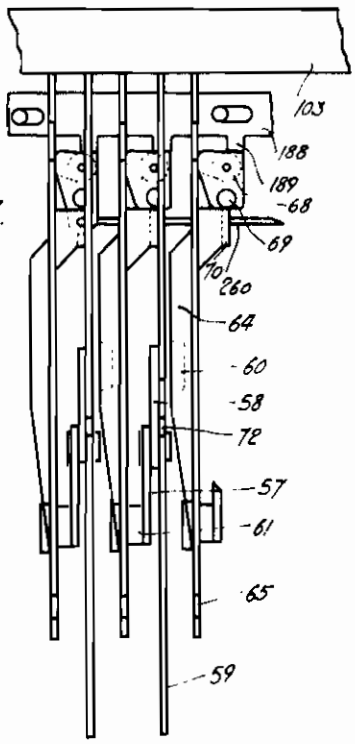


Fig. 11

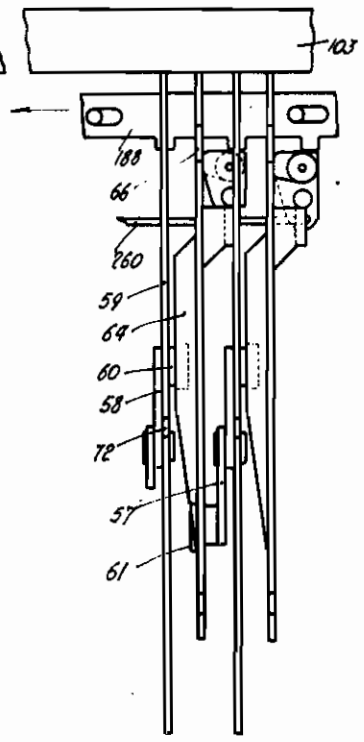
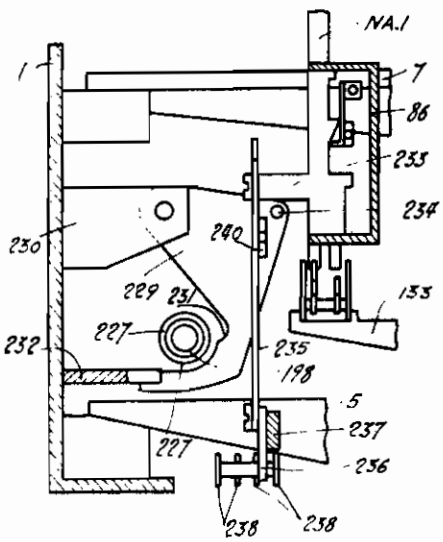
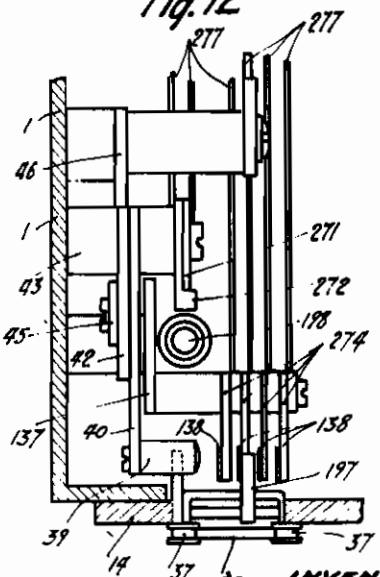


Fig. 12





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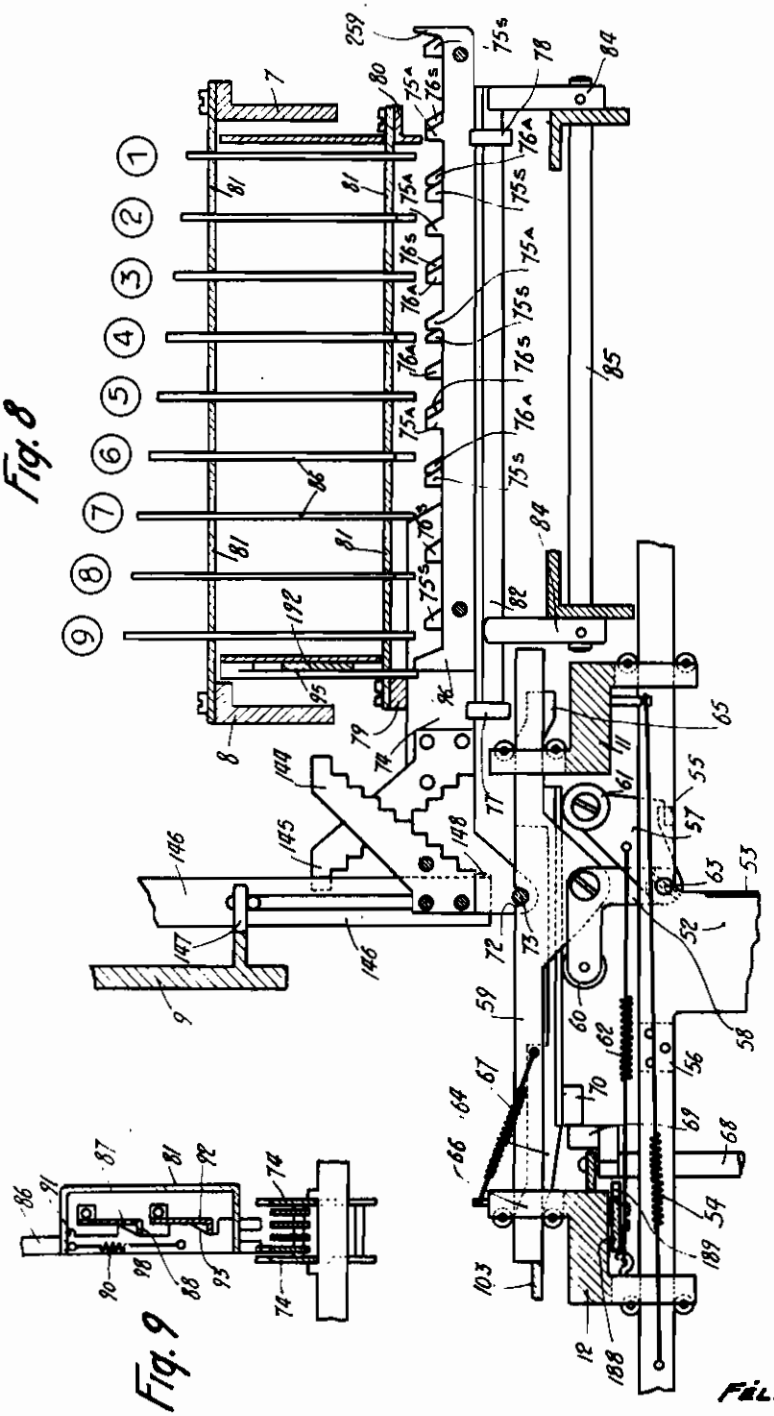

Fig. 8

Fig. 9

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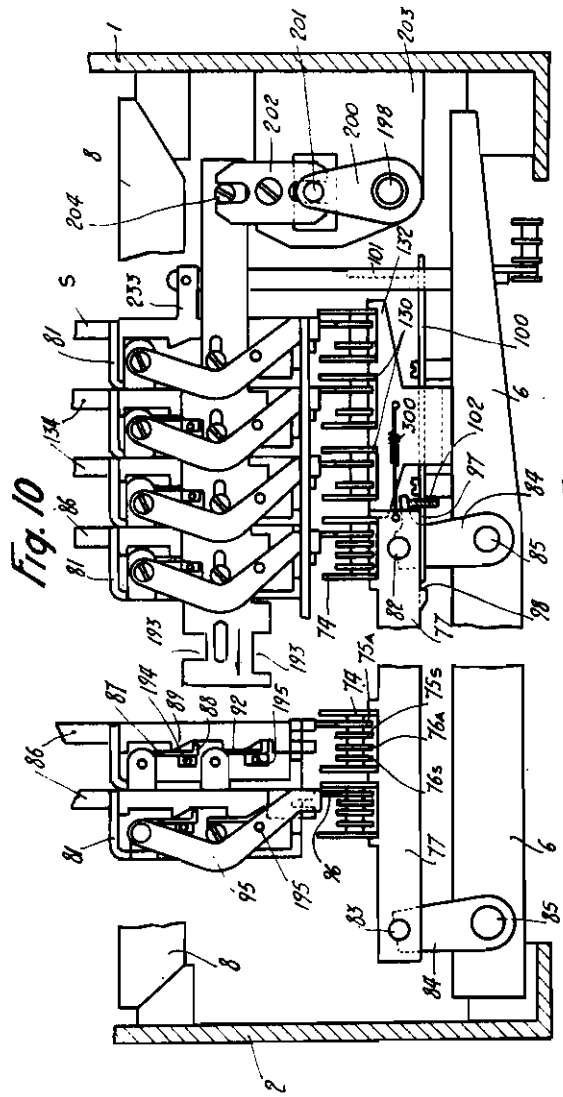

Fig. 10

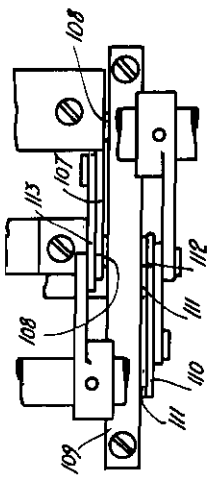

Fig. 14

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Fig. 13

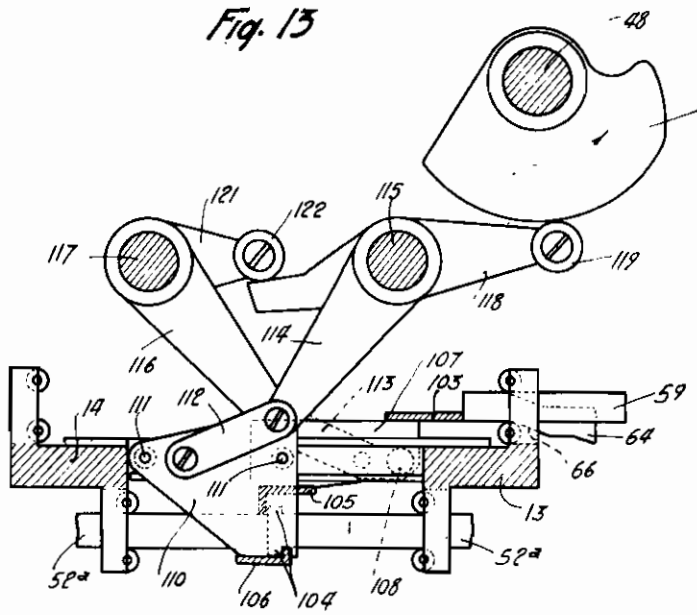

Fig. 15

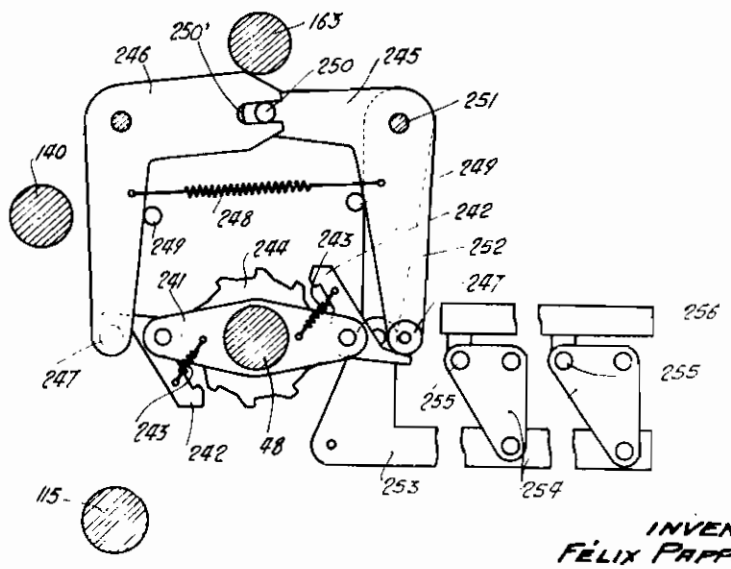

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Fig. 18

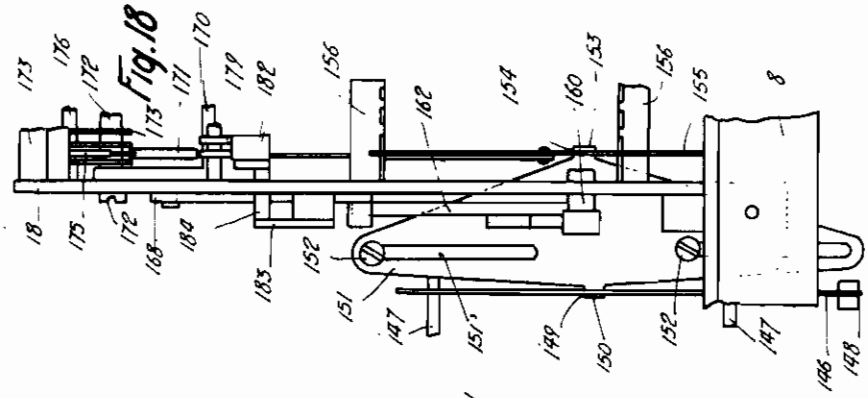

Fig. 16

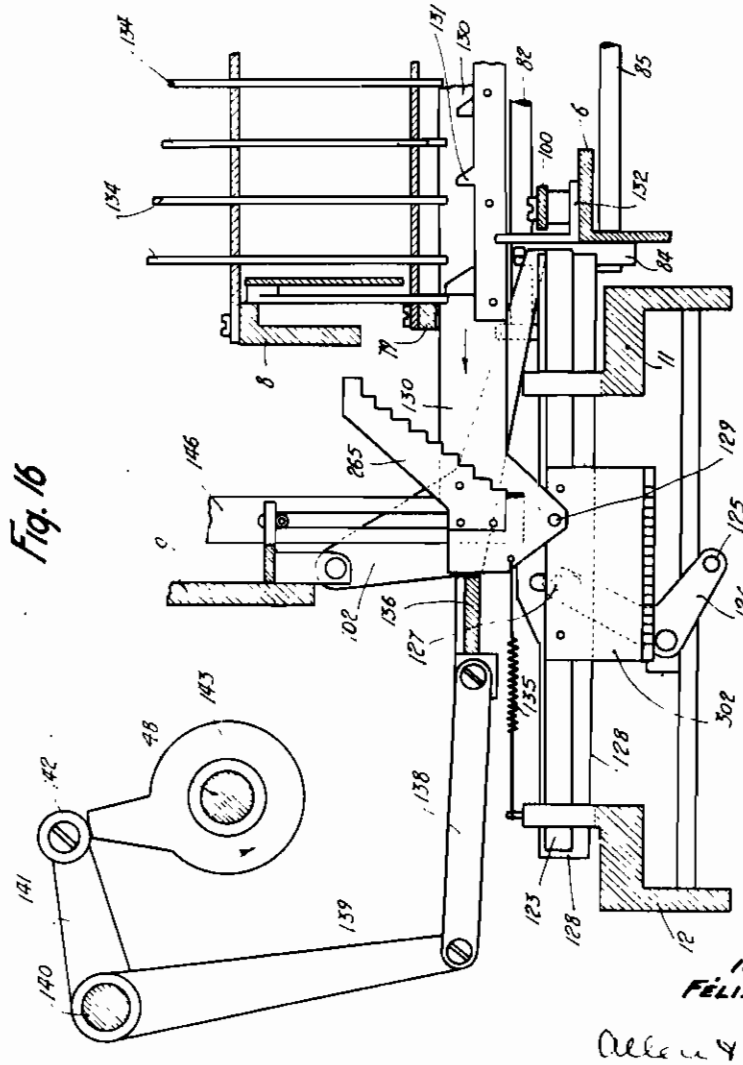

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Fig. 17

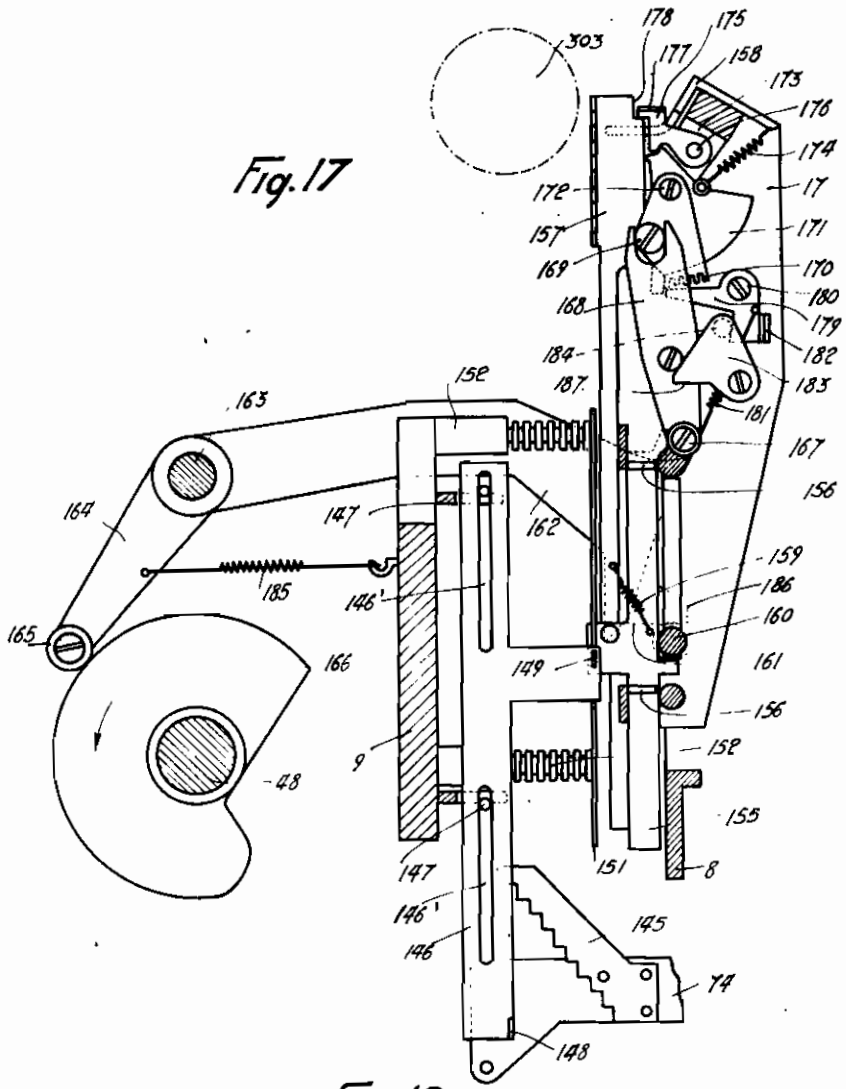

Fig. 19

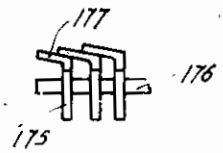

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Fig. 20

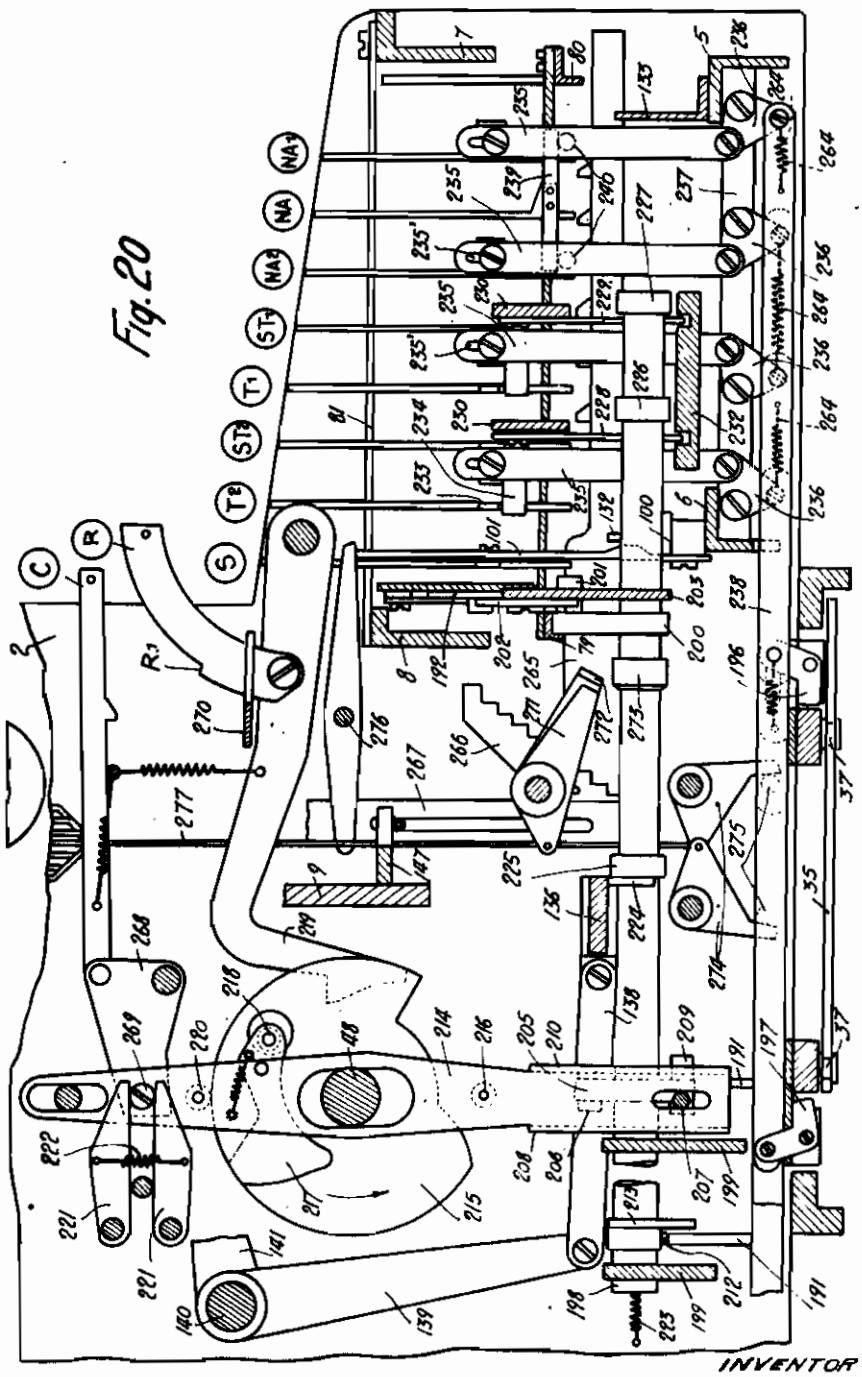

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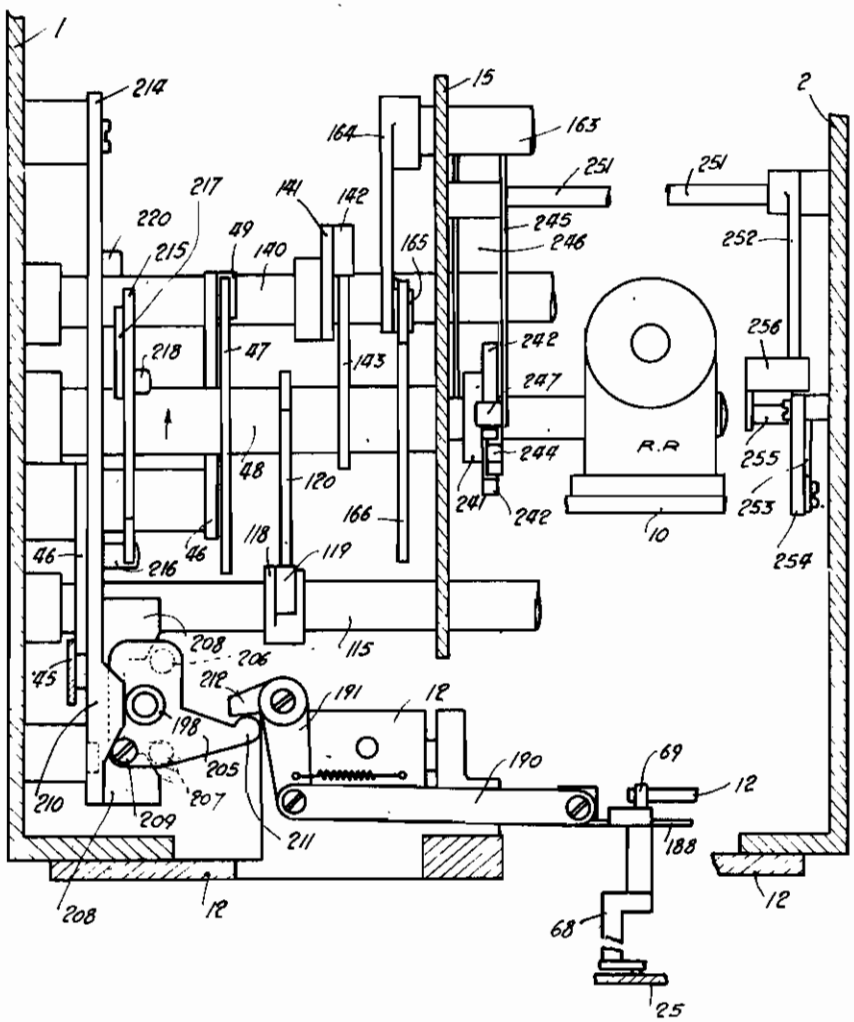
Fig. 21



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Published May 25, 1943

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ALIEN PROPERTY CUSTODIAN

CALCULATING MACHINE

Félix Pappé, Paris, France; vested in the Alien Property Custodian

Application filed February 1, 1940

Accountancy and statistics necessitate machines capable of recording and grouping payments under numerous headings and/or in different accounts. Adding machines now in use occupy much too much space to make them suitable for practical purposes. Recording machines are also known which have the disadvantage of necessitating the employment of additional calculating machines into which the payments recorded have to be transferred for the purpose of such further operations as might be necessary. Statistical machines are likewise known which are designed on the principle of perforated cards, but require numerous previous mechanical operations before they can give results that are finally utilisable. Moreover, their cost price and their high selling price brings them within the reach of large concerns only.

This invention relates to a calculating machine of simple construction which is capable of algebraically adding various elements in different accounts. These different elements may be grouped in several sections of the machine in such manner as to be grouped, if necessary, under different or similar headings belonging to the same section or to different sections of the machine. The principle of the calculating machine, according to this invention, is based on the use of calculating tables (abacus) well known in arithmetical problems. It is known that in such tables a certain number of calculating elements (ten, for instance, when operations are made according to the decimal system) are grouped in rows, the number of such rows being proportional to the number of the "categories or ranks of numeration", which it is intended should come in the calculations. In these known devices the calculation elements are displaced by hand in a number equal to the number corresponding to the data of the problem. So soon as a row of elements is entirely displaced, it is brought back to its initial position and an element of the immediately higher row is brought forward. These arrangements are obviously too cumbersome to be used in practice in statistical and accountacy calculations.

According to this invention a calculating machine has been evolved which comprises calculating tables, said machine being characterised by calculation elements, transfer elements and printing elements to record corrections, and particularly by the following features taken together or separately:

(1) Mechanical means effecting automatically and simultaneously, with the aid of an electric or other motor, all the forward and backward movements of all the calculation elements contained in all the rows of a calculating table;

(2) Mechanical means ensuring the co-ordination or combination of any kind of several calculating tables in several sections of the machine;

Mechanical means serving to operate the algebraical addition of the quantities represented by calculating tables in another calculating table set in another section of the machine;

(3) Mechanical means serving to record or print on sheets or strips of paper the data of the problems, the results and the transfers made from one section of the machine to another.

Each calculating table represents an "account" or "item". The calculating tables are horizontally superimposed in the frame of the machine. The calculation elements of each row in each calculating table are represented by pegs provided in rods or reglets, the number of such pegs being equal to the basis (less one) of numeration adopted (9 for the decimal system, 11 and 19 for the system based on pence and shillings etc.).

The reglets are normally stationary in the frame of the calculating table but, by means of fingers, each calculating table can be slightly displaced and cause the unlocking and functioning of the reglets, that is to say, of the calculation elements. This operation results in forward and backward movements, in the longitudinal direction of said reglets. Each calculating table comprises a reglet for each category of numeration.

The forward and backward movements of the reglets are controlled by square members, the vertical edges of which can engage the pegs of the reglets when the latter are unlocked. There is one square member for each category of numeration. If it is desired, for instance, to calculate up to a maximum 1999 (in the decimal system) three square members are necessary.

The horizontal edges of the square members slide on guides fixed on the frame of the machine.

The square members are horizontally influenced by retracting springs in the direction of the recession of the reglets, but they may nevertheless be drawn in the forward direction against the action of the retracting springs by means of operating bars with which they are engaged.

The operating bars are guided in the frame of the machine; they slide horizontally and parallel with the horizontal edges of the square members. These bars are, in their turn, operated by operating springs of greater power than the

power of the retracting springs of the square members and they are brought back to their starting position by a strap operated by hand or by a motor of any kind.

The movement of the operating bars is limited by stop bars which are themselves stopped by the rods of a key-board bearing the figures or signed for marking so that the movement of the operating bars is limited in accordance with the inscriptions marked on the key-board.

The stop bars are always in engagement with the operating bars; they therefore go forward and backward simultaneously and longitudinally to the same extent. They can also move transversely without departing from their parallelism with the operating bars. The stop bars are guided and slide on guides fixed in the frame of the machine.

The stop bars comprise two rows of stops (one for adding and the other for subtracting) arranged in such a manner that the length of the forward movement allowed by a subtraction stop is equal to the completion at 9 (decimal system) of the forward length allowed by the corresponding addition stop.

The engagement of the square members and the operating bars is produced by a system of rods comprising the following essential mechanical elements: an operating lever, a hooking pawl, an operating stop for carrying forward and a releasing pawl.

The operating lever is fixed by a pivot on the operating bar. Said lever comprises two perpendicular arms of equal length. One of said arms occupies normally a horizontal position and carries a roller which rolls on the carrying forward guide corresponding to the preceding category of numeration immediately below.

The hooking pawl is pivoted on the vertical arm of the operating lever and carries a roller which rolls on the carrying forward guide corresponding to its numeration category, whilst pressing from underneath. The operating spring is hooked at a point of the pawl between its point of rotation and that of the roller. The hooking pawl comprises a nose which engages the square member in order to operate it in the forward movement of the operating bar.

The operating stop is fixed on the square member and located in such manner that, if the hooking pawl releases the square member with which it becomes engaged, the square member operated by its spring is struck by its operating stop, gliding first along a distance equal to the length to which are added as many calculation elements as there are units in the system of numeration adopted as, for instance, 10 in the decimal system, 20 for the shillings, 12 for the pence, and so forth.

The carrying forward bar is guided in such a manner in the frame of the machine that it is capable of moving upwards along a determined distance, whilst remaining parallel to itself, that is to say, that it can go up to its stop without ever losing its horizontal position.

The carrying forward bar is maintained in its normal position by a releasing pawl. So long as the carrying forward bar is maintained in its normal position, it will maintain also in their normal position in height the operating levers and the hooking pawl, whatever may be the position of these elements.

On the other hand, so soon as the carrying forward bar is released by the releasing pawl, it can rise parallel to itself and the horizontal arm of the operating lever rises likewise. Due to this movement, the vertical arm progresses to the same extent. The position of the stop, in order to limit the upward movement of the carrying forward bar, is such that the forward movement of the vertical arm of the operating lever relatively to the operating bar shall be equal to a calculation element.

The releasing pawl consists of a shaft eccentrically pivoted in the vertical direction in the frame of the machine and located in such a manner that, when one reglet has moved a distance exceeding the added length of all its calculation elements, that is, the length reduced by the length of an element, such reglet strikes against the shaft which, owing to its eccentricity, then rotates sufficiently to disengage the carrying forward bar.

Each section of the machine comprises a transfer bar.

The transfer bars are guided in the frame of the machine in such a manner as to be capable of performing a longitudinal movement. They are located in such a manner that, when such movement has been imparted to them, they block all the releasing pawls corresponding to the section of the machine to which they belong.

When the pawls are blocked, the carrying forward bar cannot become disengaged, even if the reglets reach their extreme forward position and, consequently, the hooking pawl maintains the engagement between the operation bar and the square member, and the latter with the corresponding reglet will not be subjected to any backward movement.

The controlling device which causes the movement of the transfer bar unblocks the key-board so that no stop bar can be stopped by the key-board. The stop bars, and together with them the operating bars, stop only when the reglet which is engaged with the square member strikes against the releasing shaft, that is to say when they reach their extreme forward position.

The operating bars are sufficiently long to be able to engage several square members by means of a hooking device similar to that above described. The vertical edges of these square members can engage the calculation elements of other calculating tables co-ordinated in the other sections of the machine. The forward movements of the operating bars cause forward or backward movements in these square members always in function of the position of the calculation elements with which they are engaged.

As the operating bars advance a distance equal to the displacement of the unlocked reglets and rows in the calculating table of the section, the releasing shafts of which have been blocked, the accumulated or recorded amounts in this calculating table are transferred to the calculation elements of the unlocked calculation table of the other sections of the machine, the releasing shafts of which have not been blocked.

The printing elements consist, for instance, of sectors mounted on the frame of the machine in such a manner as to be capable of sliding vertically, that is to say, perpendicularly to the movement of the stop bars. They are drawn upwards by springs and they are brought back to their extreme lower position by a strap. A printing sector is associated with each stop bar.

Each stop bar comprises two printing ramps of such form that, at each forward position of the stop bar, said ramps present two lower edges at two different heights for each forward position.

These ramps are cut out in such a manner that, in the intersection plane with the corresponding printing sector, the sum of the heights or levels of the two lower edges starting from the extreme height of the ramp is always proportional to the basis of numeration adopted.

A printing sector slides between these two ramps. The printing sectors comprise two hooks which can become hooked alternately to one or the other edge of the ramp according to the lateral position of the corresponding stop bar.

When the printing strap rises and permits the printing sectors drawn by their printing spring to rise, the printing sectors stop at a height corresponding to the forward position of the stop bars, inasmuch as they are hooked by one or the other of the printing ramps.

Each printing sector forms an integral part of a bar of printing characters the spacing of which corresponds to the rise of the printing ramps so as to present before the printing line of a printing element (a cylinder for instance) the character corresponding to the representative figure of the forward position of the stop bar.

It has been observed above that this forward position corresponds to the case where the releasing shafts are not blocked. On the other hand, when the releasing shafts are blocked, this forward position corresponds to the position of the calculation elements formed in a row and the unlocked calculating table, that is to say, to the results of the accumulation due to the previous calculation operations.

The accompanying drawings show, by way of non-limitative example, the embodiment of a calculating machine according to the invention. This machine comprises two sections and is designed to operate according to the decimal system.

In the drawings:

Figure 1 is a longitudinal section in elevation of the frame of the machine.

Figure 2 is a plan view of a section showing a calculating table, the frames of the structure being supposed removed.

Figure 3 represents a plan view of an operating bar.

Figure 4 represents a plan view of the coupling of a section of calculating elements.

Figure 5 is an elevation of the coupling mechanism.

Figure 6 represents the operating elements of the coupling mechanism.

Figure 7 is a plan view of the calculating elements.

Figure 8 is a lateral view of the calculating mechanism and of the key-board, the left-hand side wall being supposed to be removed.

Figure 9 is a section of an element of the key-board shown in Figure 8.

Figure 10 represents the locking device of the key-board.

Figure 11 is an elevation of the controlling mechanism.

Figure 12 represents the controlling rods of the carrier.

Figure 13 shows the mechanism of the straps.

Figure 14 shows a plan of a part of Figure 13.

Figure 15 affords a side view of the disengaging members.

Figure 16 is a side elevation of the engaging members and of the keys controlling them.

Figure 17 shows a side view of the printing device, the left-hand side being removed.

Figure 18 is a partial elevation of the device shown in Figure 17.

Figure 19 shows the detail of connection for the hammer pawls.

Figure 20 is a side elevation of the controlling members, the left side plate being removed.

Figure 21 is an elevation showing the general arrangement of the carrying cams.

As shown in the drawings, the machine in accordance with the present invention has two sides, i. e. a right side 1 and a left side 2 (the latter is not shown) joined by cross pieces 3, a carriage bar 4, two stop bars 5 and 6, two key rods 7 and 8, one quadrant bar 9, one motor member 10, two counting frames 11, 12 and 13, 14 respectively.

Arranged between the bars 9 and 10 are a cam plate 15 and a printing plate 16, whilst mounted between the bars 4 and 8 are two printing plates 17 and 18.

The machine rests on four legs 19 fixed to the side plates 1 and 2.

The various calculating tables consist of a frame 20 (see Figures 2, 4, 5 and 6) whose longitudinal sides are provided with notches 21 acting as guides for slides 22. The rims of the frames 20 enter grooves 23 provided in supports 24; one end of these supports 24 is secured on the one hand to the counting frames 11 and 12 and, on the other hand, to the counting frames 13 and 14, the other end being brought on to base plates 25. This arrangement allows the calculating tables to slide in a longitudinal direction. One of the transverse edges of each table 20 is formed as a nose 26 which may be moved by teeth 27 of an engaging shaft or column 28.

Each of the slides 22 has nine notation notches 50 on one of its sides 2 and on the other side nine notches or stop notches 30. Moreover, on the side of the notches 50, the slides 22 are provided with a notch 71.

To one of the ends of the counting frames 11 to 14 and of the base plates 25 respectively are fixed stop bars 29: these bars are able to stop the slides 22 in any position whatsoever by engaging one of the stop notches 30. Stop springs 31 are mounted in such a manner as to draw the tables 20 towards the stop bars 29 and keep the slides 22 in the locked position.

Each section of the machine comprises a shaft or engaging member 23 provided with teeth 27; the members 28 are mounted on levers 32 and 33 (see Figures 2, 5 and 6) fast with a shaft 34 rotating in bearings fixed to the frame of the counter 11 to 13 and to the base plate 25. Attached to the frames of the counters 11 to 14 are four rollers 37 serving the purpose of guides for an engaging bar 35, in a suitably shaped slot on which a roller 36 fixed to the lever 32 is able to move. The displacement of the roller 36 thus entails the rotation of the shaft 34. The engaging shaft 28 is mounted in such a way on the levers 32 and 33 as to be able to revolve and at the same time slide in a longitudinal direction; this dual movement causes a tooth 27 to be brought opposite a nose 26 in the abacus 20 which has to come into engagement in order to effect the calculation, the revolving and sliding movements of the shaft 28 are controlled starting from the keyboard of the machine by means of a contrivance to be described in detail below.

A spring 38 tends to hold the ramp of the engaging bar 35 against a roller 39 mounted rotatably at the end of a lever 40 pivoted at 43 on the left side plate 1 of the machine. A spring

41 holds the lever 40 against the end of the ramp 35. Likewise pivoted on the spindle 43 is a lever 42 whose free end is provided with a stud 44 acting as a stop for the lever 40. One end of the connecting rod 45 is rotatably mounted on the lever 42, and its other end is carried along by a lever 46 pivoted at 46^1. One end of the lever 46 acts on the connecting rod 45; the other end of the lever 46 supports a roller 49. A cam 47 fast with the spindle 48 fixed in the side 1 and in the plate 15 acts on the roller 49 of the lever 46. The spindle 48 is set in rotation by a spring, electric or other motor, as will be fully explained later on. It is understood, of course, that there is an abacus to each section of the machine with its own set of levers 40 to 42. It will be seen that when the machine is in the position of rest the studs 44 on the levers 42 will hold the levers 42 against the pull of the springs 41; the ramp on the bar 35, held by the spring 38, will thus remain in the position of rest (in the direction opposite to that shown by the arrow in Figure 6).

The shape of the cam 47 comprises a part forming one projecting sector; the cam 47 is keyed to the shaft 48 in such a way that when the cam 47, carried along by the shaft 48, is set in rotation the hollow part of the cam will cause the lever 46 to tilt; the studs 44 will then disengage the corresponding levers 40 and the ramps on the bars will be displaced in the direction indicated by the arrow (see Figure 36) under the action of the springs 41 and the engaging shaft 28 will have one of its teeth pressing against the nose in one of the calculating tables 20 whose corresponding slides will thus be released.

If the cam 47 continues to rotate, the profile will encounter the roller 49 which, by means of the lever 46, will push back the rod 45 and the corresponding lever 42 in such a manner that the stud 44 will again hold the lever 40, and will also, owing to the action of the spring 38, bring the ramp 35 in the direction contrary to that indicated by the arrow.

During this part of the movement of the shaft 48, and whilst this shaft 48 is in the position of rest, the springs 38 will bring the bars 35 back again in a direction contrary to that of the arrow, the teeth 27 of the engaging shaft 28 are maintained away from the noses 26 in the calculating tables 20 and all the slides 22 will now be kept locked, by means of the springs 31, against the stops 29.

Owing to the fact that by means of the first part of the movement of the cam 47 the slides 22 of one of the calculating tables 20 have been unlocked, the notation notches 50 in the slides 22 will engage in the rim 51 of the square members 52.

These square members 52 comprise two horizontal arms 52*a* and one vertical arm 52*b*; arranged on the frames of the counters 11 to 14 are guides in which the horizontal arms slide; the lower end of each vertical arm is displaceable in the groove in the base plate 25. Springs 54, attached on the one hand to the frames of the counters and on the other hand to the square members 52, always bring the said square members 52 back again; when the unlocking which has just been described is effected, the slides 22 will engage in the rim 53 of the vertical arms 52*b* of the square members 52 (see Figures 3, 7 and 8).

Mounted on the horizontal arms 52*a* of the square members are two studs 55 and 56. Normally, the stud 55 is engaged by a detent 57, itself jointed to the lower end of the vertical arm of a crank lever 58 which in its turn is jointed to a guide bar 59.

The detent or pawl 57 is provided at its other end with a roller 61.

Each guide bar has on its rim a notch 72 for taking a tooth 73.

At the end of the horizontal arm of the lever 58 is a roller 60. A steel spring 62 is attached on the one hand to the frames of the counters 12 and on the other hand to the detent 57 at a point lying between the joint 63 and the pivot of the roller 61.

The rollers 60 and 61 rotate in two different planes (see Figure 3) and their position with regard to height is determined by two consecutive carrying forward bars 64; that is to say, if the two rollers 60 and 61 in question correspond, for instance, to the tens, the roller 61 of the detent 57 will run on the carrying forward bar 64 corresponding to the tens, and the roller 60 of the detent 58 will run on the bar 64 corresponding to the units. Of the rollers 60 of the lever 58, the one corresponding to the last order of notation will run on a carrying forward bar, i. e. a bar of subtraction, whose function and construction will be described later on. In other words, running on each carrying forward bar 64 is a roller 60 and a roller 61, the roller 61 corresponding to the order of notation of the bar 64 in question and the roller 60 of the carrying forward bar which corresponds to the order of notation immediately lower.

Each carrying forward bar 64 has two ramps 65 and 66 (see Figures 7 and 8) which are displaced on guides fixed to the frames of the counters 11 to 14; the position of said guides is such that when, owing to the action of the springs 67, the carrying forward ramps are displaced longitudinally they will at the same time execute an upward movement whose amplitude is a function of the shape and of the slope of the ramps 65 and 66. The springs 67 always endeavour to bring the carrying forward bars 64 back into their highest position. A disengaging shaft 68 provided with a stud 69 (see Figures 4 and 8), overcoming the pull of the spring 67, holds the carrying forward bars 64 in their lower position, the stud 69 acting in the same way on the angle rims 70 of the bars 64.

The ends of the disengaging shafts are supported in holes provided in the frame of the counters 12 and 14 and in the base plate 25. The said spindles 63 are concentrically mounted (see Figure 4) in such a manner that when the slides 22 are unlocked and reach their extreme position the notch 71 will come opposite the eccentric part and will thus slightly rotate the disengaging shafts 68. During this rotation the studs 69 will be disengaged from the angle rims 70 of the carrying forward bars 64 which will thus be released and will then be able, owing to the action of the spring 67, to be displaced longitudinally and at the same time to be raised through the ramps 65 and 66 of the bars 64.

Teeth 73, engaged in the notches 72—one of which is provided on each of the guide bars 59—are integral with the stop bars 74 arranged longitudinally in the machine. Each bar 74 is fitted with teeth 75 and 76 arranged in sets of two, i. e., 75A, 75S and 76A, 76S (see Figures 8, 9, 10); stepped bars (stepped ramps) 144 and 145 (see Figure 8) are integral with the bars 74, the ramp 144 being fixed on the left and the ramp 145 on

the right of said bars. A transverse motion common to all the bars may be imparted to the bars 74 and a longitudinal motion independently for each of the stop bars. These displacements are effected in the following manner:

(a) Mounted between the stop bars 5 and 6 are two spindles 85 on which one end of two levers 64 can turn (one at each end of the shafts 85) the other ends of which are fast with the shafts 82 and 83 (see Figures 8 and 10) to which the transverse guides 77 and 78 are fixed.

(b) Secured to the key-boards 81 are transverse guides 79 and 80 (see Figures 1, 8 and 10).

The stop bars 74 are liable to slide on the four transverse guides 77, 78, 79 and 80. The transverse motion, common to all the bars 74, is rendered possible by the fact that the tooth 73 is long enough to prevent any transverse displacement of the bars 74 disengaging them from the notches 72 in the slide bars 59.

The key-board of the machine comprises a certain number of rods 86 arranged in rows: each row corresponds to one order of notation; the number of rows provided will depend upon the orders of notation necessary to the machine. The number of rods 86 in each row is equal to the number reduced by 1 of the units in the basis of the numeration adopted; for instance, if the machine is operated on the decimal system, the number of rods will be nine. The key-board cases 81 are provided with grooves which allow the rods 86 to be displaced vertically.

The rods 88 are provided with a tooth 89 and a ramp 93; they comprise a path-limiting stop 91 and, with a view to facilitating their manipulation, are provided with a key which may be attached to the end of the rod in any suitable manner.

Arranged on the key-board cases 81 (see Figure 9) for each row of rods 86 is a vane 87 provided with a right-angled flange 88 which normally engages in the teeth 89 and, under the vane 87, is another vane 92 likewise provided with a right-angled flange which slides on the ramps 93 of the teeth. A spring 80 fixed to the rods and key-board cases always pulls the rods 86 in an upward direction, their displacement in this direction being limited by the stud 91. The aggregate of these devices is such that when one of the rods 86 is depressed the vane 87 is simultaneously disengaged from all the other rods 88 which may previously have been engaged. As to the vane 92, this is dropped, under the influence of the ramps 93, when any one of the rods 86 is depressed.

To the key-board casing 81 are pivoted at one of the ends of bell crank levers 95 the free ends of which are, when in the normal position, opposite blocking tooth 96 of the index row A of the stop bars 74. The lever 95 is held out of its normal position by a finger 195 mounted on the vane 92 when this latter oscillates. In other words, the lever 95 prevents any sliding movement of the bar 74 as long as one of the keys 86 has not been depressed or all the bars 74 have not made any transverse movement.

When the stop bars 74 are in their normal position, when one of the keys is depressed, the end of the corresponding rod 86 descends until it is in the plane of the row A of the teeth 75—76 of the stop bar 74.

On the other hand, when the stop bars 74 have undergone a transverse movement, a rod 86 is depressed, the extremity of which becomes located in the plane of the row S of the teeth 75—76.

The guide 77 is drawn towards the left by a spring 300, called the subtraction spring. This spring therefore draws towards the left the whole of the stop bars 74. On the guide 77 is provided a stop 98 against which a stop lever 97 bears when in its adding position, which prevents the displacement or oscillation of the whole of the stop bars 74. The lever 97 is held in the adding position by a spring 99. Under the action of the lowering of a ramp 101, defined hereinafter, a lever 108 is enabled to oscillate slightly the lever 97 on the stop bar 6. The ramp 101 is rendered integral by a suitable system of rods with the subtraction bar S the guiding of which is similar to that of the rods 86.

When at rest or when in the normal position the whole of the stop bars 74 are held in the adding position (or normal position) by the lever 102 which leaves its position as soon as the machine commences a working cycle (see Figure 16).

The driving bars 59—and at the same time the stop bars 74 which are in one therewith as regards longitudinal movements—are held in the normal position, or the position of rest, by a yoke or strap 103 (see Figures 7, 8, 13 and 14) comprising a bar fixed by both ends to two slides 107 provided with rollers 188 which run in grooves in guides 109 fixed to the counting frames 13 and 14.

The horizontal bars 52a of the squares 52 are provided with stops 104 (see Figure 3) which permit of the said arms being carried along by yokes 105 and 106 (see Figure 13) and which hold the squares 52 in their normal position or position of rest.

In like manner, the yoke 105 is fixed by its ends to the said slides 107. The yoke 188 is fixed to two slides 110 guided by rollers 111 which run in external grooves formed in the guides 109 (see Figures 13 and 14). Two small connecting rods or links are pivoted at one of their ends to the two outer slides 110. Two small connecting rods or links 113 are pivoted to the internal slides 107.

At their other ends the small connecting rods or links 112 are pivoted to the levers 114 fast with the shaft 115 and the small connecting rods or links 113 are pivoted to the levers 116 fast with the shaft 117. The shafts 115 and 117 turn in bearings formed in the side pieces 1 and 2 of the machine (see Fig. 1).

The shaft 115 is in its turn fast with a two-armed lever 118 carrying on the end of one of its arms a roller 119 which rolls over a cam 120 mounted on the shaft 48 (on which is also mounted the cam 47). The shaft 117 is integral with a lever 121 provided at its other extremity with a roller 122 arranged so as to be capable of rolling on the other arm of the lever 118.

When the cam 120 holds the roller 119 in its lowered position, the yokes 105 and 106 keep all the square numbers 52 in their normal position or position of rest, while the yoke bar 103 keeps all the driving bars 59 and all the carry-over bars 64 in the position of rest. Shortly after the commencement of the rotation of the cam 120, it leaves the roller 119. All the yokes 103—105—186 retire and abandon the driving bars 59, the carry-over bars 64 and the square numbers 52 to the action of their respective springs. In continuing its rotation the cam 120 will again come into contact with the roller 119 which will bring back the yokes to the front again and cause the

bars 59 and 64 and the square numbers 52 to return to their normal position.

On the engagement shaft 28 is keyed, or fixed in any other manner, a pinion 301 (see Figures 5 and 16). A ratchet collar 302 fast with a shaft 123, always remains in engagement with the pinion 301; even when the engagement shaft 28 is caused to rock by the levers 32 and 33, the ratchet 302 can accompany this movement because the shaft 123 can rotate about its axis.

A grooved pulley 124 is likewise fast with the engagement shaft 28. A finger 125 penetrates into the groove of this pulley 124 and this finger is mounted on the end of a rectangular lever 128, fixed to the counting frames 11 to 14, while the other end carries a finger 127 which penetrates into a groove formed in a bar 128,

Under these conditions any longitudinal movement of the shaft 123 is translated into a corresponding rotation of the shaft 28 and any longitudinal movement of the bar 128 is translated into a corresponding sliding movement (upwards or downwards) of the same shaft 28.

In the shaft 123 and in the bar 128 are formed grooves in which enter lugs 129 on the stop bars 139. Contrary to the stop bars 74, the stop bars 130 carry only a single row of teeth (131—Figures 10 and 16) and they are guided by guides 132–133 which cannot be moved laterally (see Figure 10).

At the same time, as they guide the rods 86, the keyboards 81 act as guides for the rods 134 which have the same characteristic features as the rods 86. When the rods 134 are lowered their inner ends are on a level with the teeth 131.

Springs 135 fixed to the counting frames always return the stop bars 130, a yoke 136 holding them against the force of the spring 135—in their normal position of rest. The walls 15 and 137 are provided with guide grooves for the yoke bar 136. This yoke is made fast by means of small connecting rods or links 138, 139 pivoted to each other and to the yoke with a shaft 140 which rotates between the side piece 1 and the wall of the cam 15. On the shaft 140 is fixed like one of the ends of the small connecting rod or link 139, by keying or otherwise, a lever 141 the free end of which is carried along by the shaft 48. In one rotation of the shaft 48 (in the direction of the arrow in Figure 1) the cam frees first the roller 142, which allows the yoke 138 to retire (by the rods 141-139-138) and the stop bars 130 can respond to their springs 135 and advance in the direction indicated by the arrow. The bars 130 will then be arrested by the bars 134 which are lowered.

The spacing of the teeth 131 and that of the rods 134 is such that, relatively to the distribution of the fingers 27 on the engagement shaft 28, at each position of arrest of the stop bars 138 a finger 27 is brought opposite the face of a member 26 of a different abacus.

An arrangement of this kind in no way limits the number of abacuses 28 which can be brought into engagement with the edges 56 of the square numbers 52. Actually the finger 57 can be distributed over the shaft 26 along a helicoidal line in such a way that for each position of arrest of a stop bar 130, the rotation of the shaft 28 shall be limited to bringing one finger 27 only accurately in front of the vertical line of the members 26. On the other hand the fingers 27 may be distributed over the shaft 26 in such a way that for each position of arrest of another stop bar 130, the sliding movement of the shaft 28 shall be limited to bringing the finger 27 (which has just been brought opposite the vertical line of the members 26) to the height of that one of these members 25 which corresponds to the abacus which is to intervene for the calculation under consideration.

Staggered ramps 144 and 145 constitute respectively an adding ramp (144) and a subtracting ramp (145). On the cross bar 9 are fixed guides 147 which permit of the sliding, upwards, of registration sectors 146, comprising two vertical slots 146' (see Figures 8, 17, 18). These sectors are constantly drawn upwards by springs (not shown). The sectors 146 comprise hooks 148. These sectors are so positioned that if the whole of the stop bars 74 is in the normal position, the left hand side of the hooks 148 is in the plane of the adding ramps 144, just below the lower echelon. On the contrary, if all the stop bars have been moved towards them, that is to say if they are all in the subtraction position, the right hand side of the hooks 148 will be situated in the plane of the subtraction ramps 145, just below the highest echelon.

Each registration sector 146 has a mortise 149. Into this mortise enters a projection 150 on a connecting or union plate 151 corresponding thereto. The connecting plates 151 have vertical slots 151' in each of which engages a shouldered shaft 152. The shafts 152 are fixed to the cross bar 9 (see Figures 17, 18). This arrangement permits the plates 151 to produce a vertical sliding movement upwards. The plates 151 each have a second projection 153 which enters a mortise 154 formed in the corresponding impression sector 155. Guides 156 fixed by their ends in the side pieces 17–18 serve to guide the sectors 155 in their upward sliding movement.

To the impression sectors 155 are pivoted the character rods 157 which are guided by a comb 158 fixed to the side pieces 17—18 and kept in a vertical position against the bottom of the said comb by springs 159. An impression roller 303 is mounted opposite the upper ends of the rods 157. Opposite the impression roller, the rods 157 carry characters each of which is separated from the adjoining ones by a distance equal to the difference of the height of the ramps 144 and 145. A yoke 160, guided by grooves formed in the side pieces 17, 18 keeps all the impression sectors 155 on the normal position, or position of rest by means of the straight part 161 of cams 162. These latter are integral with a shaft 163, which is itself integral with a lever 164. This lever 164 carries on its free end a roller 165 which rolls over a cam 166, keyed or otherwise fixed on the shaft 48 of the cams (see Figures 17, 18). A spring 185 fixed on the cross bar 9 and to the lever 164 holds the said against the cam 166.

The cams 162 have a curved part which bears against rollers 167 mounted on the ends of levers 168, which, in order to be able to rock, are mounted betwen the side pieces 17, 16. The levers 168 act on rollers 169 varried by yokes 170 of hammers 171. The yoke 170, which is fixed to the side pieces 17, 18 in view of its rocking movement, holds all the hammers 171 in the normal position or position of rest. The hammers 171 are pivotally mounted on a shaft 172 fixed to a comb 173 which is itself fixed to the side pieces 17, 16. Each hammer 171 is biassed by a spring 174 mounted in such a way that the hammer strikes the rods 157 when the yoke 170 is free. To each hammer 171 corresponds a pawl 175 mounted on a shaft 176 fixed

to the comb 173. The pawls 175 hold normally, by their hooked ends, the corresponding hammers. On the other hand the pawls 175 have a bent edge 177 (see Figure 19) which normally enters a notch or groove corresponding thereto in the character rods 157. The bent edge 177 of each of the pawls 175 is situated above the bent edge corresponding thereto of the pawl 175 of the immediately superior order of numeration. Relatively to the notches 178 and to the hammers 171 the arrangement of the pawls 175 is such that when one of the character rods 157 moves upwards by an amount greater than the value of a space, this rod lifts the corresponding pawl, which in its turn lifts the next pawl and so on. Under these conditions all the pawls 175, of an order of numeration lower than that of the pawl lifted by the character rod considered, are lifted, thus affording the hammers opportunity to strike.

The side pieces 17 and 18 carry a shaft 180 on which are pivoted pawls 179 which are held by springs 181 so as to prevent the hammers from striking even if the stirrup has been moved away and if the pawls 175 have to be lifted. The pawls 179 have a flange 182 (figures 17, 18) which fits against the corresponding flange of the pawl 179 of the order of numeration immediately superior to that of the first one. The side piece 17 carries a lever 183 (having an arm 187) which oscillates about its point of fixation and carries a finger 184 (at right angles to its plane). This finger 184 releases the first of the pawls 179 which, by its bent edge releases the next one and so on until all the hammers 171 not held by the pawls 179 are released in succession for the purpose of making their successive striking movements.

When the shaft 48 has made one revolution, the cam 166 liberates the roller 165. The spring 185 causes the cams 162 to oscillate upwards so that they allow the yoke 160 and the impression sectors 155 to rise. These sectors 155 can however rise only just so far that the hooks 148 are arrested by the echelons of the echelon adding ramp 144 or of the subtraction ramp 145 (according to the position of all the stop bars 74). This upward movement of translation is followed by the side connecting pieces 151 and the impression sectors 155 which will be arrested likewise as a function of the position of the echelon ramps 144, 145. The cams 162 follow their upward movement, and slightly before the end thereof they will completely free the rollers 167. At this moment, the levers 168 and the yoke 170 oscillate which partly frees the hammers 171 which, however, are still held by the pawls 179. At the end of the movement of the cams 162, their wedge 186 pushes the arm 187 of the lever 183. This latter acts on the first of the pawls 179 which are disengaged successively as has been described above in such a way that the hammers 171, already disengaged from the pawls 175, will be able to strike them also successively.

Continuing its rotation the cam 166 will again come into contact at its larger diameter with the roller 165 and the cams 162 will descend again. The right hand part 161 of these cams will draw the yoke 160 downwards and in consequence of this the sectors 155, the plates 151 and the sectors 146 will resume their normal respective lower positions. During the time which this takes the curved part of the cams 162 will cause the lever 168 to rock which will bring back the yoke 170 into its normal position. The yoke 170 in its turn will bring back the hammers 171 into the normal position. The pawls 175 will resume at the same time under the action of gravity, the position of rest and the springs 181 will draw the pawls 179 into their position of rest.

The frame of the counters 12 and 14 carry total blocking bars 188 which can be moved lengthwise (see figures 7, 8, 21). These bars 188 are provided with teeth 189 which are adapted to block the stops 69 when they move. To the bars 188 are pivoted small connecting rods or links 190, which are pivoted at their other ends to levers 191 fixed so as to permit them to rock, on the counting frames 12, 14.

In order to block the keyboard, a bar 192 (the keyboard blocking bar) is provided which is mounted on the keyboard casing 81 so as to be able to make a longitudinal translation (see Figure 10). The bar 192 is provided with recesses 193 into which enter fingers 194 and 195 fixed to the members 87 and 82. The position of these recesses 193 is such that when the bar 192 moves in the direction of the arrow they cause to rock, by the fingers 194, all the members 87, thus liberating all those of the rods 86 which are lowered. The recesses 193 act at the same time on all the fingers 196 so as to liberate all the stop bars 74. When the bar 192 moves in the direction opposite to that indicated by the arrow, the upper recesses 193 block the figures 194 and prevent any movements of the parts 87 and therefore of the rods 86.

Pawls 186—1—7 are pivotally mounted on the counting frame 13—14, on each side of the engagement ramp 35 (see Figures 12, 20). The lower arms of each of the pawls 186, 187 arrest, in their lowered position, the movements of the ramps 35. The pawl 196 is called the "sub total pawl" and is adapted to arrest the ramp 35 when it is attracted by the spring 38 (see Figure 6). The pawl 197 is called the "non-adding pawl" and is adapted to arrest the ramp 35 when it is attracted by the spring 41.

A driving shaft 198 is mounted on guides 199 which are fixed to the side piece 2 (see Figures 10, 12, 20, 21). This shaft is adapted to slide longitudinally and to oscillate about its axis in the guides 199.

On the shaft 198 is fixed a keyboard locking device 200, provided with a projection 201 which enters a recess formed in a lever 202 fixed on a support 203 which permits the said lever 202 to oscillate about its point of fixation. The lever 202 has a second recess into which enters a roller 204 fixed to the keyboard blocking device 182. The mounting of these different parts is such that when the shaft 198 rocks in one direction or the other, the blocking bar 192 will slide in the corresponding direction by the exact amount necessary to ensure the blocking operations above described.

On the shaft 198 is likewise fixed another driving block 205 provided with two projections 206 and 207 (Figure 21) which can be engaged by a driving ramp 208 and a projection 209 normally engaged by the "total driving ramp" 210.

The block 205 has an arm 211 which is adapted to engage an arm 212 of the lever 191 (corresponding to section I of the machine) when the shaft 198 makes no further longitudinal movement.

An arm 213 (Figure 20) is likewise integral with the shaft 198. This arm 213 is adapted to engage with the arm 121 of the lever 191 of another section (II for example of the machine) when the shaft 188 moves longitudinally.

The ramps 208 and 210 are integral with a pin 214 which is fixed, for the purpose of its to and fro movement, to the side piece 2. On the cam shaft 48 is mounted a cam 215 (see Figure 20) and the pin 214 carries a roller 216. On the cam 215 is mounted a second cam 217 provided with a roller 218 which can be engaged by a ramp 219 called the repetition ramp. Finally the cam 215 is adapted to engage a second short roller 228 likewise mounted on the pin 214.

When the shaft 48 makes a revolution the cam 215 first engages the roller 216, which causes the pin 214 to descend. The ramp 219 then engages the roller 218 and causes the cam 217 to project forwards which will then engage the roller 220 which will raise the pin 214 above its normal position. Finally levers 221 and springs 222 will bring back the pin 214 to its normal position.

A spring 223 attracts the shaft 198 but its action is counteracted by a fork 224, integral with the yoke 136, which bears against a ring 225, fixed on the shaft 198 and thus holds the shaft 198 in the normal position or position of rest.

The shaft 198 also carries two rings 226, 227 (see Figures 11–20). The side piece 1 carries supports 230 between which are fixed pivotally levers 228, 229, notched at 231 so as to be able to engage rings 226, 227 and thereby arrest the longitudinal movement of the shaft 198 produced by the spring 223. The lower ends of these levers 228, 229 are guided in slots formed in a support 232 which guides them and are likewise fixed to the side piece 1.

The position of the rings 226, 227 on the shaft 198 and the distance between the levers 228 and 229 relatively to the distance apart of the arms 211, 213 on the shaft 190 are such that when the lever 228 for example, rocks, only the arm 211 of the lever 191 of the section II of the machine, while, when the lever 229 oscillates, only the arm 213 will engage the arm 211 of the lever 191 of the section I of the machine.

On the end of each of the usual driving rods S, T_2, ST_2, T_1, ST_1, NA_2, NA and NA_1 is fixed a key. These rods are mounted in a keyboard casing 81 as already described for the rods 86. All the said rods have an arm 233.

The various mechanisms which are capable of operating the rods S, T_2 . . . enumerated above, will now be described.

The subtraction rod S is pivoted to the ramp 101. When the rod S is depressed, the ramp 101 causes the lever 106 to rock about its point of fixation on the cross bar 6. The lever 100 causes the lever 97 to rock which permits the stop bars 74 to make their rocking movement.

By the depression of the rods T_2 and ST_2 the arms 233 corresponding to them will cause the shaft 234 fast with the rock lever 226 to descend.

By the depression of the rods T_1, ST_1, the arms 233 corresponding to them will cause the shaft 234 fast with the lever 229 to descend. At one of their ends the connecting rods 235 are connected by means of key hole slots 235' to the driving rods ST_2, ST_1, NA_2 and NA_1. At their other ends the connecting rods 235 are pivoted to fixed levers 236 rocking on the support 237 integral with the cross bars 5 and 8. The connecting rods 235 of the rods NA_2 and NA_1 each carry a projection 240. Each of the levers 236 has a second arm at right angles to the first one and on the end of which are pivoted the connecting rods 238. The other end of the connecting rods 238 is pivoted to one of the pawls 196, 197 under conditions which will be described in full hereinafter.

The depression of the rod ST_2 causes the rocking of the pawl 198 of section II

The depression of the rod ST causes the rocking of the pawl 196 of section I of the machine

The depression of the rod NA_2 causes the rocking of the pawl 197 of section II

The depression of the rod NA_1 causes the rocking of the pawl 197 of section I.

The rod NA is provided with a cross bar 239 which causes the projections 240 to descend so as to cause the two pawls 197, which correspond to the two sections of the machine, to rock.

On the shaft which carries the cams 48 is mounted a lever 241 (see Figures 15 and 21) carrying on each of its ends a pawl 242 with corresponding return springs 243. A ratchet 244 is mounted on the shaft of a reducer RR. The arrangement of these parts is normally such that the ratchet 244 acts on the pawls 242 which thus drive the cam shaft 48.

On the wall 15 are pivoted two bell crank levers 245, 246. Each of the two levers carries, on the end of one of their arms, a projection 247 and they are held together by a spring 248 (the ends of which are fixed respectively to each of the arms carrying the projections 247). The approach of the levers 245, 246 to each other is limited by two stops 249. The other arms of the levers 245 and 246 carry respectively a projection 250 and a notch 250' (into which the projection 250 enters). The projections 247 are situated in the paths of the tails of the ratchets 242 so that the said projections will cause the tails of the pawls 242 to rock as soon as they have reached them; the pawls 242 will disengage themselves from the ratchet 244 and the cam shaft 48 will cease to revolve.

The lever 245 is fast on a shaft 251 mounted to revolve between the side piece 2 and the wall 15. In its turn this shaft 251 drives an arm 252 pivoted to a small connecting rod or link 253 on an arm of which are pivoted two levers 254 the oscillation of which takes place on the other hand about a point on the side piece 2. Each of the levers 254 carries a shaft 255. A driving bar 258 is mounted on these two shafts 255. The arrangement is such that when pressure is applied to the bar 258, the two levers 254 rock parallel. This rocking movement will be transmitted by the connecting rod 253 to the lever 245 and the levers 245 and 246 will be separated from each other. The pawls 242, attracted by the springs 243 engage the ratchet 244 and the cam shaft 48 will begin to rotate. The said shaft 48 will make only one revolution exactly because in the meantime the spring 248 has drawn the levers 245 and 246 together and the tails of the pawl 242 will meet, in returning to their starting position after one revolution of the ratchet 244, the rollers 247 of which will result in the pawls 242 of the ratchet being moved away thus arresting the shaft 48.

The way in which the machine which has just been described works in the different operations for which it has been provided is as follows:

I. Addition.—The operator depresses the keys 134 corresponding to the abacus 20 which must be set in operation and the keys 86 corresponding to the figures which are to be added in the various rows of calculating elements 22. The operator then strikes the driving bar 256. The cam shaft 48 then produces a rotation of a complete revolution (see above). During this time (1)

the cam 143 allows the roller 142 to fall the yoke 136 retires with the lever 102 and the fork 224. The lever 102 disengages all the stop bars 74 but it does not rock (since the lever 97 has not rocked under the action of the subtraction ramp 101). The spring 223 drives round the shaft 196 in a sliding movement which places the projection 206 and 207 within reach of the ramp 208.

(2) the cam 215 engages the roller 216, the pin 214 descends and the damp 208 engages the projection 206 which causes the shaft 198 to rock. The projection 201—the length of which is sufficient to prevent its coming out of the lower notch in the lever 202—rocks this latter. The lever 202 causes the blocking bar 182 to slide in the opposite direction to that indicated by the arrow. All the rods 86 are thus held in the position which has been imparted to them by the operator.

(3) in continuing its rearward movement the yoke 136 allows the stop bars 130 to advance until they are arrested by those of the rods 134 which have been lowered by the operator. The bars 128 and the shafts 123 are driven in this movement and by this fact the engagement shafts 28 of each section of the machine are brought into the position corresponding to the composition realised by the operator on the keyboard. In other words one of the fingers 27 is placed in front of the projection which corresponds to the abacus 20 which must be set in operation for the calculation to be made.

(4) the cam 47 leaves the roller 48, the lever 46 rocks and the levers 40 are drawn back by the springs 41. The rollers 39 push the engagement ramps 35 forwards thereby causing the engagement shafts 28 to rock. These latter by their fingers 27 arranged opposite the abacus 20 cause the said abacus to slide with all its reglets 22. At the same time, the said reglets 22 are disengaged from the blocking bar 29 and enter into engagement with the bent edges 56 of the square numbers 52.

(5) the cam 120 frees the roller 119 so that the three yokes 103, 105 and 106 retire and permit of the advance of the driving bars 59 attracted by their springs 62. The bars 59 drive the square numbers 52 by the pawls 57. At the same time the bars 59 drive the stop bars 74 by the shafts 73 until the rods 86, lowered by the operator, arrest the said bars 74. As the reglets 22 of the considered abacus 20 are in engagement with the square number 52, these reglets 22 advance by an amount equivalent to that by which the rods have been lowered.

It may happen that the amount by which the reglets 22 advance, augmented by their progression in a previous operation is equal to or greater than the basis of numeration adopted for the machine (that is to say greater than nine in the case of the decimal numeration). In this case, the carrying over parts will intervene as follows:

The echelon 71 of the reglets 22 will then engage the disconnecting shaft 68 which rocks slightly with the stop which is integral with it. This latter disengages the carrying over bar 84 which rises under the action of its spring 67 and disengages the roller 61 corresponding to its row of numeration and also the roller 60 corresponding to the row of numeration immediately above it. Under the action of the spring 62, the pawl 57 which carries the roller 61 rises at this moment and disengages the stop 55 so that the square number 52 recedes until the stop 56 meets the shaft 63 of the pawl 57. Now it will be remembered that the position of the stop 56 is such that the recoil of the square number 52 is exactly equal to the length of the number of calculating elements 50 formed by the basis of numeration (ten, in the example chosen of the decimal numeration).

The roller 60, of the next higher row of numeration has likewise been raised. The roller permits the lever 58 (of the same order of numeration) to rock so that the pawl 57, on which the lever 58 is pivoted, advances by an amount which is supplementary to that which it ought to have progressed according to the position of the rod 86 of the order of numeration considered and which would have been eventually lowered by the operator of necessity.

The carrying over bar 64 can only rise by such an amount that the above mentioned supplementary amount is exactly equal to the length of an element of calculation 50.

(6) the cam 166 abandons the roller 165 and the cams 162 consequently rise. The registering members then function as has already been described. The stop bars 74 have advanced until stopped by the rods 86 which have been lowered by the operator. None of the stop bars have made any lateral movement so that the addition echelons 144 are located in the plane of the straight hook 148 of the registration sectors 146. The arrangement of these echelons 144 is such that the rise—which they limit—of the impression devices corresponds exactly to the emplacement of the rods 86 arrested by these bars. At the same time the registration of the advance of the stop bars 130 takes place. Concerning this it is necessary to remark that the character bars 157, corresponding to the stop bars 130, can carry special signs other than figures or in addition to figures.

(7) the cam 166 again engages the roller 165 and as has just been described the impression devices are brought back to their position of rest.

(8) the cam 47 engages the roller 49 which brings back the levers 40 to their position of rest. The same thing happens in the case of the ramps 35 (under the action of the springs 38). This movement moves the shaft 28 and the fingers 27 also away from the projection 26 of the abacus 20 considered, which returns to its position of rest under the action of the springs 31. This return to rest of the abacuses 20 may also be controlled by the key hole slots 257 pivoted to the levers 32, 33 by means of the small connecting rods or links 258.

(9) the cam 120 engages the roller 119 which causes levers 103, 105 and 106 to rock towards their normal position, the said levers 183, 105, 106 bring back to their normal position all the driving bars 59, all the carrying over bars 84 and all the square numbers 52 which have been removed as the result of the calculation.

(10) the cam 217, after having been rocked by the ramp 218 engages the projection 220 which lifts the pin 214 above its normal position. The ramp 208 pushes the projection 207 which rocks the driving shaft 198 and the block 200 integral therewith. The block 200 then drives the blocking bar 192 in the direction indicated by the arrow. The notches 193 in the upper edge of the bar 192 unlock the members 87 and push them back so as to unlock all the rods 86 and 134 depressed by the operator. As soon as the cam 217 has passed the roller projection 220, the pin 214 and the shaft 198 return to their normal positions under the action of the levers 221 and of the spring 222.

(11) the cam 143 engages the roller 142 so that the levers 139 rock and the yoke 136 resumes its normal position bringing back into the position of rest all the stop bars 130 and the rods 134.

(12) the shaft 198 can return to its normal position under the action of the fork 224, integral with the yoke 136. All the stop bars 74 return to rest under the action of the lever 102.

II. Subtraction.—The operations to be effected are the same as for addition, with the following differences. Besides the keys depressed for addition, the operator depresses the key marked S. This causes the ramp 101 to rock the lever 100 which rocks the lever 97 and moves it away from the stop 99. When the yoke 136 recedes carrying with it the lever 102, the whole of the stop bars 74 are displaced laterally under the action of the spring 96. The bars 74 are then arrested by their teeth S. These latter teeth are in such a position that they do not arrest the stop bars when they are displaced by sliding a distance proportional to the value of the rod depressed, but rather by a length or distance proportional to the difference between this value and a number of calculating elements 50 equal to the basis of numeration diminished by one (that is to say nine in the decimal system).

As all the stop bars 74 are displaced laterally, the tooth 96 of the addition row (see Figures 8, 10) becomes disengaged from the fingers 95; the stop bars 74, corresponding to the rows of numeration for which no bar 86 has been depressed by the operator, can then slide freely—and they slide freely—until the tooth 259 comes into contact with the cross bars 80, the tooth 259 being at a distance from the cross bar 80 equal to the length of as many calculating elements 60 less one which there are in the basis of numeration employed. As a result subtraction is performed by addition of the complement and the registration of the operation takes place in the same direction by the ramp 145 for subtraction which is placed in the reverse direction to the ramp 144 for addition so that the rise of the printing devices is inversely proportional to the longitudinal displacement of the stop bars 74. A rod 260 (see Figure 7) acts on the stop 69—on which it is pivoted—of the disconnecting shaft corresponding to the higher row of numeration.

III. Totalisation.—For the totalisation of the counters and the registration of the totals, the working is analogous to that of the machine which adds, with the following differences: the abacus 20 which has to be "totalised" belongs to one or the other of the Sections I or II of the machine which is supposed here to comprise only two sections. The operator then depresses the key T_1 or T_2 according as the abacus in question belongs to the first or second section of the machine. Owing to this depression one of the levers 228 or 228 is rocked and the notch 231 in this lever engages one of the rings 226 or 227 integral with the shaft 196. When the yoke 136 recedes, the shaft 198 is arrested by one of the levers 228, 229. The arms of the levers 211, 213 carried by the shaft 199, engage with one or other of the arms 212 of the lever 181 according to the section of the machine contemplated. The projection 209 remains engaged with the ramp 210 in such a way that when the said ramp descends the shaft 198 rocks in the direction opposite to that of the addition producing the following operations:

(*a*) the bar 192 which blocks the keyboard slides in the direction of the arrow moving all the teeth 95 away from the plane of the large tooth 96. At the same time, it rocks all the members 87 which liberates every rod 86 which may have been depressed by the operator

(*b*) one of the arms 211, 213 pushes the lever 212 corresponding to the section of the machine under consideration.

(*c*) the total blocking bar 188 moves in the direction of the arrow (see Figure 7) and its teeth 188 block the stops 69 and the disconnecting shaft 69 on which they are fixed.

When the yoke 103 recedes, all the stop bars 74, the driving bars 59 and the reglets 22 which have been engaged move forward under the action of the springs 62 (see Figure 8) because neither the rods 86 nor the bars fingers 95 oppose this advance. When, however, the echelon notch 71 of the reglets 22 strikes against the disconnecting shafts 68, these latter do not rock since they are blocked by the bar 188. Under these conditions, the reglets 22, the square numbers 52, the bars 39 and finally the stop bars 74 with the echelons 144 and 145 are arrested by overcoming the force of the springs 62. At this moment the printing devices come into action as has been described above and they register a sum corresponding to the position of the echelons 145 that is to say one equal to the complement of the distance covered by the reglets 22 when they move into their extreme position. The result is that when the cam 47 engages the roller 49—which produces the disengagement of the reglets 22—the latter are located in their extreme forward position, that is to say, are in the zero position.

IV. Negative balances.—The bar 59, corresponding to the highest row of numeration, has a stop 262 which engages, when the said bar arrives in the zero position, the lever 97 which disengages in its turn the stop 88 thus permitting the lateral displacement of the stop bars 74. When the moment of registration arrives, all the stop bars 74 rock under the action of the spring 88 and the echelons 144 are located in the plane of the notches 148. The amount registered is, therefore, equal to the distance covered by the reglets 22 when they move to their zero position.

A connecting rod 263 consolidates the longitudinal movements of the bars 59 of each order of numeration corresponding to the two sections of the machine. As only the disconnecting bars 68 of one section of the machine are blocked it is obvious that the totals registered are transferred to the other section of the machine. This transfer is made solely for the distance covered by the reglets 22 up to their zero, that is to say for the complement of their position before totalisation of the counters. As the transfer is made in the opposite direction to that in which the various amounts have accumulated on the abacus emptied by the totalisation, the negative balance required is obtained.

V. Sub total.—The differences between the operation of totalisation described under III and the "sub-totalisation" are the following:

The operator depresses one of the keys ST_1 or ST_2 according to the section of the machine which is to intervene. The pawl 196 of the section under consideration rocks. Consequently when the lever 40 is brought back to its normal position, the ramp 35 can no longer follow it and the spring 38 expands. When the keys ST_1 or ST_2 are liberated the pawl 188 rises under the action of the springs 284 and the ramp 35 returns to its normal

position under the action of the spring **41**. In other words, the disconnecting movement of the reglets **22** is retarded so as to be produced after the return of the yoke instead of taking place previously. The reglets **22** do not therefore remain in the zero position when the registration is effected by the printing devices but as they still are engaged by the square members **52**, return to their original position.

VI. Non addition.—The operator depresses one of the keys NA_1 or NA_2. The pawl **197** of the section corresponding thereto rocks so that when the lever **40** is disengaged by the lever **42**, the lever **48** remains blocked because the ramp **35** is arrested by the pawl **197**. If the operator then depresses the key NA_1, the corresponding rod lowers, through the cross bar **239**, the connecting rod **235** corresponding to the keys NA_1 and NA_2. All the pawls **197** rock and the two ramps **35** of the two sections of the machine are arrested.

A stop bar **265**, provided with echelons **266**, slides on the guides **132** and **133**. A registering sector **267** (see Figure 20) is connected to an assemblage of registering devices described with reference to Figures 17, 18, 19 in which assemblage, however, the character bar **157** carries instead of figures the signa or indications corresponding to the functions under consideration.

VII. Correction.—A lever **268** is fixed to the side piece **1** of the machine so as to be able to rock (see Figure 20). At one end of the said lever is pivoted a rod C. The other end of the lever **268** is adapted to engage the projection roller **228** of the pin **214**. To cancel any amount set up on the keyboard the key C is depressed. Both the pin **214** and the ramp **210** which rocks the driving shaft **198** with the block **200** is thus lowered. The blocking bar for the keyboard **192** then slides in the direction of the arrow (see Figure 10) which rocks all the members **87** and unlocks all the rods **86**.

VIII. Repetition.—The ramp **219** can rock about a point on the side piece **1** and is pivoted to a lever R provided with a key and guided by a support **270**. The lever R has a notch R_1. When the operator depresses the key R, the lever remains hooked by R_1 in the support **270**. The ramp **219** descends and moves away from the periphery of the roller **218**. When the shaft **48** makes a revolution, the cam **217** is not rocked and does not therefore come into contact with the roller **220**. The pin **214** thus remains arrested in the normal position which is imparted to it by the levers **221** and the spring **222**. At the end of the rotation of the shaft **48**, the pin **214** does not move upwards which—as has been seen—would cause the unlocking of all the rods **86**; the amount set up by the operator therefore remains set up on the keyboard by the ulterior operations.

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