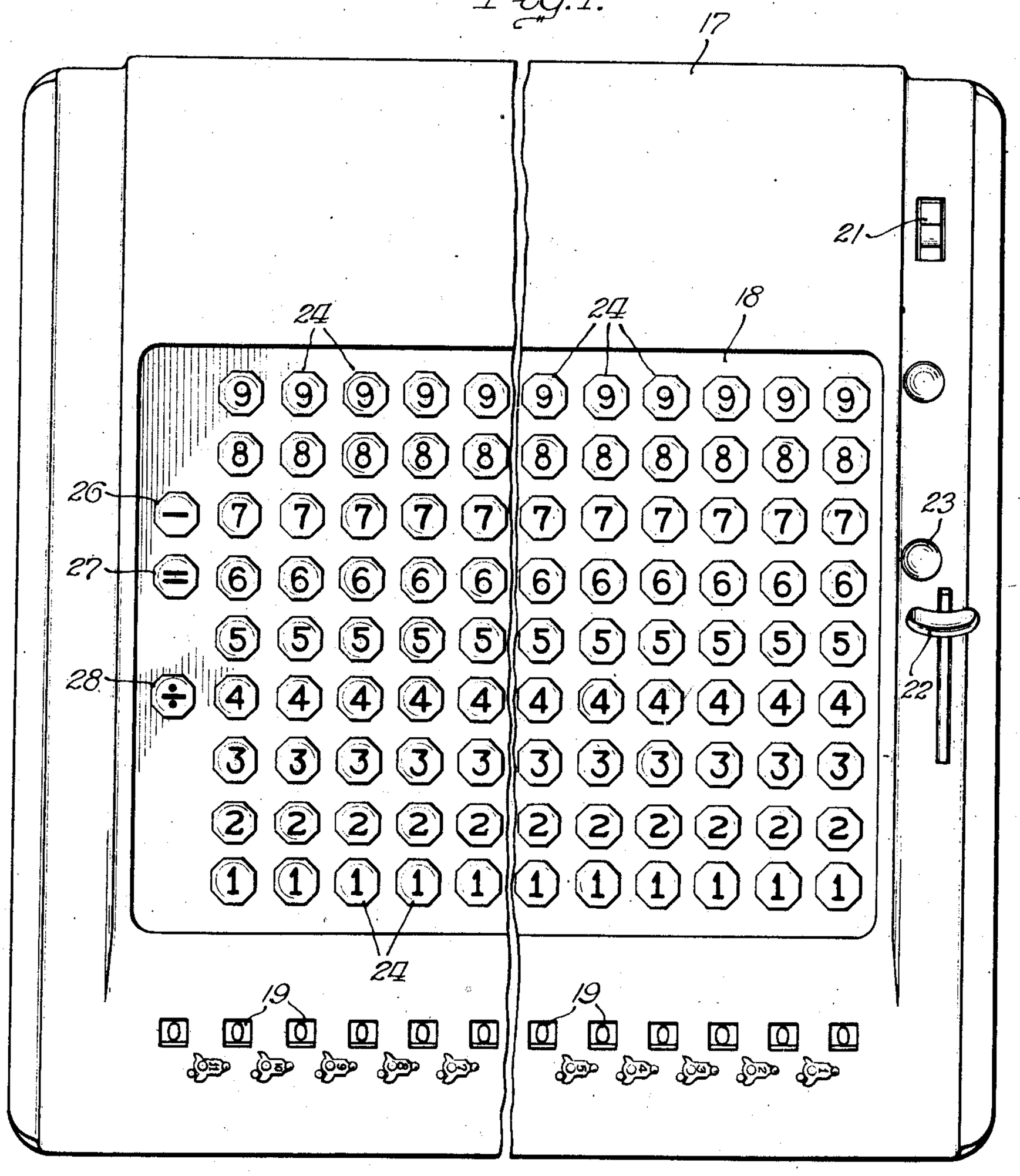
Nov. 11, 1947. J. M. LAIHO 2,430,575

KEY-RESPONSIVE CALCULATING MACHINE

Filed Feb. 5, 1945 4 Sheets-Sheet 1

Fig. 1.



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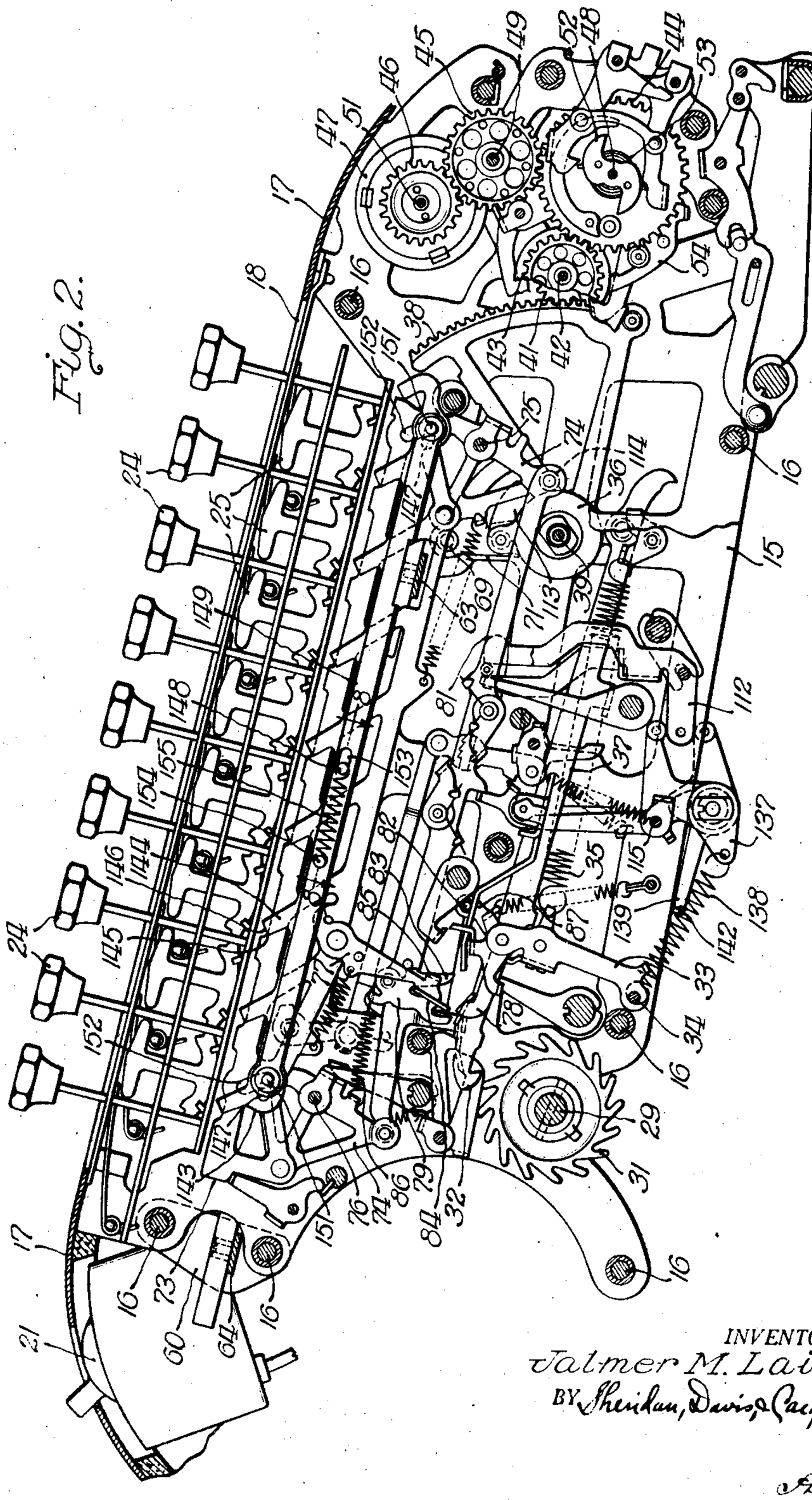
KEY-RESPONSIVE CALCULATING MACHINE

Filed Feb. 5, 1945 4 Sheets-Sheet 2

Fig. 2.



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KEY-RESPONSIVE CALCULATING MACHINE

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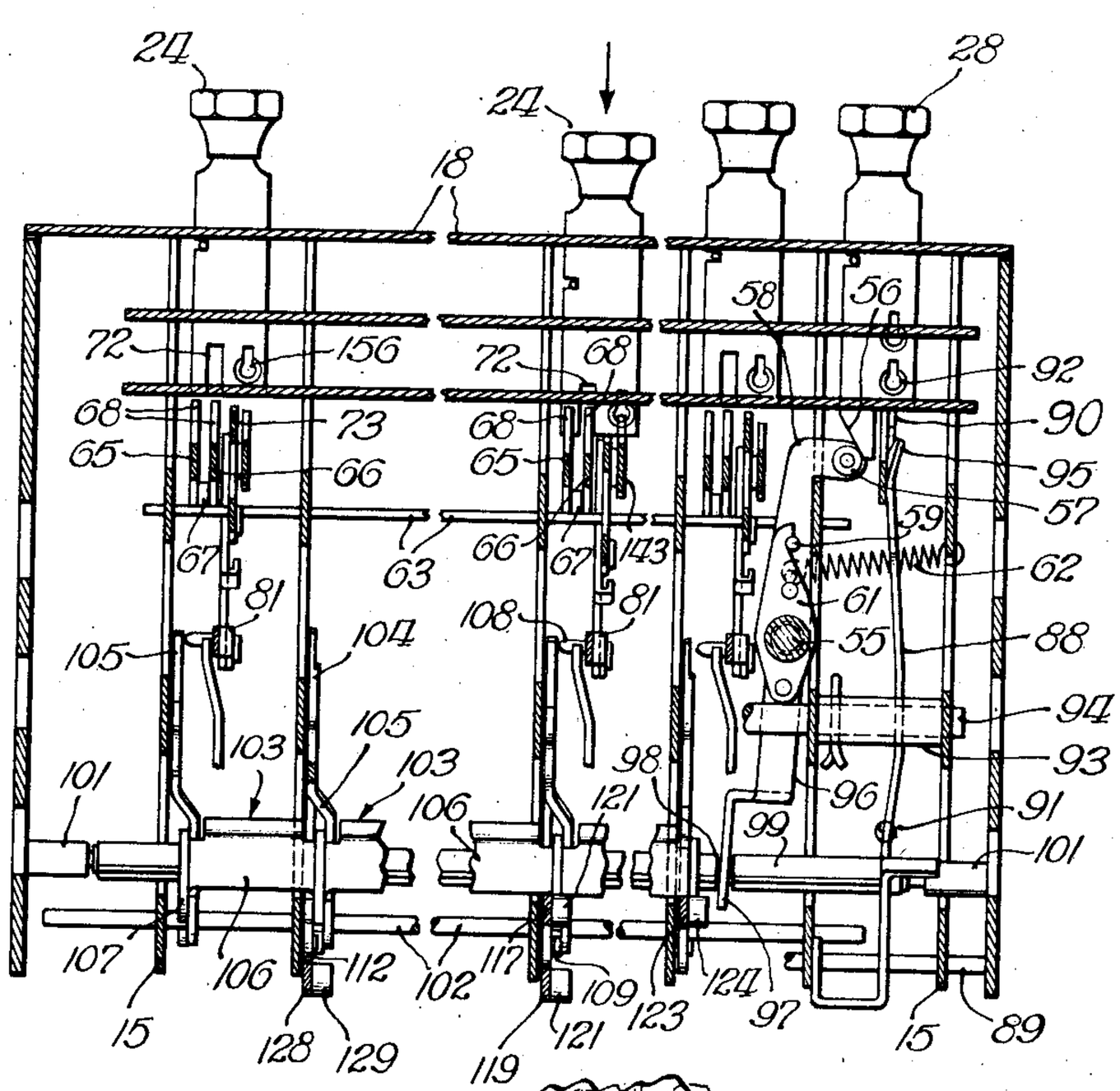
Fig. 3.



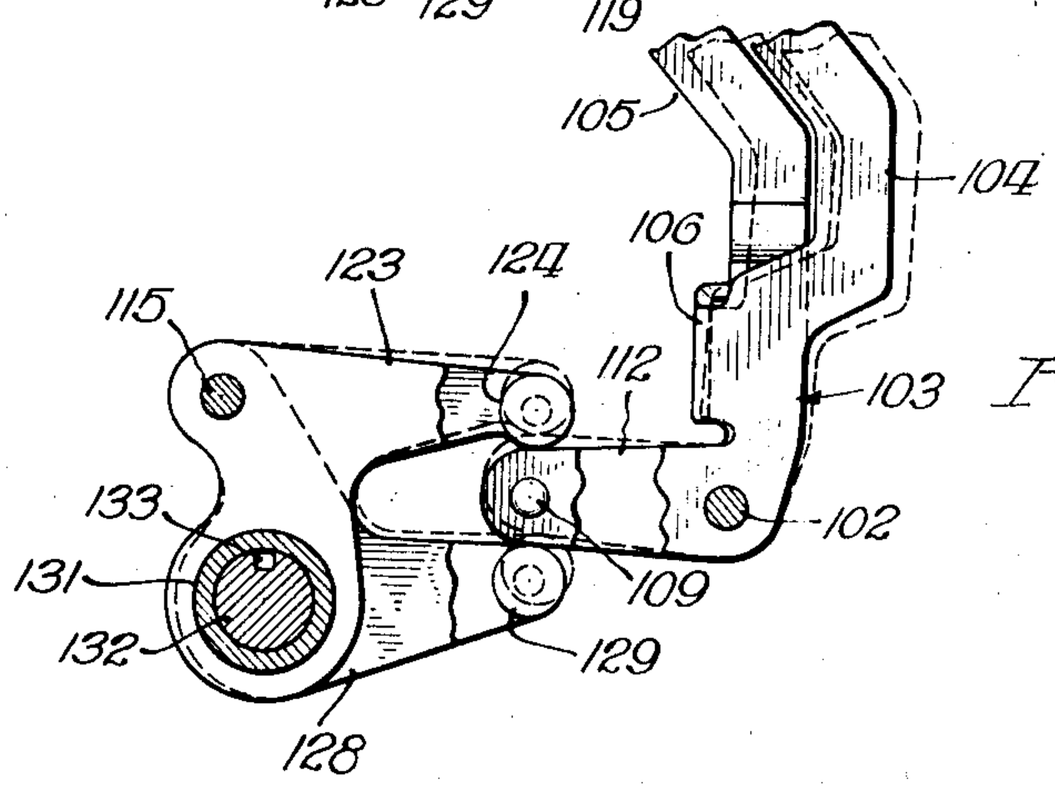


Fig. 4.

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KEY-RESPONSIVE CALCULATING MACHINE

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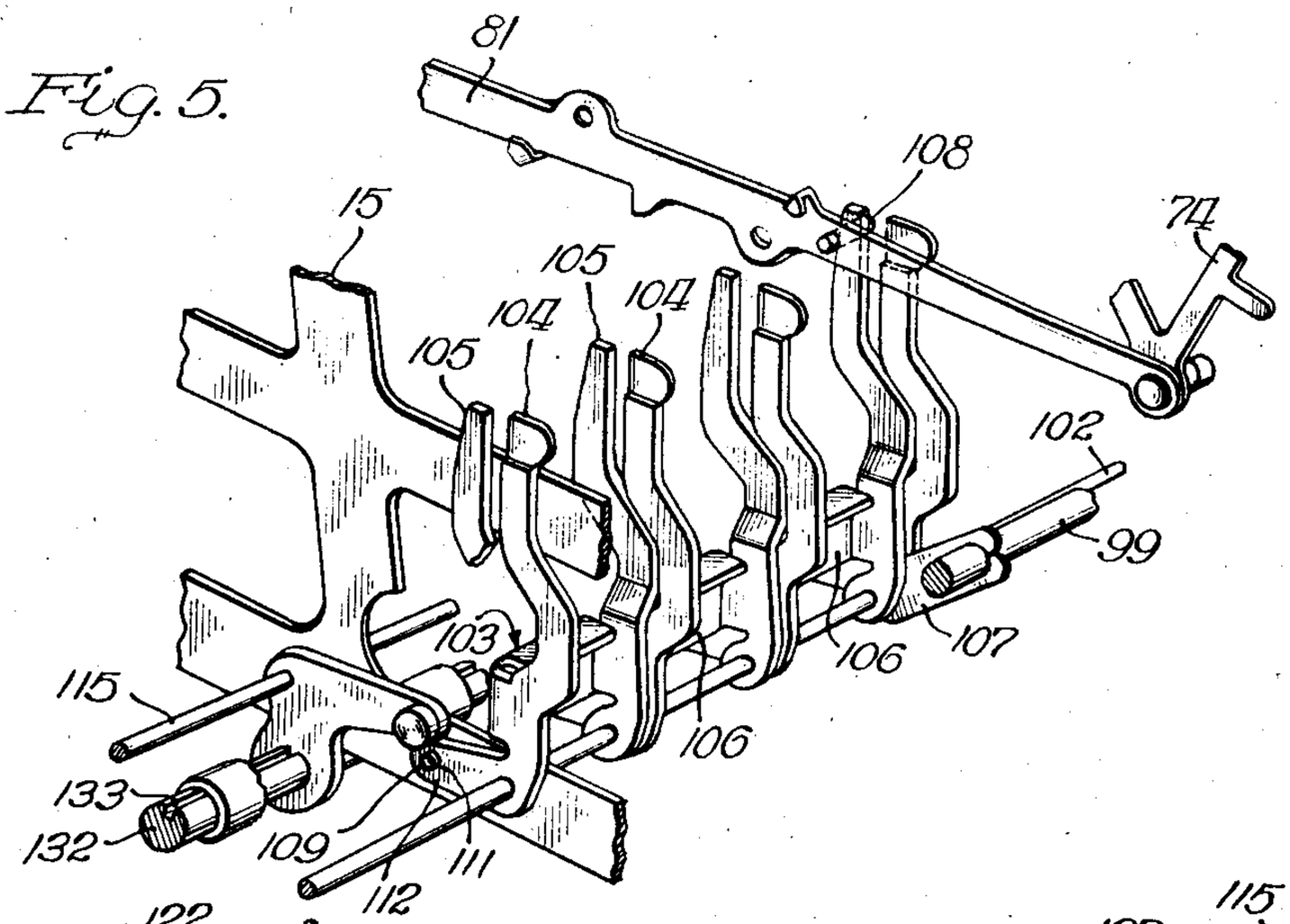
Fig. 5.



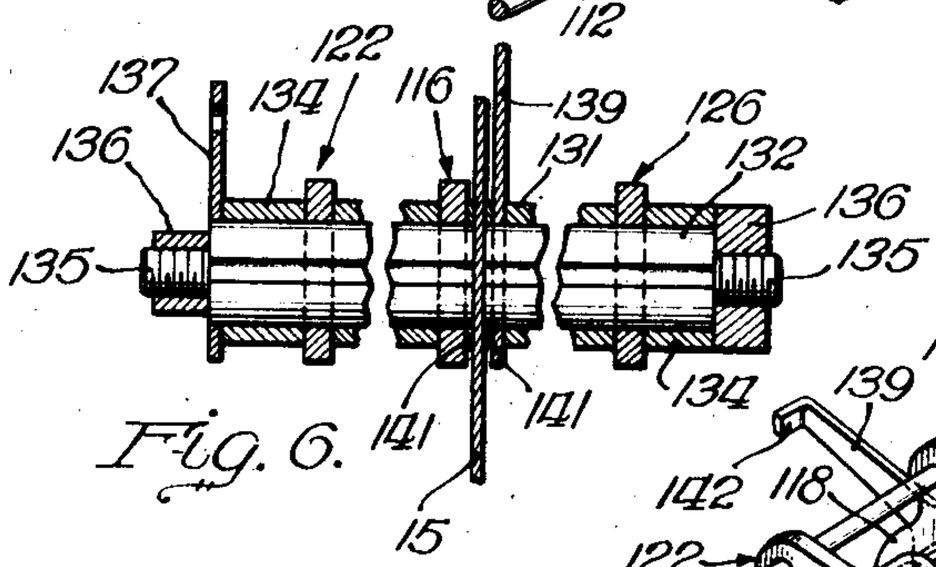
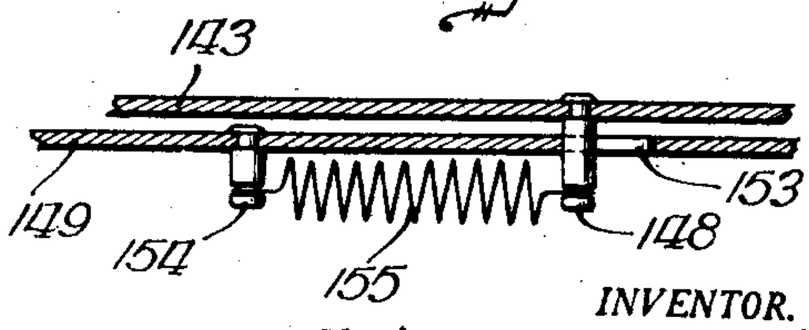


Fig. 6.

Fig. 7.

Fig. 8.



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Patented Nov. 11, 1947

2,430,575

UNITED STATES PATENT OFFICE

2,430,575

KEY-RESPONSIVE CALCULATING MACHINE

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Application February 5, 1945, Serial No. 576,334

16 Claims. (Cl. 235—82)

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This invention relates in general to calculating machines and has more particular reference to power-driven, key responsive calculating machines adapted to be selectively preset for any of the positive or negative forms of calculation and in response to key manipulation thereafter to perform the selected form of calculation.

An object of the invention is to simplify, facilitate, and expedite the performance of division operations in and with key-responsive calculating machines.

A further object of the invention is to enable the speedy, uniform, rhythmic, reciprocative operation, during division calculations, of the keys of a calculating machine of the type disclosed, by making a series of denominational orders of calculating mechanism respond more nearly simultaneously to the operation of keys in some of those orders and by enabling all of the keys so reciprocatively operated to be completely depressed to a uniform depth even if the operator depresses the keys so non-synchronously that at the instant that a key is only a small fraction of the way down the calculating mechanism in that order has already operated to the same extent as if that key were all the way down, by virtue of its responding substantially simultaneously with other orders of calculating mechanism to the more advanced depression of a key in a higher denominational order.

Another object of the invention is the provision of novel and improved means for causing the automatic entry in the accumulator of nines (9's) in each denominational order, without depression of a digital key therein, between the leftmost or highest order of the divisor in a division operation and the units order and the automatic entry of ten (10) in the units order if no key is depressed therein.

A further object of the invention is the provision of such means for the automatic entry of ten (10) in the units order and nines (9's) in the higher orders to the left thereof to and excluding the highest order of the divisor without depression of a digital key in the units or such higher orders, which functions substantially simultaneously in the various automatically actuated orders.

Another object of the invention is the provision of novel and improved transmission means adapted to be rendered effective when the machine is set for division and thereafter to transmit the actuation of a key-operated order to all orders to the right thereof substantially simultaneously.

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A further object of the invention is the provision of inter-order transmission means which in response to digit-key manipulation in any order of the machine is adapted in the key-operated order to operate means for simultaneously operating the transmission means in a plurality of orders to the right of the key responding order whereby to operate all orders of the register actuator to the right of the key operated order substantially simultaneously.

The invention has as another object the provision of such key-detaining means which, if in key-detaining position as an associated digital key is depressed, is engageable by the downwardly moving key and yieldable under such engagement to permit complete depression of the key.

Numerous other objects of the invention will be apparent as it is better understood from the following description, which, when taken in connection with the accompanying drawings, discloses a preferred embodiment thereof.

In the drawings:

Fig. 1 is a top plan view, more or less diagrammatically showing a multi-order, power-driven, key-responsive calculating machine embodying the features of the invention;

Fig. 2 is a longitudinal vertical cross-section of a portion of the machine shown in Fig. 1, taken on a plane adjacent a column of digital keys, with portions of the casing broken away or otherwise removed and with certain more or less conventional parts omitted for purposes of clarity, and shows one of the orders of calculating mechanism;

Fig. 3 is a transverse cross-section taken at the rear of the machine looking forwardly, with certain parts omitted more clearly to bring out the details of the division control means and the transmission means when the machine is set for additive actuation;

Fig. 4 is a fragmentary end elevation of the novel transmission means, partially in cross-section and with parts broken away or removed for facilitating an understanding thereof;

Fig. 5 is a fragmentary perspective view of the transmission means shown in relation to a key-operable member and a supporting frame element of the machine;

Figs. 6 and 7 are a fragmentary longitudinal cross-section and perspective view, respectively, of a portion of the transmission means shown at the left in Fig. 4, Fig. 6 being taken substantially along the lines 6—6 of Fig. 7, but drawn at a different scale; and

Fig. 8 is a fragmentary longitudinal cross-sec-

tion through an element of the novel key-detaining means, taken substantially along the lines 8—8 of Fig. 2.

For the purpose of illustrating the invention, the drawings more or less diagrammatically show a key-responsive, power-driven calculating machine of the multi-order type, that is to say having a plurality of denominational orders of calculating mechanism. The illustrated machine is similar to that disclosed in United States Letters Patents No. 2,018,933, issued October 29, 1935, and No. 2,063,962, issued December 15, 1936, with improvements disclosed and claimed in United States Letters Patent No. 2,410,823, issued November 12, 1946, and my copending application, Serial No. 454,111, filed August 8, 1942.

The various instrumentalities of the illustrated machine are mounted in cooperative relationship on skeleton frame members or partition plates 15. Those frame members 15 are secured together in spaced relationship by tie rods 16 and are respectively arranged between the actuating mechanisms of each succeeding and the next preceding denominational orders of calculating mechanism in a suitable casing 17. The upper wall of the casing 17 is adapted to accommodate a suitable key board 18, and is provided with suitable sight openings 19 revealing the digits of any number registered by the registering mechanism, and other apertures to render accessible a motor control switch 21, a register clearing or zeroizing lever 22, and a release key 23.

Slidably depending through the key board 18 are the stems of a plurality of reciprocable digital keys 24 which are normally held in their raised or elevated positions by suitable springs. There is one such column of digital keys 24 for each denominational order of calculating mechanism. The keys of each column bear the numerals, progressing from the forward end of the keyboard toward its rear end, of from one (1) to none (9), respectively corresponding to the digital values of the keys. As more fully described in United States Letters Patent No. 2,043,021, issued June 2, 1936, a plurality of anchor-shaped locking members 25 respectively arranged between each succeeding and the next preceding key stems in each column of keys 24 cooperate with one another and the key stems to prevent the simultaneous depression of more than one key in any one denominational order, without interfering with the simultaneous operation, where desired, of any one key and any other key in each of any number of the denominational orders.

Also slidably depending through the keyboard are the stems of a plurality of reciprocable calculation control keys which like the digital keys 24 are normally held in their raised or elevated positions by suitable springs. Those calculation control keys are adapted to cooperate with the zeroizing lever 22 and the release key 23 to enable a user to set the machine for performing any desired form of calculation, and comprise a pair of subtraction control keys 26 and 27, the former, called a subtraction key, being indicated by a conventional minus or subtraction symbol and the latter, called an equals key, being indicated by a conventional equals symbol, and a division control key 28, called a division key, and being indicated by a conventional symbol for division.

Briefly, depression of the subtraction key 26 sets the machine for subtraction and for key-set operation wherein the digital keys 24 upon depression remain depressed without actuating the accumulator and registering mechanisms until

the equals key 27 is operated. Operation of the equals key while the subtraction key is depressed effects the application of power to each denominational order in which a digital key 24 is in depressed position and results in the subtraction of the value represented thereby from the number previously set up in the registering mechanism, the release of the depressed digital key or keys and the subtraction key, and their return to their elevated positions by their respective springs. Depression of the division key 28 sets the machine for division. The release key 23 is operable to release the division key for return to its raised position and to release the digit keys 24 which were inadvertently or erroneously depressed while the subtraction key 26 is in the depressed position. The zeroizing lever 22 is operable to perform the same functions as the key 23 in addition to its main function of zeroizing the register. Only one of the calculation control keys 26 and 28 can be depressed at any one time. When neither is depressed, or if either is depressed, when it is returned to its elevated position, the machine is set for addition or multiplication.

While as mentioned above and as in fact indicated in Figs. 1, 3, and 5 to 7 of the accompanying drawings, the illustrated machine is of the multi-order type, only one denominational order of calculating mechanism is shown in Fig. 2. All other denominational orders of the machine, except as may be hereinafter otherwise indicated, are duplicates of that shown in Fig. 2 and need not therefore be individually disclosed.

It will be understood by those skilled in this art that each such denominational order of calculating mechanism comprises in general a registering mechanism adapted to register a digital portion of an answer or number, an accumulator mechanism including carrying mechanism adapted to accumulate digital values and, when such value exceeds nine (9), to transfer one (1) to the next higher denominational order for addition therein, and an actuating mechanism adapted to apply power to the accumulator and registering mechanisms whereby digital values entered by direct actuation of the denominational order of calculating mechanism and those transferred from the next lower denominational order, if any, may be accumulated and registered by the accumulator and registering mechanisms. The control devices 21, 22, 23, 26, 27 and 28 hereinbefore mentioned so control the various denominational orders of calculating mechanism that the machine may be selectively preset for the various forms of positive calculation, i. e., addition and multiplication, and negative calculation i. e., subtraction and division, and in operation the machine is adapted to perform the selected form of calculation.

The structural and functional details of the above mentioned mechanisms are all either fully and completely disclosed in one or more of the above identified patents and application or, in any event, per se constitute no part of the present invention. The disclosure of such details will not therefore be repeated herein. Instead only so much thereof as may be necessary for an understanding of the invention will be described hereinafter.

In operating such a calculating machine, the motor control switch 21 is closed to energize an electrical motor, not shown. The electrical motor, when energized, through suitable connections, continuously rotates a power shaft 29 in a coun-

terclockwise direction as viewed in Fig. 2. The power shaft 29 rotates a plurality of toothed wheels or power clutch members 31 fixed thereon and respectively associated with the various denominational orders of calculating mechanism.

Each toothed wheel 31 is engageable by one of a plurality of hooks or power clutch members 32 in the respective orders of calculating mechanism and, when engaged, pulls the associated hook 32 rearwardly of the machine or to the left in Fig. 2. The rearward movement of each hook 32 results in counterclockwise swinging movement of a vertical guide arm 33, to the upper end of which the hook is pivoted, about a shaft 34 extending transversely of the machine through the frame members 15 and carrying the guide arms 33. Such swinging movement of any guide arm 33 extends a spring 35, there being one spring 35 for each guide arm 33, connected at one end to the guide arm and at its other end to a transverse shaft or rod extending through the frame members 15. When a toothed wheel 31 engaged by its hook 32 rotates counterclockwise a predetermined distance, about the distance between succeeding teeth, a succeeding tooth on the toothed wheel cams the hook out of engagement with the toothed wheel, whereupon the energized spring 35 swings the hook and the vertical guide arm 33 clockwise in Fig. 2 or forwardly of the machine about the shaft 34 to their initial positions.

Rearward movement of any hook 32 as just described acts through a yielding clutch 36 and a link 37, pivotally connected at its opposite ends to the hook and yielding clutch, to move a gear sector 38 downwardly (Fig. 2) on an idle stroke a variable distance of from one (1) to nine (9) graduated steps, determined by the digital value of the particular key 24 which may be depressed in that order of calculating mechanism. There are one such yielding clutch, link, and gear sector for each order of calculating mechanism, and the gear sectors are rotatably mounted on a transordinal shaft 39 extending through the frame members 15. Each yielding clutch 36 permits interruption of the downward movement of the associated gear sector 38 without interrupting the full rearward movement of the hook 32. Upon the return movement of the hook 32 by the spring 35, after disengagement of the hook by the toothed wheel 31, as already described, the yielding clutch permits movement of the hook 32 and the link 37 relative to the gear sector and thereafter drives the gear sector upwardly from the position at which it was stopped during its downward movement, to its initial position.

During each upward movement of any gear sector 38 as just described, it imparts digital advancement to a corresponding one of a plurality of denominational orders of correlated accumulator and registering mechanisms, the degree of advancement being determined by the variable distance that the gear sector 38 is moved by the reciprocation of the corresponding hook 32. For that purpose, in each denominational order of the machine as shown in Fig. 2, the gear sector 38 meshes with an actuating pinion 41 rotatable on a transordinal shaft 42 supported by the frame members 15. The actuating pinions 41, during idling downward movement of the respective gear sectors 38, rotate relative to, and, during upward driving movement thereof, drive through internal ratchet mechanisms not shown, combined lantern wheels and accumulator gears 43, each journaled on the shaft 42 in cooperative relationship with one of the actuating pinions 41. The gear of each

combined lantern wheel and accumulator gear 43, when so driven, rotates a carrying gear 44 meshing therewith and thereby rotates an intermediate gear 45 meshing with the carrying gear 44, a numeral wheel gear 46 meshing with the intermediate gear 45, and a numeral wheel 47 secured to the numeral wheel gear 46 for rotation therewith. The carrying gears 44, the intermediate gears 45, and the numeral wheel gears 46 with their respective numeral wheels 47 are respectively journaled in cooperative relationship in the various denominational orders of the machine on transverse shafts 48, 49 and 51. The transverse shafts 49 and 51 are supported in the frame plates 15, and the shaft 48, as will be understood by those skilled in this art, is in a rock frame that is pivoted on the shaft 49. The numeral wheels 47 bear the ordinal numbers of from "1" to "9" and a zero or cipher equispaced about their peripheral flanges and registerable with the respective sight openings 19 in the casing 17. Those numbers on each numeral wheel respectively correspond in position to the movements of the numeral wheel under the actuation of the gear sector 38.

Carrying mechanism is provided in each denominational order of accumulator mechanism for imparting a digital unit of actuation thereto each time that the digital value accumulated in the next lower denominational order of accumulator mechanism exceeds nine (9). Such carrying mechanism, as well as the accumulator mechanism is fully disclosed in United States Letters Patents No. 1,357,747 and No. 1,357,748, both issued on November 2, 1920, and as shown in Fig. 2 includes, briefly, a carrying-cam member 52 which is given a half revolution by a suitable carrying motor spring 53 associated with the carrying gear of the next lower denominational order when the digital value accumulated therein exceeds nine (9). The carrying-cam member 52 acts on a roll secured to a bell-crank carrying lever, not shown, to swing the latter in such a direction that it will cause a carrying pawl 54 pivotally mounted thereon to rotate the combined lantern wheel and accumulator gear 43 sufficiently to impart, through the meshing gears 44, 45, and 46, a digital unit of actuation to the numeral wheel 47.

When the division key 28 is depressed from the elevated position shown in Fig. 3 to its set position, it rotates a suitably supported, longitudinally extending rock shaft 55 counterclockwise as viewed in Fig. 3 by means of a cam portion 56 at the lower end of the stem of the division key, a cam roll 57 carried at the upper end of an upright arm 58 of a rockable lever rotatably supported on the rock shaft 55, a pin 59 fixed in and projecting from the upright arm 58, and another upright arm 61 fixed on and rotatable with the rock shaft 55 adjacent the arm 58 and yieldably held in engagement with the pin 59 by a suitable spring 62. Somewhat similar means, not shown, are associated with the subtraction key 26 for rotating the rock shaft 55 as just described. Such an arrangement permits the rotation of the rock shaft 55 by either the subtraction key 26 or the division key 28 against the action of the springs like that shown at 62, and those springs reversely rotate the rock shaft to its initial position upon the return to the elevated position of whichever key 26 or 28 is employed to set the machine for subtraction or division, respectively.

The rock shaft 55 in rocking as just described, reciprocates, through suitable connections, not shown, a forward transverse support member 63

and a rearward transverse support member 64 that are supported in the intermediate frame members 15 and auxiliary frame pieces 60, respectively, for slidable movement transversely of the machine. Supported on the transverse members 63 and 64 for individual, reciprocable movement longitudinally of the respective columns of digital keys is a plurality of movement controlling members adapted to cooperate with the digital keys 24 for controlling the degree of digital actuation of the machine. Each such movement controlling member comprises a pair of complemental stop bars 65 and 66 secured together in spaced relationship by studs 67 and each has formed thereon a plurality of spaced, vertically projecting stop lugs 68. Each pair of stop bars 65 and 66 is pivotally connected at 69 to an arm 71 of the gear sector 36 in the same denominational order of the machine and is moved forwardly and rearwardly by the gear sector as it is moved downwardly and upwardly, respectively, by the hook 32 of the power clutch.

The stop lugs 68 on each stop bar 65 are so spaced relative to the depending stems of the digital keys 24 in each denominational order of the machine that they are normally, when the machine is set for positive forms of calculation, during forward movement of the pair of stop bars, engageable with the lower ends of the stems of the respective digital keys in that denominational order, when in the depressed position, to limit the downward idling movement of the connected gear sector 38 to distances respectively corresponding to the digital values of the digital keys 24 depressed. The gear sector 38 during its return to its upper position to advance the accumulator and registering mechanisms corresponding amounts, returns the pair of stop bars 65 and 66 to their initial positions. The stop bars 65 are therefore called positive calculation-control stop bars, and when they are in such cooperative relationship with the key stems, as shown in Fig. 3, the stop lugs 68 on each stop bar 66 are aligned with upwardly extending slots 72 in the lower ends of the digital key stems in the respective denominational orders of the machine. The slots 72 of the key stems are of such dimensions that the stop lugs 68 on the respective stop bars 66, when aligned therewith, may pass therethrough during reciprocation of the stop bars by the gear sectors.

When either the subtraction key 26 or the division key 28 is depressed, the support members 63 and 64 are shifted transversely of the machine to the left as viewed in Fig. 3 to move the stop lugs 68 on the stop bars 65 out of and those on the stop bars 66 into cooperative relationship with the stems in the respective columns of digital keys 24. The stop lugs 68 on each stop bar 66 are so spaced relative to the depending stems of the digital keys 24 in each denominational order of the machine that they, when the bars 63 and 64 have been shifted to the left as just described, are engageable, during forward movement of the pair of stop bars, with the lower ends of the stems of the respective digital keys 24 in the same denominational order when in the depressed position, to limit the downward idling movement of the connected gear sector 38 to distances respectively corresponding in all denominational orders, except the units order, to the nines complement, and, in the units order, to the tens complement of the digital value of the digital key 24 depressed. The gear sector 38 during its return to its upper position to advance the accumulator and registering mechanisms corresponding amounts, returns the pair of stop bars 65 and 66 to their initial rearward positions. The stop bars 66 are therefore called negative calculation-control stop bars, and when they are in such cooperative relationship with the key stems, the stop lugs 68 on each positive calculation-control stop bar 65 are to the left and clear the left sides of the key stems, as viewed in Fig. 3, during reciprocation of the stop bars by the gear sectors.

The digital keys 24 are adapted for manipulation to cooperate, as just described, with the complemental stop bars 65 and 66 to determine the digital degree of actuation to be imparted to the different denominational orders of accumulator and registering mechanisms. In moving downwardly into the path of one of the stop lugs 68, the stem of any depressed digital key 24 in the various denominational orders, as fully disclosed in the above mentioned Patent No. 2,063,962, engages and depresses a parallel motion bar 73, there being one such bar 73 for each column of keys 24, pivotally connected at its forward and rear ends to a pair of levers 74. The levers 74 at the forward ends of the bars 73 are pivotally carried on a cross-shaft 75 and those at the rear ends of the bars 73 are pivotally carried on a cross shaft 76, the shafts 75 and 76 being supported in the frame members 15. The downwardly moving bar 73 carries with it a depending, spring-held dog 77 pivoted thereon. The spring-held dog 77 in moving downwardly engages and depresses a spring-lifted lever 78 pivotally mounted on the guide member 33 with the hook 32 and yieldably connected thereto. When the lever 78 is thus depressed in response to the depression of one of the digital keys 24 in the same denominational order, it moves the hook 32 into clutching engagement with the toothed wheel 31, unless the hook is restrained in its disengaged position. To prevent the return of the dog 77 and the bar 73 to elevated positions before the hook 32 fully engages the toothed wheel 31, a spring-urged latch member 79 is pivoted on a power-trip link 81 in each denominational order of the machine. The power-trip links 81 are pivotally connected at their opposite ends to the respective pairs of levers 74. Just prior to the release of the hook 32 by the toothed wheel 31 during rearward movement of the former, a pin 82 in an upwardly extending arm 87 of the guide member 33 engages a finger 83 of the latch member 79 and rotates the latch member sufficiently to remove its engaging arm 84 out of latching engagement on a laterally projecting end lug 85 of the dog 77. That frees the dog 77 from the latch, thus permitting the parallel motion bar 73 to return to its normal, raised position. Suitable springs 86, each attached at one end to one of the rear levers 74 below its pivot and to the corresponding one of the latch members 79 contribute toward yieldably holding the respective parallel motion bars 73 in their elevated positions.

When the division key 28 is depressed, the lower end of its stem engages an angular surface of a projection 90 formed at the upper end of a vertical lock lever 88 (Fig. 3). The lock lever is rotatably mounted at its lower end on a transverse shaft 89 supported in the frame members 15. The downwardly moving stem of the division key 28 cams the lever 88 forwardly about the shaft 89 against the action of a suitable spring 91. When the division key reaches its set position, the projection 90 registers with an aperture

92 in the key stem and the spring 91 rotates the lever 88 rearwardly about the shaft 89 sufficiently to move the projection 90 into the aperture 92. Thus the division key 28 is locked in its depressed or set position, and will remain in that position until released by operation of the zeroizing lever 22 or depression of the release key 23. Intermediate its ends, the lock lever 88 is arranged in a slot cut in a sleeve 93 on a transordinal shaft 94 supported in the frame members 15. That slot in the sleeve registers with a slot in the shaft 94 providing a flat portion against which the lock lever 88 is yieldably held by the spring 91 when the division key is in its set position. Operation of the zeroizing lever 22 or depression of the release key 23 rotates the shaft 94 causing its flat portion to cam the lever 88 against the action of the spring 91 in a direction to remove the projection 90 from the aperture 92. After the projection 90 is removed from the aperture 92 by the advance of the lever 88, due to the rotation of the shaft 94, then further advance of the lever 88 causes a cam finger 95 on the upper end of the lever 88 to engage the stem of the division key 28 and thereby to cam the division key 28 upwardly, thus cooperating with the spring of the division key to elevate the key to its initial position.

In the use of such a machine to perform division, the motor control switch 21 is operated to cause the rotation of the power shaft 29. The dividend is registered on the numeral wheels 47 by depressing the digital keys 24 bearing the figures of the dividend and located in the denominational orders respectively corresponding to those of the digits in the dividend. The division key 28 is thereafter depressed to its set position and releasably locked therein as just described. In moving downwardly the division key 28 rotates the shaft 55 and thus moves the positive calculation control stop bars 65 out of and the negative-calculation control stop bars 66 into cooperative relationship with any digital keys 24 which are subsequently depressed. Consequently the subsequent depression of digital keys will result in the entry of the tens complement of the value on the keys depressed in the units order and the nines complement of the value on the keys depressed in each other order.

Beginning with the left-most sight opening 19 revealing a digit of the dividend and proceeding to the right, a number of digits of the dividend equal to the number of digits in the divisor are compared in value with the divisor. If, on the one hand, such digits of the dividend, considered as a number, are equal to or greater than the divisor, the finger tips are arranged to contact the digital keys 24 representing the respective digits of the divisor in those left-most denominational orders, unless one or more of the digits in the divisor are ciphers, indicating a lack of values in such denominational order or orders of the divisor. If, on the other hand, such digits of the dividend, considered as a number, are less than the divisor, the finger tips, similarly arranged, are shifted to the right a distance equal to that between adjacent columns of digital keys 24 to contact the digital keys representing the respective digits of the divisor in the denominational orders wherein the second-from-the-left and rightward-succeeding digits of the dividend appear, unless one or more of the digits in the divisor are ciphers. Like the machine disclosed and claimed in the above-mentioned Letters Patent application Serial No. 454,111, the finger tips are arranged to contact a "9" key in each corresponding denominational order wherein a figure "9" occurs in the divisor, and not to contact a digital key in any denominational order corresponding to a digit of zero value of the divisor.

With the finger tips so arranged, the digital keys 24 representing the divisor are repeatedly and simultaneously depressed until the number of depressions equals the changing leftmost figure appearing in the sight openings 19 and thereafter until the digital values, considered as a number, appearing in the sight openings 19 of the denominational orders wherein the digital keys representing the divisor were depressed are less than the divisor. The finger tips identically arranged are then shifted to the right a distance equal to that between adjacent columns of digital keys 24, and the digital keys representing the divisor so displaced to the right are repeatedly and simultaneously depressed until the number of depressions equals the changing figure appearing in the sight opening 19 immediately to the right of the sight opening 19 wherein, during the preceding manipulation of the digital keys 24 representing the divisor, appeared the changing number, and until the digital values, considered as a number, appearing in the sight openings 19 of the denominational orders wherein the digital keys representing the divisor were depressed during this second manipulation of the digital keys are less than the divisor. The described key manipulation and shifting of the divisor to the right are repeated until the divisor is shifted to the right at least sufficiently to bring its right-most digit into the same order as the right-most sight opening 19 revealing a digit of the original dividend. The answer is then registered and is visible through the sight openings 19.

When the division key 28 is depressed, it not only conditions, as already described, the illustrated machine to add to the respective denominational orders of the dividend the tens complement of any digital key thereafter depressed in the units order and the nines complement of any digital key thereafter depressed in each of any number of other denominational orders of the machine, but it also conditions the machine, when the digital keys representing the divisor extend to the units order, to add the respective complements of zero in each order, except the units order, to the right of the leftmost or highest order of the divisor wherein no digital key is depressed, and to add "10" in the units order if no key is depressed therein; and, when the digital keys representing the divisor are spaced to the left of the units order automatically to add nines (9's) in the respective orders, except the units order, to the right of the lowest significant figure of the divisor; and to add ten (10) in the units order to cause the carrying mechanism to add one (1) in the denominational order in which the digital key representing the lowest significant digit of the divisor is being depressed.

Thus, the aforesaid Letters Patent application, Serial No. 454,111 discloses novel transmission means which is rendered effective by the division key 28 to transmit the manual force exerted in depressing a digital key 24 representing a digital value of a divisor from the order wherein that digital key is depressed to the right, transordinally, from one order to the next, to and including the units order. Such transmission means, as shown best in Figs. 3 to 5 herein, is so controlled from the division key 28 by virtue

of a downwardly extending arm 96 of the rockable lever having the upright arm 58. At its lower end the arm 96 is provided with a bifurcated portion 97 with its furcations arranged in a peripheral groove or slot 98 at opposite sides of a transordinal shaft 99. The shaft 99 is journaled for axial movement in bearings 101 fixed in the outer frame members of the machine, and is adapted to be moved to the right as viewed in Fig. 3 against the action of the spring 62 upon depression of the division key 28. When the division key is elevated, as already described, the spring 62, acting through the upright arm 61, the pin 59, and the arms 58 and 96 of the rockable lever, returns the shaft 99 to its initial position.

The reciprocation of the shaft 99 by the division key 28 and the spring 62 renders the transmission means just mentioned effective and ineffective, respectively. That transmission means comprises a transordinal shaft 102 supported by the frame members 15 in parallel relationship to the shaft 99, and a plurality of overlapping actuation levers 103, there being one such lever rotatable on and slidable along the shaft 102, and extending between each two adjacent denominational orders of the machine. Each lever 103 is provided with spaced upstanding arms 104 and 105 which near their lower ends are connected together by a transverse spanning or bail member 106. The arm 105 of each overlapping lever 103 is offset rearwardly and transversely of the machine (Fig. 5) sufficiently to be aligned with the arm 104 of the lever 103 in the next lower denominational order of the machine.

The overlapping levers 103 are normally yieldably maintained in the lateral position shown in Figs. 3 and 5 by the spring 62. Fixed on the shaft 99 is a plurality of spaced lever shifting arms 107 which are provided with bifurcated rearward portions embracing the shaft 102. One such arm 107 embraces the shaft 102 between each two adjacent levers 103 and outwardly of each of the left-most and right-most levers 103 adjacent the arms 104 and 105, respectively. In the lateral position of Figs. 3 and 5 the upper ends of the overlapping arms 104 and 105 of each two adjacent levers 103 are out of the path of a pin 108 projecting to the right from and intermediate the ends of the power trip link 81 of that denominational order of the machine. In that position the levers 103 are held against rotation on the shaft 102 by pins 109 fixed in and projecting leftward from the respective frame members 15 and into respectively registering apertures 111 in rearwardly extending arms 112, there being one such arm 112 formed at the lower end of the arm 104 of each lever 103.

When the shaft 99 is shifted to the right viewing Fig. 3 by depression of the division key 28, the shifting arms 107 move with it and in turn move or slide the levers 103 along the shaft 102 to bring the overlapping lever arms 104 and 105 into the paths of the pins 108 in the respective power trip links 81. Such shifting of the levers 103 moves the rearwardly extending arms 112 sufficiently to disengage the pins 109, thus freeing the levers 103 for rotation about the shaft 102. In such position, the respective arms 104 of the levers 103 are forwardly and the respective arms 105 are rearwardly of the pins 108 (Fig. 5).

With such an arrangement, depression of a digital key 24 in any denominational order of the machine is, through the downward movement of the associated parallel motion bar 73 and its

supporting levers 74, translated into and results in the forward movement of the power trip link 81 connecting those levers 74, and hence forward movement of the pin 108 of that power trip link. Thus the forward moving pin 108 moves away from the arm 105 of the lever 103 extending into the next higher denominational order, if any, and engages the arm 104 of the lever 103 extending into the next lower order, if any, of the machine. Through the arm 105 of the last mentioned lever 103, forward movement is transmitted to the pin 108 of the power trip link 81 of the next lower order, causing forward movement of that link 81. Such forward movement of that power trip link 81 of the next lower order acting through the associated levers 74 of that order is translated into and results in the downward movement of the associated parallel motion bar 73. In moving downwardly while the power trip link 81 is moving forwardly, that parallel motion bar 73 acting through the spring-held dog 77 thereon, and the associated spring lifted lever 78 causes the depression of the hook 32 into engagement with its toothed wheel 31, thus actuating that order of calculating mechanism. During the operation of that order of calculating mechanism, so actuated without depression of a digital key therein, the next lower order of calculating mechanism is likewise actuated by the associated arms 104 and 105 of the overlapping levers 103 of those orders, and the power trip link 81, levers 74, parallel motion bar 73, spring-held dog 77, spring-lifter lever 78, hook 32, and toothed wheel 31 of such next lower order, and so on from each preceding denominational order to each succeeding lower denominational order to and including the units order.

Thus as any power trip link 81 is given forward movement by depression of a digital key 24 in its denominational order, the movement is transmitted from the arm 104 to the arm 105 of the lever 103 of the actuated order and the next lower order, respectively, thence to the power trip link 81 of that next lower order, and as each of that and succeeding power trip links 81 in lower denominational orders is given forward movement, it transmits the forward movement through the arms 104 and 105 to the power trip link 81 in the next lower order to cause actuation thereof. Since no digital key was depressed in any such lower denominational order, it will be seen that the forward movement of the negative calculation control stop bar 66 in each such lower denominational order is not interrupted, hence that stop bar 66 receives full forward movement. Consequently, the gear sector 38 of each such lower denominational order receives its maximum downward movement from its toothed wheel 31 and hook 32 through the connecting link 37 and yielding clutch 36. That maximum downward movement of the gear sectors 38 in those lower denominational orders is sufficient upon the upstroke of those gear sectors 38 under the action of the respective springs 35 to add ten (10) in the units order and nine (9) in each of the other denominational orders, where no key is depressed, lower than the highest or leftmost order actuated by depression of a digital key 24 therein.

The adding of ten (10) in the units order, as just described, causes a carry to take place in every order in which nine (9) was automatically added to the right of the lowest order of the divisor as described, and the resulting successive transfers of one (1) transordinally from right to left of the machine continues until the one (1) is carried or transferred into the order in which

the proper complement of the units digit of the divisor was added. Thus the transmission of the key depressing force from the denominational order of calculating mechanism wherein the digital key **24** representing the digital value of the units digit of the divisor progresses to successively adjacent lower orders or to the right as viewed from the front of the machine, while the carrying action caused thereby when ten (10) is added in the units order proceeds therefrom in the opposite direction or to the left as viewed from the front of the machine.

Unless the automatic actuation of the orders of calculating mechanism to the right of a key-actuated order occurs substantially simultaneously and unless such simultaneous actuation occurs substantially concurrently with the key operation in the key-actuated order or orders, the desired speed of repetitive manipulation of the digit keys **24** to perform, for example, division as already described, may not be possible of attainment because if the digit keys in the key-actuated orders are released quickly enough, then the series of overlapping levers **103** which cause actuation in the automatically actuated orders, may be released before they have caused such automatic actuation in some of the orders, or before all the parts of the actuating mechanism in such orders have returned to normal. A quick re-depression of the keys in the key-actuated orders can then cause the series of overlapping levers to exert a pressure on the pins **108** of their respective power trip links **81**, thereby to cause the operation of such automatically actuated orders which did not take place in the first instance, or to prevent the return to normal of the power trip links **81** and parallel motion bars **73**, and thereby to tend prematurely to cause a second actuation in such orders. Also the digital keys may be operated so non-synchronously that when the operator has depressed a key only a small fraction of the way down the parallel motion bar and power trip link normally operated thereby may have already been operated automatically as a result of a more advanced key depression in some column to the left. The key can nevertheless intercept the stop bar in time to permit no error in the calculation, and means are provided in the instant invention to permit said key to be fully depressed so as not to break the uniformity and rhythm of the reciprocative operation of the keys.

In order to enhance the speedy operation of the keys, means are provided in the present invention to cause the automatically actuated orders to operate more nearly simultaneously and concurrently with the operation of the key-actuated orders. Yieldability or deformation of the desirably light parts employed in the transmission means thus far described may result in a varying lag in the automatic actuation of successively adjacent orders, and the lags in such orders, however produced, are cumulative.

As in the above identified application, Serial No. 454,111, the illustrated machine includes means for insuring full forward movement of the power trip links **81** despite the cumulatively increasing strain upon the ordinal elements of the series of overlapping actuating levers **103** during the progressive actuations thereof. Such means comprises a cam portion **113** formed integrally with the center disc of each yielding clutch **36**. As each power trip link **81** is moved forwardly as earlier described and causes engagement of the associated hook **32** the link **37** connected thereto

moves rearwardly. That link **37** as already described, so moving rotates the center disc of the yielding clutch **36** in a clockwise direction as seen in Fig. 2. Such operation of the yielding clutch **36** causes its cam portion **113** to engage a roll **114** on the pivot between the forward end of the power trip link **81** and the forward one of the supporting levers **74** of the parallel motion bar **73** in the same denominational order of the machine and to force the roll **114** and hence the power trip link **81** forwardly. Such action removes or at least relieves the strain upon the overlapping levers **103** during operation thereof and therefore tends to avoid the above described lag in the progressive operation of those levers **103**.

The means including the cam portions **113** and the rolls **114** for insuring full forward movement of the power trip bars **81** and the overlapping levers **103** of the transmission means are quite satisfactory, where the transmission elements are sufficiently large and of sufficiently heavy stock to avoid undue yielding and are accurately made and arranged for a limited number of orders of calculating mechanism. To avoid the necessity of providing such heavy stock, and of incurring the expense and expending the time required in exercising such accuracy in the making and arranging of such elements, and to avoid the above described lagging effects of yielding, the novel transmission means is provided with means for operating all of the overlapping levers **103** to the right of any such lever operated in an order wherein a digital key is depressed substantially simultaneously with the operation of such last mentioned lever. The novel transmission means is thus adapted to effect, upon the depression of a digital key **24** representing the digital value of the units digit of the divisor, the automatic and substantially simultaneous addition of ten (10) in the units order and nine (9) in every other denominational order between the units order and the order of the machine wherein the mentioned digital key is depressed.

To that end, a transverse rod **115**, supported in the frame members **15** intermediate their ends and near the bottom side thereof, pivotally carries centrally thereof a two armed lever **116** having an upper forwardly extending arm **117**, a depending body or bail portion **118** at the pivoted end of the lever, and a lower arm **119** extending forwardly from the lower end of the depending body portion **118** and spaced below the upper arm **117**. The forward end of each arm **117** and **119** is provided with a stud **121** and the lever **116** is so positioned on the rod **115** that the studs **121** of its forwardly extending arms **117** and **119** respectively engage on and under the rearwardly extending arm **112** of the overlapping lever **103** having its arm **104** in a central denominational order of the machine.

Pivotally carried on the transverse rod **115** in spaced relationship with one another and with and to the left of the lever **116** is a plurality of overhanging levers **122**, each having a forwardly extending arm **123** with a stud **124** at its forward end and an arm **125** depending from the pivoted end thereof. The levers **122** are so arranged on the rod **115** that the respective studs **124** engage on the rearwardly extending arms **112** of the overlapping levers **103** having their arms **104** in the respective denominational orders of the machine to the left of the denominational order with which the lever **116** is associated as already described. To the right of the lever **116** and in spaced relationship therewith is a plurality of underlying

levers 126 pivoted in spaced relationship on the rod 115, each having an arm 127 depending from that rod and an arm 128 extending forwardly from the lower end of the arm 127 and provided at its forward end with a stud 129. The arrangement of the levers 126 is such that the respective studs 129 engage under the rearwardly extending arms 112 of the overlapping levers 103 having their arms 104 in the respective denominational orders of the machine to the right of the denominational order with which the lever 116 is associated as already decribed. Since the arm 104 of the right most lever 103 is in the tens denominational order or the order next the left of the units order, no lever 126 is provided in the units order.

The levers 116, 122, and 126 constitute a gang of levers arranged in two groups with the lever 116 forming a part of each group. These levers are held in the spaced relationship just described for rocking movements as a unit about the rod 115 by means of spacing sleeves 131 on a rod 132 which extends under and transversely of the frame members 15 and through the alternatingly arranged spacing sleeves and the depending portions 118, 125, and 127 of the respective levers 116, 122, and 126. The rod 132 is provided with a longitudinal slot or keyway 133 to facilitate keying or otherwise locking the levers thereto and at its opposite ends with sleeves 134 and threaded reduced portions 135 adapted to receive suitable nuts 136 for retaining the levers and sleeves in proper spaced relation on the rod 132. At its left end viewed from the front of the machine, the rod 132 carries an arm or member 137 arranged between the sleeve 134 and the nut 136, to which one end of a spring 138 is connected. The spring 138 extends rearwardly from the arm 137 and its other end is connected as shown in Fig. 2 to the pivot shaft 34. The spring 138 is tensioned for urging the lever assembly just described in a clockwise direction about the pivot rod 115 as viewed in Fig. 2, and a rearwardly extending arm 139 fixed on the rod 132 and spaced from the two-armed lever 116 by a sleeve 141, is provided with a laterally extending end lug or portion 142 engaging under the adjacent frame member 15 to limit the clockwise rotation of the levers 116, 122, and 126 about the rod 115 by the spring 138. Thus the spring 138 yieldably holds those levers in the position shown in Fig. 2.

With the machine set for division, the forward movement of any one of the power trip links 81 in or to the left of the order with which the lever 116 is associated, resulting from the depression of a digital key in the denominational order of that power trip link, is transmitted through the associated lever arm 104 to the rearwardly extending lever arm 112 on which the stud 121 or 124 of the overhanging arm 117 or 123 of the lever 116 or 122 engages. The resulting movement of the lever arm 112 swings the engaging overhanging lever 116 or 122 and hence all of the levers 116, 122, and 126 in a counterclockwise direction, as viewed in Figs. 2 and 7, about the rod 115 against the action of the spring 138. The upwardly moving arms 123 of the overhanging levers 122 in the orders to the left of the order wherein is located the two-armed lever and between the last mentioned order and the key-operated order permit the progressive transmission of the actuation from the key operated order to the order with which the lever 116 is associated, by the overlapping levers 103 of such adjacent orders automatically to add nine (9) in each of the intervening orders if no key is depressed therein, as already described. The upwardly moving lower or underlying arm 119 of the two-armed lever 116 and the arms 128 of the underlying levers 126, while the power trip link 81 of the key-operated order is moving forwardly, simultaneously rotate the respectively engaging lever arms 112 to cause the offset lever arms 105 to move the power trip links 81 forwardly in each order from the order with which the lever 116 is associated to the units order, inclusive. That causes, as already explained, the automatic addition of ten (10) in the units order and nine (9) in each of the other orders to the left thereof to and including the order with which the lever 116 is associated if no digit keys were depressed therein. Since the stud 121 on the upper or overhanging arm 117 of the two-armed lever 116 and the studs 124 on the overhanging levers 122 in such operation are in engagement with the rearwardly extending arms 112 of the respectively associated overlapping actuating levers 103, the levers 116, 122, and 126 are held in that operated position against the action of the spring 138 until the power trip links 81 in the order including the lever 116 and all higher orders to the left thereof are being returned to their initial rearward position as already described.

During such return movement of the power trip links 81, the pins 108 in moving rearwardly free the arms 104 of the associated overlapping levers 103, whereupon the spring 138 rotates all of the levers 116, 122, and 126 in a clockwise direction about the rod 115 as viewed in Figs. 2 and 7 until the laterally extending end portion 142 of the arm 139 is returned to its position of engagement under the frame member 15 as shown in Fig. 2, which as already described serves to limit and stop such clockwise rotation of the levers by the spring 138. In so moving, the arms 128 of the underlying levers 126 simultaneously free the rearwardly extending arms 112 of the overlapping lever in each of the orders to the right of the two-armed lever 116. The upper arm 117 of the two-armed lever 116 and the arms 123 of each overhanging lever 122 during such return movement simultaneously urge the rearwardly extending arms 112 in the order including the lever 116 and the other automatically actuated orders to the left thereof in a direction to rotate the respective overlapping levers 103 about the shaft 102 to their initial positions.

In the rapid and repetitive manipulation of a plurality of digital keys 24 in performing division, for example, as described hereinabove, the automatically actuated orders must operate substantially simultaneously and concurrently with the most advanced of the key-operated orders. It is not, however, desirable to compel the operator to preserve a perfectly timed relationship between the reciprocations of each manipulated digital key 24 in order to enable and permit the rhythmic manipulation of the keys with uniform length of stroke and thus to contribute to speedy operation without introducing the possibility of error. For that purpose I provide the illustrated machine with key detaining means which yieldably holds down the digital key in each denominational order wherein such a key is depressed until the parallel motion bar 73 of each such order is free to return to its normal elevated position, and which as mentioned is yieldable in its key detaining position, if therein when a key is depressed, in response to the downwardly mov-

ing key to permit the proper manipulation of the key under such conditions.

That yieldable key detaining means is best shown in Figs. 2 and 8 and comprises in each denominational order of the machine a bar **143** having upwardly and rearwardly inclining locking lugs or teeth **144** provided with downwardly and rearwardly inclining upper ends forming on each lug a detent portion **145** and a forwardly adjacent cam surface **146**. The lugs **144** of each bar equal in number the number of digital keys **24** in each denominational order and are spaced from one another along the bar about the distance between the stems of succeeding digital keys in the associated column of such keys. Each such bar **143** is provided with elongated apertures **147** at its opposite ends and with a laterally projecting pin **148** intermediate its ends and is slidably mounted between the parallel motion bar **73** of one of the denominational orders and an associated bar **149** on studs **151**. The mounting studs **151** project laterally from the forward and rear levers **74** of each denominational order of the machine through arcuate apertures **152** in the adjacent parallel motion bar **73** supported by those levers **74** and through the elongated apertures **147** in the bar **143** and suitable mounting apertures in the associated bar **149**. Intermediate its ends, each bar **149** is provided with an elongated aperture **153** through which the pin **148** extends and with a laterally projecting pin **154** rearwardly of the aperture **153**. A suitable spring **155** extending between and secured to the pins **148** and **154** yieldably holds the bar **143** in such position that the detent portions **145** of its lugs **144** are spaced slightly forwardly of the depressed positions of the respective stems of the digital keys and that the studs **151** are at the forward ends of the respective apertures **147** in the bar **143** and the pin **148** is at the rear end of the aperture **153** in the bar **149**.

The depression of any digital key **24** in any order of the machine moves the associated parallel motion bar **73** downwardly and its supporting levers **74** counterclockwise (Fig. 2) about their shafts **75** and **76**. That results in rearward movement of the associated bars **143** and **149**, such movement being transmitted to such bars by the studs **151** and being sufficient to move the detent portion **145** of the locking lug **144** corresponding to the depressed key into an aperture **156** (Fig. 3) in the lower end of the key stem, the stem of each digital key **24** being provided with such an aperture. When so operated the detent portion yieldably holds the key in its depressed position until the parallel motion bar **73** is returned to its normal elevated position.

If any such parallel motion bar **73** is in its lower position, as for example when the associated power trip link **81** is moved forwardly automatically by reason of the automatic actuation of lower denominational orders from a higher key-operated order as above described in connection with the performance of division, and while in that position one of the digital keys **24** is depressed in the order wherein the parallel motion bar is down, the lower end of the downwardly moving key stem engages the cam surface **146** of the corresponding locking lug **144** on the bar **143** and cams the bar **143** forwardly, the elongated apertures **147** in the bar **143** permitting forward movement of the bar relative to the studs **151** and the elongated aperture **153** in the bar **149**, through which the pin **148** extends permitting forward movement of the bar **143** relative to the bar **149**. Such forward movement of the bar **143** is relative to the bar **149** and the parallel motion bar **73** and is sufficient to permit the downwardly moving key stem to move to its completely depressed position. At that position the aperture **156** in the key stem registers with the detent portion **145** of the associated locking lug **144**, whereupon the spring **155** moves the bar **143** rearwardly relative to the bar **149** sufficiently to move the registering detent portion **145** into locking engagement in the aperture **156** of the stem of the depressed key yieldably to hold it down until the parallel motion bar **73** is being returned to its elevated position.

It is thought that the invention and many of its attendant advantages will be understood from the foregoing description and it will be apparent that various changes may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention or sacrificing all of its material advantages, the form of the invention hereinabove described being merely a preferred embodiment thereof.

I claim:

1. In a calculating machine having a plurality of ordinal columns of digit keys, a multi-denominational register, a multi-denominational register actuator responsive to said keys, ordinal digit stops which normally limit the motion of the actuator, ordinal complementary digit stops, a division control key, and means operable by said division control key to replace said digit stops by said complementary digit stops; normally inoperative means to cause substantially simultaneous operation of each denominational element of the register actuator by the next adjacent higher denominational element in all orders in which no keys have been depressed lower than the highest denominational order which is responsively operated by said digit keys, means cooperating with said last means, and arranged in two groups of consecutively adjacent orders and adapted to cause all elements of the lower denominational group to operate simultaneously upon the operation of any one or more elements of the higher denominational group responsive to the depression of a digit key in such denominational orders, and means operable by said division control key to bring said normally inoperative means and said cooperative means into operative relationship with said register actuator.

2. In a calculating machine having a keyboard, a multi-denominational accumulator, a multi-denominational accumulator actuator, stops to limit the maximum motion of each denominational element of the accumulator actuator to nine units except the lowest denominational element which may have a maximum motion of ten units, ordinal digit stops which limit the motion of the elements of the accumulator actuator according to the digit values set up on the keyboard, tens-complementary digit stops associated with the lowest denominational element of the accumulator actuator, and ordinal nines-complementary digit stops associated with all other denominational elements of the accumulator actuator; normally inoperative overlapping connections to cause substantially simultaneous operation of each denominational element of the accumulator actuator by the next adjacent higher denominational element in all orders in which no keys have been depressed lower than the highest denominational order which is responsively operated by said key board, means cooperating

with said overlapping connections and arranged in two groups of consecutively adjacent orders and adapted to cause all elements of the lower denominational group to operate simultaneously upon the operation of any one or more elements of the higher denominational group responsive to the depression of a digit key in such denominational orders, a division control key, means operable by said division control key to replace said digit stops by their respective complementary digit stops, and means operable by said division control key to bring said normally inoperative overlapping connections and said cooperating means into operative relationship with the denominational elements of said accumulator actuator to responsively enter the complement of the value set up on the keyboard into said accumulator.

3. In a calculating machine having a plurality of ordinal columns of digit keys, a multi-denominational register, and a multi-denominational register actuator each denominational element of which is responsive to an ordinal column of digit keys; means for substantially simultaneously operating each denominational element of the register actuator by the next adjacent higher denominational element in all orders in which no keys have been depressed lower than the highest denominational order which is responsively operated by said digit keys, and means cooperating with said last means and arranged in two groups of consecutively adjacent orders and adapted to cause all elements of the lower denominational group to operate simultaneously upon the operation of any one or more elements of the higher denominational group responsive to the depression of a digit key in such denominational orders.

4. In a calculating machine having a plurality of ordinal columns of digit keys, a multi-denominational register, and a register actuator comprising a series of denominational elements each responsive to an ordinal column of digit keys; a calculation control key, normally inoperative means for substantially simultaneously operating each denominational element of the register actuator by the next adjacent higher denominational element in all orders in which no keys have been depressed lower than the highest denominational order which is responsively operated by said digit keys, means cooperating with said last means and arranged in two groups of consecutively adjacent orders and adapted to cause all elements of the lower denominational group to operate simultaneously upon the operation of any one or more elements of the higher denominational group responsive to the depression of a digit key in such denominational orders, and means operable by said calculation control key to bring said normally inoperative means into operative relationship with the denominational elements of the register actuator.

5. In a calculating machine having a plurality of ordinal columns of digit keys, a multi-denominational register, a multi-denominational register actuator responsive to said keys, ordinal digit stops which normally limit the motion of the actuator, ordinal complementary digit stops, a division control key, and means operable by said division control key to replace said digit stops by said complementary digit stops; normally inoperative means to cause substantially simultaneous operation of each denominational element of the register actuator by the next adjacent higher denominational element in all orders in which no keys have been depressed lower than the highest

denominational order which is responsively operated by said digit keys, means cooperating with said last means and arranged in two groups of consecutively adjacent orders and adapted to cause all elements of the lower denominational group to operate simultaneously upon the operation of any one or more elements of the higher denominational group responsive to the depression of a digit key in such denominational orders, means operable by said division control key to bring said normally inoperative means and said cooperating means into operative relationship with said register actuator, and means associated with each denominational element of said register actuator and with its associated ordinal column of digit keys to hold a key in depressed position during operation of said register actuator element responsive to depression of said key and to permit the complete depression of a digit key in said ordinal column of keys subsequent to operation of the associated element of the register actuator by the normally inoperative means in response to the depression of a digit key in a higher ordinal column.

6. In a calculating machine having a plurality of ordinal columns of digit keys, a multi-denominational register, and a multi-denominational register actuator each denominational element of which is responsive to an ordinal column of digit keys; means for substantially simultaneously operating each denominational element of the register actuator by the next adjacent higher denominational element in all orders in which no keys have been depressed lower than the highest denominational order which is responsively operated by said digit keys, means cooperating with said last means and arranged in two groups of consecutively adjacent orders and adapted to cause all elements of the lower denominational group to operate simultaneously upon the operation of any one or more elements of the higher denominational group responsive to the depression of a digit key in such denominational orders, and means associated with each denominational element of said register actuator and with its associated ordinal column of digit keys to hold a key in depressed position during operation of said register actuator element responsive to depression of said key and to permit the complete depression of a digit key in said ordinal column of keys subsequent to operation of the associated element of the register actuator by the said first means or by both the said first means and the cooperating means in response to the depression of a digit key in a higher ordinal column.

7. In a calculating machine having a plurality of ordinal columns of digit keys, a multi-denominational register, a multi-denominational register actuator each denominational element of which is responsive to an ordinal column of digit keys; overlapping connections between all denominational elements of the register actuator for substantially simultaneously operating each denominational element of the register actuator to the right of any other single denominational element of said register actuator which is operated either responsively to the digit keys or by the next higher denominational element acting through the medium of an overlapping connection, means cooperating with said overlapping connections and arranged in two groups of consecutively adjacent orders and adapted to cause all elements of the lower denominational group to operate simultaneously upon the operation of any one or more elements of the higher denominational

group responsive to the depression of a digit key in such denominational orders, and means associated with each denominational element of said register actuator and with its associated ordinal column of digit keys to hold a key in depressed position during operation of said register actuator element responsive to depression of said key and to permit the complete depression of a digit key in said ordinal column of keys subsequent to operation of the associated element of the register actuator by the overlapping connections or by both the overlapping connections and the cooperating means in response to the depression of a digit key in a higher ordinal column.

8. In a multi-order calculating machine having a plurality of ordinal columns of digit keys, a multi-denominational register, and a multi-denominational register actuator, each denominational order of which is responsive to an ordinal column of digit keys, inter-order transmission means responsive to digit-key manipulation in each order for progressively operating all orders of the register actuator to the right of any order operating in response to the manipulation of a digit key therein, and means operated by said transmission means in the order wherein a said digit key is manipulated for simultaneously operating said transmission means in a predetermined plurality of orders to the right of the key responding order.

9. In a calculating machine having a plurality of denominational orders of calculating mechanism including a plurality of ordinal columns of digit keys, a multi-denominational register, and a multi-denominational register actuator responsive to said keys, ordinal digit stops movable to and from effective positions for controlling said register actuator for the actuation of said register in accordance with the complemental digital values and the respective digit keys, a division key controlling said digit stops and operable to control said register actuator in accordance with the complemental digital values of the respective digit keys when manipulated, inter-order transmission means responsive to digit-key manipulation in each order for operating all orders of the register actuator to the right of an order operating in response to the manipulation of a digit key therein, means operable by said division key for bringing said transmission means into operative relationship with said register actuator, and means operated by said transmission means in the key-responding orders for simultaneously operating said transmission means in a predetermined plurality of the orders to the right of the key-responding order.

10. In a multi-order calculating machine, the combination with a plurality of columns of digit keys, those of each column corresponding to the digits of 1 to 9 inclusive, a multi-denominational register, a multi-denominational register actuator each denominational order of which is responsive to one ordinal column of digit keys, and means for controlling said register actuator for the actuation of said register in accordance with tens-complements of the respective digit keys manipulated in the lowest denominational order of the machine and the nines-complements of the respective digit keys manipulated in each of any number of other orders of the machine, of a series of overlapping members each controlled by a denominational order of said actuator and extending from a preceding order into overlapping relationship in the next succeeding order to the right with the next succeeding overlapping member for

causing operation of the latter and of said actuator in said next succeeding order, and a gang of levers each engageable with one of said overlapping members and operable as a unit by any one of a plurality of said overlapping members for operating a preselected group of said overlapping members to the right of said plurality of members to cause simultaneous actuation of the orders of the register respectively corresponding to said preselected group.

11. In a calculating machine having a plurality of ordinal columns of digit keys, a multi-denominational register, and a multi-denominational register actuator each denominational order of which is responsive to an ordinal column of digit keys, overlapping connections operable to operate all denominational orders of the register actuator not operated by digit keys to the right of the left-most denominational order that is operated in response to the digit keys, and a transordinal member having denominational elements in each of a plurality of orders, operable by the overlapping connection in response to a key in any order to the left of said plurality of orders, for operating each element in said plurality of orders to the right of the key-responding order whereby to operate said overlapping connections in each of said plurality of orders simultaneously.

12. In a calculating machine having a plurality of ordinal columns of digit keys, a multi-denominational register, and a multi-denominational register actuator each denominational element of which is responsive to an ordinal column of digit keys, transmission members between all denominational elements of the register actuator, each adapted to be operated in response to key manipulation in its order and by the next preceding transmission member and upon operation to operate the next succeeding one of said transmission members to the right, and means operable by any one of a group of said transmission members responding to key manipulation in its order to permit operation of the remainder of the group to the right of that responding to key manipulation progressively, and to operate a plurality of succeeding transmission members to the right of said group simultaneously, for substantially simultaneously entering ten in the units order of the register and nine in each of the orders between the units order and the key responding order.

13. In a multi-order, key responsive calculating machine having a plurality of ordinal columns of digit keys, ordinal actuating elements, and means operated by the keys for initiating operation of said elements, an inter-order transmission operable by the initiating means in an order wherein a key is manipulated to operate the initiating means in all orders to the right thereof, comprising a plurality of overlapping levers each extending from a preceding order into overlapping relationship with a succeeding lever in the adjacent order to the right, and a gang of levers each engageable with one of said overlapping levers and operable as a unit in response to the operation of one of said overlapping levers of a first predetermined group for simultaneously operating a plurality of said overlapping levers in a second predetermined group to the right of the first mentioned group.

14. In a multi-order calculating machine having ordinal complements of digit keys arranged in denominational orders, one key in each of a number of denominational orders being repetitively and simultaneously operable, ordinal ac-

tuatcrs, means cooperating with the keys of each denominational order for initiating actuation of the ordinal actuator in said order when a digit key is operated therein, transmission means actuated by the operation of a digit key in any denominational order for operating the first said means in a different order from the one wherein the digit key is operated, and yieldable key detaining means movable to key-detaining position upon operation of the first said means in said different order and yieldable to permit operation of a digit key in said different order while said key detaining means is in its key detaining position.

15. In a multi-order calculating machine having ordinal complements of digit keys arranged in denominational orders, one key in each of a number of denominational orders being repetitively and simultaneously operable, ordinal actuators, means cooperating with the keys of each denominational order for initiating actuation of the ordinal actuator in said order when a digit key is operated therein, transmission means actuated by the operation of a digit key in any denominational order for operating the first said means in a different order from the one wherein the digit key is operated, yieldable key detaining means movable to key-detaining position upon operation of the first said means in said different order and yieldable to permit operation of a digit key in said different order while said key detaining means is in its key detaining position, comprising a bar in each denominational order of the machine, pivotal mounting means carrying the bars, and a bar slidably carried by said pivotal

mounting means in each denominational order and yieldably connected to the first said bar for slidable movement relative thereto.

16. In a multi-order calculating machine, the combination with a plurality of columns of digit keys, those of each column corresponding to the digits of 1 to 9 inclusive, a multi-denominational register, and a multi-denominational register actuator each denominational order of which is responsive to one ordinal column of digit keys, of means responsive to key manipulation in any denominational order higher than the units order of the machine for causing said register actuator to enter the nines-complement of the manipulated key in the corresponding order, ten in the units order, and nine in each order between the key-responding order and the units order of the machine, and a gang of levers each arranged in a denominational order of the machine, said gang of levers being operable as a unit in response to manipulation of a digit key in any order of a first predetermined group of orders of the machine and adapted when so operated to cause operation of the last said means in the orders of a second predetermined group simultaneously.

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The following references are of record in the file of this patent:

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