

Feb. 12, 1946.

K. R. SCHNEIDER

2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets-Sheet 1

FIG. 1.

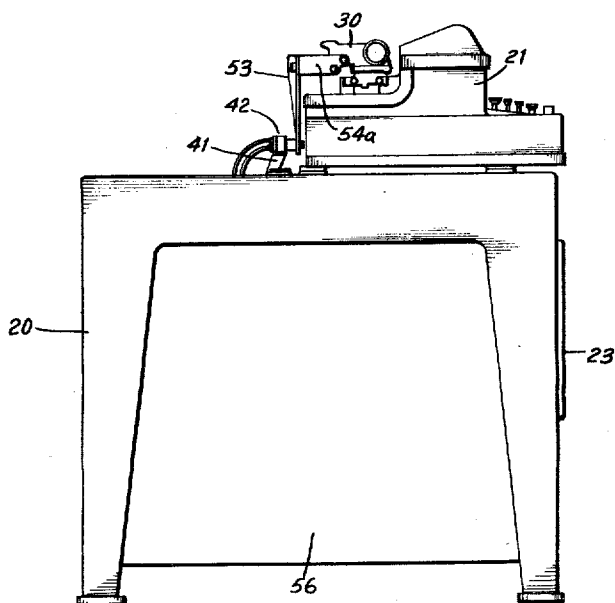
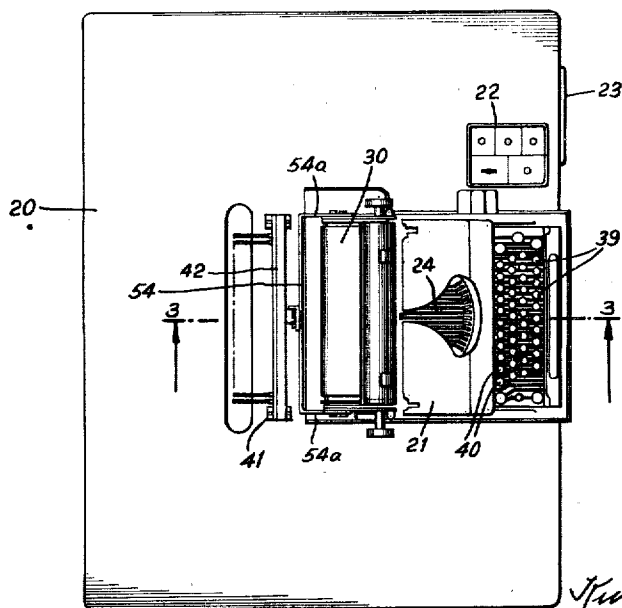


FIG. 2.



INVENTOR
Kurt P. Schneider
BY
W. M. Wilson
ATTORNEY

Feb. 12, 1946.

K. R. SCHNEIDER

2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets-Sheet 2

FIG. 3.

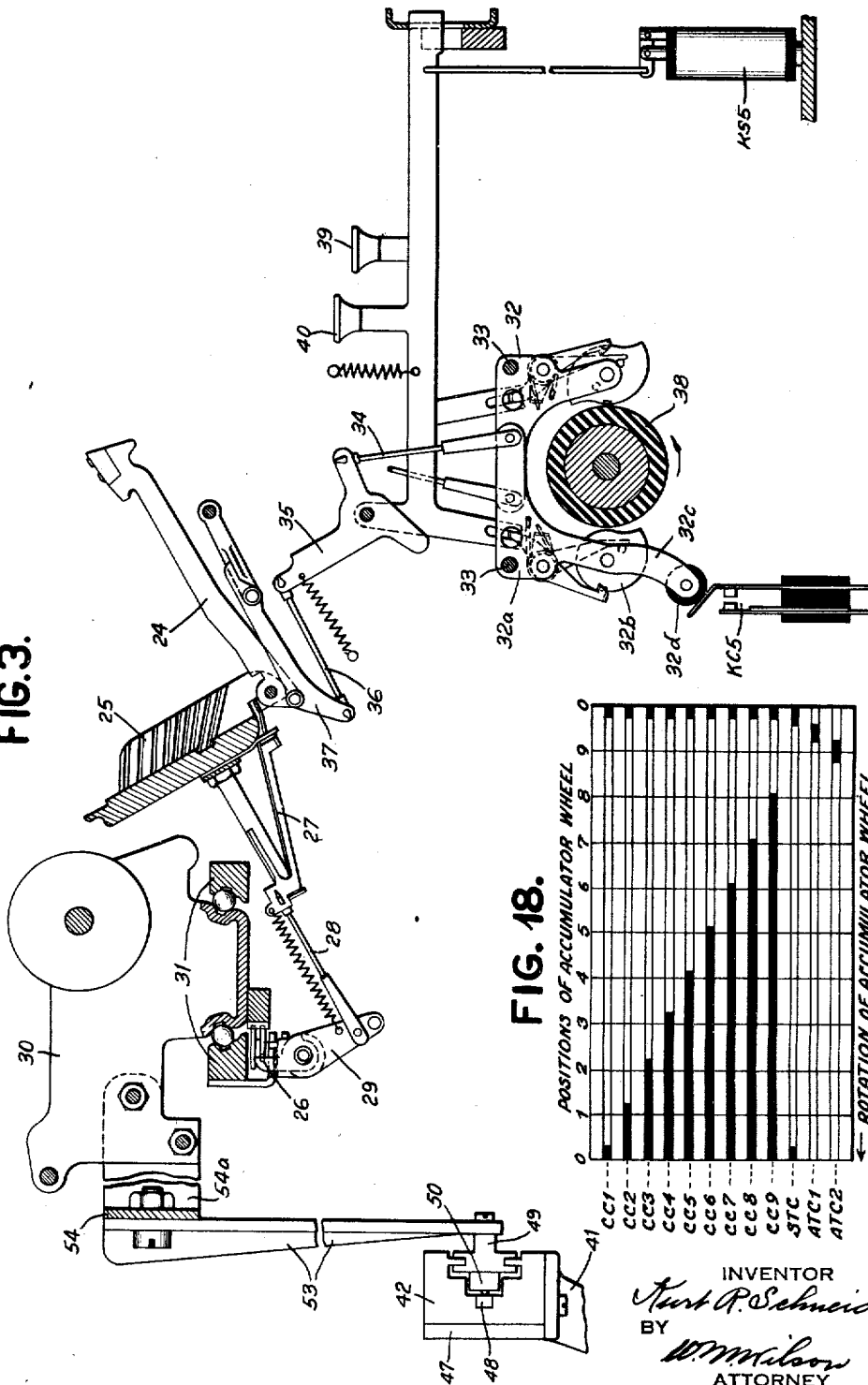
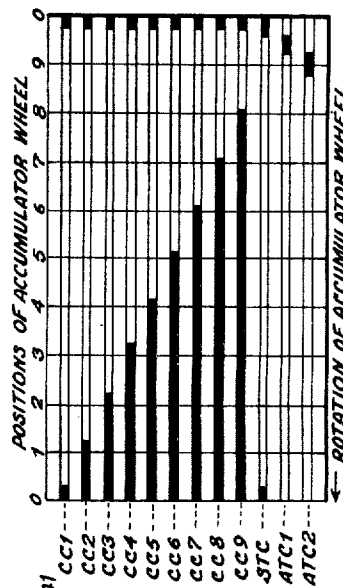


FIG. 18.



INVENTOR

Kurt P. Schneider

BY

W. M. Wilson
ATTORNEY

Feb. 12, 1946.

K. R. SCHNEIDER

2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets-Sheet 3

FIG. 4.

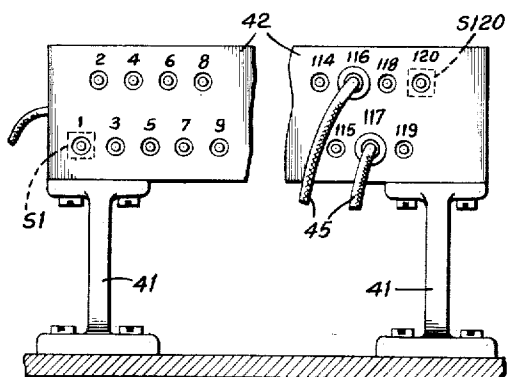


FIG. 5.

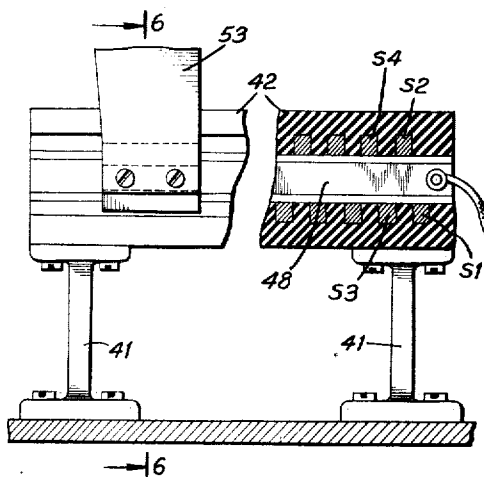
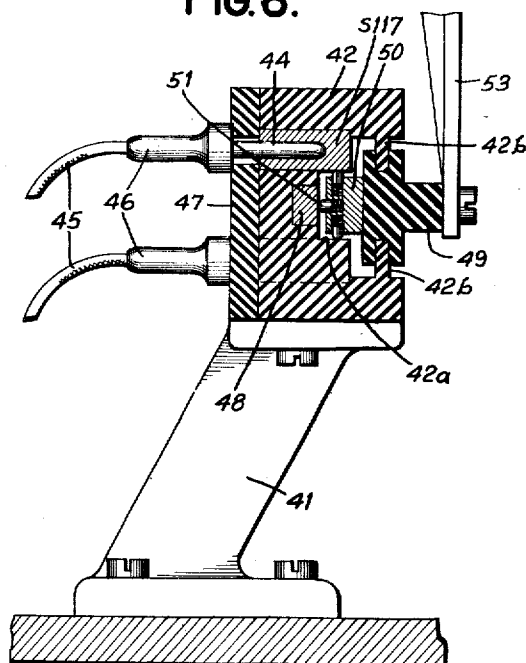


FIG. 6.



INVENTOR
Kurt R. Schneider
BY
W. M. Wilson
ATTORNEY

Feb. 12, 1946.

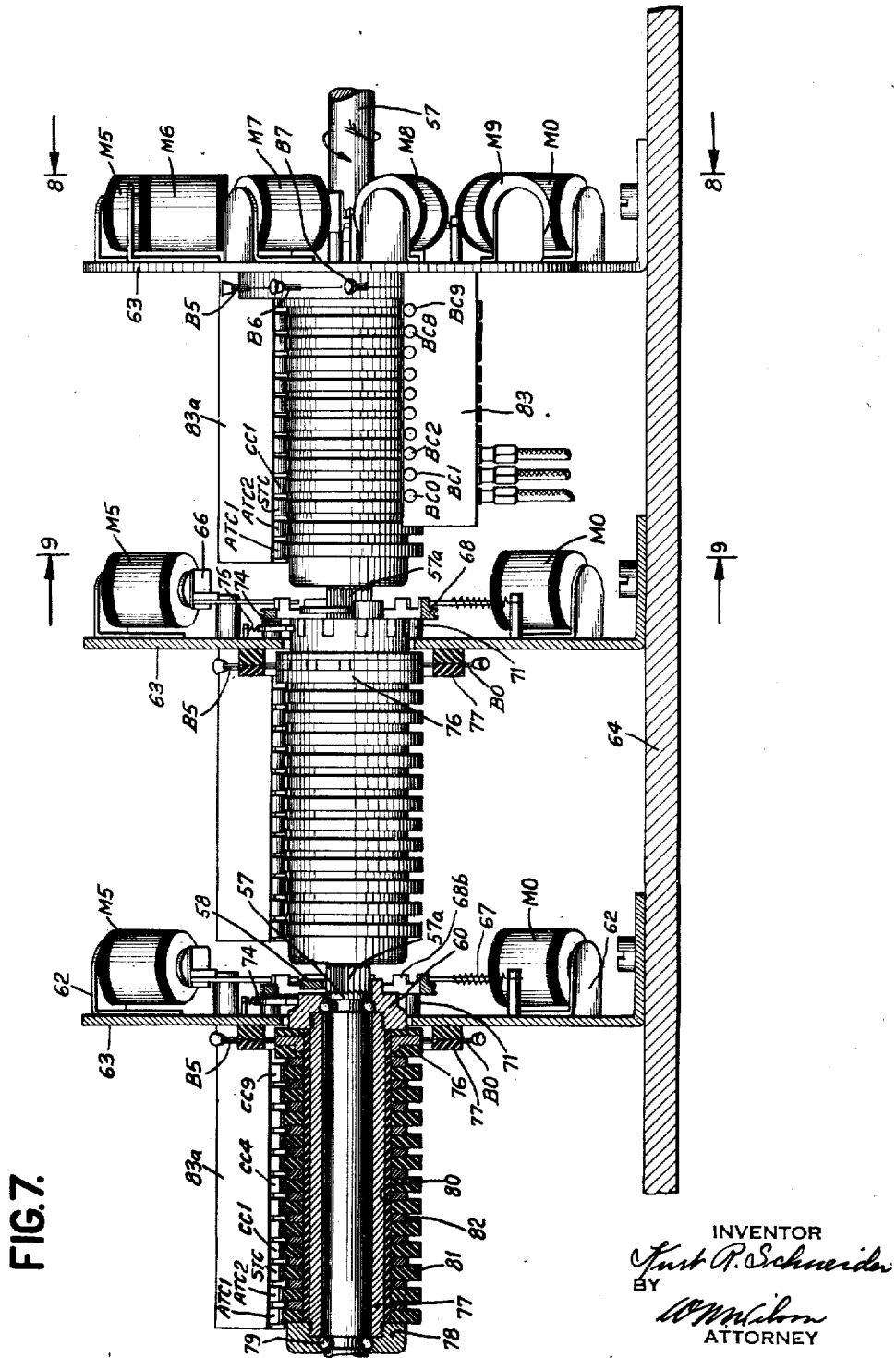
K. R. SCHNEIDER

ACCOUNTING MACHINE

Filed May 24, 1941

2,394,637

11. Sheets-Sheet 4



INVENTOR

Just P. Schneider
BY

W. M. Wilson
ATTORNEY

Feb. 12, 1946.

K. R. SCHNEIDER

2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets-Sheet 5

FIG. 8.

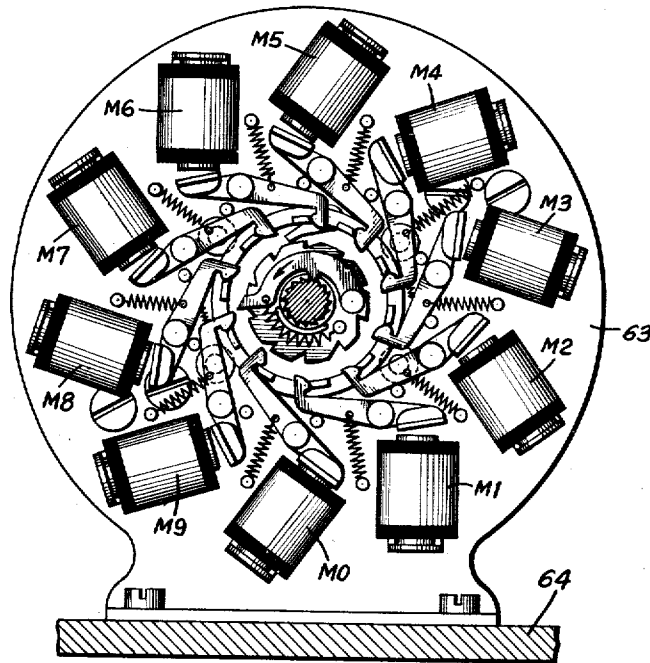
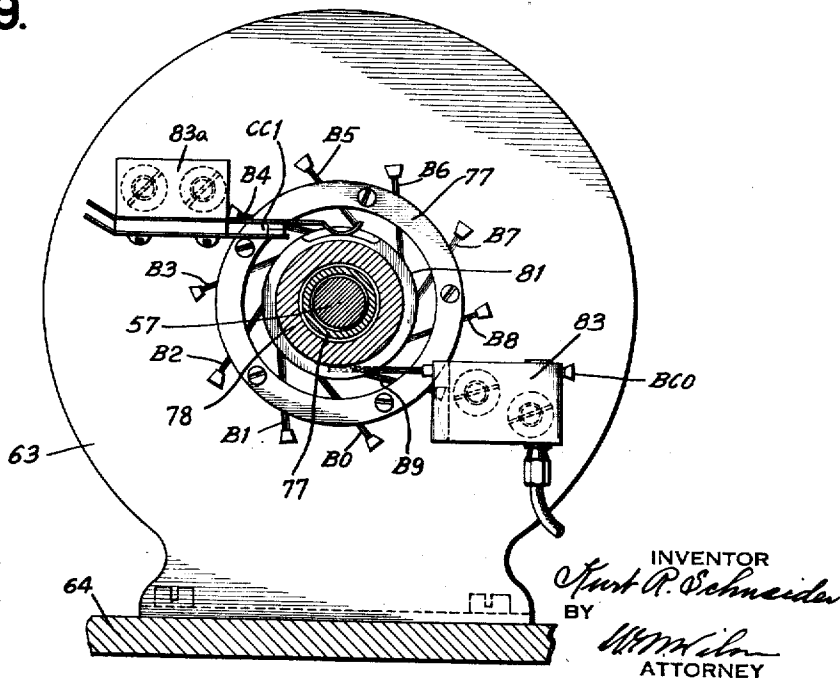


FIG. 9.



Feb. 12, 1946.

K. R. SCHNEIDER

2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets-Sheet 6

FIG.10.

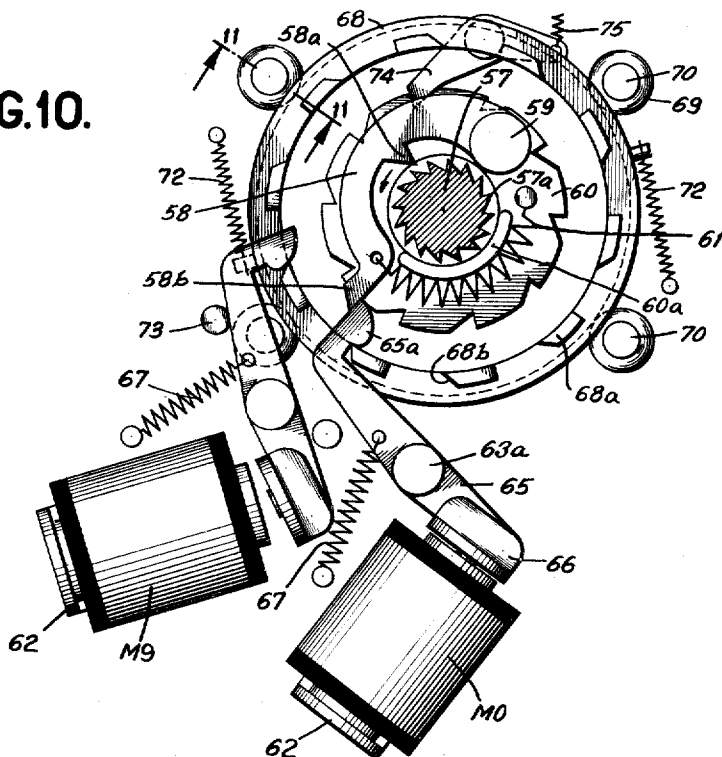


FIG.12.

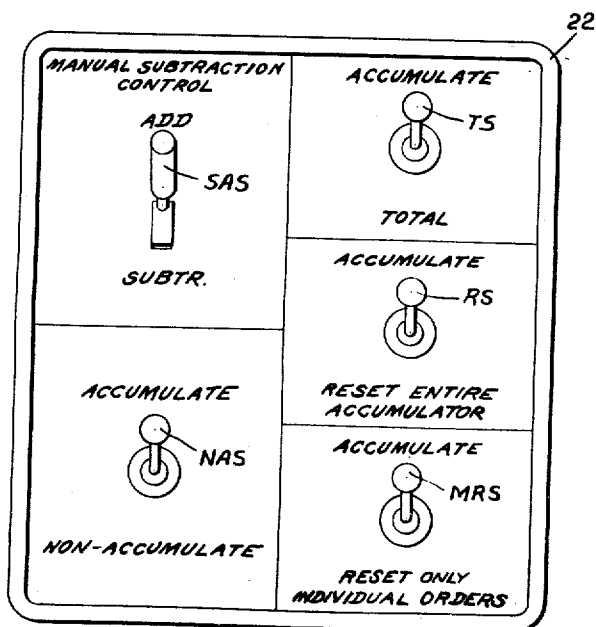
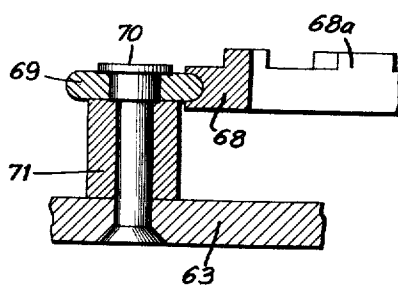


FIG.11.



INVENTOR
Kurt P. Schneider
 BY
W. M. Wilson
 ATTORNEY

Feb. 12, 1946.

K. R. SCHNEIDER

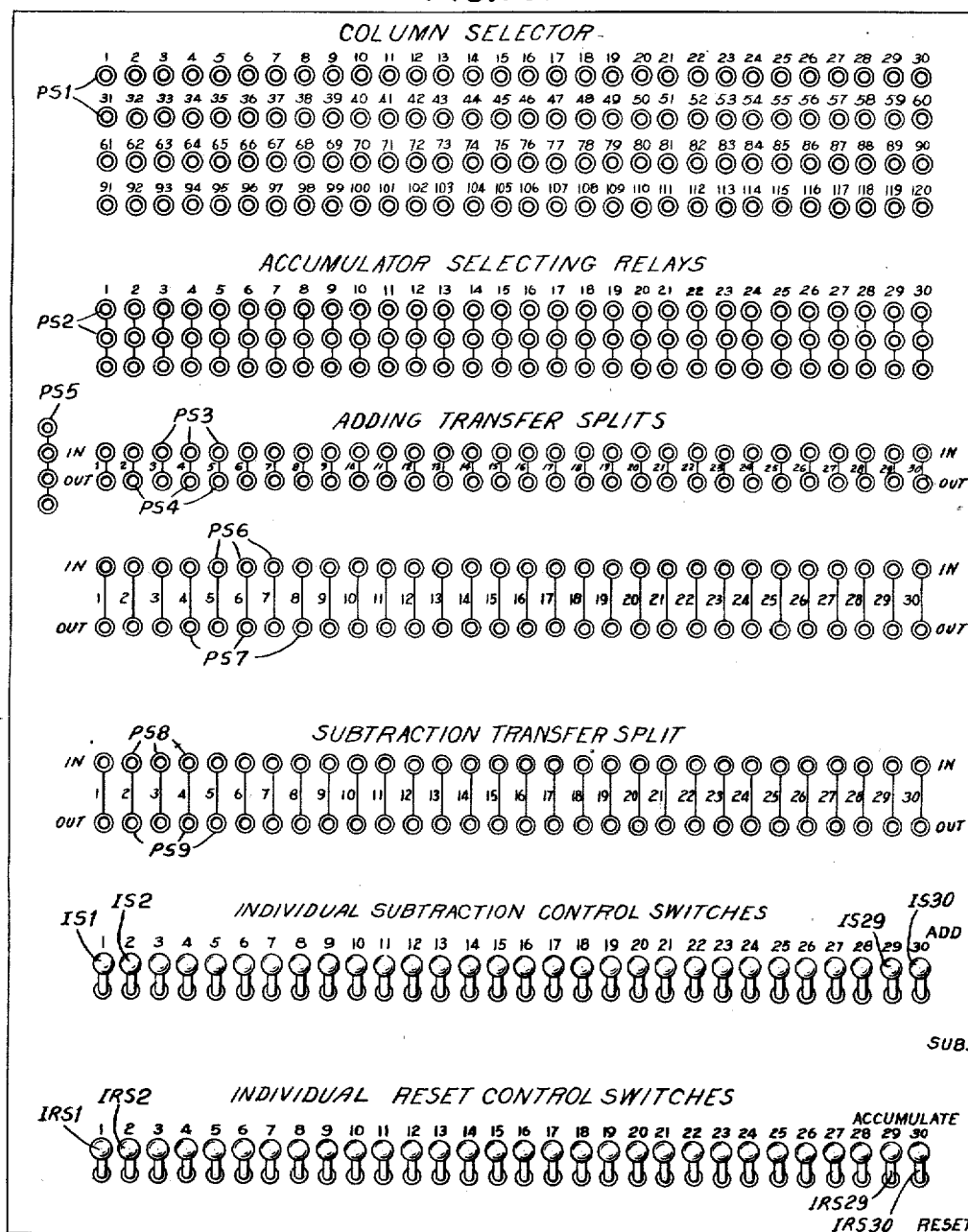
2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets-Sheet 7

FIG.13.



INVENTOR
Kurt R. Schneider
BY
W. M. Wilson
ATTORNEY

Feb. 12, 1946.

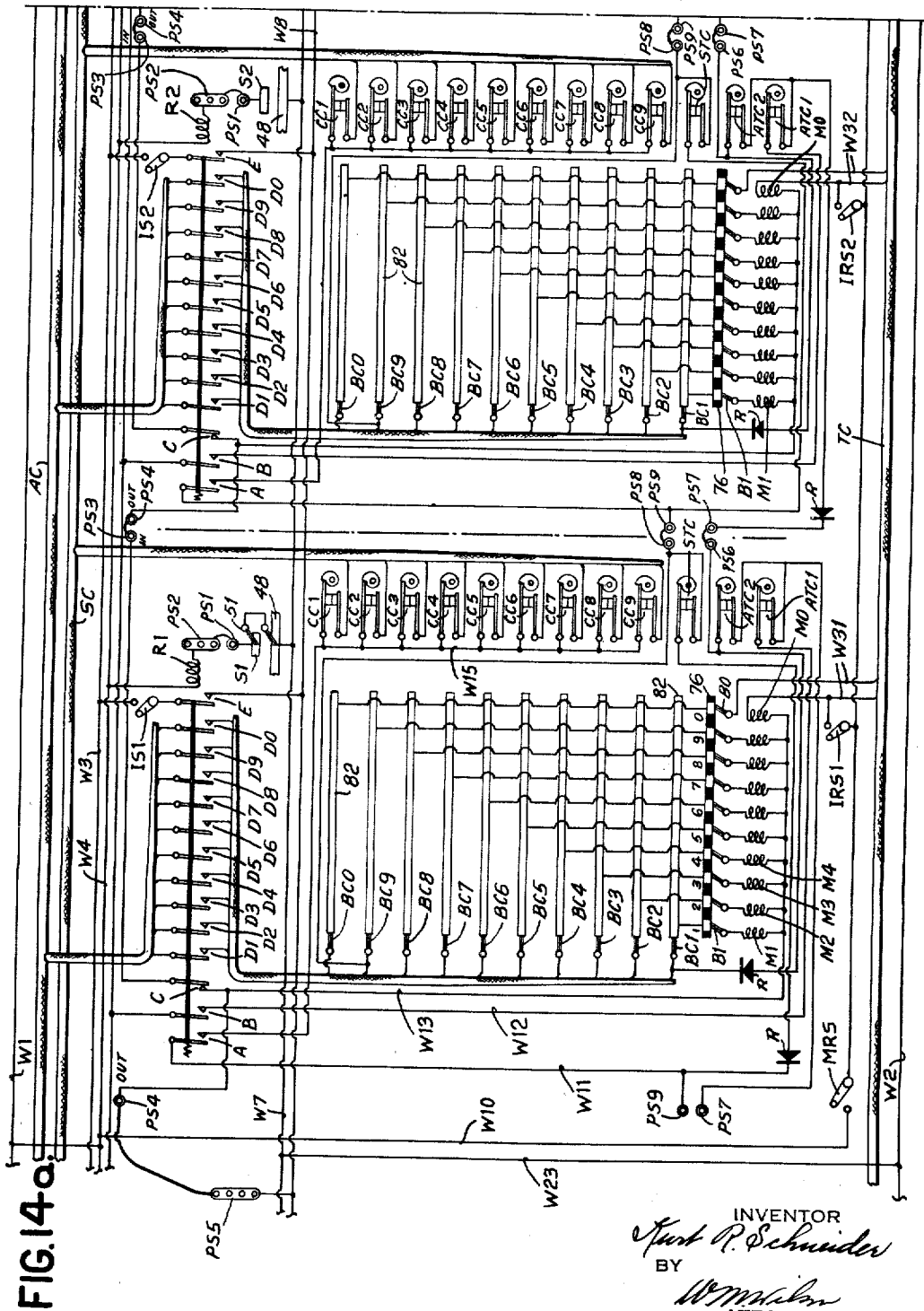
K. R. SCHNEIDER

2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets-Sheet 8



Feb. 12, 1946.

K. R. SCHNEIDER

2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets—Sheet 9

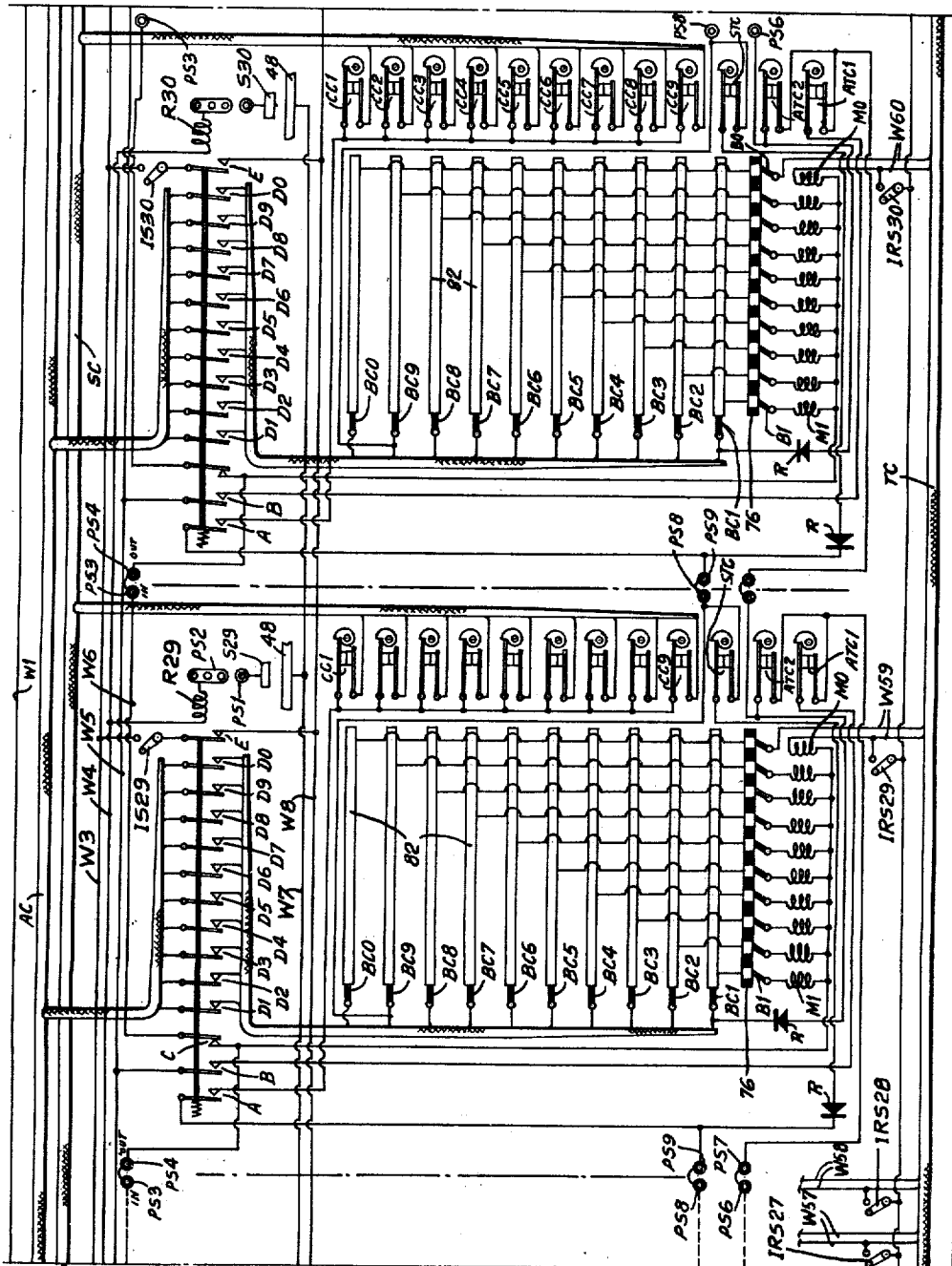


FIG. 14b

INVENTOR
Kurt R. Schneider
BY
W. M. Wilson
ATTORNEY

Feb. 12, 1946.

K. R. SCHNEIDER

2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets-Sheet 10

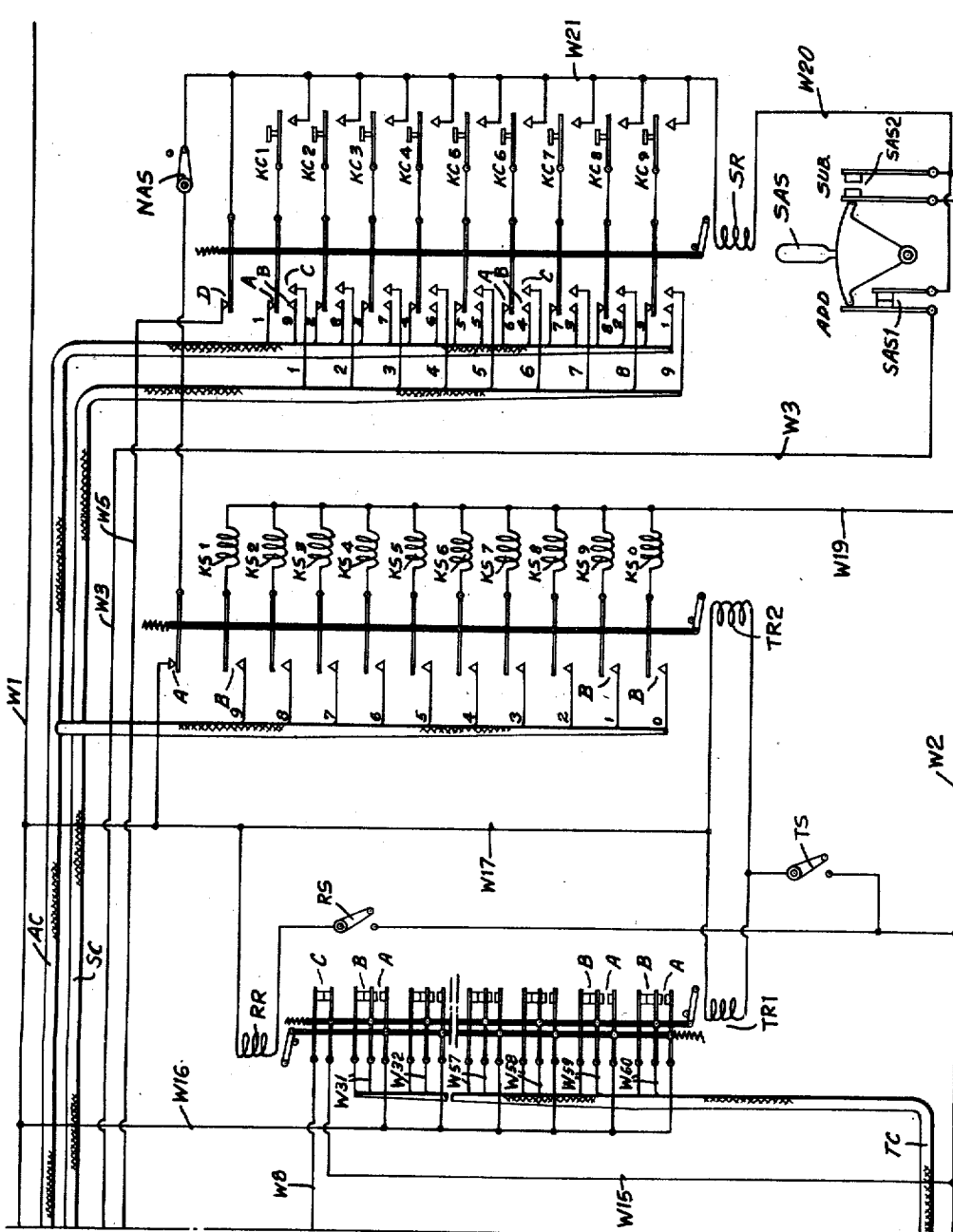


FIG. 14c.

INVENTOR
Kurt R. Schneider
BY
W. M. Mahon
ATTORNEY

Feb. 12, 1946.

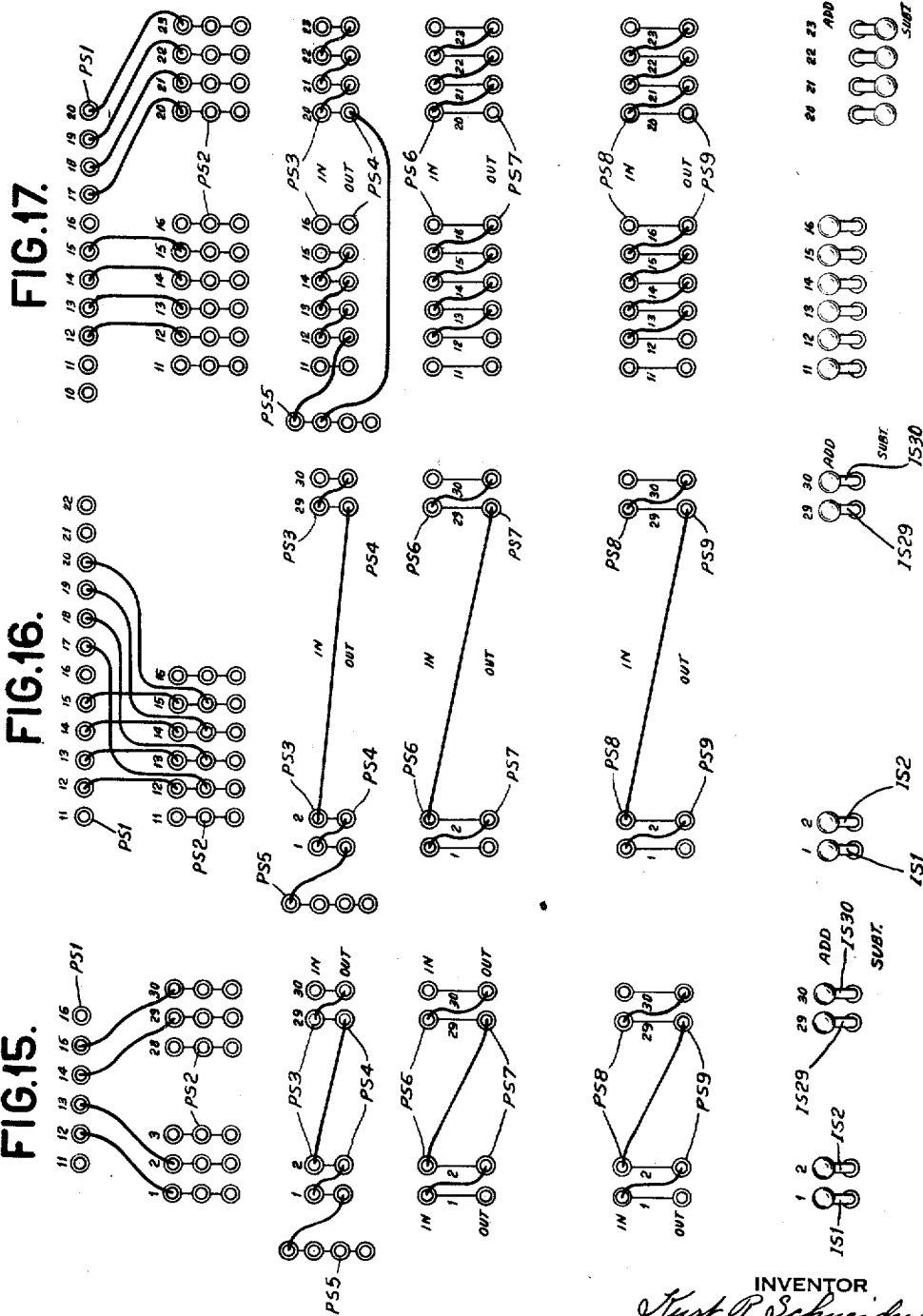
K. R. SCHNEIDER

2,394,637

ACCOUNTING MACHINE

Filed May 24, 1941

11 Sheets-Sheet 11



INVENTOR
Karl R. Schneider
BY
W. Mahon
ATTORNEY

UNITED STATES PATENT OFFICE

2,394,637

ACCOUNTING MACHINE

Kurt Rudolf Schneider, Endicott, N. Y., assignor
to International Business Machines Corporation,
New York, N. Y., a corporation of New
York

Application May 24, 1941, Serial No. 395,023

41 Claims. (Cl. 235—59)

This invention relates to combined typewriting and computing machines.

The primary object of the present invention is to provide a combined typewriting and computing machine which is more flexible than prior art machines of this class and capable of operations which are either impossible of accomplishment in present commercial forms of such machines or require very complex mechanisms which must be mechanically operated, in part at least, by the carriage of the typewriting machine.

An object is to provide accumulating mechanism for a combined typewriting and computing machine in which the accumulation of amounts is not limited to accumulators of definite sizes but may be arbitrarily divided by the operator into as many accumulators as may be desired, and in which the number of denominational orders is limited only by the total number of accumulator orders with which the machine is equipped.

An object is to provide a combined typewriting and computing machine with what amounts to a single accumulator of large size which may be arbitrarily split into accumulator sections, each section having any capacity desired by the operator.

Another object is to provide a novel accumulating mechanism for combined typewriting and computing machines.

An object is to provide an accumulator and amount entering mechanism which is mechanically independent of the typewriter keys and type bar operating mechanism so as to impose no additional load thereon.

An object is to provide a combined typewriting and computing machine in which the operations of column selection, addition, subtraction, and total printing may be effected electrically under control of the keys and the typewriter carriage.

An object is to provide a novel automatic total taking means.

An object is to provide an automatic total taking mechanism in which individual sections of the accumulator mechanism may be reset at will, either automatically or under manual control.

An object is to provide novel electrical transfer mechanism which is adapted for both addition and subtraction.

An object is to provide a combined typewriting and computing machine which is completely electrically controlled and operated and does not require the use of load inducing mechanical connections between the accumulating amount en-

tering, and total taking mechanisms and the typewriter carriage or keys.

An object is to provide an electrically controlled amount entering and accumulating mechanism in which the operation of denominational selection is effected electrically by a relatively simple column-selecting switching device actuated by the carriage of the typewriter.

An object is to provide a computing mechanism which may be coupled to practically any standard typewriter, without substantial change in the machine, and without appreciably increasing the load upon the carriage or upon the keys of the typewriter.

An object is to provide a combined typewriting and computing machine which is so constituted that the operator is relieved of the work of operating the computing mechanism and in which the entire machine is controlled by simple switches and keys and does not require any greater effort than is incidental to the actuation of keys to effect the operations of typing and computing of numbers.

The present invention has for one of its aims to provide a novel computing mechanism which overcomes the limitations to which the machines mentioned above are subjected.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a left side elevation of the machine.

Fig. 2 is a plan view.

Fig. 3 is a section on the line 3—3 in Fig. 2 showing certain parts of the typewriter.

Fig. 4 is a rear view, partly broken away, of the column selector.

Fig. 5 is a front view, partly broken away and partly in section, of the column selector.

Fig. 6 is a large scale vertical section on the line 6—6 of Fig. 5.

Fig. 7 is a view of three adjacent denominational orders of the accumulating mechanism, showing one of the orders in elevation and the other two in section.

Fig. 8 is a vertical section on the line 8—8 in Fig. 7.

Fig. 9 is a vertical section on the line 8—8 in Fig. 7.

Fig. 10 is a large scale detail view of the accumulator clutch mechanism.

Fig. 11 is a section on the line II—II in Fig. 10.

Fig. 12 is a view of the main control switch unit.

Fig. 13 is a front view of the plugboard.

Figs. 14a, 14b, 14c constitute a wiring diagram.

Fig. 15 shows how four accumulator orders are plugged for addition.

Fig. 16 shows how amounts printed in two separate amount columns may be added or subtracted in a group of orders constituting a single accumulator.

Fig. 17 shows how two groups of orders may be plugged for addition in one group and subtraction in the other.

Fig. 18 is a timing chart for the switching mechanism actuated by the accumulator wheels.

The machine is shown in Figs. 1 and 2 as comprising a base 20 on the top of which is supported a typewriter 21. It is preferred that a power operated typewriter be employed and accordingly there is shown in Figs. 1 and 2 the well known "Electromatic," also known as the "International." It will be understood, however, that a manual machine or any other suitable form of power operated typewriter may be used if desired. Since the "Electromatic" typewriter is now well known in the art, only a brief description will be given of such parts as immediately cooperate with or control the mechanism or circuits of the machine. If desired, the adding, subtracting, and total printing readout mechanism hereinafter to be described may be considered as an attachment for a typewriter and may be connected thereto by suitable cables, with the typewriter 21 mounted on a desk. This is possible because the typewriter is only electrically connected with the adding, subtracting, and total readout mechanisms. Therefore, it need not be mounted upon the base 20. This feature makes it possible to use any typewriter having numeral keys and a carriage which is moved one letter space at a time to space the characters printed by type bars or other suitable printing instrumentality.

In Fig. 2, the numeral 22 designates a control board which is shown on a larger scale in Fig. 12 and comprises several switches which control adding, subtracting, total printing, and resetting operations. The numeral 23 (Figs. 1 and 2) designates a suitable plugboard which is shown on a larger scale in Fig. 13. This latter figure shows the arrangement of the plug sockets which are connected to the column selector, the accumulator selecting relays, and certain parts of the circuits involved in the transferring of units from one order to the other in addition and subtraction and also contains switches for controlling subtraction and resetting with respect to individual orders of the accumulating mechanism. The purpose of the various switches and plug sockets shown in Figs. 12 and 13 will be brought out more clearly hereinafter with reference to the wiring diagram.

In order to adapt the typewriter for use with the present invention only minor alterations in its construction are required.

In Figs. 2 and 3, the numeral 24 designates the usual type bars of the "Electromatic" pivotally mounted in the wire segment 25 which is mounted for case shifting movement in a well known way. The type bars actuate the usual escapement mechanism generally designated 26, through the medium of a universal bar 27 connected by a link 28 and an operating arm 29 to the escapement mechanism. The universal bar

has a portion which is arcuate and extends into a slot formed in the segment 25 so as to be engaged by the type bars 24 when they are close to the platen and operated thereby whereby the escapement is actuated for each operation of a type bar.

The escapement 26 controls the letter spacing movement of the carriage 30 which is mounted on the rails 31 by suitable anti-friction bearings. As will be explained hereinafter, the carriage operates an electric column selector device which controls the entry of amounts into preselected denominational orders of the accumulating mechanism. Hereinafter the word "order" will be used generally to refer to the portion of an accumulator which receives one digit of an amount and the orders will be distinguished from each other by referring to them as the units order, the tens order, etc.

The type bars 24 are operated in a well known way by cam units 32, 32a, which are pivoted on the rods 33, by means of the links 34 connecting the cam units 32 to sublevers 35, the links 36, and toggles 37. The cam units 32, 32a cooperate with a power roller 38 which rotates continually in the direction of the arrow in Fig. 3 while the machine is in use. The operation of the cam units is controlled by keys 39, 40 of which the keys 39 control the cam units which operate the type bars other than the numeral type bars, while the keys 40 control the cam units 32a which operate the numeral type bars. The operation of the type bars by the cam units under control of the keys will not be described in detail because this is well known in the art. It will suffice to state here that whenever the number key 40 is depressed, the cam unit 32a associated therewith is rocked clockwise in consequence of the cooperative relationship established between the cam carried thereby and the power roller 38. This effects operation of the associated numeral type bar by drawing down a link 34.

Although it is not believed to be absolutely necessary, it is preferred, as a safety measure, that the cams 32b have a single lobe in order to allow ample time for certain parts of the accumulating mechanism to operate before the next digit of an amount is printed in order to insure that the adding, subtracting, and total printing operations with respect to a single order of the accumulating mechanism will be completed before similar operations are commenced in the next denominational order. The cam units 32, as is usually the case, are provided with double lobe cams which make one-half revolution for each operation of a key 39.

Associated with the key levers of the numeral keys 40 are ten operating solenoids designated KS0 to KS9 (Figs. 3 and 14c), inclusive. These solenoids are selectively and successively energized during total printing operations to print totals automatically as will be made clear hereinafter at the proper point and will be termed the key selecting solenoids or simply key solenoids. The cam units 32a also operate certain contacts which control the amounts to be added and subtracted and for this purpose are provided with extensions 32c (Fig. 3) having disks 32d of insulating material thereon engaging one of the spring contact members supporting contacts designated KC1 to KC9, inclusive in Fig. 14c. These contacts will be referred to hereinafter as the key contacts and the numbers associated therewith indicate the digit which will be added or subtracted. Thus, when the numeral key controlling

the one type bar is depressed, contacts KCI will be closed and cause one to be added in any order which is selected for operation.

The denominational orders are selected for addition, subtraction, and total printing by means of a column selector part of which is actuated by the carriage in its letter spacing movements and is shown in detail in Figs. 4, 5, and 6. Secured to the top of the frame 20 are two brackets 41 (Figs. 1 to 6, inclusive) on which is mounted a bar 42 of insulating material. This bar 42 contains molded therein inserts or segments S1 to S120 of bronze, copper, or other current conducting material of which there is one segment for every letter space position of the carriage. It will be convenient to assume that the typewriter 21 is an elite machine with a 12 inch carriage having a total travel of ten inches. Consequently there will be 120 of the segments required. In order to provide adequate insulation between the segments and to make them of generous width, the segments S1 to S120 are staggered as best shown in Figs. 5 and 6. This makes it possible to make the segments S1 to S120 of the same width as the letter spaces of movement of the carriage and also minimize weakening of the bar 42 between the segments as might be the case if the spaces between the segments were very small.

The segments S1 to S120 are provided with longitudinal holes receiving plugs 44 (Figs. 4 and 6) attached to the connecting wires 45. These connecting wires 45 may be provided with rubber finger pieces 46 to protect the operator from shock and for the same reason the rear part of the bar 42 has secured thereto an insulating strip 47 (Fig. 6) provided with holes slightly larger than the holes in the segments S1 to S120 and registering therewith to prevent accidental contact with the segments. These features of construction also make it impossible to set up incorrect circuits by contact of metallic objects such as pins, paper clips, etc. which are likely to be dropped around office machines.

Molded in the bar 42 is a common contact strip 48 (Figs. 5 and 6) which extends throughout the length of the bar 42 and is set flush with the bottom of an inner channel 42a, the side walls of which are partly formed by the plastic material from which the bar 42 is molded and partly by the sides of the right hand ends of segments S1 to S120. The bar 42 is also formed with two confronting ribs 42b which act as guides for a block of insulating material 49 grooved to accommodate the ribs 42b. This block is T-shaped in cross section, as shown in Fig. 6, and has secured to the rear face thereof a metallic block 50 provided with three sockets receiving three contact plungers 51 which are urged against the bar 48 and against the sides of the segments 43 by suitable compression springs. Thus for each letter space position of the carriage, one of the segments S1 to S120 will be electrically connected to the bar 48 which acts as a common contact strip.

The block 49 is secured to an arm 53 mounted on the cross bar 54 (Figs. 1 and 3) of a U-shaped bracket having its arms 54a secured to the side plates of the carriage 30. The arm 53 is located at substantially the midpoint of the bar 54 whereby the plungers 51 will electrically connect the segment S1 (Fig. 4) to the bar 48 when the carriage is in the first column position and similarly connect the segment S120 to bar 48 when

the carriage is in the last or 120th column position.

With reference to Figs. 13, 14a, and 14b, the segments S1 to S120 are connected to plug sockets PS1, which provide a means for electrically connecting the accumulator selection relays to the column selector by means of plug wires for the purpose of selecting the order in which amounts are to be entered. There is a column selection relay for each order of the accumulating mechanism. Conveniently it may be assumed that an accumulating mechanism comprising 30 orders is provided requiring 30 column selector relays which may be designated R1, R2 * * * R29, R30. In Figs. 14a and 14b only four denominational orders are shown including the column selector relays R1, R2, R29, R30, but it will be assumed that twenty-six similar accumulator orders whose relays are designated R3 to R28 intervene between the two parts of the wiring shown in Figs. 14a and 14b. Since the wiring would be merely a repetition of Figs. 14a and 14b, a showing of all the orders is omitted but the plugboard (Fig. 13) is shown with all the necessary switches and plug sockets for a column selector comprising 120 positions or columns and accumulating mechanism having thirty denominational orders. It will be understood that the number of denominational orders is purely arbitrary and merely involves providing the proper number of circuit sections shown in Figs. 14a and 14b between the broken vertical lines with accessory mechanical structure to be described hereinafter comprising clutch mechanism and commutators of novel form.

The relays R1 to R30 (Figs. 14a, 14b) are connected to a common wire W4 which in turn is connected to the line wire W1, while the contact strip 48 is connected to the wire W7 which in turn is connected to the line wire W2. The relays R1 to R30 are individually connected to plug sockets PS2 (Figs. 13, 14a and 14b) whereby any relay, such as relay R1, may be connected by a plug wire to any of the segments S1 to S120 by inserting the plug wire between the appropriate plug sockets PS1, PS2. For example, if it is desired to print numerals in column 1 of the work sheet and add the amounts printed in the first denominational order of the accumulator, a plug wire will be inserted between the plug socket PS1 for the segment S1 and the plug sockets PS2 for the relay R1. With this system of plugging, if the carriage is in the column 1 position, relay R1 will be energized and will render the first order of the accumulating mechanism operative for adding or subtracting according to the setting of other switches in a manner to be made clear hereinafter.

As the carriage moves from right to left in the course of printing characters or multi-digit amounts, the relays R1 to R30 will be selected in succession according to the number and positions or columns to which they are plugged. For example, if it were desired to add a six-digit number in the first six positions of the accumulating mechanism, relays R1 to R6 would be plugged to columns 1 to 6 by inserting plug wires as described above to connect the segments S1 to S6 to the coils of the relays R1 to R6. With this arrangement, the movement of the carriage in the letter spacing direction to print an amount comprising six digits or less would result in the denominational selection of the relays R1 to R6, the relay R6 corresponding in this case to the units order since it will be the last one to be

energized, while the relay R1 will correspond to the hundreds of thousands order. In substance, therefore, the insertion of a plug wire in a selected one of the plug sockets PS1 and a plug socket PS2 will render the accumulating mechanism operative to add or subtract with respect to a particular column on the work sheet and order of the accumulating mechanism.

The accumulating mechanism is quite simple and comprises a plurality of accumulator sections or orders, each of which includes a series of adding magnets, a differential clutch, a commutator rotated variable extents under control of the clutch according to the amount to be added and subtracted, and a series of cam operated contacts which control subtraction and for other purposes. These accumulator orders exist as independent units which may be rendered operative and inoperative at will and may be combined or grouped in any desired way irrespective of their specific mechanical arrangement in the machine. The units are fully mechanically independent of each other and may be plugged in various preselected combinations at the will of the operator.

The accumulating mechanism may be housed in a compartment 56 (Fig. 1) supported by the base 20 and includes one or more shafts 57 (Figs. 7 to 10, inclusive) rotated continually in the direction of the arrows in these figures by a suitable motor not shown. The number and arrangement of the shafts 57 are purely arbitrary and are governed solely by considerations of machine capacity, compactness of spacing, and physical size of the compartment 56. It will be convenient to assume that there are thirty accumulator sections or orders, each including its own clutch and associated commutator and cam operated contacts. Also associated with each accumulator order is one of the relays R1 to R30.

In Fig. 7 are shown three different accumulator orders of which the one at the right is shown in side elevation while the one at the extreme left is shown in vertical section. The one in the middle is shown partly in section to more clearly indicate the construction of the clutch mechanism. As will be seen at the left in Fig. 7 and in Figs. 8 and 10, the shaft 57 is formed with ratchet teeth 57a designed to cooperate with a tooth 58a (Fig. 10) on a clutch dog 58 pivoted at 59 on a ten-tooth ratchet 60 loosely journaled on the shaft 57 adjacent the teeth 57a. The ratchet 60 is formed with a flange 60a acting as a support and guide for a tension spring 61 anchored to the end of the clutch dog 58 and the spring 61 constantly tends to rotate the dog 58 in a counterclockwise direction to engage the tooth 58a with one of the teeth 57a. There are ten teeth in the ratchet 60 representing numerals 0 to 9, inclusive. This ratchet 60 and other parts secured thereto may be considered an accumulator wheel and there is one for each of the thirty orders.

The ratchet 60 is allowed to rotate from 1 to 9 increments to add amounts by controlling the length of time the teeth 58a remain in engagement with the ratchet teeth 57a. For the purpose of controlling the rotation of the ratchet 60, there is provided a group of ten magnets for each order, designated M0 to M9, but the designation of these adding magnets in respect to the numerical suffix need not have any fixed relation to the amount actually added, since the starting point of any single addition in any order will be constantly shifted according to the amounts pre-

viously added in such order. However, it will be convenient to assume that the magnet M0 corresponds to the zero position and, through its detent mechanism to be described hereinafter, holds the corresponding ratchet 60 against forward rotation when the commutator and cam mechanism associated with such ratchet are standing in the zero position. With this assumption in mind, the initial energization of the adding magnet M1 will cause the addition of a unit; the magnet M2, two units; magnet M3, three units, etc., but after the initial entry in the accumulating mechanism, the numerical suffixes of the magnets M0, M1, etc., will lose their significance so far as the actual digit entered is concerned. For example, if one unit is added by energizing the adding magnet M1, the commutator and cam assembly associated with the ratchet 60 will rotate one unit and if another unit is to be added, magnet M2 will be energized instead of magnet M1.

It is desired to make clear at this point that, while the numeral suffixes of the designations of the magnets M0 to M9 do not always have any significance in entering amounts and, from that standpoint only, are purely arbitrary, the designations do have a definite relation to the digits represented by the positions of the accumulator wheels. Thus magnet M0 and its detent stop the wheel in zero position, magnet M1 stops the wheel in the "1" position, and so on up to magnet M9 which stops the wheel in the "9" position, as will be explained hereinafter. Furthermore, magnets M0 have the special function, when the accumulator is reset, of stopping the wheels at zero, hence magnets M0 will be referred to hereinafter as zero magnets. It will be seen, therefore, that the magnets M0 to M9 correspond both in respect to numerical designation and in respect to the position of clutch dogs 58 in relation thereto, to the values of the numeral keys 40. This correspondence will be more clearly explained or emphasized hereinafter at appropriate points in the description.

The magnets M0 to M9 of each group are mounted on brackets 62 (Figs. 7, 8, and 10) secured to partition plates 63 fastened in spaced relation on a suitable frame plate 64. Associated with each magnet and pivoted at 63a on the plate 63 adjacent each magnet is a clutch detent lever 65 to which is secured an armature 66 cooperating with one of the associated magnets. Springs 67 anchored to the detent levers 65 and to pins on the plate 63 tend to rock the detent levers in a counterclockwise direction. The end of each detent lever 65 opposite the armature 66 is shaped like a fish hook as most clearly shown in Fig. 10 and cooperates with a retaining ring 68 which is rotatably mounted, as best shown in Fig. 11, on rollers 69 which ride in a groove formed in the retaining ring 68. The rollers 69 are rotatably mounted on studs 70 and are spaced from the plate 63 by collars 71, the studs 70 being shouldered to clamp the collars 71 to the plate 63 and allow free rotation of the rollers 69. Springs 72 (Fig. 10), anchored to pins on the retaining ring 68 and pins carried by the plate 63, respectively, urge the retaining ring 68 for each group of detent levers 65 in a clockwise direction but rotation of the retaining ring is limited by engagement of latch lugs 68a formed in such ring with the inside portion of the fish hook shaped end of at least one detent lever 65 as shown by the one for magnet M0 in Fig. 10.

The detent levers 65 and the lugs 68a are so shaped that the lugs 68a act as latches to prevent

retraction of the detent lever 65 by its spring 67 whenever it has been operated by a magnet as illustrated by the case of the magnet M0 and the associated detent lever 65 in Fig. 10. The lugs 68a are shaped with a cam surface 68b which cooperates with a cam surface 65a in the fish hook shaped end of the detent lever 65 so that energization of any magnet except the one whose detent lever 65 has a latching relationship with the retaining ring 68 will cause the retaining ring to be rotated in a counterclockwise direction a slight extent to release the previously operated detent lever 65. In the released position the detent levers 65 are held by the springs 67 against stop pins 73, as shown by the lever 65 for the magnet M9 in Fig. 10.

The fish hook shaped ends of the detent levers 65, when in the position shown by the lever for adding magnet M9 in Fig. 10, are clear of a stop portion 58b on the clutch dog 58, but when the detent lever is latched in the position shown by the one for the magnet M0 in Fig. 10, the dog 58 is restrained against movement to bring its tooth 58a into engagement with the tooth 57a on the shaft 57. In order to prevent back rotation of the ratchet 60 under the influence of the springs 61, there is provided a detent 74 pivoted on a stud carried by plate 63 and urged into engagement with the ratchet 60 by a spring 75.

In order to explain the operation of the differential clutch, it will be assumed that the ratchet wheel 60 stands in zero position which is determined by the detent lever 65 for the adding magnet M0 as shown in Fig. 10 and that it is desired to add 9. If a circuit is closed through magnet M9, the cam surface 65a on the hook shaped end of the lever 65 for magnet M9, by cooperation with the cam surface of the associated lug 68a in the retaining ring 68, will cause such retaining ring to be rotated slightly in a counterclockwise direction. This will result in the release of the detent lever 65 for the adding magnet M0 and will result in latching of the detent lever 65 for magnet M9 in a position similar to the position of detent lever 65 for magnet M0 now shown in Fig. 10. The release of the latter detent lever will allow the spring 61 to rock the clutch dog 58 in a counterclockwise direction to engage the tooth 58a thereon with one of the teeth 57a in the continually rotating shaft 57. Consequently the ratchet 60 will be coupled to the shaft 57 and rotate therewith until the end 58b of the dog 58 will engage the detent lever 65 of the magnet M9. This will force the tooth 58a in dog 58 out of engagement with teeth 57a and stop rotation of the ratchet 60 after exactly nine-tenths of a revolution of such ratchet. The pawl 74 will drop behind one of the teeth in the ratchet 60 and prevent rebound of such ratchet and clockwise rotation thereof after the dog 58 has been disengaged from the teeth 57. Had the adding magnet M6, for example, been energized instead of the magnet M9, the ratchet 60 would be stopped after six-tenths of a revolution. It will be seen that the position of dog 58 may be used as a basis for "reading" the amount standing on the accumulator, considering the detent for magnet M0 as the "0" position, the detent for magnet M1 as the "1" position, and so on.

The ratchet 60 drives a commutator and cam switch assembly which controls the energization of the adding magnets M0 to M9 according to the amount to be added and according to the position of the ratchet 60, and the transfer from one order to the next. It has been assumed that the magnet M0 corresponds to both the zero position

of the accumulator and the point of beginning addition on the ratchet wheel 60 for sake of simplicity in explaining the operation of the clutch mechanism. The point at which addition actually commences in each case will depend upon the point at which the ratchet wheel 60 stopped after the last operation. However, provision must be made for energizing the first, second, third, etc. magnets from that point according to the amount to be added. In other words, the reference point for selection of the magnets M0 to M9 will vary from adding cycle to adding cycle and for this reason it is impossible to designate the magnets M0 to M9 to truly represent the values added in each case.

To effect the proper selection of the magnets for addition and subtraction, each ratchet 60 is provided with a commutator generally designated 76 in Figs. 7, 14a, and 14b having ten conducting segments with which cooperate ten brushes designated B0 to B9 in Figs. 9, 14a, and 14b which are mounted in an insulating frame 77 secured to the plate 63. On account of lack of space for reference numerals only the end brushes are designated in Figs. 14a and 14b. As is clearly shown in Figs. 14a and 14b, the brushes B1 to B9 are connected to the adding magnets M1 to M9 respectively and, when the ratchet wheel 60 stands in the zero position, the brush B0 rests upon the zero segment of the commutator 76. If now the value 9 is added as explained above, the zero segment for commutator 76 will be rotated until the brush B9 of magnet M9 rests upon the zero segment.

The selective energization of the magnets M0 to M9 takes place with reference to the zero segment of the commutator 76 rather than with reference to the magnet M0. In other words, the first, second, third, etc., adding magnets to the right (Fig. 14a) of the particular one opposite which the zero segment happens to be located, will be energized according to the value to be added. For example, supposing the addition started at zero, the value 6 had been added, the zero segment is underneath the brush B6, and it is desired to add 2; the magnet M8 will be energized which is, of course, the second magnet to the right from the magnet M6 (Fig. 14a) or counterclockwise (Fig. 8) opposite which the zero segment came to rest after adding 6.

Each ratchet 60 (Fig. 7) is part of an end ring which is screwed on the right hand end of a tube 77 and on the left hand end of such tube is screwed another end ring 78. The ratchet 60, the end ring 78 and the ends of the tube 77 are formed as the ball races of a bearing including balls 79 which ride in grooves formed in the shaft 57. Concentric with each tube 77 is an insulating tube 80 on which is mounted a series of cams 81, preferably made of insulating material, which separate conducting rings 82. The rings 82 are individually connected to the segments of the commutator 76. Secured to the plate 63 is a brush carrier block 83 (Figs. 7 and 9) provided with slots in which are secured in a well known way brushes designated the BC0 to BC9 respectively (Figs. 7, 14a, and 14b). The numerical suffixes in the designations BC1 to BC9 indicate the value to be added when a circuit is to be established to a magnet M0 to M9 by means of the keys KC1 to KC9.

The brushes BC0 to BC9 inclusive for each order of the accumulating mechanism are connected to normally open contacts of one of the relays R1, R2 . . . R28, R29. These contacts are designated D0 to D9 respectively and are also con-

connected to an adding cable designated AC and having ten wires which connect in common all of the similarly designated D contacts of the relays R1 to R30. This adding cable leads to the normally closed contacts A of a subtraction relay SR (Fig. 14c). The contacts A of the relay SR are connected individually to the key controlled contacts KC1 to KC9, inclusive. Normally the subtraction relay SR is deenergized whereby the closure of any selected key contacts KC1 to KC9 according to the amount to be added, will cause a circuit to be established to one of the magnets M1 to M9 of an order of the accumulating mechanism in which the column selection relay R1, R2, etc., happens to be energized, this circuit being established through the appropriate wire of the cable AC, the proper D contact of the relay, the appropriate ones of brushes BC1 to BC9 and B1 to B9, and the corresponding magnets M1 to M9. The tracing of this circuit will be more clearly explained hereinafter in conjunction with the description of the operation of the machine.

As shown in Fig. 9, each of the twelve cams 81 operates a pair of contacts which pairs of contacts are mounted on a block 83a and are designated ATC1, ATC2, STC, and CC1 to CC9 in Figs. 7, 14a, and 14b.

Contacts CC1 to CC9 are connected to the wires of the subtracting cable SC in such fashion that all contacts CC1 are connected in common through the "1" wire of such cable to the C contacts of relay SR corresponding to the contacts KC1; CC2 to C contacts KC2; CC3 to C contacts KC3, etc. The B contacts of relay SR are connected to the wires of cable AC complementary to the A contacts of such relay, according to the tens complements of the values represented by keys KC1 to KC9. For example, if a number is to be subtracted, relay SR will be energized in a manner to be explained later, then closure of contacts KC1, for example, will set up two circuits, one through the "9" wire of cable AC to brush BC9 by way of contacts B, and the other to contacts CC1 by way of the C contacts of relay SR and the "1" wire of cable SC. The "9" key contacts KC9 has exactly the opposite effect. The actual additions which take place in the accumulator order rendered effective by energization of a relay R1, R2, etc., is denoted by the numeral suffixes 1 to 9 in the reference numerals KC1 to KC9, BC1 to BC9, D1 to D9, and CC1 to CC9. The small numerals 1 to 9 in Fig. 14c adjacent the contacts A, B, C of relay SR also refer to the numbers actually added whether the true number or tens complement.

The cam contacts are so timed (Fig. 18) that the contacts ATC1 are closed momentarily when the ratchet 60 (Fig. 10) is turned from the "9" position to the "0" position in the process of adding; contacts ATC2 are closed only at "9"; while the contacts STC are closed only at the "0" position of the ratchet for the purpose of controlling transfer operations during subtraction. Contacts CC1 to CC9 are timed so that all are closed at the zero position but are opened progressively as shown in Fig. 18. For example, when the ratchet 60 moves from "0" to "1," the contacts CC1 open, when the ratchet moves to "2" contacts CC2 open, etc. The purpose of this mode of operation is to cause a subtraction transfer to take place only when the ratchet 60 of a particular order is standing at a value lower than the tens complement of the amount to be subtracted. For instance, if the position of the ratchet 60 of any order in which a subtraction is to occur indicates

"6" and "5" is to be subtracted, then the closure of a circuit through the contacts CC5 cannot be effected since the contacts CC1 to CC6 are open and a transfer cannot take place. This will be made clear hereinafter in describing the general operation of the machine in reference to particular examples.

In order to illustrate the process of addition and subtraction, it will be assumed that the four accumulator orders shown in Figs. 14a and 14b comprise a single accumulator and that this accumulator is to be operative with respect to an amount column including space columns 12 to 15, inclusive. In order to render these four orders operative for a simple case of subtraction and addition, the plug sockets PS1 (Fig. 13) for columns 12 to 15 will be connected to plug sockets PS2 for accumulator orders 1, 2, 29, and 30 by means of suitable plug wires as in Fig. 15. With this arrangement, the relays R1, R2, R29 and R30 will be energized successively in the order named when the carriage moves from column 11 to column 15. Any selected one of the relays R1, R2, R29, R30 will remain energized during the periods in which any of the numeral type bars are being operated under control of the numeral keys. Plug wires are also inserted between socket plug PS5 and the "out" plug socket PS4 for order 1 of the accumulating mechanism. A plug wire is inserted between the "in" plug socket PS3 for accumulator order 1 and the plug socket PS4 for order 2, also between plug socket PS3 for order 2 and PS4 for order 29. A plug wire is inserted between PS3 for order 29 and PS4 for order 30. Plug wires are inserted between plug sockets PS6, PS7 for orders 1, 29, and 30 as described above except that the plug wire to PS5 is omitted. The subtraction transfer split plug sockets PS8, PS9 are plugged in the same way as the adding transfer splits PS6, PS7.

The effect of this plugging is shown in Figs. 14a and 14b by solid lines between the respective plug sockets. It will be understood that the individual subtract switches IS1, IS2, IS29, and IS30; the individual reset switches IRS1, IRS2, IRS29, AND IRS30; the total switch TS, the manual reset switch MRS; and the reset switch RS are all open. The non-accumulate switch NAS is closed to effect addition. Switch SAS remains in neutral position as in Fig. 14c.

The carriage of the typewriter is moved to column 12 in any desired way as by hand, or by means of either the space bar or tabulating mechanism. This causes the relay R1 (Fig. 14a) to be energized by a circuit from line wire W1, wire W4, the coil of relay R1, the plug wire between plug sockets PS1, PS2 for order 1; the column selector contact segment S12 for column 12, the contact elements 51 and the contact bar 48, and wires W1 and W23, to line wire W2. The contacts A, B, D0 to D9, and E of relay R1 close and contacts C open.

Assume the value 6 is to be added in accumulator order 1 which, in this case, will be the thousands order of the accumulator. The "6" key 40 of the typewriter is now depressed thereby causing the cam unit 32a associated with the "6" key (Fig. 3) to operate the contacts KC6 and at the same time print the numeral "6" in column 12 on the work sheet. The closure of contacts KS6 associated with the "6" key (Fig. 14c) establishes an adding circuit as follows: line wire W1, contacts A of the total relay TR2 (Fig. 14c), the non-add switch NAS, wire W21, contacts KC6, contacts A of the subtraction of relay SR,

the "6" wire of the adding cable AC, the contacts D6 of the relay R1 (Fig. 14a), the brush BC6, the "6" segment of commutator 78, adding magnet M6, the common wire W13, the plug wire between plug sockets PS4 for order 1 and PS5, wire W8, contacts C of total relay TR1 (Fig. 14c) and wire W15, to the line wire W2.

Energization of the magnet M6 causes the ratchet 60 associated with order 1 of the accumulating mechanism to turn six-tenths of a revolution, thereby moving the zero segment of the commutator connected thereto to a point opposite the magnet M6. Incidental to the printing of the numeral 6 in column 12 of the work sheet, the escapement mechanism 26 (Fig. 3) will be operated and the carriage will escape to column 13. This cycle of events is repeated when the next three digits are typed. The effect of rotating the commutator each time a digit is added, as explained above, is to shift the zero spot as many units as the amount to be added and to establish a new starting point for the addition of a subsequent digit of another amount. Thus if after adding 6 in order 1 it is desired to add 5, the fifth magnet from magnet M6 in a counter-clockwise direction (Fig. 8) or M1 will be energized.

Assuming that the accumulator mechanism stands at zero at the start, the addition of say a four-digit number in the four accumulator orders shown in Figs. 14a, and 14b, as plugged in Fig. 15, will not require a transfer operation. The transfer of a unit when any ratchet wheel 60 turns through the zero position is effected electrically in the following manner: Let it be assumed that the value 1978 has been accumulated on the four orders or orders shown in Figs. 14a and 14b, and that the amount 36 is to be added. The carriage is moved to space column 12 as before and the space bar depressed twice or if it is desired to print the zeros, the zero type bar may be caused to be operated by pressing the zero key twice. Since there are no electrical connections involving the zero key, no circuit will be established when the zeros are printed but the carriage will merely space to column 14 and energize the relay R29. The "3" key is now depressed and the value 3 will be added in order 29 of the accumulating mechanism. This rotates the ratchet 60 corresponding to order 29 to the zero position, thereby causing the adding transfer contacts ATC1 to close in order 29. This establishes an adding transfer circuit as follows: line wire W1, contacts A of relay TR2 (Fig. 14c), switch NAS, wire W21, contacts D of relay SR, wire W5, contacts B of relay R29 (Fig. 14b), contacts ATC1 for order 29, the plug wire between plug sockets PS1 for order 29 and PS6 for order 2, the brush BC1 for order 2, a wire W32 in total cable TC, contacts B of relay TR1 (Fig. 14c), another wire W32, magnet M0 (Fig. 14a), the plug wire between plug sockets PS4 for order 2 and PS3 for order 1, contacts C of relay R1, the plug wire between plug sockets PS4 for order 1 and PS5, wire W8 (Figs. 14a to 14c), contacts C of relay TR1 (Fig. 14c), and wire W15, to line wire W2. This causes a unit to be added in order 2 (controlled by relay R2) of the accumulating mechanism, thereby causing the ratchet 60 associated therewith to move to the zero position, since the ratchet wheel 60 for order 2 formerly stood at the "9" position. Because of this fact, the contacts ATC2 for order 2 are in closed condition when the circuit through contacts ATC1 for order 29 is closed, thereby establishing a parallel circuit to the magnet M2 for

order 1, this circuit being traced from the plug socket PS6 for order 2, contacts ATC2 for order 2, the plug wire between plug sockets PS6 of order 1 and PS7 for order 2, the brush BC1 for order 1; the magnet M2 to order 1, bearing in mind that the zero segment of order 1 is opposite the magnet M1, to plug socket PS4 for order 1. This causes a unit to be added simultaneously in the first and second denominational orders of the accumulator. The contacts ATC2 for any order which stands at "9" anticipates the need for a transfer to the next higher order and enables the transfer to be effective simultaneously with a transfer to the intermediate order. In the event that all of the accumulator wheels of higher order stood at "9," the same parallel circuits would be set up through all of the higher orders to energize all of the magnets M1 for such orders. The amount 2008 will stand on the accumulator at the end of these operations.

The carriage will now move to space column 15 and the "6" key 40 will be depressed thereby closing contacts KC6. Similar circuits will be established through the magnet M4 for order 30, since the zero segment is opposite the magnet M0, and an adding transfer circuit through contacts ATC1 for order 30 to magnet M1 of order 29, as traced above. This circuit is closed when the second unit of the 6 has been added in column 30, causing ratchet 60 for this column to pass through the zero position, defined by the detent 65 for the magnet M0. Since contacts ATC2 for orders 2 and 29 are open when the "6" key is depressed, both ratchets 60 for these orders being in zero position, only one transfer circuit is established.

The machine may be conditioned for subtraction in two different ways, one automatic and the other manual. The denominational relays R1 to R30 each are provided with contacts E (Figs. 14a and 14b) for causing subtraction to take place automatically when the corresponding individual subtract switches designated IS1 to IS30 are closed (see Fig. 13 also) or in "Sub." position. Each of the switches IS1 to IS30 is in series with one of the contacts E between wires W3, W8 of which the wire W8 is connected to the line wire W2 through the contacts C of the total relay TR1, while the wire W3 is connected to line wire W1 through the contacts SAS1 of subtract-add switch SAS, wire W20, the coil of relay SR, wire W21, switch NAS, and contacts A of total relay TR2. Switch SAS is a well-known form having three positions. When in neutral position as in Fig. 14c, contacts SAS1 are closed and SAS2 are open. It is evident, therefore, that whenever the carriage is in a position to select one of the relays R1 to R30, and switch SAS is in neutral position, the closure of the contacts E associated with the selected relay will close a circuit which will cause the energization of the relay SR and may be traced as follows, assuming for convenience that the relay R30 (Fig. 14b) is energized: Line wire W1 (Fig. 14c), contacts A of relay TR2, switch NAS, wire W21, relay SR, wire W20, contacts SAS1, wire W3, the individual reset switch IS30 (Fig. 14b), contacts E of relay R30, wire W8, contacts C of relay TR1 (Fig. 14c), and wire W15, to line wire W2. The relay SR, when energized, closes its contacts B and C and opens its contacts A, whereby the closure of any selected set of the key contacts KC1 to KC9 will cause two branch circuits to be established from the wire W21 to the adding cable AC and the subtracting cable SC.

It will be recalled that the connections from

the adding cable AC to the contacts B of relay SR are such that the circuits to the adding cable are inverted according to the tens complement of the numeral values represented by the numeral keys. For example, the contacts KC1 instead of closing a circuit to the "1" wire of the adding cable AC, now closes a circuit to the "9" wire of the adding cable. However, the connections of contacts C of relay SR to the subtracting cable SC are not inverted whereby the contacts KC1 connect the wire W21 to the "1" wire of cable SC. The subtracting cable SC is provided with a branch for each order of the accumulating mechanism leading to one of the contacts CC1 to CC9. For example, the "1" wire is connected to contacts CC1, the "2" wire to contacts CC2, etc. It will be remembered that each group of the contacts CC1 to CC9 opens in succession as the ratchet 60 with which they are associated turns from the zero to the "9" position. For example, contacts CC1 will be opened and contacts CC2 to CC9 closed when the ratchet wheel is in the 1 position.

When it is desired to subtract automatically under control of the carriage of the typewriter, the individual subtract switches IS1 to IS30 are selectively set manually (Fig. 13) to the closed or "Sub." position for the particular orders or groups of orders of the accumulating mechanism which will correspond to an amount column in which subtraction is to be effected, it being assumed that a positive number, such as a balance has already been entered in the selected group of orders by an adding operation which may be performed under manual control by means of the switch SAS. When it is desired to add in any order automatically, the switches IS1 to IS30 for the selected orders or groups of orders will be left in the open or "Add" position but it will, nevertheless, still be possible to subtract in such orders under manual control by setting the switch SAS to "Add" position. Switch SAS, in "Add" position (Fig. 14c), opens contacts SAS1 to prevent automatic energization of the subtraction relay SR and, in "Sub." position, closes contacts SAS2 to energize relay SR to enable subtractions. This makes it possible to correct errors and add or subtract under special conditions where the normal operation would be the reverse.

If a group of orders of the accumulating mechanism associated with a particular amount column on a work sheet have been conditioned for addition by inserting plug wires between the proper plug sockets PS1, PS2, and it is desired to subtract one item only where otherwise addition would take place, the switch SAS (Figs. 12 and 14) may be moved downwardly in Fig. 12 or to the right in Fig. 14c to the subtract position. This closes contacts SAS2 and energizes the subtract relay SR by a circuit similar to the first part of the one traced above except that the contacts SAS2 shunt the open switches IS1 to IS30 whereby the relay SR is directly energized regardless of the condition of the individual subtract switches IS1 to IS30.

Under certain circumstances it may not be desired to either add or subtract amounts printed in a particular amount column where either addition or subtraction would normally take place automatically. Accordingly, the non-accumulate switch NAS may be opened and prevents any circuits from being established by means of the key contacts KC1 to KC9. The operation of switch NAS also will deenergize the subtract relay

SR if it is being maintained in energized condition as consequence of a selection by one of the column selection relays R1 to R30.

A subtraction operation will now be described, assuming that the four orders shown in Figs. 14a and 14b have been plugged as described above with reference to Fig. 15 for addition and that the switches IS1, IS2, IS29, IS30 have been closed to cause subtraction to take place automatically whenever the carriage of the typewriting machine is positioned to select the relays R1, R2, R29, R30. The combined plugging for both addition and subtraction transfers is shown in Fig. 15. With this plugging the machine will normally automatically subtract in the first, second, twenty-ninth and thirtieth orders of the accumulating mechanism operating as a single accumulator of four orders for amounts typed in a column of the work sheet including space columns 12 to 15 of the typewriter carriage.

It will be assumed that the four ratchets 60 associated with the four orders selected have positions representing the amount 0060 and that it is desired to subtract 0028. The operator positions the carriage to space column 14 which causes the relay R29 to be energized in the manner described above, thereby closing its contacts E and causing the energization of the subtraction relay SR. Since the ratchet 60 for the 29th order is now standing at "6," the contacts CC1 to CC6, inclusive will all be open while contacts CC7 to CC9 will be closed. Also the contacts ATC1, ATC2, and STC will all be open.

The operator now presses the "2" key which, through operation of the cam unit 32a associated with the "2" key, causes the "2" type bar to be operated and also causes the contacts KC2 to close. This potentially establishes two separate circuits to the 29th order of the accumulating mechanism. The first circuit causes the value 8, the tens complement of "2," to be added and is traced as follows: line wire W1 (Fig. 14c), contacts A of relay TR2, switch NAS, wire W21, contacts KC2, contacts B of relay SR, the "8" wire of adding cable AC, contacts D8 of relay R29, (Fig. 14b) the brush BC8 and the common ring 82 associated therewith, the adding magnet M4 for the 29th order because the zero segment of commutator 76 is now opposite the magnet M6, and thence to line wire W2 as explained above. This causes the ratchet 60 to be rotated far enough to carry the zero segment to a point opposite the magnet M4. No adding transfer circuit is closed however, although the ratchet wheel 60 of the 29th order has turned to zero and closed the contacts ATC1, because the energization of the subtract relay SR has opened contacts D of this relay to prevent any circuits from being established from the wire W5 through the contacts B of relay R29 to the contacts ATC1. Thus the ratchet 60 for the 29th order rotates as if 8 and 6 had been added to give 14 but the transfer of the unit is eliminated.

The second circuit which might be established by contacts KC2 through contacts C of relay SR cannot be made in the present case because the contacts CC2 (which are now connected to contacts KC2) are open in the beginning of this case because of the fact that the ratchet 60 stood at "6" in the beginning with all contacts CC1 to CC9 open. Thus at the end of the operation of adding 8, the complement of 2, the result is the same as if 20 had been subtracted from 60 and the 29th and 30th orders now retain the value 40. The circuit established by the contacts KC2 is mo-

mentary and will not be held long enough for the second circuit to be established through any of the other contacts CC1 to CC9 in the event that one closes as a result of the addition. As a result of typing the value 2 in space column 14 on the work sheet, the carriage will escape to space column 15, thereby selecting the relay R30. The relay SR is momentarily deenergized but is reenergized in consequence of the fact that the switch IS30 is closed.

The operator now depresses the "8" key which can, in this case, establish two circuits through the contacts KC8 because the ratchet wheel 60 for the 30th order now stands at zero with all of the contacts CC1 to CC9 closed. The first circuit is traced as described above through the contacts KC8 to the "2" wire of the adding cable AC and through the magnet M2 for the 30th order, since the zero segment of commutator 76 for this order is at the zero position, that is, opposite magnet M0. As a result of pressing the "8" key, the value 2 will be added in the 30th order.

The second or subtraction transfer circuit is established from the contacts KC8, through contacts C of relay SR (Fig. 14c), the "8" wire of the subtract cable SC, contacts CC8 for the 30th order, contacts A of relay R30 (Fig. 14b), the plug wire between the "out" plug socket PS8 for such order and the "in" plug socket PS8 for the 29th order, the brush BC8 for the 29th order, the brush B3 and magnet M3 for the 29th order, and wires W6 and the plug wires between the plug sockets PS3, PS4 and PS5 for the 1st and 2nd orders, wire W8, contacts C of relay TR1, and wire W15, to line wire W2. Since the ratchet wheel 60 of the 29th order initially stood at 4, the contacts STC will be open and a branch subtraction transfer circuit cannot be established to the second order. However, the energization of the magnet M3 causes the value 9 to be added in the 29th order, whereby the ratchet wheel for this order will turn to the value 3 while the ratchet wheel 60 for the 30th order will turn to the value 2. Thus, at the end of the second adding cycle, the accumulator will stand at 0032. No units carry can be effected in the normal way because contacts D of relay SR are open, preventing the contacts ATC1 from having any effect. The contacts ATC2 cannot have any effect because they, in turn, depend upon the operation of the contacts ATC1.

It will be noted from the foregoing that subtraction is effected by always adding the tens complement of the digit to be subtracted in the order of the accumulator in which subtraction is effected. When the actual value to be subtracted is less than the amount standing on the accumulator a transfer of the tens complement of 1 to the next order on the left is not possible because of the action of the contacts CC1 to CC9, but where the amount to be actually subtracted is greater than the amount standing on the accumulator order, the tens complement is transferred to the next adjacent order on the left through one of the contacts CC1 to CC9.

In the process of subtraction there is one condition which must be met by the subtraction transfer mechanism which the contacts STC are provided to meet. In the above illustration, the minuend was presumed to be greater than the subtrahend so that the result was positive. It might happen, however, that in the tabulation of a long column of figures, the amount standing on the accumulator might temporarily become negative or exactly balance. In other words, the

amount standing on the accumulator, or minuend, might be zero or less than the amount to be subtracted, or subtrahend. This also might be true at the end of a tabulation of debit and credit items in which the total of added debit items might be less than the total of the credit items subtracted.

Let it be assumed that the value 0060 stands on the accumulator as in the above case but that the value 0082 is to be subtracted instead of 0028. The operator positions the carriage to column 14 and presses the "8" key. This will cause the value 2 to be added in the 29th order of the accumulator by circuits similar to the one traced above. Since the ratchet 60 for the 29th order initially stood at 6, the contacts CC1 to CC9 will all be open and contacts CC7, CC8, CC9 are closed so that a subtractive transfer through contacts A of relay R29 to the brush BC9 of the second order can be affected by the second circuit of which the contacts KC8 are capable of establishing. Furthermore, the ratchets 60 for the first and second orders both stand at zero and their contacts STC are closed. A circuit will be set up from contacts KC8 through the contacts CC8 for the 29th order through contacts A of relay R29 to the "in" plug socket PS8 for the second order. Since the contacts STC are closed for this order and the first order, two parallel circuits will be established through the magnets M9 for these orders, thereby causing the ratchets 60 for the first and second orders to rotate to 9. As a result, the amount 9980 will stand on the accumulator after the first digit of 82 has been subtracted. This is the complement of 20, the difference between 80 and 60. The carriage, of course, will space to the 15th column space and the operator will depress the "2" key, thereby causing the value 8 to be actually added in the 30th order and, since the 30th order ratchet 60 stands at zero, a transfer of 9 to the 29th order will occur through the contacts CC2 of the 30th order as described above but, since the first and second order wheels now stand at 9, this transfer of 9 will be limited to the 29th order. As a result, the accumulator will register 9978. This will be found to be the complement of 22 which is the algebraic difference between 60 and 82. Thus, whenever a total is printed which contains a 9 in the highest order denominationally of the accumulator, it is an indication that the accumulator contains a negative balance stored as the complement of the balance.

The above mode of operation also takes place with respect to intervening orders which may happen to have a zero standing on them between the highest digit of an amount and the lowest. For example, in subtracting 9 from 108, a unit will be added in the 30th order and the 9 will be transferred to the 29th order as explained above through the operation of the contacts CC9. Since the ratchet 60 for the 29th order stands at zero, its contacts STC will be closed, thereby setting up the branch circuit to the 9 magnet of the second order to cause a 9 to be added in the second order also. The second order, however, stands at 1 and its contacts STC are open whereby the transfer of 9's will be limited to the second and 29th orders. The effect, therefore, of subtracting 9 from 108 is to add the value 991 to 108, yielding the result 099, it being remembered that the normal adding transfer is disabled, whereby a unit cannot be transferred to the first order in consequence of adding 900 to 100.

In Fig. 16 there is shown a modification of plugging to enable addition and subtraction to be

effected in an accumulator comprising four orders of the accumulating mechanism with respect to two amount columns of the work sheet. With the arrangement shown in Fig. 16, one column of the work sheet comprises the 12th to 15th column spaces on the work sheet, while the other column comprises the 17th to 20th column spaces. Denominationally the 15th position or order of the accumulating mechanism is used as the units order and may receive entries of digits printed in the 15th or 20th column spaces, respectively. Similarly the 14th, 13th, and 12th orders of the accumulating mechanism comprise tens, hundreds, and thousands orders of the accumulator and may receive entries of the digits printed in space columns 12, 13, 14, or 17, 18, 19. If the individual subtraction switches IS12 to IS15 are in the subtraction position, subtraction will always automatically be effected when amounts are typed in either of the two corresponding columns of the work sheet, since the same relays R12 to R15 will be energized in both cases. However, by manual control of the switch SAS, adding can be accomplished of amounts printed in the amount column comprising the 12th and 15th spaces and subtraction effected of amounts printed in the amount column comprising the 17th to 20th spaces, and vice versa.

With the plugging arrangement of Figs. 16, items typed in two columns of a sheet, such as an invoice sheet or ledger sheet, may be accumulated to determine either the total of the amounts written on one line, as in cross-footing; or determine the balance of all items written in both columns; or the total of all items written in two columns. If the individual subtraction switches IS12 to IS15 are to be kept in the subtraction position for a specific job, it is possible to enter a balance in the accumulator comprising the 12th to 15th orders by setting the switch SAS in add position and typing the balance as a preliminary to commencing operations. The same procedure may be followed prior to commencing any group of operations with respect to any group of orders of the accumulating mechanism operating as an accumulator.

Any desired numbers of orders or positions of the accumulating mechanism may be grouped with the plugging arrangement shown in Fig. 17, according to the number of amount columns on the work sheet and according to the number of column spaces allotted to an amount column. It is also possible to combine the arrangement shown in Fig. 16 with the one shown in Fig. 17.

With the arrangement shown in Fig. 17, a balance may be entered in the amount column comprising space columns 12 to 15, in which the switches IS12 to IS15 are normally set to effect addition, by merely typing the balance if positive or setting subtract-add switch SAS to subtract position before writing the balance. If this last step is done in the beginning with the accumulator clear, the balance will be converted to a complement but will be converted to a positive number as soon as the positive amounts accumulated additively exceed the total of the balance and the negative amounts accumulated subtractively.

With respect to the amount column comprising space columns 17 to 20, inclusive, the corresponding switches IS20 to IS23 (Fig. 17) of which are set to subtract position, the balance may be entered by setting the switch SAS to add position before typing the balance, if the balance is

positive, or merely typing the balance if it is negative. In the group of accumulator orders corresponding to columns 12 to 15, an amount may be subtracted at any time, notwithstanding the position of the switches IS12 to IS15, by setting the switch SAS to the subtract position. Similarly, in the group of orders corresponding to space columns 17 to 20, addition may be effected at any time by setting a switch SAS to add position.

When it is desired to effect addition in any amount column strictly under manual control, as where items must be subtracted about as often as added, the switch SAS may always be used and switches IS12 to IS15 left in add position so that the machine will normally add unless the switch SAS is set to subtract. The switches IS1 to IS30 are of most advantage where a balance is to be entered initially and all items are to be added to or deducted from the balance. In certain types of bookkeeping operations, for example, the balance brought forward may be a debit balance and all items written on the work sheet may be debits, whereby manual control of the switch SAS may only be necessary to determine the balance of the debits and credits by a final subtracting operation.

The operations of printing a total will now be described with reference to the simple arrangement of Fig. 15, assuming that the accumulator comprising the 1st, 2nd, 29th and 30th orders of the accumulating mechanism stands at 0060. To print this total, the operator moves the carriage to the 12th column space in any suitable way, as by means of the tabulating key, and closes the total switch TS by moving it downwardly (Fig. 12) to the total position. This results in energizing the total relays TR1, TR2 thereby closing all of the contacts A of the relay TR1 and all of the contacts B of the relay TR2. This has the effect of connecting the key solenoid KS1 to KS9 complementarily to the "1" to "9" wires of the adding cable AC. The "0" wire of the adding cable is connected to the "0" solenoid KS0. The reason for the inversion of the connections of the key selecting solenoids KS0 to KS9 to the wires of the adding cable will be seen with reference to Fig. 14a. It will be noted that when the value 1, for example, is added, the clutch dog 58 will be disengaged from the detent for the magnet M0 and will be stopped by the detent for the magnet M1. Thus, by the position of the dog in relation to the magnets M0 to M9, the value standing on a wheel may be determined by inspection of the clutch. However, when the accumulator wheel is advanced one unit, the 9 segment of commutator 76 will move under the zero brush B0. In other words, the accumulator wheel will indicate 1 with reference to the position of the clutch dog 58 but will indicate 9, the complement with respect to the designations of the segments of commutator 76. It is necessary, therefore, to invert the wiring of the adding cable to the relay TR2 in order to print the total correctly. The contacts A of the relay TR2 open and prevent any circuits from being established to the adding cable AC by means of the key contacts KC1 to KC9 and also prevent adding transfer circuits over wire W5. The closure of contacts A of the total relay TR1 has the effect of connecting all of the zero brushes B0 for the 1st, 2nd, 29th, and 30th orders of the accumulating mechanism directly to the line wire W1 through the wire W16 (Fig. 14c).

The two highest orders of the accumulating mechanism, which in the present case are controlled by relays R1 and R2, both stand at zero and the adding magnet circuits will be in the condition shown in Fig. 14a with the brushes B0 contacting the zero segments of commutator 76. As a result, a digit printing circuit will be established as follows, when the total switch TS is closed with the carriage in the 12th column space position: Line wire W1, wire W16 (Fig. 14c), contact A and a wire W31 of the total cable TC, the brush B0 (Fig. 14a) of the first order of the accumulating mechanism, the collector ring 82 of the associated brush BC0, contact D0 of the relay R1, the zero wire of the adding cable AC, the zero contacts B of relay TR2 (Fig. 14c), solenoid KS0, and wire W19, to line wire W2.

The energization of the key solenoid KS0 results in typing a zero in the 12th column space of the amount column on the work sheet and the carriage will automatically space to the 13th column space. A second zero printing circuit will be established in the same manner through the brush B0 of the second order of the accumulator mechanism to cause the energization of the solenoid KS0 a second time and the carriage will escape to the 14th column space. Since the 29th order of the accumulating mechanism now stands at six, with the brush B0 for this order bearing on the "4" segment of commutator 76, a printing circuit will be established through ring 82 associated with the brush BC4 and said brush, the contacts D4 of relay R29, the "4" wire of adding cable AC, and solenoid KS6, resulting in the numeral 6 being typed on the work sheet. The carriage will escape to the 15th column space and another zero printing circuit will be established through solenoid KS0 and the contacts D0 of relay R30 in the same fashion as described above with reference to the first and second orders of the accumulating mechanism. As a result of these operations, the figures 0060 will be typed in succession in the amount column on the work sheet, but the accumulating mechanism will not be reset or otherwise changed since none of the magnets M0 to M9 have been energized.

Resetting of the entire accumulating mechanism at once is accomplished very simply by energizing together all of the zero magnets M0. The carriage is moved to a position where none of the relays R1 to R30 which may have been plugged to operative position can be selected and the switch RS closed by moving it downwardly in Fig. 12. This energizes the reset relay and causes all of the magnets M0 to be energized by circuits similar to the following: Line wire W1 (Fig. 14c), wire W16, contacts A and B of relays TR1, RR, one of wires W31, for example, of total cable TC, the magnet M0 for the first order (Fig. 14a) and parallel wire W13, the plug wires between the plug PS4, PS5, wire W8, contacts C of relay TR1 (Fig. 14c), and wire W15, to line wire W2. With the energization of the magnets M0, the ratchets 60 of all accumulator orders will be turned to the zero position. Those which are already in the zero position will not move, while those which are not in the zero position will merely move the remaining distance to the zero position.

It may be desired to reset some accumulator orders and not others. For example, with reference to Fig. 17, it might be desirable to reset the accumulator comprising the 20th to 23rd orders but not the one comprising the 12th to 15th

orders inclusive. In order to effect resetting, the individual reset switches IRS1 to IRS30 and the manual reset switch MRS are used, for example, the switches IRS20 to IRS23 may be closed (designated "Reset," Fig. 13) and switches IRS12 to IRS15 left in open ("Accumulate") position with reference to the plugging shown in Fig. 17. This places all of the magnets M0 for the 20th to 23rd orders of the accumulating mechanism in parallel through the switch MRS. As long as this switch remains in open position the magnets M0 will not be energized, but, as soon as switch MRS is closed, circuits will be established to the magnets M0 which can be traced from line wire W1, wire W10 (Fig. 14a), switch MRS, the magnets M0, wires W13; the plug wires between plug sockets PS3 and PS4, and contacts C of the relays R20 to R23, inclusive; the plug wire between socket PS4 and PS5, wire W8, contacts C of relay TR1 (Fig. 14c) and wire W15, to line wire W2. It will be seen that this circuit is similar to the one previously traced except that the magnets M0 are energized more directly by shunting the contacts A and B of the relays RR, TR1. The magnets M0 for the 12th to 15th orders will not be energized since the reset relay RR was not energized.

With the relays plugged as shown in Fig. 16, it is possible, not only to accumulate all items printed in either or both of two amount columns, but also to print the total in either or both of these columns. This is apparent from the above description of how totals are printed because the relay R12 will be energized to condition the machine for printing a total from the 12th order of the accumulator, both when the carriage is in the 12th column space position and the 17th column space position. Since the accumulator is not reset after a total printing operation except by separate operation of the manual reset switch MRS or the main reset switch RS, the total could be printed in space columns 12 to 15 and then repeated in space columns 17 to 20 or initially the carriage could be set at either column 12 or column 17 and only one total printed. This feature is of convenience when it is desired to print a balance of items such as debits and credits entered in the debit and credit columns of a work sheet, particularly where it is known beforehand that one or the other will always total a greater amount. For instance, if the debits always exceed the credits, the total may be printed in the debit column. In order to operate the machine in this manner, the manual switch SAS is used to effect the addition of items printed in one column and the subtraction of items printed in the other column.

In order to prevent undesirable back circuits and to compel the circuits traced herein to flow in the proper direction, some well known means, such as the rectifiers R (Figs. 14a and 14b), may be provided. These may be of the well known copper oxide type.

While there has been shown and described and pointed out the fundamental novel features of the invention as applied to a single embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention therefore to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In an accounting machine, a plurality of accumulator orders, each order including an ac-

5 cumulator wheel, a series of read-in circuits, one for each digit, each circuit having a magnet for causing the entry of a single digit, each order including a switching device actuated by said wheel to select one of the read-in circuits according to the position of said wheel; a series of digit keys corresponding to said digits and circuits, contacts controlled by said keys for closing said read-in circuits and energizing said magnets to enter amounts to be totalled, a series of digit key controlling magnets, means to connect said magnets to the read-in circuits in place of said contacts to convert said read-in circuits to readout circuits and to close circuits through the switching devices to selected read-in circuits, and means to selectively render the read-in circuits effective, one order at a time, to selectively control the digit key controlling magnets according to the total accumulated.

2. An accumulating mechanism comprising a plurality of separate orders, each order including an accumulator wheel, and separate means to rotate said wheel variable extents to enter amounts, each of said rotating means including a series of magnets for controlling the entry of digits; a single set of numeral keys common to all of the orders of the accumulating mechanism, contacts controlled by said keys, a plurality of circuit closing means each individual to one order for connecting said contacts to said magnets, and means operable in successive steps to select the circuit closing means one order at a time in succession.

3. In a combined typewriting and computing machine; computing mechanism comprising a plurality of accumulator orders, each order having an accumulator wheel, a differential clutch mechanism for rotating said wheel different extents, a series of magnets for controlling the clutch mechanism to enter digits in the associated wheel, and a switching device actuated by said wheel and connected to said magnets for selecting the magnets digitally for a succeeding entry according to the final stopping position of said wheel after an entry; a single series of numeral keys representing different digital extents of movement of the wheel and corresponding to a series of said magnets, contacts controlled by said keys for closing circuits to the magnets through said switching device, and selecting means for coupling said contacts to the switching devices one switching device at a time and successively.

4. In a combined typewriting and computing machine, an accumulator wheel, a series of digit circuits; differential mechanism for entering digits of amounts on said wheel including a series of magnets for causing the entry of different digits and corresponding in number to the digit circuits, and a switching device actuated by said wheel for connecting said digit circuits to said magnets to change the numerical reference point for each digit entered according to the position of the wheel; a series of numeral keys; and contacts in said digit circuits controlled by said keys, said contacts and digit circuits being numerically associated whereby the actuation of a selected key causes the closure of the correspondingly valued digit circuits and the energization of an appropriate one of the magnets.

5. In a combined typewriting and computing machine, an accumulator wheel, a series of digit circuits; differential mechanism for entering digits of amounts on said wheel including a

series of magnets for causing the entry of different digits and corresponding in number to the digit circuits, and a switching device actuated by said wheel for connecting said digit circuits to said magnets to change the numerical reference point, for each digit entered, according to the position of the wheel; a series of numeral keys; contacts in said digit circuits controlled by said keys, said contacts and digit circuits being numerically associated whereby the actuation of a selected key causes the closure of the correspondingly valued digit circuits and the energization of an appropriate one of the magnets; a series of total recording magnets for recording different digits, each magnet corresponding to a digit, and a total switch mechanism for coupling the total recording magnets to the digit circuits in place of said key controlled contacts and for closing a circuit through the first named switching device to one of the digit circuits according to the position of the associated accumulator wheel.

6. In a computing machine, accumulator wheels, a single series of digit keys common to all of said wheels and corresponding in number to the number of digits which can be represented by the different positions of the wheels, contacts closed by operation of said keys; a plurality of differential clutch mechanisms, each associated with a wheel, each clutch mechanism including a series of magnets for causing the entry of the digits corresponding to the different digit keys, and switch means operated by said wheels for causing the magnets to be controlled selectively by said contacts according to the digit represented by the position of the wheel; and column selecting means for selectively connecting the switch means one at a time to said contacts.

7. In an accumulating mechanism, an accumulator wheel, a clutch dog mounted on said wheel, a toothed driver with which said dog is engageable, means tending to engage said dog with said driver; a series of detents arranged concentrically of said wheel and movable into the path of said dog to arrest said dog in its movement by said driver, one of said detents normally holding the dog out of engagement with the driver; a retaining member for holding said detents in the path of said dog and operable by the movement of any selected detent to release any other detent holding said dog; a series of magnets, each for operating one of said detents; a series of digital adding circuits, one for each magnet; and a commutator device coupling said circuits to said magnets, said commutator device being operated by said accumulator wheel and, when rotated by said wheel, changing the connections of said circuits to said magnets in rotation according to the extent of rotation of said wheel.

8. In an accumulating mechanism, an accumulator wheel; means to rotate said wheel to enter digits comprising a series of detents defining different value positions and a zero position, and a series of magnets for actuating said detents; including zero magnet value recording mechanism including a series of digit recording magnet corresponding to the value positions defined by first named magnets; a series of digit circuits, including a series of contacts corresponding to the value defined by the detent magnets, each circuit when closed energizing one of the detent magnets; a switching device rotatable by said wheel for coupling said detent

magnets to said circuits, said switching device, by its position, denoting the value accumulated by said wheel; means to couple said recording magnets to said circuits for the recording of a total; means to close a circuit through said switching device to energize a recording magnet; and means to energize the zero magnet to reset the accumulator wheel and said switching device to zero.

9. In an accumulating mechanism, the combination of a series of accumulator wheels; means to rotate said wheels to represent the digits of amounts including a separate series of adding magnets for each wheel and a differential clutch mechanism including a separate clutch controlled by said magnets for each wheel, one of said magnets in each series defining a zero position and the other magnets defining different digital positions of the wheels; means, including separate switching devices operated individually by said wheels and a series of digit circuits, for energizing the magnets selectively to enter digits; a single series of contacts common to all of said wheels and representing different digits to be entered, column selecting means for coupling said contacts to said circuits to select said magnets one digit at a time, and separate means to close a circuit through all of the zero magnets to cause all of the wheels to move to the zero position.

10. In an accumulating mechanism, a series of accumulator wheels, means for entering amounts in said wheels including a separate differential clutch for each wheel having a series of magnets for controlling the clutch, the magnets of each series corresponding to different digital positions of the accumulator wheels including a zero position, means to energize said magnets to enter amounts in the accumulating mechanism, separate means to close circuits to energize the zero magnets together to cause the accumulator wheels to be rotated to their zero position by their respective clutch mechanisms and means to selectively connect the zero magnets to said circuit closing means.

11. In a machine of the class described, the combination of a series of digit keys, a series of accumulator wheels; differential clutch mechanisms, one for each wheel, each including a series of digit magnets defining digital stopping positions of the associated accumulator wheel and including a corresponding switching device for each wheel rotated by said wheel; contacts controlled by said keys for closing circuits to any series of magnets separately through the corresponding switching device, said switching device selecting the magnet which is to be energized by closure of selected digit contacts, said switching device defining, by its position, the total accumulated by its associated wheel; column selection means for coupling said contacts to the switching devices one order at a time to enable digits to be entered one at a time, a series of recording magnets, representing the digits, means to couple the recording magnets to the switching devices through the column selection means in place of said contacts, and means for closing a circuit to a selected one of the recording magnets through a switching device selected by the column selector device.

12. In combination with a typewriting machine having a carriage, a series of numeral keys and numeral printing mechanism controlled by said keys; a series of accumulator wheels, means for entering amounts in said wheels the amounts

printed comprising a differential clutch for each wheel and a series of digit magnets for controlling the clutch mechanism to enter the digits represented by said keys, contacts controlled by said keys, switching devices individual to each accumulator wheel for coupling said contacts to the magnets of the associated clutch device, all of said magnets being normally disconnected from the contacts; and means controlled by said carriage for selectively connecting said switching devices to said contacts, one device at a time to enable a digit to be entered in an accumulator wheel corresponding to a column in which the same digit is printed by the printing mechanism.

13. In combination with a typewriting machine having a carriage, a series of numeral keys, and a numeral printing mechanism controlled by said keys; a series of accumulator wheels, means for entering the amounts printed in said wheels comprising a differential clutch for each wheel and a series of magnets for controlling the clutch mechanism to enter digits represented by said keys; contacts controlled by said keys; switching devices, each individual to and operated by an accumulator wheel, for coupling said contacts to the magnets of the associated clutch device, all of said magnets being normally disconnected from the contacts; column selection means controlled by the carriage for selectively connecting said switching devices to said contacts one device at a time to enable a digit to be entered in an accumulator wheel corresponding to a column in which the same digit is printed by the printing mechanism, a series of recording magnets for operating said keys, means to disconnect the key controlled contacts from their circuits and interpose the recording magnets, and means to close a circuit to one of said recording magnets through the switching device rendered effective by the column selector device whereby to print single digit of a total accumulated by said wheels.

14. In a machine of the class described, the combination of higher and lower order accumulator wheels, means to enter amounts in said wheels one digit at a time including a series of numeral keys, transfer means between said wheels operative to control the entering means to cause a unit to be entered in the higher order wheel by the entering means when the lower order wheel is turned to zero, means to condition the entering means for a subtracting operation under control of said keys, subtraction transfer means for controlling the entering means when it is conditioned for subtraction to enter the 9 in a higher order wheel, and means operated by the lower order wheel for preventing the entry of the 9 in the higher order wheel when the lower order wheel stands at a value greater than the amount to be actually subtracted.

15. In combination with a typewriting machine having a carriage and numeral keys, numeral contacts individual to and controlled by said keys, accumulating mechanism comprising a plurality of separate and independent orders, each order including an accumulator wheel, means to rotate the accumulator wheel different extents under control of the numeral keys including a series of magnets, a switching device operated by the accumulator wheel, and a multicontact relay having its contacts connected to said magnets through said switching device; a column selector device coupled to the carriage, circuits to said relays from said column selector device for selectively operating said relays one at a time as the carriage moves to select the order in which a digit is to be added;

common circuits from the contacts of said relays to the first named key controlled contacts, each of said key contacts when closed by the operation of the associated key closing a circuit to one of said magnets of the order corresponding to a selected relay; and a switching device in said circuits from said relay contacts to said key controlled contacts for complementarily connecting said relay key controlled contacts to said contacts to effect subtraction when the switching device is operated.

16. In a machine of the class described, an accumulator including higher and lower order accumulator wheels, means to rotate said wheels additively or subtractively including a series of selectable elements individual to each wheel and causing rotation of the wheel different extents according to the different digits to be added or subtracted, transfer means including connections from the lower order wheel to the selectable elements causing rotation one and nine units respectively, of the higher order wheel and operative when the lower order wheel turns to the zero position to actuate the selectable element causing rotation one unit and, when the given wheel stands at a value less than a digit to be subtracted, to operate the selectable element causing rotation of the higher order wheel nine units; and subtraction control mechanism including means to prevent a transfer of a unit to the higher order wheel during a subtraction operation.

17. In a machine of the class described, the combination of a series of accumulator wheels, means individual to each wheel for rotating said wheel including a series of selectable elements representing different digital positions of said wheel and selectively operable to cause entry of different digits, a series of digit keys for controlling said selectable elements, said keys being common to all of the accumulator wheels; a column selector device for selectively coupling the keys to the selectable elements one series at a time to enter amounts in the accumulator one digit and wheel at a time; and subtraction control means operable to change the connections between said keys and the selectable devices to enable subtraction to be effected by adding the complement of each digit.

18. In a machine of the class described, accumulating mechanism comprising a series of orders, each order having an accumulator wheel, power means for driving said wheel and clutch mechanism between said driving means and said wheel, said clutch mechanism including a series of detents defining different digital stopping positions of the wheel and a group of magnets each for operating one of said detents; a series of keys common to all of said wheels and representing different digits, a series of contacts each individual to one of said keys, a plurality of switching devices, each actuated by a wheel, for rotatively changing the connections between said contacts and the group of magnets associated with a selected wheel according to the extent of rotation of said wheel, means to connect said contacts to any switching device to enable the associated group of magnets to be selectively controlled by depression of the keys, and a second switching device connecting said contacts to said first named switching device to complementarily change the connections from the magnets to said contacts to enable subtraction to be effected by complementary addition.

19. In an accounting machine, the combination of a carriage; a plurality of accumulator orders, each order including a series of read-in circuits, one for each digit, each circuit having a magnet

capable of causing entry of a digit; a series of digit keys corresponding to said circuits, contacts controlled by said keys for closing said read-in circuits and energizing said magnets, a series of digit recording magnets in the read-in circuits in place of said contacts to convert said read-in circuits to readout circuits, column selecting means controlled by the carriage for selectively coupling the read-in circuits to said recording magnets and means to close said read-in circuits for the taking of a total.

20. In an accounting machine, a carriage; an accumulating mechanism comprising a plurality of separate orders, each order including an accumulator wheel and means to rotate said wheel variable extents to enter a digit of an amount, said rotating means including a series of digit entry controlling magnets for each order; a single series of numeral keys common to all of the orders of the accumulating mechanism, contacts controlled by said keys, switching means individual to each other for electrically connecting said key control contacts to the magnets for such order, and a column selector device operated by the carriage for selectively operating the switching means.

21. In a combined typewriting and computing machine, a carriage; computing mechanism comprising a plurality of accumulator orders, each order having an accumulator wheel, a differential clutch mechanism for rotating said wheel different digital extents, a series of digit entry controlling magnets controlling the clutch mechanism, and a switching device actuated by said wheel and connected to said magnets for selecting the magnets digitally for a succeeding entry according to the final stopping position of said wheel after an entry; a series of numeral keys representing the different digits, contacts controlled by said keys for closing circuits to the corresponding magnets, means individual to each wheel for coupling a switching device to said contacts, a column selector operated by the carriage for selecting the last named means one at a time.

22. In an accumulating mechanism, an accumulator wheel; means to rotate said wheel to enter digits comprising a series of detents defining different value positions of the accumulator wheel, including a zero position, and a series of magnets for actuating said detents to enter digits of amounts; value recording mechanism including a series of digit recording magnets corresponding to the first named magnets; a series of digit circuits, including a series of contacts corresponding to the detent magnets, each circuit when closed energizing one of the detent magnets; a switching device rotatable by said wheel for coupling said detent magnets to said circuits, said switching device, by its position, denoting the value accumulated by said wheel; means to couple said recording magnets to said circuits for the recording of a total; and means to close a circuit through said switching device to energize a recording magnet.

23. In an accumulating mechanism, the combination of a series of accumulator wheels; means to rotate said wheels to represent the digits of amounts comprising a separate group of adding magnets for each wheel and a differential clutch mechanism including a separate clutch controlled by said magnets for each wheel, one of said magnets in each group defining a zero position and the other magnets defining different

stopping positions of the wheels; means including separate switching devices connected to said magnets and operated individually by said wheels and a series of digit circuits including said magnets and switching devices for energizing the magnets selectively to enter digits; a single series of contacts common to all of said wheels and representing different digits to be entered, and column selecting means for coupling said contacts to said circuits to select said magnets one group at a time.

24. In an accumulating mechanism, a series of accumulator wheels, means for entering amounts in said wheels including a separate differential clutch mechanism individual to each wheel, each clutch mechanism having a group of magnets for controlling the clutch, each magnet defining a different stopping position for the accumulator wheel and, when energized, causing the accumulator wheel to rotate from any previous stopping position to the position defined by the energized magnets, said magnets including a zero magnet which may be energized to cause the accumulator wheel to turn to the zero position; means to energize said magnets to enter amounts in the accumulating mechanism, and separate means to energize the zero magnets to cause the accumulator wheels to be rotated to their zero positions by their respective clutch mechanisms.

25. In an accumulating mechanism, a series of accumulator wheels; a differential clutch mechanism associated with each wheel for rotating it different extents, including a series of equally spaced magnets, each defining a different stopping position of the wheel including a zero position; a series of adding circuits including digit key controlled contacts for closing said circuits, a switching device actuated by said wheel including a series of brushes, each associated with a magnet and including a zero brush for the zero magnet, said switching device when actuated by its associated accumulator wheel shifting the connections of the magnets to the adding circuits in rotation to enable entry of a digit by closing said contacts, a series of total recording control elements, and switching means for coupling the total recording control elements to the adding circuits in place of said contacts to enable a total to be taken and also closing a circuit through the zero brush and switching device to select one of the total recording control elements according to which adding circuit happens to be connected to the zero brush through the switching device.

26. In a machine of the class described, the combination of an accumulator wheel, a driving shaft; a differential clutch for coupling the accumulator wheel to the driving shaft, including a series of magnets arranged concentrically of the shaft and defining different digital stopping positions of the accumulating wheel including zero and when energized causing the accumulator wheel to rotate until stopped in the digital position corresponding to the energized magnet, said zero magnet, when energized, causing the accumulator wheel to move to the zero position; a series of digital adding circuits including separate digit key controlled means in each circuit for closing said circuit; a switching device for connecting said magnets to said circuits, said switching device being rotated by the accumulator wheel to progressively shift the connection of said magnets to said circuits according to the extent of rotation of said wheel and separate means to close circuits to the zero

magnets to effect resetting of the accumulator wheels to zero.

27. In a machine of the class described, the combination of a series of accumulator wheels; amount entering means for the accumulator wheels including groups of digit entering magnets, each group of magnets controlling the entry of different digits in an associated accumulator wheel; a series of circuit closing devices, each representing a different digit; connections between said devices and magnets, a subtraction control relay for complementarily changing the connections of the circuit closing devices to said magnets to enable the magnets to be energized either directly by closure of said contacts or complementarily according to the position of the subtraction relay, column selection means, and manually selectively settable means for placing the subtraction control relay under control of the column selection means to cause the subtraction control relay to be energized to effect subtraction with respect to preselected columns.

28. In a machine of the class described, the combination of a series of accumulator wheels, means individual to each wheel for entering amounts in such wheel including a series of digit magnets for each wheel for controlling the entry of different digits; a series of circuit closing devices representative of digits and common to all of said wheels, each device representing a different digit and when closed energizing one of the magnets; a series of selector relays, each individual to an accumulator wheel, for connecting the circuit closing devices to the series of magnets for the associated wheel; and a column selector for selecting the relays one at a time.

29. In a machine of the class described, the combination of a series of accumulator wheels, means individual to each wheel for entering amounts in such wheel including a series of digit magnets; a series of circuit closing devices representative of digits and common to all of said wheels, each device representing a different digit and when closed energizing one of the magnets; a series of selector relays, each individual to an accumulator wheel for connecting the circuit closing devices to the magnets of the associated wheel, a column selector for selecting the relays one at a time, a subtraction control relay operable to change the connections to said circuit closing devices complementarily and means for placing said relay under control of the first named relays.

30. In a machine of the class described, the combination of a series of accumulator wheels, means individual to each wheel for entering amounts in such wheel including a series of digit magnets for each wheel for controlling the entry of different digits; a series of circuit closing devices representative of all the digits and common to all of said wheels, each device representing a different digit and, when closed, energizing one of said magnets to enter the digit represented by said device; a series of selector relays, each individual to an accumulator wheel, for connecting the circuit closing devices to the series of magnets for the associated wheel; a column selector for selectively controlling the relays one at a time, and presettable means to render selected ones of said relays selectively controllable by said column selector.

31. In combination, an accumulating mechanism comprising higher and lower order accumulator wheels, key controlled means for entering amounts additively or subtractively in the ac-

accumulator wheels, adding transfer means controlled by the lower order wheel for controlling the amount entering means of the higher order wheel to enter a unit in the higher order wheel when the lower order wheel is turned to zero, means controlling said entering means to enter a 9 in the higher order wheel upon a subtraction operation when the lower order wheel is turned to zero, means operated by the lower order wheel for preventing the transfer of 9 to the higher order wheel when the amount standing on the lower order wheel is greater than the amount actually to be subtracted, and means for conditioning the entering means for a subtracting operation including means to suppress the adding transfer means when the entering means is conditioned for subtraction and to suppress the subtraction transfer means when the entering means is conditioned for addition.

32. In a machine of the class described, the combination of higher and lower order accumulator wheels; means to enter amounts in the accumulator wheels, including a series of magnets and a differential clutch mechanism controlled by said magnets for each of said wheels, amount keys, contact means controlled by the amount keys, and switching means individual to each wheel for connecting the contact means to the magnets, said switching means being rotatable by the wheel to select the magnet to be energized by closure of the contact means; a second switching means for conditioning the entering means for subtraction and operative to invert the circuits to said magnets through the first switching means; transfer means including contact means operated by the lower order wheel and arranged upon an adding operation, when the wheel is turned to zero, to control the entering means for the higher order wheel to add a unit, and including a second contact means actuated by the lower order wheel upon a subtracting operation to control the entering means of the higher order wheel to add 9 to such wheel; and means to prevent the entry of the 9 upon a subtracting operation when the lower order wheel stands at a value greater than is to be subtracted from such wheel.

33. In combination with a typewriting machine having a carriage and numeral keys; accumulating mechanism comprising a plurality of separate and independent orders, each order comprising an accumulator wheel and means to rotate the accumulator wheel different extents under control of the numeral keys, the rotating means for each wheel having a series of selectable elements disposed equal distances apart and controlling the entry of different digits in the associated wheel; a column selector device actuated by the carriage, means controlled by the column selector device for successively connecting the selectable elements for the different wheels to said keys for the entry of digits one at a time, and subtraction control means for complementarily changing the connections of the keys to the selectable elements to effect subtraction.

34. In a machine of the class described, accumulating mechanism including a series of accumulator wheels; separate means associated with each wheel for rotating said wheel to enter different digits, the entering means for each wheel including a separate series of selectively operable elements each causing the entry of a different digit; a series of numeral keys, a carriage movable step by step, selectively operable de-

vices between said keys and said selectively operable elements for selecting all of the elements associated with a particular wheel for selective operation under control of said keys, means controlled by said carriage for selecting the selectively operable devices, and subtraction control means for changing the connections between said elements and said keys to effect subtraction complementarily.

35. In a machine of the class described; accumulating mechanism comprising a series of orders, each order having an accumulator wheel; power driving means for said wheel; clutch mechanism between said driving means and said wheel including a series of detents defining different digital positions of the wheel and a group of magnets each for operating one of said detents; a series of keys common to all of said wheels and representing different digits, a series of contacts each individual to one of said keys, switching devices each actuated by one of said wheels and connected to the group of magnets for said wheel for rotatively changing the connections between said contacts and the associated group of magnets to select said magnets according to the extent of rotation of said wheel, and selectively operable means to connect said contacts to said switching devices to enable any group of magnets and its switching means to be selectively controlled by the keys.

36. In a machine of the class described, the combination of a series of accumulator wheels; means individual to each wheel for rotating said wheel to represent a digit of an amount including a series of selectable elements for causing entry of different digits and a series of magnets for operating said elements, each magnet operating one of said elements; a plurality of adding circuits, each representing a different digit and including key controlled means for controlling said circuits to said magnets, said circuits also including switching means for each accumulator wheel rotated thereby to the different positions designating digits of amounts and selectively controlling the connection of the key controlled means to said magnets; a series of recording elements each representing a different digit, means to couple said adding circuits to said elements in place of the key control means for a total printing operation, and means selectively to close circuits through said switching devices one at a time to select the recording elements through said adding circuits to record the part of the total on each wheel.

37. In a machine of the class described, a series of accumulator wheels; amount entering means, including a read-in switching device for each wheel and actuated by the latter and a series of magnets for each wheel for controlling the entry of digits, each magnet controlling entry of a single digit, said magnets being connected to the read-in device for the associated wheel and arranged so that the rotation of said wheel shifts the connections to said magnets; a series of digit keys, contacts controlled by said keys, means to connect said switching devices to said contacts one wheel at a time to enable the magnets of a selected wheel to be selectively controlled by said keys according to the digit to be entered; a series of selectable control elements representing different digits, said series of elements being common to all of said wheels; and total conditioning means including means to disconnect said contacts from said connecting means and connect the latter to the recording control elements to en-

able said elements to be operated one at a time according to the positions of the selected switching devices, and including means to close circuits through said switching devices to enable the operation of the control elements.

38. In a machine of the class described, lower and higher order accumulator wheels; means for entering amounts in the accumulator wheels comprising a differential clutch mechanism, digit magnets for controlling the extent of rotation of the wheels by the clutch mechanism, there being a series of magnets and a clutch mechanism individual to each wheel, each of said magnets in the series causing a different digital extent of rotation of the wheel, each series of magnets including a magnet for entering a unit and a magnet for entering a nine in a higher order wheel upon transfer from a lower order wheel and effective for each digital position of the higher order wheel; adding transfer contact means operated by each wheel and arranged to close when the associated wheel is turned to the zero position; subtracting transfer contact means for each wheel designed to close when the associated wheel attains the zero position, said adding transfer contact means being connected to that magnet of the higher order which is effective for causing the entry of a unit therein and the subtracting transfer contact means being connected to that magnet of the higher order which is effective for causing the entry of 9, whereby, upon an additive transfer, the selected magnet of the next higher order will cause said wheel to turn one unit upon an additive transfer and the other magnet will cause the wheel to turn nine units upon a subtractive transfer.

39. In combination with a typewriting machine having a carriage and numeral keys; numeral contacts individual to and controlled by said keys, accumulating mechanism comprising a plurality of separate and independent orders, each order including an accumulator wheel, means to rotate the accumulator wheel different extents under control of the numeral keys including a series of magnet coils, a switching device operated by the accumulator wheel, and a multicontact relay having a coil and contacts connected to said magnet coils through said switching device and, when selected, partly closing circuits to the magnet coils through the switching device; a column selector device coupled to the carriage, separate circuits to the coils of said relays from said column selector device for selecting said relay coils one at a time as the carriage moves to select the order in which a digit is to be added; and a series of common circuits extending from the contacts of said relays to the corresponding numeral key controlled contacts, each of said key contacts, when

closed by the operation of the associated key, closing one of the common circuits to the corresponding one of said magnet coils for the order corresponding to a selected relay coil.

40. In a machine of the class described, the combination of a series of accumulator wheels; a series of amount entering mechanisms, each individual to one of said wheels, each amount entering mechanism including a series of magnets for causing entry of different digits and a switching device actuated by the wheel for selecting the magnets, a series of numeral keys corresponding to digits entered by the magnets, contacts controlled by said keys; a series of selection relays, one for each accumulator wheel and having contacts for connecting said key controlled contacts to said magnets through the respective switching devices; a column selector device operable step-by-step to select said relays one at a time to enable amounts to be entered in the accumulator wheels, one wheel at a time; a subtraction control relay having contacts normally connecting said first named relay contacts to said key controlled contacts to normally cause addition to take place and also having alternate contacts connected to the key controlled contacts in such manner that, when said subtraction control relay is operated, the key controlled contacts will be connected to said magnets complementarily through the alternate contacts to enable subtraction by complementary addition to take place; and means to place the subtraction control relay under control of the first named relays to cause subtraction to take place automatically in preselected orders.

41. In a machine of the class described, accumulating mechanism including higher and lower order accumulator wheels; differential clutch mechanisms, each associated with one of said wheels and each having a series of magnets for controlling the extent of rotation of such wheel by the clutch mechanism, each series including a magnet for entering a unit in a higher order wheel upon transfer from a lower order wheel and effective for each digital position of the higher order wheel; adding transfer contacts, actuating means driven by the lower order wheel and arranged to close the adding transfer contacts when the lower order wheel turns to the zero position; and means to cause the magnet of the higher order wheel which is effective for causing the entry of a unit in such order to be energized when the lower order wheel turns to zero position, including a circuit connecting the adding transfer contacts of the lower order wheel to that magnet of the higher order wheel which is effective for causing the entry of a unit in such higher order.

KURT RUDOLF SCHNEIDER.

Certificate of Correction

Patent No. 2,394,637.

February 12, 1946.

KURT RUDOLF SCHNEIDER

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Page 12, second column, line 67, claim 8, after "detents" strike out the semi-colon and insert the same after "magnet" in same line; line 69, same claim 8, for "magnet" read *magnets*; page 13, second column, line 54, claim 14, for "the 9 in a" read *a 9 in the*; page 14, second column, line 21, claim 20, for "accumualting" read *accumulating*; line 23, same claim, for "other" read *order*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of May, A. D. 1946.

[SEAL]

LESLIE FRAZER,*First Assistant Commissioner of Patents.*