

Jan. 11, 1955

W. HOPPE

2,699,290

ELECTROMAGNETIC ADDING DEVICE FOR COMPUTERS

Filed March 19, 1951

5 Sheets-Sheet 1

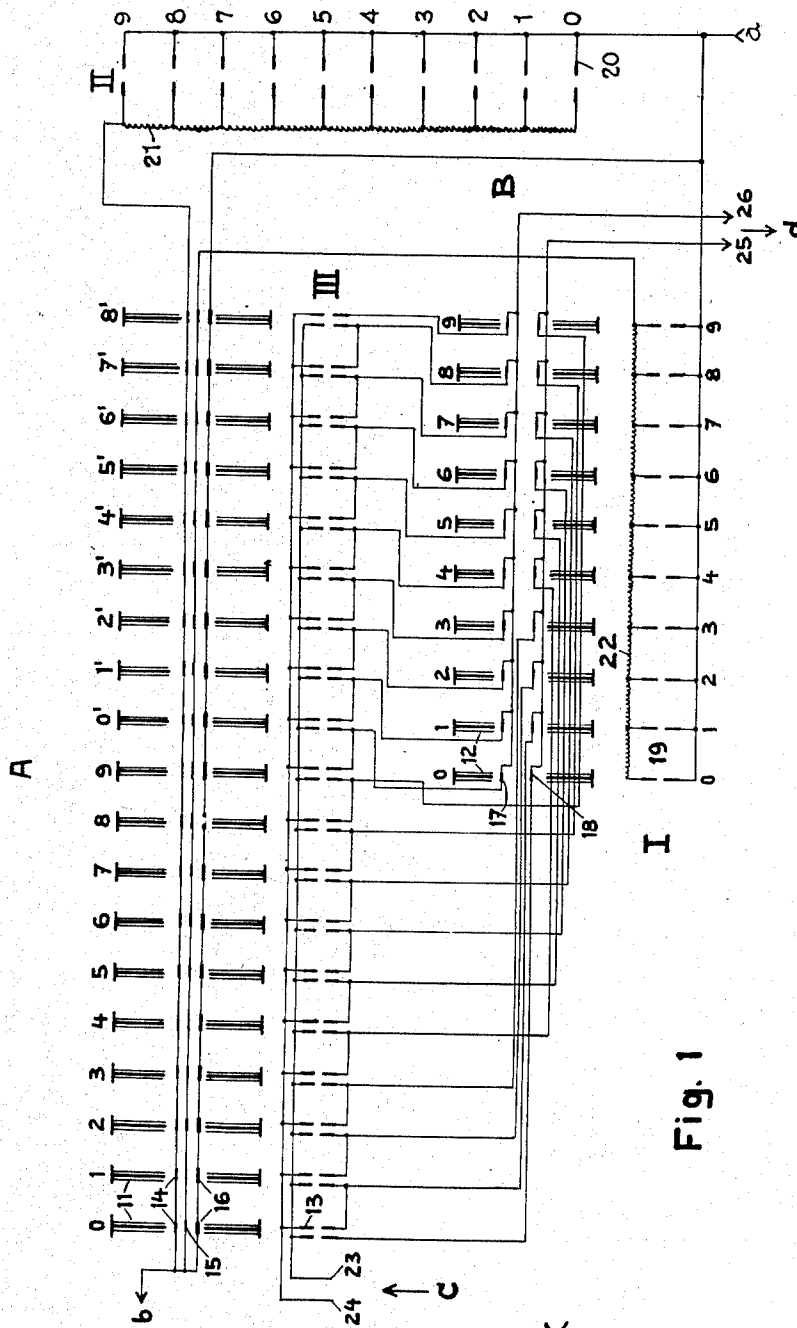


Fig. 1

Inventor
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by the undersigned
- 1 -

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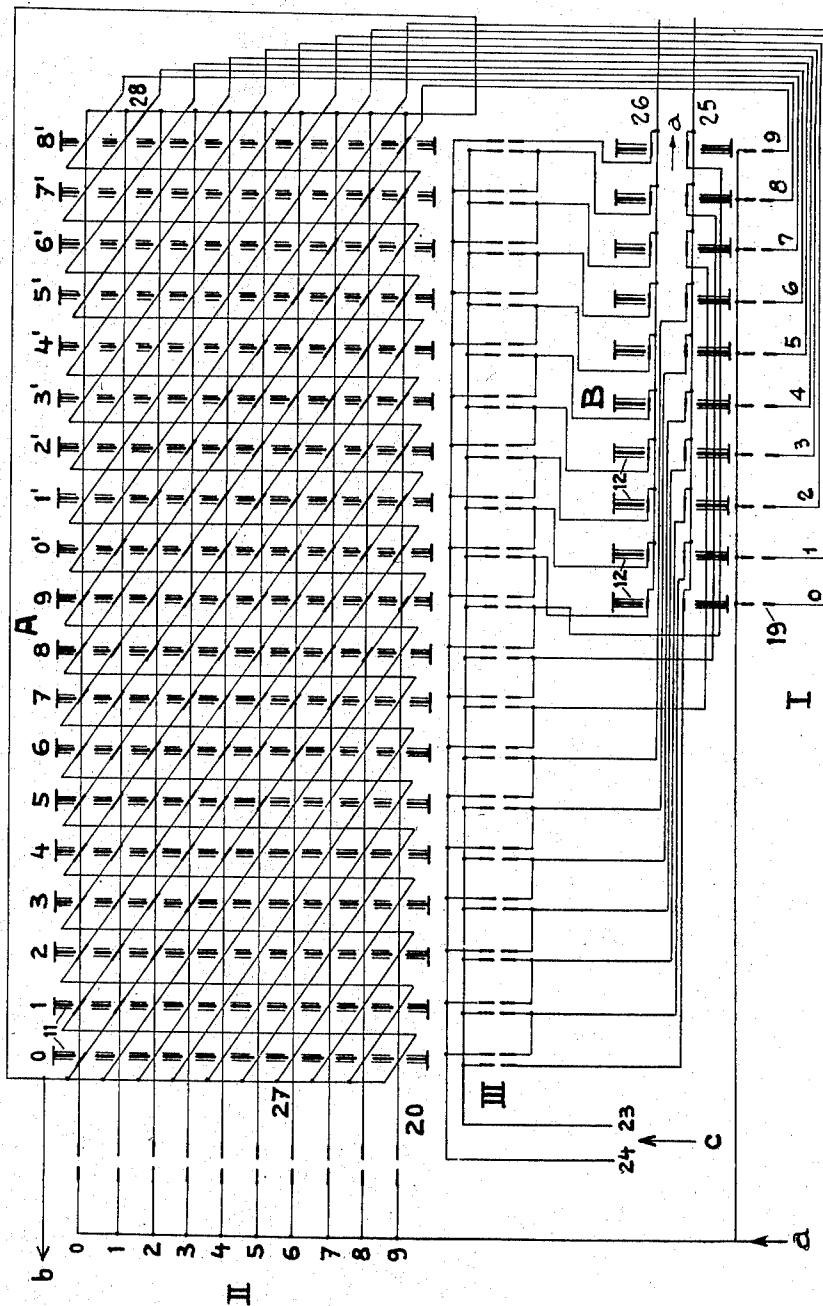
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2,699,290

ELECTROMAGNETIC ADDING DEVICE FOR COMPUTERS

Filed March 19, 1951

5 Sheets-Sheet 2



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Jan. 11, 1955

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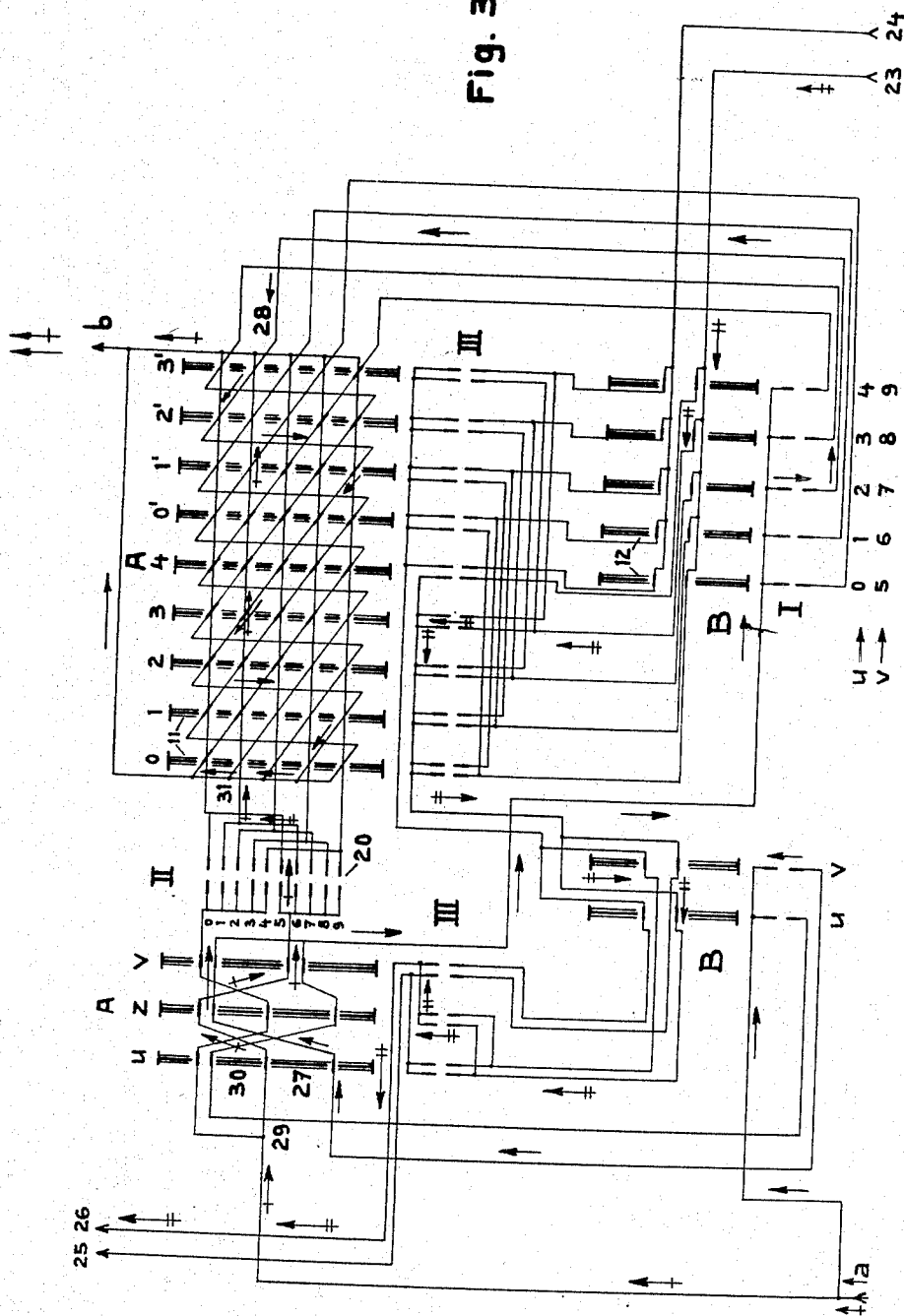
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ELECTROMAGNETIC ADDING DEVICE FOR COMPUTERS

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5 Sheets-Sheet 3

Fig. 3



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5 Sheets-Sheet 4

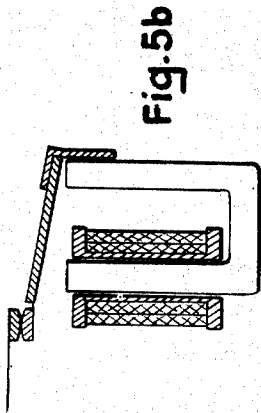


Fig. 5b

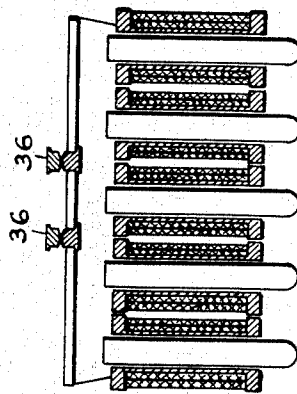


Fig. 5a

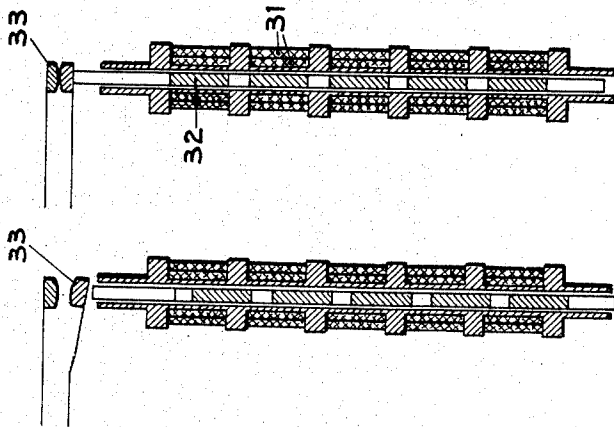


Fig. 4a

Fig. 4b

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ELECTROMAGNETIC ADDING DEVICE FOR COMPUTERS

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5 Sheets-Sheet 5

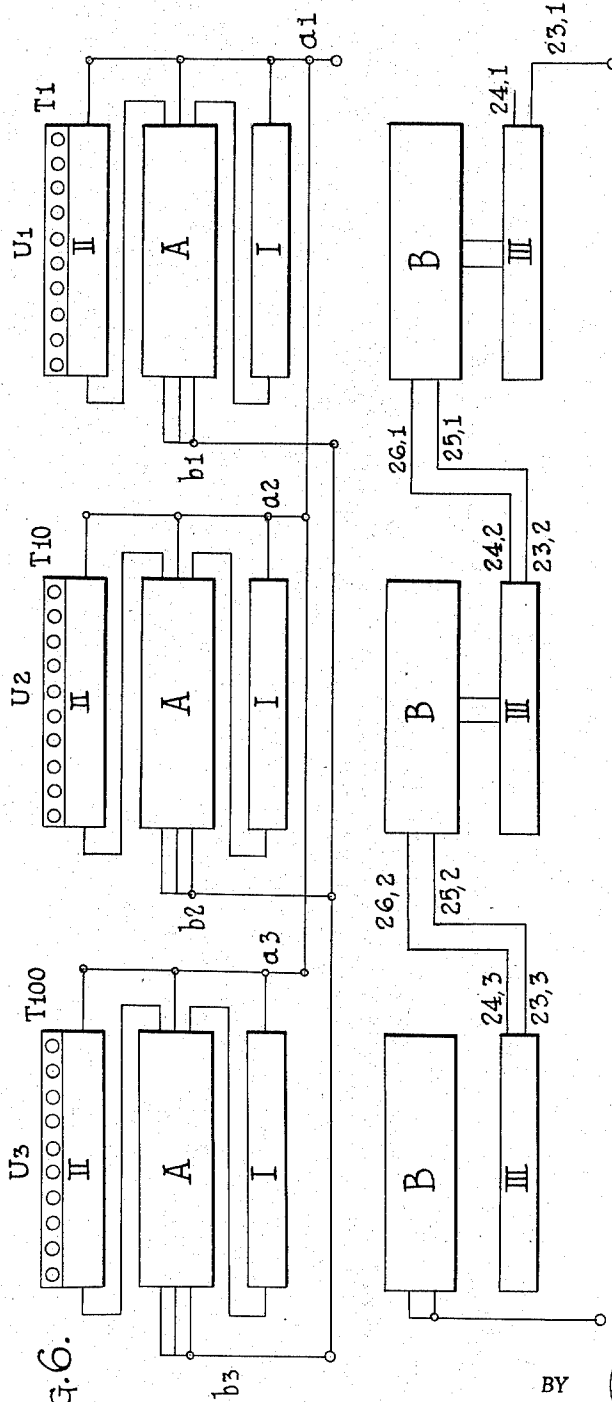


FIG. 6.

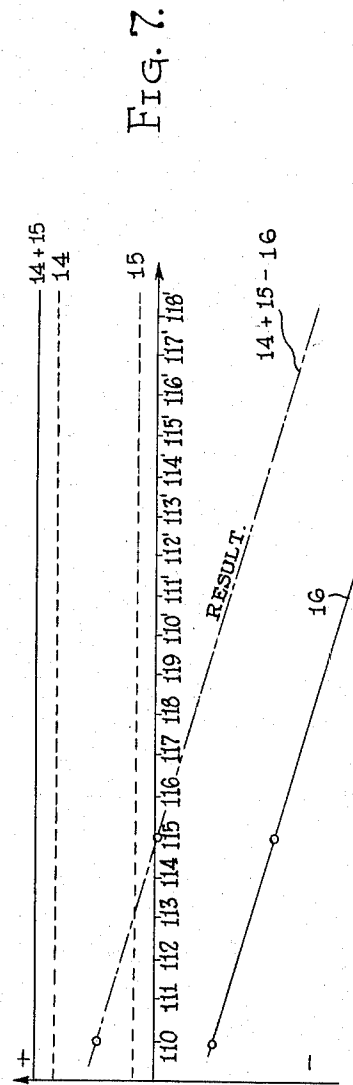


FIG. 7.

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ELECTROMAGNETIC ADDING DEVICE FOR COMPUTERS

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Application March 19, 1951, Serial No. 216,361

Claims priority, application Switzerland March 20, 1950

8 Claims. (Cl. 235—61)

The invention relates to a device for the electromagnetic operation of switches by groups of contact operators according to two or more parameters.

A problem frequently occurring in electrical engineering is the electrical operation of switches by groups of contact operators according to a parameter. This parameter must be capable of being introduced in an electrical way in order to be electrically effective, e. g. by the closing of contacts say in a key board. Each individual key has certain functions allotted in a group of relays, indicating mechanisms etc., which functions are unequivocally defined by this key and which are performed when the said key is operated. However, there are further appliances in the art of electrical switching in which the functions which are triggered off in a group of relays, indicating mechanisms or the like are determined not by a single parameter, but by two or more parameters. These parameters can be introduced into the appliance, for example, by two key boards so that always two keys have to be operated, or one or both key boards can be replaced by electromagnetically operated switches (contact operators, e. g. relays). In special cases the device required for determining one of the parameters can be formed directly by the group of the electrical contact operators the function of which is controlled by the two or more parameters; however, more than one parameter (e. g. existing parameters) can be given by these contact operators if desired. In these special cases, results just obtained by the appliance are introduced as controlling values (parameters) for the next operation phase of the appliances, either alone or with others.

In a device with simultaneous introduction of two parameters, the first series I may comprise the possible (discrete) values 1 to n_1 , and the second series II may comprise 1 to n_2 , then $n_1.n_2$ different parameter combinations are possible, which accordingly can trigger off a maximum of $n_1.n_2$ functions in the contact operators to be operated or in indicator mechanism. In a simple case each of these functions consists in the operation of an electrical contact operator (e. g. of a relay) in a group of $n_1.n_2$ electrical contact operators. However, they may as well consist in the simultaneous operation of a group of two or more contact operators in various combinations wherefor obviously a total number of less than $n_1.n_2$ contact operations is required for $n_1.n_2$ different functions.

The consideration set forth hereinabove apply to the case that for each couple of parameters a different function of the electrical contact operators and/or indicating mechanisms is to be triggered off; however, it is also possible that several different couples of parameter are coordinated to a single function of the contact operators. This is for example the case when the result of one phase of operation of the appliance is introduced as one of the parameters into the next phase of operation of the appliance; the number of contact operators required is reduced in this case to n_1 (or to n_2) and the number of couples for equal function to n_2 (or to n_1 , respectively). Such switching operations have practical importance everywhere where by means of groups of electrical contact operators certain functions are to be triggered off and/or are to be indicated in indicating mechanisms, as the case may be, such as e. g. for automatic telephones, duplex talking systems etc., and particularly for coding machines and a certain group of electrical calculating machines.

By the aid of such appliances for the electrical opera-

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tion of switches with indicating mechanisms according to two or more parameters, electrical calculating machines can be built up. A calculating operation which is characterized by a mathematical operator (e. g. the addition), connects two calculation figures (in a numerical calculation: numbers) in such a manner that as a result a third figure (in a numerical calculation: again a number) is formed. Let us now consider the addition in the decimal system of numbers rather more closely:

Firstly each place may be considered as an individual group. Then, the two parameters of the appliance occur as two series each of 10 discrete values, which correspond to the digits of the decimal system. Each individual combination of two parameters determines a function of electrical contact operators, together with indicating mechanisms, if desired; however, the same functions may correspond to different combinations a total of ten functions being possible, which in turn correspond to the ten digits. Thus, for example, the function which corresponds to the digit 5 is formed by the following combinations of parameters: (0, 5), (1, 4), (2, 3), (3, 2), (4, 1), (5, 0). To these devices for each place, however, a further device in common for all places has to be superimposed, which has the effect that with certain combinations of parameters in the subordinate devices which correspond to the individual places a follow-up action is imparted on to the immediately preceding subordinate device (decade transfer).

This kind of calculating machines is distinguished in principle from those calculating machines which are based on the counting procedure, and it is irrelevant in principle whether the number of teeth of sprocket wheels, of stepped drums or the like is counted and added as in the known mechanical calculating machines, or the number of electrical impulses as in some electrical calculating machines. They have a separate independent element for each number whereas the mechanical or electrical machines of the kind mentioned first have an element for each place.

Devices for the electrical operation of switches and/or electrical indication by means of groups of electrical contact operators and/or indicating mechanisms according to, for example, two parameters can be built up in a known manner by means of switches and sets of switches corresponding to the parameters, and by suitable arrangement of lines between the same and the contact operators (say for the reintroduction of the result into the next phase of operation of the appliance) and/or the indicating mechanism (for the indication of the result). As a rule, n_1 single switches are used for the first series, and n_2 sets of switches for the second series, each of which sets consists of n_1 individual switches to be operated jointly. The disadvantage of these devices consists in the great total number of switches, as well as in the great number of switches in the individual sets of switches, which have to be operated jointly by the switching forces available which in most cases are limited.

The digital type computer according to the invention described hereinafter carries out additions by electromagnetic operation of switches and is free from these disadvantages of accumulation of switches, since it is based on a magnetic principle. It is characterized by a special construction of the electromagnetic contact operators which have at least two groups of coils connected to one another, at least two of which are current-carrying and either cooperate or act against one another electromagnetically. By appropriate dimensioning of the number of turns of the individual windings, of the current intensity of the current passing through them and finally by providing a different sense of winding of the individual windings, it can be achieved that in the contact operators magnetic forces of attraction are set up corresponding to the function desired, or (with windings having opposite senses of winding, bifilar circuits) cancelled out, whereby the switches desired are operated, and accordingly the function desired is triggered off.

In the accompanying drawings, embodiments of the invention are shown by way of example, in which:

Fig. 1 is a schematic representation of a first embodiment with switching diagram,

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Fig. 2 is a schematic representation of a second embodiment with switching diagram,

Fig. 3 is a schematic representation of a third embodiment with switching diagram,

Figs. 4a and 4b show an embodiment of a contact operator, partly in section,

Figs. 5a and 5b show a further embodiment of a contact operator, partly in section,

Fig. 6 is a diagram illustrating the general arrangement of several decimal order units,

Fig. 7 is a graph showing the magnetic field strengths of associated relay coils.

The digital computer according to the present invention consists of a plurality of order units, one order unit being provided for each decimal order. The general arrangement of the computer is shown in Fig. 6. The order units are indicated with the reference numerals U_1, U_2, U_3 , and it will be understood that there are as many order units U provided as decimal orders are to be computed. Each order unit U_1 to U_{100} is provided with a key bank T_1, T_{10}, T_{100} etc. which serve for entering the addendum. The key banks are generally indicated by the reference character II , and are provided with ten keys corresponding to the digits from zero to nine.

Each order unit as shown in Fig. 1 contains two groups A and B of electrical contact operators which may be for example electromagnetic relays. The group A contains nineteen members 0 to 9 and 0' to 8' which are equipped with twin switches 13 (series III) which are closed when the relay armatures are not attracted. Members 0 to 9 represent the numbers from 0 to 9, while members 0' to 8' represent the numbers from 10 to 18. Each individual contact operator 11 of the group A comprises three windings 14, 15, 16 which are indicated by short heavy lines on the associated conductors. The windings 14, 15, 16 of each contact operator 11 are connected with one another and are thereby arranged in series. All the windings 14 and 15 have the same number of turns whereas the windings 16 have gradually and linearly increasing numbers of turns so as to produce a progressively increasing field strength in the solenoids 16 associated with members 0 to 8'. The group B contains ten electromagnetic contact operators 12, e. g. holding relays which correspond to the ten digits of a place, and which may be provided with indicating members for the indication of the result stored in them. They comprise two mutually equal windings 17 and 18 each. At the same time, their working switches 19 serve for introducing the parameter of the series I, in the present case the augend to be subjected to addition. The addendum is introduced into the switches 20 of the keyboard II by key operated switches.

For carrying out the addition of two numbers, the same have to be introduced into the keyboard II. Before the first number is introduced, i. e. in the initial position, the switch 0 of the series I is closed; after introducing the first term of the sum, the switch corresponding to the same is closed.

After introducing one term of the sum, the following circuits are set up, leading from the current source a to the issue b :

1. Into the coils 16,
2. Via the keyboard II into a portion of the resistance 21 the size of which is determined by the number keyed in, and from there into the coils 14;
3. Via a switch 19 of the series I which had been closed during the preceding calculation by a holding relay 12, say 0, then via a portion of the resistance 22 into the coils 15.

The resistances 21 and 22 which are capable of being tapped are so dimensioned that, after the closed switches 19 and 20 the windings 14 and 15 are passed by gradually and linearly increasing currents so that the magnetic forces add up, assuming the same sense of winding of the coils. Now the coils 16 are wound in the opposite sense to the coils 14 and 15, or if the sense of the winding is the same, they are passed by a current in the opposite direction, so that upon their being passed by currents, the magnetic forces generated by them are weakened by those generated by the windings 14 and 15. All coils 14, and all coils 15 carry the same current when two switches 19, 20 are operated, and produce the same field strength on each member 11. The field strength of the coils 16 progresses from 0 to 8' and is chosen in such manner that the field of the coil 16 of the member 11 which corresponds to the result is cancelled by the op-

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posing fields of the associated coils 14, 15. As clearly shown in Figure 1, the branches of the current $a-b$ passing through resistances 22 and 21, respectively, are larger when passing through a shorter portion of the resistance, for instance when switches 8 of the group of switches 19 and 20 are closed, respectively, then when passing through the entire resistances 21 and 22, respectively, when switches 0 of the group of switches 19 and 20, respectively, are closed. The maximum of each of the branches of current $a-b$ is reached when the respective switches 19 and 20 (9) are closed. Consequently, windings 16 have the least number of windings on contact operator 1, and the maximum number of windings on contact operator 8', since the magnetic force of each winding 16 must be capable of compensating the combined magnetic forces of the corresponding windings 14, 15. In order to indicate opposite passage of current through 14, 15 on one hand and windings 16 on the other hand the windings are shown by lines of different thickness. Accordingly, if in the course of operation two windings of a relay are energized which are indicated in different strength of lines, the same operate against one another magnetically.

By appropriately dimensioning the current intensities and numbers of windings, it can be achieved that always in one of the nineteen contact operators of the group A a full compensation of the magnetic forces is attained, while in all others, remnant forces are active which make them respond. Fig. 7 graphically illustrates the magnetic forces and the field strengths in the coils 14, 15, and 16. The field strength in coil 14 is constant and indicated by the broken line 14. The field strength in coils 15 is also constant and indicated by the broken line 15. The field strengths of the coils 16 progressively increase since the number of the windings of the coils 16 is progressively increased from relay members 110 and 118'. The magnetic field strengths of the coils 16 is opposed to the field strength of the coils 14 and 15, and therefore illustrated on the negative side of Fig. 7. The resultant of the magnet field strengths of the coils 14 and 15 is indicated as a solid line 14, 15 and is opposed to the field strengths of the coils 16. In Fig. 7 is shown how the resultant field of the coils 14 and 15 equals only on one relay 11 the gradually progressive field strength of the coils 16 while in all other relays 11 resultant forces, indicated by a dash and dot line, remain, which are partly positive and partly negative, and effect opening of the twin contacts 13, while the single contact 5 corresponding to the result 5 remains closed. According to whether the addition has led to a value below 10 or above 10, a relay of the group A from 0 to 9, or from 0' to 8' will be energized. That switch 13 of the series III which is associated to the said relay which does not respond since the fields of windings 14, 15 have the same field strength as the winding 16 on this particular relay, accordingly remains closed, while all the other switches 13 are opened. With the passage of current from a to b the first phase of operation of the calculation procedure is terminated, and so is the calculation proper.

The second phase of the operation serves merely for storing the result in group B and to perform a decade transfer, if necessary:

The entrance of the current is denoted c , the exit of the current is denoted d . As will be seen from the figure, the current at c can be passed alternatively via the circuit 23 or 24. If the arrangement or decimal order unit shown in Fig. 1 is associated with a decimal order higher than the unit order, the current entrance 23 is connected directly to the current exit 25 of the next lower order, and the current entrance 24 is directly connected with the current exit 26 of the next lower order. Suitable gating means, not shown, are provided for the lowest decimal order in which the current always enters at 23. Entrance of the current at 23 means that the preceding place does not require any decade transfer. Entrance of the circuit at 24 means that a decade transfer has got to take place. The current exit at 25 or 26 of the preceding place accordingly determines the entrance into the next place. The zero contacts 10 and 110 are closed by a clearance operation preceding each series of computing operations. A separate unit is provided for each decimal place of a number consisting of several digits, Figure 1 showing the unit for the lowest digit. In the event that two figures are added, the sum of which does not exceed 9, the current passes during the second phase

of the operation from 23 through any one of the twin contacts 13 (0) to 13 (9) through the windings 18, and further through the current exit 25.

In the event that the sum of the added figures exceeds 10, one of the switches 13 (0') to 13 (8') is closed, since such switches represent numbers from 10 to 18. Consequently, the current passes from 23 through the closed switch, through the corresponding winding 17 and to current exit 26, which is connected to current entrance 24 of the next higher unit, corresponding to the next higher decimal place. Assuming that there is no figure stored in this next higher unit, which corresponds to closed zero contacts, the current entering the next higher unit at 24 will pass through switch 13 (0) of the next higher unit through coils 18 (1) and through current exit 25. By coil 18 (1), or switch 19 (1) an indicating mechanism indicating a 1 in the next higher decimal place may be actuated. The operation of this second phase of operation is quite clear from the drawing: the holding relays and the indicating members 12 are made to respond to a current passing one of the windings. The cooperation, according to the invention, of several windings in one contact operator does not, therefore, occur in the second phase of operation. The decimal order units, each of which corresponds to one decimal place, are connected in series, and the conductors 25, 26 are always connected to the conductors 23, 24, respectively, of the next higher decimal order unit.

In the arrangement or order unit shown in Fig. 1 the means for the tens-transfer may be omitted in the first unit for computing the lowest decimal order. However, to simplify manufacture, the order units for all decimal orders are the same as illustrated in Fig. 1. For a faultless interplay of the phases of operation it is necessary that the effect of one phase reaches over into the other phase (which can be achieved by mechanical arresting in the sets of switches I and III, by the use of delayed drop relays, holding relays, etc.). The same applies likewise to the embodiments according to Figs. 2 and 3 which will be described later.

According to a preferred embodiment, the resistance portions of the resistance 21 are dimensioned as follows:

Resistance Portion Located Between Contacts—	Resistance of Resistance Portion If Total Resistance is R
0-1.....	R/0.2
1-2.....	R/0.6
2-3.....	R/1.2
3-4.....	R/2
4-5.....	R/3
5-6.....	R/4.3
6-7.....	R/5.6
7-8.....	R/7.2
8-9.....	R/9

The resistance portions are varied from 27.9 ohms to 0.631 ohm if R is approximately 5.6 ohms. The voltages required for 100 effective ampere windings are:

1. For coils 14 and 15: Voltage U_{14} equals U_{15} and is approximately 11 volts.

2. For coils 16 voltage U_{16} is approximately 19 volts. The impulse load of the elements varies between 0.35 w. and 8.67 w. in accordance with the computed values. The impulse currents in the coils 14 and 15 vary between 0.2 and 2 amperes. The impulse currents of the coils 16 are constant 3.33 amperes.

In what follows, a working example for the present embodiment will be given: The calculation $6+7=13$ is to be carried out. The current flows in the switch diagram of Fig. 1 into the circuit at a , and branches into three paths: one leads directly via the windings 16, the two others via the closed contacts 17 and 16, via part of the resistances 22 and 21 and via the windings 15 and 14, which magnetically counteract the winding 16. By weakening the resistances in the two last mentioned circuits 15 and 14, it will be achieved that the magnetic forces cancel one another out in the contact operator $A3'$ only, the twin switches of the series $III3'$ remaining here closed, while all the others are opened by magnetic attraction. Thereby the first phase of operation is terminated.

It may now be assumed that the calculation in the preceding case has led to a result without a decade trans-

fer. Then the current in the subsequent phase of operation enters at $c23$ and energizes the contact operator $B3$ so that the switch 13 is closed. The current leaves the place at 26 and flows at 24 into the next higher unit which has the effect that instead of the value u calculated in A, the value $u+1$ is indicated on the switches I.

Another embodiment, also for performing additions, is shown in Fig. 2. It is characterized in that the electromagnetic contact operators 11 have several separate and independent windings or electromagnet systems, and solenoid cores or armatures, respectively, cooperating with them; these cores or armatures are, however, mechanically connected to one another, so that the attracting of one core or armature carries along all the cores or armatures, which movement effects the operation of switches and, if desired, also the operation of indicating mechanisms. The device according to Fig. 2 corresponds in principle to that according to Fig. 1, with the difference only that the selection of the contact operator of the series A giving the result does not take place by means of resistances which vary the current intensity in the individual coils, but by the choice of the coils in the contact operators 11 each of which comprises ten coils. Accordingly the same reference numerals have been used for parts corresponding to those of Fig. 1.

In this embodiment the resistances 21 and 22 are dispensed with, and instead of the windings 14, 15, 16 of the electrical contact operators 11, in Fig. 2 two windings of each of the ten coils of the contact operators 11 are used oppositely wound coils are again indicated by lines of different thickness, according to the sense of the passage of current. For the sake of clearness lines of equal thickness indicate the connecting wires for the windings of one kind, and the respective winding itself so that the crossing of a connecting wire with the symbols 11 denoting the coil windings indicates a winding of one sort.

The windings of the coils are accordingly again passed by currents partly in the opposite sense, partly in the same sense. Let us follow e. g. the calculation $7+6=13$: In the series I, the switch of the digit 7 is closed, in the series II the switch of the digit 6. If we follow the circuits, we see that in all contact operators separate coils are passed the two branches of current $a-b$, with the exception of the contact operators 3 and $3'$. Since the individual electromagnetic systems of the contact operators work magnetically independent of one another, in all contact operators in which only one winding of each of two separate coils is passed by a current, the core-systems will be attracted. In the contact operator 3 the two windings of one coil are passed by the current in the same sense so that here, too, response of the contact operator takes place, whereas in $3'$ two windings of one coil are passed in the opposite sense so that the magnetic forces cancel one another out. In the ultimate effect consequently all twin rest contacts of the series III are opened except the twin contact $3'$ which remains closed. The further operation of the appliance takes place analogous to the scheme of Fig. 1.

An advantage of the appliance described consists in that all the contact operators attached are operated by an equally strong magnetic force.

The manner of operation of this device is as follows: The calculation, say, $6+7=13$ is to be carried out.

The current flows into the wiring diagram of Fig. 2 at a and is branched into two paths: one leads via the switch 116 into the horizontal group 27 of windings, the other via the switch 17 into the oblique group 28 of coils. In the contact operators $A3$ and $A3'$ the windings passed by a current are arranged on the same coils. In $A3$ the same are wound in such a manner that the forces energized by the passage of current reinforce one another, whereas they cancel one another out in $A3'$. In all other contact operators A the magnet systems are operated independently of the sense of passage, since according to an assumption the individual magnetic systems operate independently of one another. Accordingly the twin switch $III3'$ only remains closed. The second phase of operation takes place completely analogous to the second phase of operation of the embodiment disclosed with reference to Fig. 1.

Fig. 3 shows again a third embodiment of an appliance for addition. Here the ten digits of each place of the decadic system are divided into two groups, e. g. into the digits 0 to 4 and the digits 5 to 9. Each digit has

accordingly to be characterized here by two members, to wit one member which selects a twin number out of the group of five (e. g. 1, 6) and a separating member which determines which one of the two digits actually applies. In Fig. 3 the contact operators of the dividing group are denoted *u* and *v*. When for example in the series I the digit 6 is obtained, the switches for 1, 6 and for *v* have to be closed simultaneously. The result which is stored as usual by the contact operators 12 requires accordingly the simultaneous response of two contact operators.

The adjusting of the second number by the key board II can, however, take place if desired in the decadic system. It is of course quite easy to let also the result of the ten switch operators 12 appear in the decadic system instead of, as shown in Fig. 3, in groups of five.

Here, too, we distinguish the first phase of calculation in which the result is furnished to the contact operators of the group A in a coded manner, as it were, from the second phase of calculation which is somewhat involved here and which effects the decade transfer, and performs the adjustment of the series I for the next calculation. When subdividing into groups of five, although one has to close two switches for each digit, one has the great advantage that the absolute number of contact operators as well as the number of their magnetically independent individual systems is substantially reduced: in group A there are twelve contact operators, each with three to five individual systems, instead of nineteen each with ten individual systems as in Fig. 2; in group B (adjustment group for series I) there are seven instead of ten.

As an example of the operation, the calculation $6+7=13$ may be carried out: the current flows into the wiring diagram of Fig. 3 at *a* and is branched into two paths. One of them leads via the switch *Bv* into the group 27 of windings of the contact operators *Au*, *Az*, *Av* and from there via the switch 127 into the group 28 of windings of the contact operators *Ao* to *A3'*. The other path leads from *a* to the point 29 and is divided here. Since in the group II the switch 116 is closed, the current passes the group 30 of windings of the contact operators *Au*, *Az*, *Av*, and from here through the group 31 from *Ao* to *A3'*. All of the contact operators of the group A are put into action except *Az* and *A3'*, in which the magnetic forces cancel one another out. In the second phase of operation the current enters at 23 (no decade transfer of the preceding place), passes, since the switch *A3* is closed, the winding of the contact operator *B3*, 8 and the left hand contact of the twin switch 1113, then the coil of the contact operator *Bu* via the left hand side contact of the closed twin switch 1112 into the current exit 26, which is connected to the current entrance 24 of the next unit. Accordingly, in the next decimal place firstly the twin number 3, 8 is indicated and, by the attraction of *Bu*, it is indicated that, of these two digits, 3 has to apply. Since the current entrance into the next place takes place at 24, a decade transfer is effected in the latter.

It is quite obvious that in an analogous manner the appliance according to Fig. 1, too, can be constructed according to the system of groups of five.

Embodiments of contact operators having several magnetic elements which are magnetically independent of one another and are arranged one on top of the other and/or side by side, are illustrated in Fig. 5; they show in principle two potential embodiments each having five winding coils. In Fig. 4 five solenoid coils 31 with two windings each, disposed on top of one another on a single coil body are provided, the coils of which co-operate with five iron cores 32 which are fixedly connected with, but magnetically separated from one another. When two separate coils are passed by a current, the system of iron cores is attracted upward, and can operate the switches 33.

In Fig. 5, five separate electromagnetic systems are arranged side by side, but with a common armature, which may also be magnetically subdivided, and which opens the twin rest contacts 36 when attracted.

The cores of the embodiment according to Fig. 4 as well as the armatures of the embodiment according to Fig. 5 may be subdivided in such a manner that they are not combined into a single whole, but into groups. Thereby the possibility of further combinations in the operation of switches is given.

I wish it to be understood that I do not desire to be

limited to the exact details of the switching diagrams and of the construction shown and described, for obvious modifications will occur to a person skilled in the art.

What I claim as my invention and desire to secure by Letters Patent is:

1. In an electric calculating machine, in combination, a plurality of switches, each switch representing a digit; a plurality of operating means, each operating means including a plurality of windings and a movable member, each of said movable members being operatively connected to one of said switches for opening the same when said movable member is actuated, at least one winding of said plurality of windings creating a magnetic field opposed to the magnetic fields of the other windings of said plurality of windings; a first group of conductor means adapted to be connected to a source of current, at least one conductor means of said first group of conductor means connecting a first set of windings in series, said first set of windings comprising at least one winding of said plurality of windings of each of said operating means; a plurality of first switch means, each switch means representing a digit and located in one of said conductor means of said first group of conductor means; a second group of conductor means, at least one conductor means of said second group of conductor means connecting a second set of windings in series, said second set of windings comprising at least one other winding of said plurality of windings of each of said operating means; a plurality of second switch means each of said second switch means representing a digit and located in one of said second group of conductor means, the arrangement being such that only in one of said operating means the magnetic forces of all windings thereof cancel each other permitting one of said plurality of switches to remain closed when one switch means of said first switch means, and one switch means of said second switch means are closed, said one closed switch representing the sum of the digits represented by the closed switch means of said first switch means and of the closed switch means of said second switch means.

2. In an electric calculating machine, in combination, a plurality of switches, each switch representing a digit; a plurality of operating means, each operating means including three windings and a movable member, each of said movable members being operatively connected to one of said switches for opening the same when said movable member is actuated; a first tapped resistance; a first group of conductor means adapted to be connected to a source of current, the parallel connection of said first group of conductor means being formed on one side thereof by said first tapped resistance, one conductor means of said first group of conductor means connecting a first set of windings in series, said first set of windings comprising at least one winding of said plurality of windings of each of said operating means; a plurality of first switch means, each switch means representing a digit and located in one of said conductor means of said first group of conductor means; a second tapped resistance; a second group of conductor means, the parallel connection of said second group of conductor means being formed on one side thereof by said second tapped resistance, one conductor means of said second group of conductor means connecting a second set of windings creating a magnetic field having the same direction as the magnetic field of said first set of windings and in series, said second set of windings comprising at least one other winding of said plurality of windings of each of said operating means; a plurality of second switch means each of said second switch means representing a digit and located in one of said second group of conductor means; a conductor means adapted to be connected to a source of current and connecting a third set of windings in series, said third set of windings comprising one further winding of said plurality of windings of each of said operating means and having a magnetic field opposite to the magnetic field of said first and second sets of windings, the number of turns of each of said further windings being progressively increased on each of said operating means, the arrangement being such that only in one of said operating means the magnetic forces of all windings thereof cancel each other permitting one of said plurality of switches to remain closed when one switch means of said first switch means, and one switch means of said second switch means are closed, said one closed

switch representing the sum of the digits represented by the closed switch means of said first switch means and of the closed switch means of said second switch means.

3. In an electric calculating machine, in combination, a plurality of switches, each switch representing a digit; a plurality of operating means, each operating means including three windings and a movable member, each of said movable members being operatively connected to one of said switches for opening the same when said movable member is actuated; a first tapped resistance; a first group of conductor means adapted to be connected to a source of current, the parallel connection of said first group of conductor means being formed on one side thereof by said first tapped resistance, one conductor means of said first group of conductor means connecting a first set of winding in series, said first set of windings comprising at least one winding of said plurality of windings of each of said operating means, the windings of said first set of windings having the same number of turns; a plurality of first switch means, each switch means representing a digit and located in one of said conductor means of said first group of conductor means; a second tapped resistance; a second group of conductor means, the parallel connection of said second group of conductor means being formed on one side thereof by said second tapped resistance, one conductor means of said second group of conductor means connecting a second set of windings in series, said second set of windings comprising at least one other winding of said plurality of windings of each of said operating means, the windings of said second set of windings having the same number of turns; a plurality of second switch means each of said second switch means representing a digit and located in one of said second group of conductor means; a conductor means adapted to be connected to a source of current and connecting a third set of windings in series, said third set of windings comprising one further winding of said plurality of windings of each of said operating means and having a magnetic field opposite to the magnetic field of said first and second sets of windings, the number of turns of each of said further windings being progressively increased on each of said operating means, the arrangement being such that only in one of said operating means the magnetic forces of all windings thereof cancel each other permitting one of said plurality of switches to remain closed when one switch means of said first switch means, and one switch means of said second switch means are closed, said one closed switch representing the sum of the digits represented by the closed switch means of said first switch means and of the closed switch means of said second switch means.

4. In an electric calculating machine, in combination, a plurality of switches, each switch representing a digit; a plurality of operating means, each operating means including a movable member and a plurality of coils, each coil comprising a first and a second winding creating equal magnetic fields, each of said coils being magnetically independent of the other coils, and each winding adapted when energized to actuate said movable member, each of said movable members being operatively connected to one of said switches for opening the same when said movable member is actuated; a first group of conductor means adapted to be connected to a source of current, the conductor means of said first group of conductor means connecting in series a first set of first windings; a plurality of first switch means, each switch means representing a digit and located in one of said conductor means of said first group of conductor means; a second group of conductor means, the conductor means of said second group of conductor means connecting a second set of said second windings in series; a plurality of second switch means each of said second switch means representing a digit and located in one of said second group of conductor means, the arrangement being such that only in one of said operating means first and second windings are passed by current and produce opposite and equal magnetic fields so that the magnetic forces of all windings thereof cancel each other permitting one of said plurality of switches to remain closed when one switch means of said first switch means, and one switch means of said second switch means are closed, said one closed switch representing the sum of the digits represented by the closed switch means of said first switch means and of the closed switch means of said second switch means.

5. In an electric calculating machine, in combination,

a plurality of switches, each switch representing a digit in one of two decimal places, and having two contact means; a plurality of operating means, each operating means including a plurality of windings and a movable member, each of said movable members being operatively connected to one of said switches for opening the same when said movable member is actuated, at least one winding of said plurality of windings creating a magnetic field opposed to the magnetic fields of the other windings of said plurality of windings; a first group of conductor means adapted to be connected to a source of current, at least one conductor means of said first group of conductor means connecting a first set of windings in series, said first set of windings comprising at least one winding of said plurality of windings of each of said operating means; a plurality of first switch means, each switch means representing a digit and located in one of said conductor means of said first group of conductor means; a second group of conductor means, at least one conductor means of said second group of conductor means connecting a second set of windings in series, said second set of windings comprising at least one other winding of said plurality of windings of each of said operating means; a plurality of second switch means each of said second switch means representing a digit and located in one of said second group of conductor means, the arrangement being such that only in one of said operating means the magnetic forces of all windings thereof cancel each other permitting one of said plurality of switches to remain closed when one switch means of said first switch means, and one switch means of said second switch means are closed, said one closed switch representing the sum of the digits represented by the closed switch means of said first switch means and of the closed switch means of said second switch means; further operating means, each including two further windings and a movable core operatively connected to one of said first switch means; two conductors connected in parallel, each of said conductors connecting one of said contact means of one of said switches and one of each of said two further windings in series, the arrangement being such that a current passing in an identical arrangement through one of said two conductors and through one of the contact means of one of said switches representing a higher decimal place is adapted to pass through the other of said conductors and another of said contact means and one of said two further windings and to actuate a switch of said first switch means being next in order to a closed first switch and representing a digit higher by one than the digit represented by said first closed switch.

6. In an electric calculating machine, in combination, a plurality of switches, each switch representing a digit in one of two decimal places, and having two contact means; a plurality of operating means, each operating means including a movable member and a plurality of coils, each coil comprising a first and a second winding creating equal magnetic fields, each of said coils being magnetically independent of the other coils, and each winding adapted when energized to actuate said movable member, each of said movable members being operatively connected to one of said switches for opening the same when said movable member is actuated; a first group of conductor means adapted to be connected to a source of current, the conductor means of said first group of conductor means connecting in series a first set of said first windings; a plurality of first switch means, each switch means representing a digit and located in one of said conductor means of said first group of conductor means; a second group of conductor means, the conductor means of said second group of conductor means connecting a second set of said second windings in series; a plurality of second switch means each of said second switch means representing a digit and located in one of said second group of conductor means, the arrangement being such that only in one of said operating means first and second windings are passed by current and produce opposite and equal magnetic fields so that the magnetic forces of all windings thereof cancel each other permitting one of said plurality of switches to remain closed when one switch means of said first switch means, and one switch means of said second switch means are closed, said one closed switch representing the sum of the digits represented by the closed switch means of said first switch means and of the closed switch means of said second switch means; further operating means, each including two further windings and a movable core op-

eratively connected to one of said first switch means; two conductors connected in parallel, each of said conductors connecting one of said contact means of one of said switches and one of each of said two further windings in series, the arrangement being such that a current passing in an identical arrangement through one of said two conductors and through one of the contact means of one of said switches representing a higher decimal place is adapted to pass through the other of said conductors and another of said contact means and one of said two further windings and to actuate a switch of said first switch means being next in order to a closed first switch and representing a digit higher by one than the digit represented by said first closed switch.

7. In an electric calculating machine, in combination, a plurality of switches, each switch representing a digit in one of two decimal places, and having two contact means; a plurality of operating means, each operating means including three windings and a movable member, each of said movable members being operatively connected to one of said switches for opening the same when said movable member is actuated; a first tapped resistance; a first group of conductor means adapted to be connected to a source of current, the parallel connection of said first group of conductor means being formed on one side thereof by said first tapped resistance, one conductor means of said first group of conductor means connecting a first set of windings in series, said first set of windings comprising at least one winding of said plurality of windings of each of said operating means, the windings of said first set of windings having the same number of turns; a plurality of first switch means, each switch means representing a digit and located in one of said conductor means of said first group of conductor means; a second tapped resistance; a second group of conductor means, the connection of said second group of conductor means being formed on one side thereof by said second tapped resistance, one conductor means of said second group of conductor means connecting a second set of windings in series, said second set of windings comprising at least one other winding of said plurality of windings of each of said operating means, the windings of said second set of windings having the same number of turns; a plurality of second switch means each of said second switch means representing a digit and located in one of said second group of conductor means; a conductor means adapted to be connected to a source of current and connecting a third set of windings

in series, said third set of windings comprising one further winding of said plurality of windings of each of said operating means and having a magnetic field opposite to the magnetic field of said first and second sets of windings, the number of turns of each of said further windings being progressively increased on each of said operating means, the arrangement being such that only in one of said operating means the magnetic forces of all windings thereof cancel each other permitting one of said plurality of switches to remain closed when one switch means of said first switch means, and one switch means of said second switch means are closed, said one closed switch representing the sum of the digits represented by the closed switch means of said first switch means and of the closed switch means of said second switch means; further operating means, each including two further windings and a movable core operatively connected to one of said first switch means; two conductors connected in parallel, each of said conductors connecting one of said contact means of one of said switches and one of each of said two further windings in series, the arrangement being such that a current passing in an identical arrangement through one of said two conductors and through one of the contact means of one of said switches representing a higher decimal place is adapted to pass through the other of said conductors and another of said contact means and one of said two further windings and to actuate a switch of said first switch means being next in order to a closed first switch and representing a digit higher by one than the digit represented by said first closed switch.

8. A device, according to claim 1 wherein said plurality of switches is arranged in two groups, each switch of one group representing two digits, and each switch of the other group representing one of said two digits represented by said switches of said first group.

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