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AUTOMATIC DECIMAL-POINT INDICATOR FOR COMPUTERS

Filed April 27, 1959 4 Sheets-Sheet 1

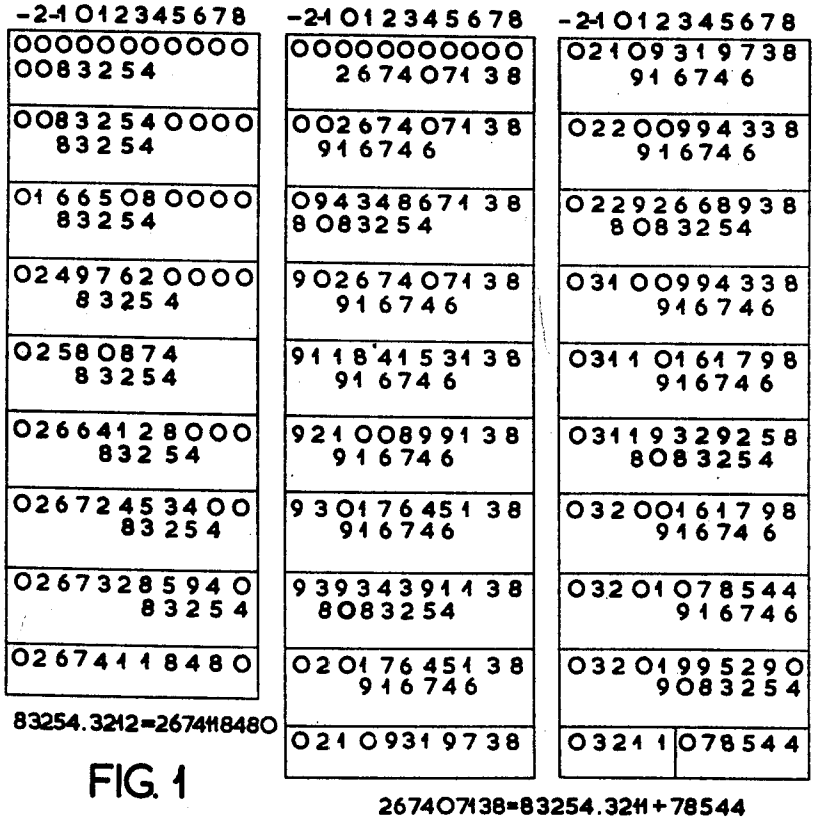

FIG. 1

FIG. 2

INVENTORS
JEAN PAUL GEORGES BORNE
ANDRE J. P. CHARLES-GEORGES
BY
Frank R. Trifari
AGENT

AUTOMATIC DECIMAL-POINT INDICATOR FOR COMPUTERS

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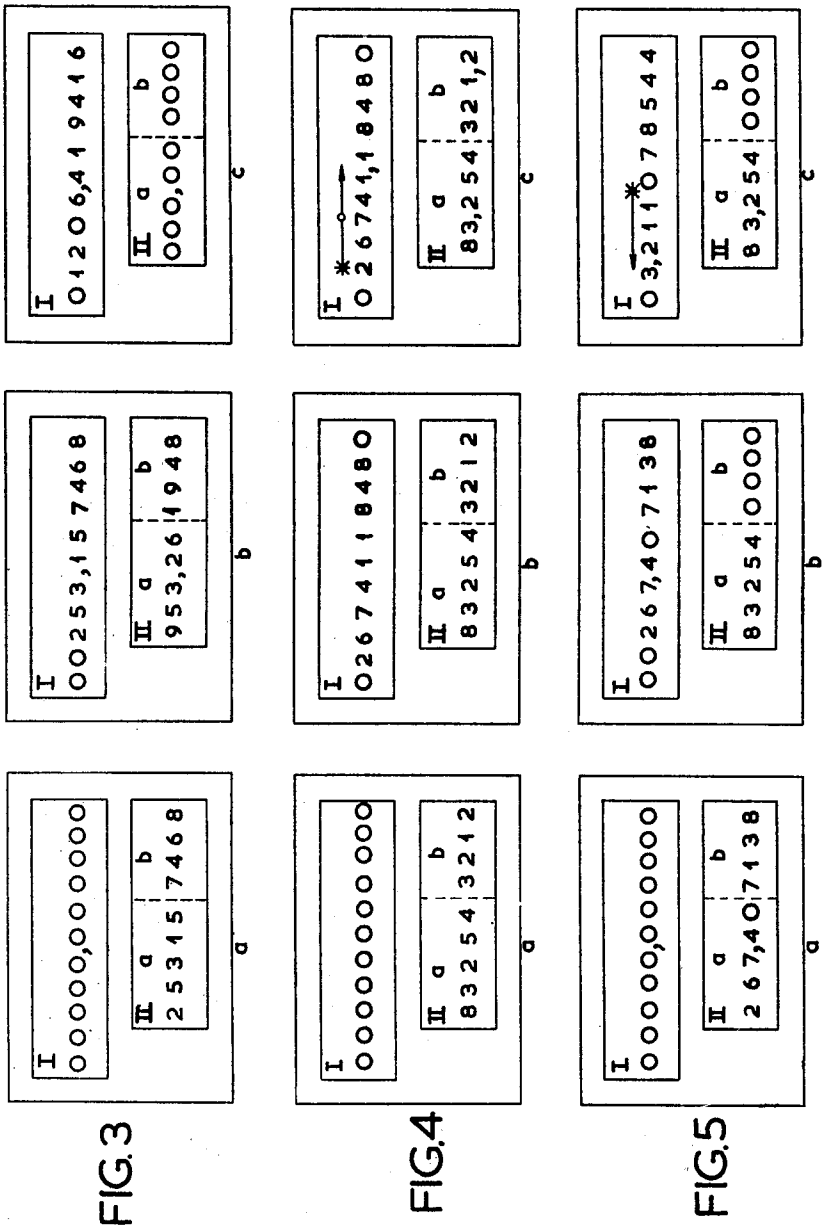

FIG.3 FIG.4 FIG.5

INVENTORS
JEAN PAUL GEORGES BORNE
ANDRE J. P. CHARLES-GEORGES
BY
Frank R. Trifari
AGENT

AUTOMATIC DECIMAL-POINT INDICATOR FOR COMPUTERS

Filed April 27, 1959 4 Sheets-Sheet 3

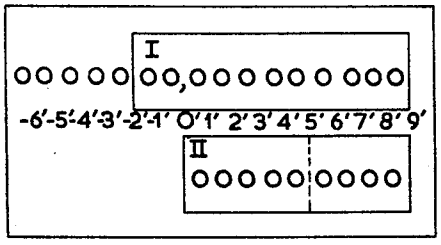

FIG. 6

±	X	:	conv.
0' = 0r		0' = 1l	1l = 15r
1' = 1r		1' = 2l	2l = 14r
2' = 2r		2' = 3l	3l = 13r
3' = 3r		3' = 4l	4l = 12r
4' = 4r		4' = 5l	5l = 11r
5' = 5r		5' = 6l	6l = 10r
6' = 6r	6' = 0		
7' = 7r	7' = 1r		
8' = 8r	8' = 2r		
9' = 9r	9' = 3r		

FIG. 7

INVENTORS
JEAN PAUL GEORGES BORNE
ANDRE J.P. CHARLES-GEORGES
BY
Frank R. Trifari
AGENT

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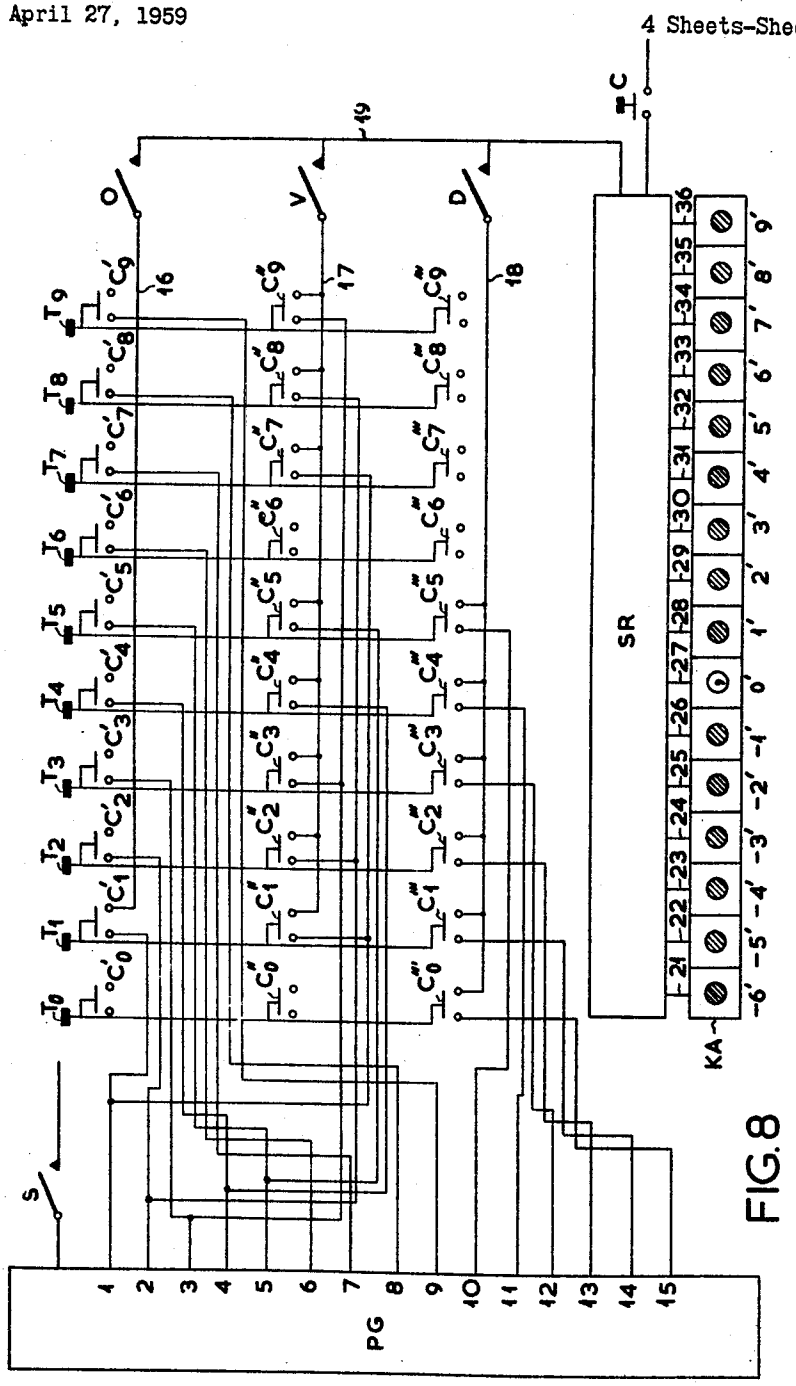

FIG. 8

INVENTORS
JEAN PAUL GEORGES BORNE
ANDRE J.P. CHARLES-GEORGES
BY
Frank R. Trifari
AGENT

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AUTOMATIC DECIMAL-POINT INDICATOR FOR COMPUTERS

Jean Paul Georges Borne, Clichy, and Andre Julien Pierre Charles-Georges, Montreux sous Bois, France, assignors to North American Philips Company Inc., New York, N.Y., a corporation of Delaware

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This invention relates to a computer, in particular a desk computer, having a number recorder I which also serves as the output, a number recorder II which is divided in two parts *a* and *b* and also serves as the input, and a device for placing decimal points in the numbers indicated by the number recorders I and II, which computer is capable of automatically performing additions and subtractions (augend or minuend in recorder I, addend or subtrahend in recorder II, and the final sum or difference in register I), multiplications (factors in the parts *a* and *b* of recorder II; after completion of the computation, product in register I) and divisions (dividend in recorder I, divisor in part *a* of recorder II; after completion, quotient in register I).

In known computers having a decimal point position indicator, the points in the numbers indicated by the number recorders I and II are placed therein independently from one another. Hence, in calculating products and quotients, the person using the computer must himself determine the position of the decimal point in the product or quotient and then insert it at the correct positions in the number recorders.

It is an object of the present invention to provide an arrangement in which this insertion is performed automatically. It is characterized in that the device for placing decimal points includes a number of point placing members in response to the energization of which a decimal point is inserted in the recorder II and by which the point is moved so that in the recorder I it assumes the arithmetically required position in the sum, the difference, the product or the quotient respectively starting, in the condition "add" or "subtract," from a certain zero-position of the point, in the condition "multiply" from the position occupied by the point due to its insertion in the first factor, and in the condition "divide," from the position which the point occupied in the dividend.

In order that the invention may readily be carried out, it will now be described more fully, by way of example, with reference to the accompanying diagrammatic drawings, in which

FIG. 1 shows the manner in which a desk computer can perform a multiplication,

FIG. 2 shows how a desk computer can perform a division,

FIGS. 3, 4 and 5 show the numbers indicated in succession by the number recorders I and II in performing an addition, multiplication or division, respectively,

FIG. 6 shows a specific embodiment of the number recorders,

FIG. 7 shows a table of the required point shifts, and

FIG. 8 is a diagram of a circuit arrangement enabling the point shifts according to the table of FIG. 7 to be effected.

FIG. 1 shows the manner in which, in a desk computer, the product 83254×3212 is calculated. First, the number recorder I is set to the position 0. Subsequently, the number 83254 is added three times to the contents

of the recorder I at the digit places 0, 1, 2, 3 and 4, then twice at the digit places 1, 2, 3, 4 and 5, than once at the digit places 2, 3, 4, 5 and 6 and finally twice at the digit places 3, 4, 5, 6 and 7. The product 267411848 now occupies the digit places −1, 0, 1, 2, 3, 4, 5, 6 and 7 of the recorder I, provided that this recorder I has an additional digit place −1.

FIG. 2 shows the manner in which the division 267407138:83254 can be performed. First the dividend 267407138 is written in the number recorder I at the digit places 0 to 8. Subsequently the 10^6—complement 916746 of the divisor 83254 is repeatedly added to the contents of the recorder I in a manner such that the digit 1 of the 10^6—complement, which digit corresponds to the initial digit 8 of the divisor, assumes the digit place 0. This is possible if the recorder I has an additional digit place −1, which initially was filled with a 0. This process is continued until there is no further change in the digit at a further additional digit place −2, which initially was also filled with a 0. In the example chosen, this is already the case at the first addition. Then the number 8083254 is added to the contents of the number recorder I in the condition in which the initial digit 8 of the divisor (that is to say, the third figure of the number 8083254) occupies the digit place 0. Then an analogous cycle of operations is repeated shifted one digit place to the right. This process comes to its natural end if no further shift to the right is possible. In the last addition, instead of the number 8083254 the number 9083254 is added to the contents of the recorder I. In the example given, the number 03211078544 appears in the recorder I and this means that the division 267407138:83254 does not terminate, that the quotient is equal to 3211 and the remainder to 78544.

It is assumed that the computer is capable of performing the above described logarithms. It comprises two number recorders which are designated I and II in FIGURES 3, 4, 5 and 6. The number recorder I is the output of the computer, that is to say, it shows the result of the operations performed, the number recorder II is the input of the computer or is directly coupled thereto, that is to say, it shows the numbers recorded in the computer, upon which numbers at operation must be performed.

FIGS. 3*a*, *b* and *c* show the numbers which are successively indicated by the recorders I and II when the addition 253157468+953261948=1206419416 is to be performed. First the recorder I is set to 0 and then the number 253157468 is written in the recorder II (FIG. 3*a*). If, now, the button "add" of the computer is depressed, the number 253157468 is transferred to the recorder I so that the recorder II is reset to 0. Now the second number 953261948 is written into this recorder II (FIG. 3*b*) and the button "add" is again pressed. As a result, this number disappears from the recorder II and the sum 1206419416 appears in the recorder I (FIG. 3*c*). The operation of subtraction is effected in a similar manner.

FIG. 4 shows the numbers which are successively indicated by the number recorders I and II, when the multiplication 83254×3212 is performed. Firstly, the recorder I is set to the condition 0 and the factors 83254 and 3212 are written in the parts *a* and *b* of the recorder II (FIG. 4*a*). If then the button "multiply" of the computer is depressed, the product 267411848 is written in the recorder I, the factors 83254 and 3212 being retained in the recorder II (FIGS. 4*b* and *c*).

FIG. 5 shows the numbers which are successively indicated by the number recorders I and II if the division

267407138:83254 is performed according to the logarithm of FIG. 2. First the dividend 267407138 is written in the recorder I and then the divisor 83254 in the recorder II (FIGS. 5*a* and 5*b*). If now the button "divide" of the computer is pressed, the number 3211078544 appears in the recorder I the meaning of this number has been stated hereinbefore (FIG. 5*c*).

The insertion of the decimal point offers no difficulty in additions and subtractions. Provision need only be made of a mechanism by means of which a point can be placed between each pair of successive figure places in the number recorder II, the assembly being designed so that in this event a point is also inserted between the corresponding figure places of the recorder I. Obviously, if there are any further numbers to be added to or subtracted from, the contents of the recorder I must be written in the recorder II in the correct figure places with respect to the decimal position used. In FIGS. 3*a, b* and *c*, for example, it has been assumed that the point has been inserted between the third and fourth figure places of the recorder II and hence between the fifth and sixth figure places of the recorder I.

Now let it be assumed that instead of the numbers 83254 and 3212 the numbers 83.254 and 321.2 must be multiplied. FIGURE 4*c* shows the positions which the points must ultimately occupy in the two factors and the product. If the device for inserting the points is designed so that, when the point is placed in the first factor, a point is also inserted at the corresponding point position in the number recorder I, as is obvious for the operations of addition and subtraction, insertion of the point in the second factor must cause the point to be moved two places to the right in the example given (FIG. 4*c*).

Now, let it be assumed that instead of the division 267407138:83254 the division 2674.07138:83.254 must be performed. FIGURE 5*c* shows the ultimate positions of the points in the number recorders I and II. In this example, the point must be moved three places to the left.

The shifts to which the point must be subjected in multiplications and divisions when it is inserted at different locations in the second factor and the divisor, respectively, can readily be ascertained. These movements of the points are summed up in the table of FIG. 7. To make this clear, attention is first directed to FIG. 6 wherein the various locations of the point in the number recorders I and II are designated by the numbers $-2'$, $-1'$, $0'$, $1'$, $2'$, $3'$, $4'$, $5'$, $6'$, $7'$, $8'$ and $9'$. If, in the dividend, the extreme position at the left-hand side in which the point can be placed is the location $0'$ (FIG. 6), allowance must be made for the fact that in the quotient the point may also appear at one of the locations $-3'$, $-4'$, $-5'$, $-6'$. Hence, the recorder I must offer this possibility, for example, by the provision of a number of additional figure places at the left-hand end of the recorder I, and these additional figure places are always filled with the digit 0, that is to say, they do not take part in the computation proper but serve only to indicate the position to be occupied by the point in the quotient. FIG. 6 shows diagrammatically a construction of the number recorders and the numbering of the point locations.

The table of FIG. 7 shows in the column "±" the point shifts in the recorder I from the location $0'$ when a point is inserted at the location i ($i=0',1',2' \ldots 9'$) in the recorder II. The column "x" shows the point shifts in the recorder I when a point is placed in the location i

$$(i=6',7',8',9')$$

in the second factor of the product, which factor is written in the part *b* of the recorder II. The initial condition is the position which the point has assumed in the recorder I by the insertion of the point in the first factor of the product, which factor is written in the part *a* of the recorder II. Since the point position $5'$ is considered as belonging to the first factor, this point position is no longer available for the second factor. The column ":" shows the movements of the point in the recorder I when a point is placed at the position i ($i=0',1',3',4',5'$) in the divisor, which is written in the part *a* of the recorder II. Here the initial condition is the location of the point in the dividend. In FIG. 7, "*pr*" means: "shift *p* places to the right" and "*ql*:" "shift *q* places to the left."

FIGURE 8 shows a circuit arrangement which enables the point to be moved in the above-described manners. In this figure, PG designates a pulse generator having 15 outputs, 1, 2, . . . 15, SR a closed-path shift register having sixteen outputs 21, 22, . . . 36, KA a point position indicator, T_0, T_1 . . . T_9 a row of ten keys, each key T_i when depressed closing three contacts c'_i, c''_i, c'''_i, C denotes a push-button which, when depressed, closes a contact *c*, and O, V, D, and S designate switches. The outputs 1, 2, . . . 15 of the pulse generator PG are connected, in the manner shown in FIG 8, to the left-hand ones of the contacts c'_i, c''_i, c'''_i while the right-hand ones of the contacts c'_i are connected to a lead **16**, the right-hand ones of the contacts c''_i to a lead **17** and the right-hand ones of the contacts c'''_i to a lead **18**. The leads **16, 17, 18** are connected, through the switches O, V and D, to a lead **19** which is connected to a first input of the shift register. The contact *c* provides access to a second input of the shift register. The switch S provides access to the supply terminal of the pulse generator PG.

The pulse generator PG is designed so that the closure of the switch S results in the pulse generator PG performing one cycle, which consists of the output **1** providing one pulse, the output **2** two pulses, the output **3** three pulses, and so on. Subsequently, the pulse generator performs another cycle only if the switch S is opened and then closed again.

The shift register SR is designed so that, in its operative condition, a voltage is set up at one of its sixteen outputs. However, if *k* pulses are applied through the lead **19** to the first input of the shift register SR, the voltage carrying output moves *k* places to the right, while, if the voltage has been set up at the sixteenth output **36**, the next pulse results in a voltage being produced at the first output **21**. If, through the contact *c*, a pulse is applied to the second input of the shift register SR, this shift register assumes the condition in which a voltage is set up at the seventh output **27** irrespective of the output which at that instant carried the voltage. The outputs of the shift register are connected to inputs of the point position indicator KA, so that at all times a point is indicated at one of the twenty-six possible point locations.

The ten keys T_0, T_1 . . . T_9 relate to the point positions 0, 1, . . . 9 and are arranged so that it is evident which key relates to which point position. Furthermore, the keys T_i are coupled mechanically or electrically to the switch S in a manner such that the depression of each key causes the switch S to be closed. However, the arrangement is such that the switch S only closes with certainty after the closure of the contacts c'_i, c''_i, c'''_i concerned. Preferably the keys are designed so that a key which has been depressed remains in the depressed position until another key is depressed.

The switch O is coupled to the buttons "add" and "subtract," which are not shown in the figure, in a manner such that this switch is closed if one of these two buttons is pushed. Similarly, the switch V is coupled to the button "multiply" and the switch D to the button "divide," which buttons are likewise not shown. Furthermore the switches O, V and D are controlled so that each switch remains closed until, by the depression of one of the buttons not coupled to the closed switch, another of the switches O, V and D is closed after the first switch has been opened for a short time.

The left-hand contacts c'_1, c'_2 . . . c'_9 are connected to the outputs 1, 2, . . . 9, respectively, of the pulse generator PG, the left-hand contacts c''_1, c''_2, c''_3, c''_4, c''_5, c''_7, c''_8 and c''_9 are connected to the outputs

1, 2, 3, 4, 5, 1, 2 and 3, respectively, of the pulse generator PG, and the left-hand contacts c'''_0, c'''_1, c'''_2, c'''_3, c'''_4, c'''_5 are connected to the outputs 15, 14, 13, 12, 11 and 10, respectively, of the pulse generator PG.

The arrangement operates as follows. If, in performing an addition, subtraction or division, a point is to be placed in the point position *i*, the point must first be moved to the point position 0 by the depression of the button C. Then the number recorders are set to 0, the first number is written in the recorder II, the button "add" (not shown in the figure) of the machine is depressed (so that the switch O closes and the number is transferred from the recorder II to the recorder I) and the key T_i is depressed. As a result, *i* pulses are applied from the output *i* through the contacts c'_i, the lead **16**, the switch O, the lead **19** to the shift register SR so that in the recorder I the point moves *i* places to the right to occupy the position *i*. If a multiplication is to be performed, the two factors are written in the parts *a* and *b* of the recorder II, the button C is pushed (so that in the recorder I the point is moved to the point position 0'), then the button multiply of the computer is depressed (so that the switch V closes and the product appears in the recorder I, the two factors being retained in the recorder II). Then the keys relating to the points in the factors are depressed in succession. In the example of FIG. 4*c*, these keys are the keys T_2 and T_8. By the depression of these keys, two pairs of two pulses each are applied in succession to the shift recorder SR, so that in the register I the point moves from the position 0' to the position 4'. As has been described hereinbefore, the point of the second factor can never be written in the point position 5', since this position is reserved for the first factor.

If a division must be performed, the dividend and its decimal point are written in the number recorder I in the manner described hereinbefore. Then the divisor is written in the part *a* of the recorder II and the button "divide" (not shown) is depressed (so that the switch D closes and the quotient and the remainder appear in the recorder I, the divisor remaining in the recorder II). Then the key relating to the point in the divisor is depressed. In the example of FIG. 5, this is the key T_2, so that in this case 14 pulses are applied to the shift register SR and the point is shifted 13 places to the right; however, this is equivalent to a three-place shift to the left. Since the shift register is closed on itself, a shift to the left is equivalent to a different shift to the right. This relationship is shown in the column "Conv." of the table of FIG. 7.

Since in multiplying we are concerned only with the sum of the shifts caused by the insertion of the points in the two factors, the wiring shown in FIG. 8 can be replaced, with respect to the contacts c''_1, by equivalent wirings. The left-hand contact c''_2 may be connected to the output **5** and the left-hand contact c''_8 to the output **15** of the pulse generator PG, for a shift through 5+15=20 places to the right is equivalent to a shift through four places to the right.

What is claimed is:

1. In a computer having a first number recorder serving as an output of the computer and a second number recorder divided into two parts and serving as an input of the computer, means for inserting decimal points in the numbers indicated by the first and second recorders, said means comprising a plurality of decimal point switches for inserting a decimal point between any two successive digit places of the second number recorder, each of said decimal point switches being provided with multiple contacts, a pulse generator having a plurality of output terminals, each terminal when activated delivering a series of pulses, each terminal delivering one more pulse than the next preceding terminal, said contacts being normally open, one of said contacts being closed when a calculation is performed and a decimal point is inserted in the second number recorder, each closed contact connecting an output of the pulse generator to an input terminal of a closed-end shift register, said register having a plurality of outputs with each input pulse successively energizing an output of said register, said outputs being connected to an indicating member for indicating a decimal point between two successive digit places in the number recorded by said first number recorder.

2. A computer as claimed in claim 1, said shift register further comprising a second input terminal and means for applying a pulse to said terminal, the register assuming a predetermined fixed zero position upon the application of said pulse.

3. A computer as claimed in claim 1, said multiple contacts being arranged in groups of three contacts each, each group of three contacts being adapted to close simultaneously, the first contacts of all the groups being connected to said shift register input through a first switch, the second contacts being connected to said shift register input through a second switch, and said third contacts being connected to said shift register input through a third switch, each of said switches being open or closed depending on the arithmetic operation being performed by the computer.

4. In a computer having a first number recorder serving as an output of the computer and a second number recorder divided into two parts and serving as an input of the computer, in which second number recorder a number can be entered to be added to or subtracted from the number recorded in the first number recorder, in the two parts of which second number recorder two numbers to be multiplied with each other can be entered, and in one of said two parts of which second number recorder a number to be divided into the number recorded in the first number recorder can be entered; means for inserting decimal points in the numbers indicated by said recorders comprising a plurality of decimal point switches for inserting a decimal point between any two successive digit places of the second number recorder, each of said decimal point switches being provided with three normally open contacts which are closed when the associated switch is closed; a pulse generator having a plurality of output terminals, each terminal when activated delivering a series of pulses, each terminal delivering one more pulse than the next preceding terminal, a closed-end shift register having first and second control input terminals and a plurality of output terminals only one of which has voltage output when the shift register is activated, the shift register being set to a fixed position when a pulse is applied to the first control input terminal and the voltage carrying output terminal being displaced over one position when a pulse is applied to the second control input terminal; a plurality of decimal point indicators for indicating a decimal point in the number recorded in the first number recorder, each decimal point indicator being connected to an associated output terminal of the closed-end shift register and being operative only when the associated output terminal has a voltage output; three normally open calculting switches one of which is closed when an addition or subtraction is performed, one of which is closed when a multiplication is performed and one of which is closed when a division is performed; the output terminal of the pulse generator delivering a series of *p* output pulses when said generator is activated being connected to the second control input terminal of the shift register through the series combination of a contact of the $(p+1)$th decimal point switch and the calculating switch which is closed during additions and subtractions; said output terminal also being connected to the second control input terminal of the shift register through the series combination of the calculating switch closed during multiplication and a contact of that one of the decimal point switches that requires, when activated during a

multiplication, a displacement of the decimal point over p decimal point places; said output terminal of the pulse generator also being connected to the second control input terminal of the shift register through the series combination of the calculating switch closed during division and a contact of that one of the decimal point switches that requires, when activated during a division, a displacement of the decimal point over p decimal point places.

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