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(54) ELECTRONIC CALCULATING APPARATUS

(71) We, VEB ELEKTRONIKAHANDEL BERLIN, a corporation organised under the laws of German Democratic Republic, of 25 Mainzer Strasse. Berlin, German Democractic Republic, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a calculating apparatus for the automated digital transcription and processing of physical quantities and units by means for example of a sequentially operating circuit including an alphanumeric input keyboard and an alphanumeric display.

The system is applicable as an extension of the equipment technology of calculators (electronic data processing systems, process computing systems, pocket calculators, and the like), measuring, control and regulating equipment as well as of data collecting and data output devices employing such a calculation apparatus.

It is known that with calculators of the usual design for calculating with physical quantities transcription is resumed by a calculation with numeral digits tailored to the special case of application.

For instance, in the quantity equation

$$\frac{v \cdot t}{s} = 1$$

v: velocity
t: time
s: path

the path can be indicated in 19 different units (as micrometer, meter, angstrom etc.), the time in 62 different units (as nanoseconds, years, millions of years) and accordingly, the velocity in 1,178 different units; in this case the given quantity equation replaces 96,596 numeric value equations, such as

$$v_x = 3.6 : 10^{-2} \frac{s_x}{t_x}$$

v_x	s_x	t_x
km/h	cm	s

It is known with measuring, control and regulating equipment that the presetting of defined values via switches and the like and subsequent display with analogously operating measuring instruments and recorders or optical as well as graphic output devices can be effected, which are however designed in each case normally only for specified kinds of quantities.

The present state of calculator operation necessitates tracing back each operation concerning physical quantities to an operation with numeric values; the following effects are connected with such calculator use:

— Extensive manual preliminary and second operations are necessary.
— The established solutions (programmes) mostly apply to a special case of application.
— The high percentage of manual work introduces a source of misinterpretations and errors.
— An automated separation and stringing of formulas by a calculator for a system solution is complicated.

The present invention is concerned with extending the present value of calculators, measuring, control and regulating equipment as well as of data collecting and data output device by achieving one or more of the following:

— the more transparent and more rapidly surveyable representation of quantities for and by the equipment mentioned;
— the universal use of quantity presetting or display equipment for a great number of kinds of quantities;
— the reduction of the requirements for the manual preliminary and second operations for the processing of quantities;
— the rationalization of the programming of calculators due to the programming of quantity equations as defined by the quantity equation rule;
— the direct processing of quantities without limitation of the kinds of quantities of a quantity system;
— the potential automated updating of the parameters of the data processing technology of quantities.

According to the invention there is provided an electronic calculating apparatus for automatically processing data corresponding to a variety of physical parameters said apparatus comprising: entry means for successively entering items of data each indicative of a physical quantity and having a first portion representing the numerical part of the data item and a second portion representing the unit of measurement of said data item and hereinafter referred to as homoscribtive data; input transformation means for automatically transforming the homoscribtive data into an internally operable format and hereinafter referred to as autoscribtive data; calculating means for processing the transformed data according to a selected calculating function; output transformation means for automatically transforming the processed autoscribtive data into homoscribtive data suitable for display and having a first portion representing the numerical part of the data and a second portion representing a unit of measurement assigned to said data, wherein the second portion of the output data from said transformation means may represent a unit of measurement which differs from at least one of the units of measurement entered by the entry means.

The invention is thus based on the technique that homoscribtively represented quantities are reversibly and unambiguously converted to autoscribtive quantities and that without further additional instructions autoscribtive quantities can be added, subtracted, multiplied, divided, raised to a power or the roots can be extracted by the apparatus for example.

A homoscribtively represented quantity is a readily recognisable representation of a physical unit of measurement (e.g. '96 KM/HR' for '96 km/h'—'96 kilometers per hour').

An autoscribtive quantity is the internal representation of this quantity chosen to allow a fast and uncomplicated processing within the calculator in the form of a sequence of numbers for the numeric value and the autoscribtive unit of this quantity, an autoscribtive unit typically being represented by two numbers as a packed unit or with n numbers as an unpacked unit; n depends on the number of base units of the selected unit system. The two numbers of the packed unit are also called the numerator unit and denominator unit.

The calculating apparatus of the invention makes it possible for one or more of the following situations to be achieved.

— homoscribtive quantities—such as '1 A' (1 Ampere), '50 GOHM' (50 gigaohms), '95 V/M' (95 volts per metre), '130 KA/HAR' (130 kiloamperes per hectare), which according to the generally accepted formation rules for units from elements of a provided set of abbreviations for elementary units (see table 1) and of abbreviations of prefixes (see table 2) are formed and stringed with a numeric value— can be put into the calculator directly and immediately as one data block.

— arithmetic operations between quantities or between quantities and numbers are solved by the calculator immediately and independently, as e.g.

15 V:3 MA = 5 KOHM

These quantities are representable as an exponential product. In the execution of the operations the calculator uses the autoscribtive representation form of quantities.

— processed autoscribtive quantities determined by the calculator are put out homoscribtively in an optimal, and easily recognisable form; thus, e.g. the output of '0.0351.10^{11} WB.S.A. is displayed in the form of '3.51 GOHM'. Dependent on the resulting quantity, the calculator generates a homoscribtive unit with a minimum number of factors of the exponential product.

— autoscribtive quantities determined by the calculator to a specified kind of measurement quantity are put out in a preset homoscribtive unit of this kind of quantity; when e.g. for velocity, the unit 'KM/HR' (kilometer per hour) is preset, the result is always put out in this unit—regardless of the units, in which the path (e.g. P.M. . . ., M, . . ., TAM, MI, INCH, ANG, . . .) or the time (e.g. PS, . . ., S, . . ., MIN, HR, DI, ANN, . . .) is given.

— autoscribtive quantities determined by the calculator to a specified kind of measurement quantity in a preset homoscribtive unit are so displayed if representation of the numeric value as a fixed-point digit in the range 0.001 to 999.999 occurs otherwise a prefix for the homoscribtive unit is generated e.g. for a calculated frequency quantity the unit 'HZ' (hertz) is preset, the output of the quantity '3 10^4 s^{-1}, is output in form of '30 KHZ' (30 kilohertz).

— when operating with various quantities the calculator executes extensive checking measures—e.g. whether useful quantities were made available for processing at all or whether the operations with quantities yield efficient new (measuring) units or kinds of quantities (this function is to be put on a level with the 'dimension computing', which technicians and physicists perform for checking formulas).

— at its output an autoscribtive quantity in the form of a pulse sequence is made available, which represents quantitatively and qualitatively unambiguously the quantity made available for processing.

— the autoscribtive quantity made available at the output of the device is in form of a pulse sequence, can be processed by all assemblies and device units without performing a special programming or matching.

— a measurement quantity of a specified kind can be put out in a preset homoscribtive unit of this kind of quantity.

— it can put out quantities of a number of kinds representable with a preset set of elementary units.

— the presetting of regulating variables, measured value limits and others is performed in the usual homoscribtive representation form.

— input and output assemblies of control and regulating devices are applicable without limitation of the kinds of quantities.

— the output of homoscribtive quantities is performed as a character sequence in an optimal and readily understandable representational form.

For solving the technical tasks the following requirements are to be met to allow realisation of the calculating apparatus:

(1) The first requirement for solving the technical task consists in a defined set of abbreviations for prefixes and abbreviations for elementary units. Prefixes are independent designations or independent designations reduced to a few characters ('abbreviations') for powers for the number 10. Elementary units are units with independent designations or independent designations reduced to few characters ('abbreviations') for coherent or incoherent (measuring) units. The defined set of abbreviations for prefixes and of abbreviations for

elementary units has to meet the following requirements:

— Only the characters of a limited character set are to be used.
— The set of prefixes as well as the set of elementary units is not to contain homonymous abbreviations.
— Abbreviations, which can be formed from the stringing of an abbreviation of a prefix and an abbreviation of an elementary unit may not be equal neither to an abbreviation of the prefixes nor to an abbreviation of the elementary units; unless, the arised abbreviation has the same semantic content as its homonym (example: 'KG' is the abbreviation of the elementary unit 'KG' (kilogram) on the one hand, on the other hand this abbreviation arises from stringing the abbreviation of the prefix 'K' (kilo) with the abbreviation of the elementary unit 'G' (gram)).

In the tables 1 and 2 such as set of abbreviations for prefixes and of abbreviations for elementary units, which meets the requirements mentioned, is listed as an example—with this set the units of the fields of natural science, engineering, industry and economy can be represented to a large extent.

In table 3 a set of abbreviations for elementary units, which is a partial amount to table 1, is listed as example; thus, with the physical-technical prefixes according to table 2 the physical-technical units are representable.

With a defined set of abbreviations for prefixes and abbreviations for elementary units homoscribtive quantities are representable. A homoscribtive quantity is a closed string of characters consisting of a 'numeric value' followed by an 'abbreviation of the unit'.

Example: 22 M/S2

With this for the formation of the abbreviation of the unit the following (generally usual) rules have to be followed:

— All abbreviations for elementary units according to table 1 or table 3 are allowed as abbreviations of the unit.
Examples: M, S, KG,
V, H, HPW

— Decimal parts and multiples of elementary units which are represented by stringing an abbreviation of a prefix with an abbreviation of an elementary unit are allowed as abbreviations of the unit; such an unit is also called a 'stringed unit' in the further context.
Examples: MM, MYS, KV

— Integer powers of elementary or stringed units are allowed as abbreviations of the unit; with this in stringed units the exponent is related as well to the prefix as to the elementary unit.
Examples: MM3, S—2

— Derived units in form of exponential products are allowed as abbreviations of the unit. They are represented by inserting a '.' between the multiplicatively stringed factors of the exponential product.
Examples: OHM.M, A.S, KM.HR—1

— Derived units in form of exponential products can be represented such that on the left side of the character '/' all elements of the exponential product with a positive exponent and on the right side all elements with a negative exponent are given, with it the negative sign of the exponent in the element is omitted.
Examples: KM/HR, A/MM2

— For the formation of stringed units legal rules, international standards and the traditional use are to be considered.
(Note: all combinations logically possible of the defined set are correctly interpretated by the technical array, when they are put in; in the output the above mentioned instructions can be followed.)
Example: The unit 'horse power' is not to be stringed with decimal prefixes.

(2) The second requirement for solving technical task is that for the defined set of elementary units there is a basic amount *B* of the base units £ and each elementary unit $\mathcal{E}_x$ is representable according to the formula

$$_x = \pounds_1^{n_1} \cdot \pounds_2^{n_2} \cdot \ldots \cdot \pounds_k^{n_k}$$

with $B = \{\pounds_1, \ldots, \pounds_k\}$
k : positive integer numeral digit
n : integer exponent

In table 4 for the set of elementary units defined in table 1 as an example the pertinent basic set of base units is represented.

In table 5 for the set of elementary units defined as an example in table 3 the pertinent basic set of base units is represented.

In table 6 the elementary units determined in table 1 as an example are listed in form of exceptional products from base units.

In the accompanying drawings:

Fig. 1 Shows the representation of the symbols for assemblies of the figs. 2 to 6 and fig. 8
Fig. 2 Shows a circuit arrangement for the input transformation of quantities
Fig. 3 Shows a circuit arrangement for the automated processing of autoscribtive quantities
Fig. 4 Shows a circuit arrangement for the controlled output-transformation of quantities
Fig. 5 Shows a circuit arrangement for the optimal output-transformation of quantities
Fig. 6 Shows a circuit arrangement for the automated digital transcription and processing of quantities and units
Fig. 7 Shows a keyboard and display arrangement suitable for a desk or pocket calculator, and
Fig. 8 Shows a schematic representation of the processing effected within such a calculator.

The circuit arrangement for the input-transformation of quantities (fig. 2) is a combination of assemblies under the control of network 21, V12 the calculating assembly 14, the logic network 9, the check code generator 10, the address register 13, the numeric value register 3, the register for an autoscribtive unit 8, the read-only memory for numeric values 20, the read-only memory for elementary units 16, the read-only memory for groups of exponents to base units 23, the read-only memory for prefixes 18 as well as other switches and memories which can be controlled in an ordered sequence, when the register for a homoscribtive unit 5 and the numeric value register 3 are loaded and the circuit is activated, e.g. via the input keyboard 1.

The loading of the register for a homoscribtive unit 5 and of the numeric register 3 is performed via the input keyboard 1. The input keyboard 1 for the character sequential input of a homoscribtive quantity is designed in such a way that for letters a numeric value code is made available and letters are distinguishable by one bit from numeral digits and special symbols.

On the input keyboard 1 there are four different classes of keys (see also Figure 7):

1rst class operation keys (e.g. "+", ":")
2nd class letter keys ("A" . . . "Z")
and special symbol keys ".", "-", "/".
3rd class numeral digit keys ("0" . . . "9", ".", "↑")
4th class switching keys (e.g. for switching in case of a multiply occupied key, switching from calculating with quantities to numeric calculating).

The input keyboard 1 is connected with an input-discriminator 2, which in conjunction with the control network 21 controls the input process.

When calculating with physical quantities each data setting has to start with the activation of a sequence of digit keys. These characters are accepted in the given sequence in the numeric value register 3 designed as a shift register. When a letter key is activated, the input-discriminator 2 activates the loading of the register for a homoscribtive unit 5, in which both this letter and all following characters are accepted, when the activated keys belong to the second or third classes. By pressing a key of the first or fourth classes the input of a quantity is finished.

The keys of the second or third classes can be used as input keys for programme instructions at the same time, when the fourth class contains e.g. a switching key "quantity" which is to be activated before the setting of a quantity and continues to be activated, until a key of the first or fourth class is activated.

To the input keyboard 1 a display device 50 can be assigned. With it for a homoscribtive quantity put in a n-digit numeric display 4 represents the numeric value, and a p-digit alphanumeric display 6 represents the unit of the homoscribtive quantity.

The representation of the content of the register for a homoscribtive unit 5 to an autoscribtive quantity is performed in several timing cycles.

In the first timing cycle sequence, the homoscribtive unit is separated in factors of the exponential product; a factor is always located between two separators ("." or "/" or ignore sign). The logic network 9 divides the homoscribtive unit in cycles, character for character; with it a register for a stringed unit 11 accepts the stringed unit of a factor and a register for a factor exponent 12 accepts the exponent of a factor of the exponential product for an intermediate storage, respectively, and a switch 'exponent sign' 15, a switch 'sign next factors' 17, a switch 'factor-end' 19, and a switch 'analysis-end' 22 are switched by the logic network 9 as a sequence of the exponential product separation and for influencing the further cycle sequence of the control network 21.

The logic network 9 influences the flow such that in the next shift cycle the first character of the register designed as a shift register for a homoscribtive unit 5

(1) is accepted in the register designed as a shift register for a stringed unit 11, when this character is a letter and when in the running cycle of separation of a factor only letters have been transferred up to now or the first character of the factor is concerned;

(2) causes a switching of the switch 'exponent sign' 15 to "L", when this character is a "-", which follows to the transfer of a letter;

(3) is accepted in the register for a factor exponent 12, when this character is a numeral digit, which follows to the transfer of a negative sign or a letter;

(4) causes a switching of the switch sign next factors 17 to "L", prepares the finishing of the representation of an exponential product factor by transfer of the switch 'factor-end' 19 to "L" and the flow control is transferred to the cycle 'separation of a stringed unit', when this character is a "/", which follows to the transfer of a letter or a numeral digit;

(5) is not exchanged and prepares the finishing of the representation of an exponential product factor by transfer of the switch 'factor-end' 19 to "L" as well as the flow control is transferred to the cycle separation of a stringed unit, when this character is a ".", which follows to the transfer of a letter or a numeral digit;

(6) is not exchanged and prepares the representation of a homoscribtive quantity by transfer of the switch 'analysis-end' 22 to "L" as well as the flow control is transferred to the cycle 'separation of a stringed unit', when this character is an 'ignore sign', which follows to the transfer of a letter or a numeral digit;

(7) is not exchanged and the flow control is transferred to the cycle 'truncation because of a syntactical error', when none of the cases (1) to (6) are concerned.

The exponent of the first factor of the exponential product is already stored in an exponent-1-register 7.

The second timing cycle sequence covers the cycle 'separation of a stringed unit'. The stringed unit stored in the register for a stringed unit 11 is separated into a prefix and an elementary unit. The timing cycle can be passed through multiply in a modified way. Under the control of the control network 21 the assemblies check code generator 10, calculating assembly 14, address register 13, read-only memory for elementary units 16 and the read-only memory for prefixes 18 perform the separation of the actual stringed unit in such a way that by the calculating assembly 14 in a maximum of m subcycles per subcycle i, starting with $i = 1$ the i-first characters are added to an ordinal number for the read-only memory for prefixes 18 and by the check code generator 10 from the sequence of i-first characters of the stringed unit bits to a check character for the accepted prefix are compounded according to an established scheme and all characters of the stringed unit from the (i + 1). character for an ordinal number for the read-only memory for the elementary units 16 are added timely parallel or in series to it and by the check code generator 10 from the sequence of all characters of the stringed unit from the (i + 1), character bits for a check character for the accepted elementary unit are compounded according to an established scheme.

The i subcycles are passed through as often, till the check character read from this read-only memory via the determined ordinal number for the read-only memory for prefixes 18 is equal to the check character for the separated prefix above determined by the check code generator 10—and when also the check character read from this read-only memory determined via the ordinal number for the read-only memory for elementary units 16 is equal to the check character for the separated elementary unit determined above by the check code generator 10.

The scheme for the generation of the check character (bit pattern mask) for an accepted prefix as well as for an accepted elementary unit can be established e.g. in the following way that the first 4 bits of the first character, the first 2 bits of the second character and the first 2 bits of the third character result in the check character.

After a positively finished i. subcycle for the separation of a stringed unit, the calculating assembly 14 generates the numeric value of the autoscribtive quantity in steps by multiplying the content of the numeric value register 3 with the numeric value of the prefix, which was read via an actual ordinal number—that has been exchanged from the read-only memory for prefixes 18—from the read-only memory for numeric values 20, and with the numeric value of the elementary unit, which was also read via an actual ordinal number—that has been exchanged from the read-only memory for elementary units 16—from the read-only memory for numeric values 20, and by storing in the numeric value register 3.

In these multiplications the switch positions of the switches 'exponent sign' 15 and 'sign next factors' 17 are considered; further, before the multiplications the numeric values read from the read-only memory for numeric values 20 are raised to a power with the content of the register for a factor exponent 12 under consideration of the position of the switch 'exponent sign' 15 and 'sign next factors' 17.

Further, after a positively finished i. subcycle for the separation of a stringed unit the calculating assembly 14 generates the unpacked unit to an autoscribtive quantity in form of a sequence of exponents to base units in steps, while the content of the register for an autoscribtive unit 8, depending on the position, and element for element for an unpacked numerator unit in form of a sequence of exponents for base units, which via an actual ordinal number, which has been exchanged from the read-only memory for elementary units 16, has been read out from the read-only memory for groups of exponents for base units 23 and for an unpacked denominator unit in form of a sequence of exponents for base units, which via a further actual number that has been exchanged from the read-only memory for elementary units 16, was read out from the read-only memory for groups of exponents for base units 23, was added in the calculating assembly 14 and stored in the register for an autoscribtive unit 8. In these additions the position of the switches 'exponent sign' 15 and 'sign next factors' 17 are considered and before the additions the numeral digits read out from the read-only memory for groups of exponents for base units 23 are multiplied with the content of the register for a factor exponent 12 under consideration of the position of the switches 'exponent sign' 15 and 'sign next factors' 17.

When the i. subcycle is finished unsuccessfully, then a number of shift cycles follow sufficient that the stringed unit 11 finishes a circulation. The stepping forward of the modified control and the beginning of the (i +). subcycle of the second cycle sequence follow.

When after a positive finishing of the cycle 'separation of a stringed unit' the switch switch 'factor-end' 19 is "L", the control network 21 initiates a new cycle 'separation of an exponential product element'.

When after a positive finishing of the cycle 'separation of a stringed unit' the 'analysis-end' 22 is "L" the cycle sequence of the system for the input-transformation of quantities is finished duly.

When one of the conditions mentioned is not met, the cycle sequence due to a syntactical error in the homoscribtive unit is truncated.

The read-only memories mounted in the system for the input-transformation of quantities have the following design:

—The read-only memory for elementary units 16 contains systematically according to the sums via the numeric value code of the letters of the abbreviation of an elementary unit the check character generated in dependence on the sequence of letters and one ordinal number each for the numeric value, the unpacked numerator unit and the unpacked denominator unit for the respective elementary unit.

—The read-only memory for prefixes 18 contains systematically according to the sums via the numeric value code of the letters of the abbreviation of a prefix for each prefix the check character generated in dependence on the sequence of letters and an ordinal number for the numeric value of the prefix.

—The read-only memory for numeric values 20 contains numeric values for the elementary units and prefixes in an established order.

—The read-only memory for groups of exponents for base units 23 contains in an established order sequences of exponents for base units, which may be unpacked numerator unit or unpacked denominator unit.

The circuit arrangement for the automated processing of autoscribtive quantities (fig. 3) is a combination of assemblies under the control of control network 26, viz,

the calculating assembly 14,
the numeric value register 3,
the register for an autoscribtive unit 8,
the numeric value accumulator 24, and
the accumulator for an autoscribtive unit 25 and

are controlled in an ordered sequence such that the registers and accumulators are loaded and the circuit is activated by the bit sequence for the execution of a special operation with quantities, e.g. via the input keyboard 1.

The circuit adds or substracts two autoscribtive quantities of the same kind without limitation of the kinds of quantity, it multiplies or divides two autoscribtive quantities of the same or different kind of quantity, or it raises an autoscribtive quantity to a power or extracts its root and makes available the resulting quantity in an autoscribtive form of representation always in the numeric value accumulator 24 and in the accumulator for an autoscribtive unit 25.

In the addition/subtraction of two autoscribtive quantities the calculating assembly 14 compares the content of the register for an autoscribtive unit 8 with the content of the accumulator for an autoscribtive unit 25, adds/subtracts in case of equality the content of the numeric value register 3 to/from the content of the numeric value accumulator 24 and stores the sum in the numeric value accumulator 24.

In the multiplication/division of two autoscribtive quantities the calculating assembly 14 adds/subtracts, depending on the position, and element for element the content of the register for an autoscribtive unit 8 to/from the content of the accumulator for an autoscribtive unit 25, further, the calculating assembly 14 multiplies/divides the content of the numeric value accumulator 24 with/by the content of the numeric value register 3, the results are stored in each case in the accumulator for an autoscribtive unit 25 and in the numeric value accumulator 24.

When an autoscribtive quantity is raised to a power or its root is extracted the calculating assembly 14 checks, whether the numeric register 3 contains an integer exponent with the mantissa "1" and whether the elements of the register for an autoscribtive unit 8 are always "0". In the case of a fulfilled condition the calculating assembly 14 divides the content of the accumulator for an autoscribtive unit 25 element for element as well as by the exponent/root-exponent of the numeric value register 3 and stores the result in the numeric value accumulator 24.
further, the calculating assembly 14 raises to a power or extracts the root from the content of the numeric value accumulator 24 with the content of the numeric value registrer 3 and stores the result in the numeric value accumulator 24.

The circuit arrangement for the controlled output transformation of quantities (fig. 4) is a combination of assemblies under the control of the control network 32 viz

the calculating assembly 14, the compounder network 31,
the first unit-generator 28,
the prefix generator 27,
the accumulator for an autoscribtive unit 25,
the numeric value accumulator 24,
the register for a homoscribtive unit 5,

the read-only memory for homoscribtive units 29,
the address read-only memory 33, and
the address register 13, and
are controlled in an ordered sequence when the circuit is activated by a starting impulse, e.g. via the input keyboard 1.

The circuit arrangement transforms an autoscribtive quantity stored in the numeric value accumulator 24 and in the accumulator for an autoscribtive unit 25 without limitation of the kind of quantity of a homoscribtive quantity, thereby determining a suitable homoscribtive unit.

From the homoscribtive quantity the numeric value in the numeric value accumulator 24 and the homoscribtive unit in the register for a homoscribtive unit 5 are stored.

From the content of the accumulator for an autoscribtive unit 25 the calculating assembly 14 determines a packed numerator unit and a packed denominator unit. These packed units are multiplied exponential products analogously to the homoscribtive form of representation, whereby for a certain base unit an abbreviations is not chosen, but a certain number. The packed numerator unit and the packed denominator unit are compounded by the compounder network 31 to a small numeral digit area. The compounder network 31 is a logic network, which reduces a certain bit sequence for a certain large number to a bit sequence for a certain small number. These compounded packed units are ordinal numbers for reading a homoscribtive unit from the read-only memory for homoscribtive units 29 in the register for a homoscribtive unit 5. When thus for the autoscriptive quantity a homoscribtive unit cannot be determined, then the unit-generator 28 generates a homoscribtive unit in form of an exponential product from base units.

The prefix generator 27 separates a factor from the content of the numeric value accumulator 24, depending on its value, and instead of it shifts the abbreviation for a prefix as first character into the register for a homoscribtive unit 5.

The control network 32 clocks the controlled output transformation in the following way:

(1) The calculating assembly 14 determines a packed numerator unit in cycles from the content of the accumulator for an autoscribtive unit 25 and stores it in the address register 13.

(2) In one cycle the packed numerator unit is compounded in the compounder network 31 and written into the address register 13. Via the packed compounded numerator unit from an address read-only memory 33 an address for a section of the read-only memory for homoscribtive units 29 is read out. When from the address read-only memory 33 an address cannot be read out, the control network 32 continues the cycle sequence according to (7).

(3) From the read-only memory for homoscribtive units 29 a repetition factor k is read in an auxiliary memory; k expresses to how many denominator units of the given numerator unit homoscribtive units are established in the read-only memory for homoscribtive units 29.

(4) Determination of the packed denominator unit analogously to (1) with following compounding analogously to (2) and storing in the auxiliary memory 30.

(5) The calculating register 14 determines k cycles (cyclic increase of the address according to (3)), whether the compounded denominator unit is contained on the read-only memory for homoscribtive units 29. When it is contained, the control network 32 causes a reading of a homoscribtive unit in the register for a homoscribtive unit 5 and an exponent to the first factor of the exponential product of the homoscribtive unit in the exponent-1-register 7 from the read-only memory for homoscribtive units 29. When the search in all k cycles is finished negatively, the control network 32 continues the cycle sequence according to (7).

(6) In connection with the calculating assembly 14 the prefix generator 27 separates a factor from the content of the numeric value accumulator 24, depending on its value and the content of the exponent-1-register 7; for it the abbreviation of a prefix is inserted into the register for a homoscribtive unit 5. The representation of an autoscribtive quantity to a homoscribtive quantity is finished.

(7) The unit-generator 28 generates a homoscribtive unit. n cycles are run through, whereby n is equal to the number of base units of the used quantity system. In each cycle an exponential product factor is generated

then, when the corresponding element is unequally zero. In the first cycle it is started with the last base unit of the established order. Within a cycle, which covers the generation of a factor, at first the exponent of the factor is accepted from the accumulator for an autoscribtive unit 25 into the register for an autoscribtive unit 5, and subsequently to it the abbreviation of the base unit is accepted from the unit-generator 28, further, the exponent of the factor is stored in the exponent-1-register 7. The control network 32 continues the cycle sequence according to (6).

The circuit arrangement for the optimal outpout transformation of quantities (fig. 5) is a combination of assemblies under the control of the control network 34, viz.

the calculating assembly 14, the unit-generator-2 51,
the prefix generator 27,
the accumulator for an autoscribtive unit 25,
the numeric value accumulator 24,
the exponent-1-register 7, and
the register for a homoscribtive unit 5 and

are controlled in an ordered sequence when the circuit is activated by a starting impulse.

The circuit transforms an autoscribtive quantity stored in the numeric value accumulator 24 and in the accumulator for an autoscribtive unit 25 without limitation of the kind of quantity of the quantity to a homoscribtive quantity, whereby the homoscribtive unit is generated in an optimal form of representation.

An optimal kind of representation of a homoscribtive unit comprises an exponential product with a minimum number of factors whereby the factors contain only certain units; these units may be

— reference units (derived units of the SI with independent names), such as Newton, Volt, Pascal
— base units, such as second, ampere
— supplementary units, such as radiant

For instance for quantities relating to specific resistivity always the unit OHM.M and not V.M/A is generated.

The unit-generator-2 51 generates an optional kind of representation of the homoscribtive unit in connection with the calculating assembly 14, thereto it contains such a combination of subassemblies that by a generator control circuit 45 in dependence on the control network-4 34

— a deficiency register 37, an overflow register 35, a reference unit register 41, a deficiency memory 38,
an overflow memory 36—these assemblies store an integer number in each case.
— a reference unit counter 40.
— a memory of the separated units 42, in which the abbreviations of certain elementary units circulate in an established order,
— a memory of the reference units 39, in which the exponents to base units of reference units circulate in an established order,

are controlled such that at first, if possible, from the content of the accumulator for an autoscribtive unit 25 reference units are separated and the remainder of the autoscribtive unit is represented with base units and supplementary units.

The unit-generator-2 51 operates according to the following scheme:

(1) A separation attempt is started, when the given unit contains at least (k—1) base units of a group of reference units, whereby all reference units of a group contain the same k base units.
(2) In case of a fulfilment of (1) an evaluation of the deviation of the given autoscribtive unit from the individual reference units according to points is performed; with it a point means that to the base units considered a base unit with the exponent 1 deviates. It is to be distinguished between deficiency points and overflow points.
(3) The reference unit with the smallest deviation is separated, but no more than two deficiency points are allowed.
(4) A reference unit may be separated reciprocally and multiply.
(5) The remainder of the given autoscribtive unit after the separation of reference units is changed into an exponential product from base units and supplementary units.

The generation of a homoscribtive unit by the unit-generator 51 shown within the broken lines is performed in several timing cycles, as e.g.

(1) The calculating assembly 14 determines the difference between the content of the accumulator for an autoscribtive unit 25 and the content of the memory of the reference units 39 element for element and sums the deficiency and overflow points, which are stored in the deficiency register 37 and in the overflow register 35 for the actual reference unit 1 in each case.

(2) When the content of the deficiency register 37 is > 2, the flow according to (1) is repeated, but with a sign reversion of the elements of the content of the accumulator for an autoscribtive unit 25.

(3) When the content of the deficiency register 37 is > 2, the memory of the reference units 39 makes available the reference unit 1 + 1; continuation according to (1), when the actual reference unit of the memory of the reference units 39 is not the last reference unit, else continuation according to (6).

(4) The content of the deficiency register 37, of the overflow register 35 and of the reference unit counter 40 is accepted in the deficiency memory 38, the overflow memory 36 and the reference unit register 41, respectively, and the cycle sequence is continued, when the content of the deficiency register 37 and the content of the overflow register 35 are zero.

(5) The content of the deficiency register 37, of the overflow register 35 and of the reference unit counter 40 is accepted in the deficiency memory 38, the overflow memory 36 and the reference unit register 41, respectively, when the content of the deficiency register 37 is smaller as to its amount than the content of the deficiency memory 38, continuation of the cycle sequence according to (1) with the reference unit (1 + 1), when the actual reference unit of the memory for reference units 39 is not the last reference unit.

(6) According to the content of the reference unit register 41 in the memory of the separated units 42 to the content of the memory location assigned to a certain reference unit a bit is added according to its sign (2), when the content of the deficiency memory 38 is < 3 as to its amount. From the content of the accumulator for an autoscribtive unit 25 the content of the memory for reference units 39 is subtracted from the reference unit indicated in the reference unit register 41 according to its sign as to (2) and the result is stored in the accumulator for an autoscribtive unit 25. Beginning of a new sequence of timing cycles (1) . . . (6) with (1), for this the deficiency memory 38 is put to 3.

(7) When the content of the deficiency memory 38 is > 3, the remaining content of the accumulator for an autoscribtive unit 25 is transferred then element for element in the memory of separated units 42.

(8) During a full circulation of the memory of separated units 42 and of the memory of unit abbreviations 44 one number each from the memory of the separated units 42 and after that an abbreviation of an unit from the memory of unit abbreviations 44 are exchanged element for element in the register for a homoscribtive unit 5, when the respective number of the content of the memory of separated units 42 is > 0, with it the first number is stored in the exponent-1-register 7 and at the first negative number a switch negative elements 43 is turned-on.

(9) In the register for a homoscribtive unit 5 the symbol "/" is shifted, when the switch negative elements 43 is "1".

(10) When the switch negative elements 43 is "1", a further ful circulation of the memory of separated units 42 and of the memory of unit abbreviations 44 follows, with it at first in each case the amount of a number from the register of separated units 42 and after that the abbreviation of an unit from the memory of unit abbreviations 44 are exchanged, when the respective number of the content of separated units 42 is < 0.

Subsequently to it the prefix generator 27 in connection with the calculating assembly 14 separates a factor from the content of the numeric value accumulator 24, depending on its value and on the content of the exponent-1-register 7; for it the abbreviation of a prefix is shifted from the prefix generator 27 in the register for a homoscribtive unit 5. The optimal representation of an autoscribtive quantity to a homoscribtive quantity is finished.

In the parameter-controlled representation of an autoscribtive quantity to a homoscribtive quantity including the generation of a prefix to the unit given as the desired parameter, depending on the numeric value of the autoscribtive quantity (see fig. 6) e.g. an autoscribtive quantity of a certain kind determined with the circuit for the automated processing of autoscribtive quantities is represented as a homoscribtive unit of the same kind of quantity given as the parameter, in this case the first factor of the exponential product of the given unit is not allowed to contain a prefix. The circuit combination necessary for it requires the circuit for the input-transformation of quantities, the exponent-1-register 7, the unit register 47, the coefficient register 48, the numeric value accumulator 24, the accumulator for an autoscribtive unit 25, the register for a homoscribtive unit 5, and the prefix generator 27.

The control network 46 controls the assemblies mentioned such that a homoscribtive unit made available as the parameter at the time T_1 is converted by the circuit for the input-transformation of quantities to an autoscribtive quantity, whereby both the autoscribtive unit and the homoscribtive unit are stored in the unit register 47, and the numeric value of this autoscribtive quantity is stored in the coefficient-register 48.

The autoscribtive quantity to be represented as the parameter comprises the content of the numeric value accumulator 24 and of the accumulator for an autoscribtive unit 25 and may be stored at the time T_2, while T_2 may be before or after T_1.

The execution of the parameter-controlled representation occurs at the time T_3:

(1) Via the calculating assembly 14 the autoscribtive unit of the unit register 47 is checked with the content of the register for an autoscribtive unit 8 as to equality and subsequently to it the content of the numeric value accumulator 24 is divided by the content of the coefficient register 48, the result is made available in the numeric value register 24.

(2) The homoscribtive unit of the unit register 47 is exchanged in the register for a homoscribtive unit 5.

(3) After separation of a factor from the content of the numeric value accumulator 24 by the calculating assembly 14 in connection with the prefix generator 27 and the content of the exponent-1-register 7 a prefix is inserted into the register for a homoscribtive unit 5. The homoscribtive quantity determined is available in the numeric value accumulator 24 and in the register for a homoscribtive unit 5.

In the parameter-controlled representation of an autoscribtive quantity to a homoscribtive quantity *without* generation of a prefix for a given unit (fig. 6) an autoscribtive quantity of a specified kind of quantity determined e.g. with the circuit for the automated processing of quantities is represented to a homoscribtive unit of the same kind of quantity given as parameter. The circuit combination necessary for it corresponds to the circuit combination of the parameter-controlled representation with generation of a prefix, but it does not require the prefix generator 27 and the exponent-1-register 7.

The described individual circuit arrangements of the calculating system for the automated digital transcription and processing of quantities and units, with which, as already mentioned, six main functions can be realized, are applicable for the extension of the device technology of calculating equipment (electronic data processing equipment, process computers, desk calculators, pocket calculators, microprocessor systems and the like), measuring, control and regulating equipment as well as data handling and data output devices. In these extensions, however, all three basic circuits (circuit arrangement for the input-transformation of quantities; circuit arrangement for the automated processing of autoscribtive quantities; circuit arrangement for the output-transformation of quantities in the two variants — controlled output-transformation and optimal output-transformation — are not to be used always, but at least always one of them; with this the two kinds of the parameter-controlled transformation of an autoscribtive quantity to a homoscribtive quantity are to be considered as an extension of the circuit arrangement for the input-transformation of quantities.

In the use of the system for the automated digital transcription and processing of quantities and units in device systems for example data handling devices are only equipped with the circuit arrangement for the input-transformation of quantities, while processors in decentral process control systems are only equipped with the circuit arrangement for the automated processing of autoscribtive quantities. When in a desk calculator however all main functions of the digital transcription and processing of quantities and units can be realized in a suitable way, in regard to usefulness a pocket calculator will only contain besides the circuit arrangements for the input-transformation of quantities and for the automated processing of autoscribtive quantities either the circuit arrangement for the controlled output-transformation or the circuit arrangement for the optimal output-transformation.

Application

The system of the invention is to be explained further in the following typical application. In this application the system incorporated in a pocket or desk calculator for scientific-technical tasks.

Fig. 7 shows typical elements of the input/output field 55 of Figure 8. It serves for setting and displaying the input quantities and for the display of the output quantities. The input keyboard consists of 6 key lines, thereby in the first key line operational keys, in the second key line numeral digit keys and in the following key lines the letter and special symbol keys are combined; further the input key field contains pressure shift keys for the switching of calculating processes. The numeral digit keys "0" . . . "9" and the special symbol keys "." and "↑" serve for the input of numbers, numeric values to quantities or exponents to units. The letter keys "A" . . . "Z" and the special symbol keys "." and "/" serve for the input of units or after the switching of the pressure shift keys "MAT" for the call of mathematical functions. With the pressure shift key "KON" it is switched from stringed operations to constant operations. By clicking of the pressure shift key "NUM" into place the pocket or desk calculator is shifted to purely numerical operation in the sense of an usual calculator. The following operational keys are distinguished:

+	addition key (with input transformation)
–	subtraction key (with input transformation)
×	multiplication key (with input transformation)
:	division key (with input transformation)
U	unit key (with input transformation, for presetting a unit as parameter)
=S	output key-1 (with a controlled or optimal output transformationm)
=U	output key-2 (parameter-controlled output without generation of a prefix)
R	register key
LR	register loading key
D	rounding key
C.	clearing key
CE	input clearing key

The output field consists of an undervoltage display 56, an overflow display 57, a 12-digit-numeric display 58 (also 10-digit mantissa, two-digit exponent) for the representation of numbers and numeric values of quantities, of a 12-digit alpha-numeric unit display 59 for the representation of homoscribtive units of the input or output quantities and of an error display 60.

Fig. 8 shows the most important functional groups of the extended calculator with the essential information lines.

With the setting via the input/output field 55 the numeric value of the homo-scribtive quantity is stored in the numeric value register 3, and its homoscribtive unit is stored in the register for a homoscribtive unit 5.

The assembly input-transformation 61 (part of the circuit array for the input transformation of quantites) represents a given homoscribtive quantity to an auto-scribtive quantity, when one of the keys "+", "–", "∗", ":" or "U" is pressed. When one of the operational keys "+, –, ∗, :" is activated, than a correction of the numeric value in the numeric value register 3 is performed, and the autoscribtive unit is intermediately stored in the register for an autoscribtive unit 8. When the operational key "U" was activated, then the homoscribtive unit and the auto-scribtive unit are intermediately stored in the unit register 47, and the numeric value of the autoscribtive quantity determined as parameter is intermediately stored in the coefficient register 48.

The assembly output-transformation 62 (part of the circuit array for the output transformation of quantities) is activated by the key "=S", it transcribes the auto-scribtive unit of the accumulator for an autoscribtive unit 25 into a homoscribtive unit and with this loads the register for a homoscribtive unit 5, simultaneously the numeric value of the numeric value accumulator 24 is corrected, and the content of the numeric value accumulator 24 as well as the content of the register for a homoscribtive unit 5 are displayed as homoscribtive unit in the input/output field 55.

When two autoscribtive quantities are stringed ("+, −, ∗, :"), the calculating unit processes the contents of the numeric value register 3 and of the numeric value accumulator 24 to a new content of the numeric value accumulator 24, and the contents of the register for an autoscribtive unit 8 and of the accumulator for an autoscribtive unit 25 to a new content of the accumulator for an autoscribtive unit 25.

The control and clock unit 63 controls the connecting lines between the individual assemblies in dependence on the actuated input key.

Further, the application contains *i* quantity registers 64 for the intermediate storage of autoscribtive units, which can be accepted from the accumulators 24, 25 or stored back into them.

The realisation of the system can be achieved using LSI (large scale integration) techniques or employing microprocessor techniques.

The following calculating examples are intended for the demonstration of the functional principles (abbreviations according to table 1 and table 2):

Handling of a non-programmable pocket calculator with automated processing of quantities

– Examples –

Example 1:

3.2 YD + 11.6 M ▪ a

YD : yard

M : metre

step	input		display
1.	[C]		0
2.		3.2 YD	3.2 YD
3.	[+]		3.2 YD
4.		11.6 M	11.6 M
5.	[=S]		14.53 M ▪ a

Example 2:

44.2 MIN + 1.53 HR = b

b is to be put out in 'HR'

MIN : minute

HR : hour

step	input	display
1.	[C]	0
2.	1 HR	1 HR
3.	[U]	1 HR
4.	44.2 MIN	44.2 MIN
5.	[+]	44.2 MIN
6.	1.53 HR	1.53 HR
7.	[=U]	2.67 HR = b

Example 3:

20 KW + 23 HPW = c

c is to be put out in 'HPW'

KW : kilowatt

HPW : horse power

step	input	display
1.	[C]	0
2.	1 HPW	1 HPW
3.	[U]	1 HPW
4.	20 KW	20 KW
5.	[+]	20 KW
6.	23 HPW	23 HPW
7.	[=U]	50.19 HPW = c

Example 4:

15 V : 3 MA = d

V : volt

MA : milliampere

step	input		display
1.	[C]		0
2.		15 V	15 V
3.	[:]		15 V
4.		3 MA	3 MA
5.	[=S]		5 KOHM = d

KOHM : kiloohm

Example 5:

11.6 M2 * 0.85 INCH = e

e is to be put out in 'L'

M2 : square metre

INCH : inch

L : litre

step	input		display
1.	[C]		0
2.		1 L	1 L
3	[U]		1 L
4.		11.6 M2	11.6 M2
5.	[×]		11.6 M2
6.		0.85 INCH	0.85 INCH
7.	[=U]		250.44 L = e

Example 6:

3 M : 120 MS = f

f is to be put out in 'MI/HR'

M : metre

MS : millisecond

MI : mile (statute)

HR : hour

step	input	display
1.	[C]	0
2.	3 M	3 M
3.	[:]	3 M
4.	120 MS	120 MS
5.	[=S]	25 M/S
6.	1 MI/HR	1 MI/HR
7.	[U]	1 MI/HR
8.	[=U]	55.923 MI/HR = f

TABLE 1

Set of elementary units for the representation of quantities in natural science, engineering, industry and economy (including Anglo-american units)

consecutive no.	abbreviation of the elementary unit	name of the elementary unit
1	A	ampere
2	ACRE	acre
3	ANG	angstrom
4	ANN	year (calendar)
5	APSB	apostilb
6	ARE	are
7	ATM	atmosphere (normal)
8	ATT	technical atmosphere
9	AUT	astronomical unit

TABLE 1 (continued)

consecutive no.	abbreviation of the elementary unit	name of the elementary unit
10	B	bel
11	BA	barye
12	BADR	barrel, dry
13	BAPE	barrel (petroleum)
14	BAR	bar
15	BARN	barn
16	BD	baud
17	BIT	bit
18	BQ	bequerel
19	BU	bushel
20	BYTE	byte
21	C	coulomb
22	CAL	calorie (International Table)
23	CD	candela
24	CEL	degree Celsius
25	CHAL	chaldron
26	CHN	chain
27	CI	curie
28	DEG	degree (angle)
29	DI	day (mean solar, lat.: dies)
30	DOL	$ (US-dollar)
31	DPT	dioptrie
32	DR	dram
33	DRAP	dram, apothecaries (drachm)
34	DRFL	drachm, fluid
35	DYN	dyne
36	ERG	erg
37	EV	electron volt
38	F	farad

TABLE 1 (continued)

consecutive no.	abbreviation of the elementary unit	name of the elementary unit
39	FATH	fathom
40	FOOT	foot
41	FUR	furlong
42	G	gram
43	GAL	gal (galileo)
44	GALL	gallon
45	GAUS	gauss
46	GIL	gilbert
47	GILL	gill
48	GON	grad
49	GR	grain
50	GRF	grain-force
51	GY	gray
52	H	henry
53	HHD	hogshead
54	HAND	hand
55	HAR	hectare
56	HPW	horse-power (metric)
57	HR	hour (mean solar)
58	HZ	hertz
59	INMI	international nautical mile
60	INCH	inch
61	J	joule
62	K	kelvin
63	KAR	carat
64	KG	kilogram
65	KNT	knot
66	L	litre
67	LB	pound

TABLE 1 (continued)

consecutive no.	abbreviation of the elementary unit	name of the elementary unit
68	LBF	pound-force
69	LBTR	pound, troy
70	LGY	langley
71	LINE	line
72	LINK	link
73	LM	lumen
74	LX	lux
75	LY	light year
76	M	metre
77	MEN	month (mean calendar, lat.: mensis)
78	MHG	metre of mercury
79	MI	mile (statute)
80	MIL	mil
81	MIM	minim
82	MIN	minute (mean solar)
83	MNT	minute (angle)
84	MOL	mole
85	MR	mark
86	MWS	metre of water
87	MX	maxwell
88	MYM	micron
89	N	newton
90	NEP	neper
91	NIT	nit
92	NAMI	nautical mile
93	OER	oerstedt
94	OHM	ohm
95	OZ	ounce
96	OZFL	ounce, fluid

TABLE 1 (continued)

consecutive no.	abbreviation of the elementary unit	name of the elementary unit
97	OZLI	ounce, liquid
98	OZTR	ounce, troy
99	OZTR	ounce, apothecary
100	P	pond
101	PAR	parsec
102	PAS	pascal
103	PDL	poundal
104	PECK	peck
105	PERS	person
106	PFS	horse-power (metric)
107	PHON	phon
108	PINT	pint
109	POI	poise
110	PPM	part per million
111	PRM	per mille
112	PTDR	pint, dry
113	PTLI	pint, liquid
114	PWT	pennyweight
115	PZ	per cent
116	QR	quarter (length)
117	QT	quart
118	QTDR	quart, dry
119	QTLI	quart, liquid
120	QTR	quarter (mass)
121	QTRL	quarter, liquid (volume)
122	RAD	radian
123	RD	rad
124	REV	revolutions
125	ROD	rod (perch, pole)

TABLE 1 (continued)

consecutive no.	abbreviation of the elementary unit	name of the elementary unit
126	ROE	roentgen
127	ROOD	rood
128	RT	register ton
129	S	second (time)
130	SAP	scruple
131	SB	stilb
132	SEP	week (lat.: septimana)
133	SEC	second (angle)
134	SFL	scruple, fluid
135	SIE	siemens
136	SLUG	slug
137	SM	nautical mile ("Seemeile")
138	SR	steradian
139	ST	piece
140	STON	stone
141	STO	stokes
142	T	tesla
143	TEX	tex
144	TNE	ton (metric)
145	TNSH	ton, short
146	TON	ton
147	TONF	ton-force
148	TORR	torr
149	U	atomic mass unit
150	UNA	1-unit
151	USSF	US Survey foot
152	V	volt
153	VAR	var
154	W	watt

TABLE 1 (continued)

consecutive no.	abbreviations of the elementary unit	name of the elementary unit
155	WB	weber
156	XE	x-unit
157	YD	yard

TABLE 2

Set of prefixes for the representation of quantities in natural science, engineering, industry and economy

1. Physical-technical prefixes

consecutive no.	abbreviation	name	numeric value
1	A	atto	10^{-18}
2	F	femto	10^{-15}
3	P	pico	10^{-12}
4	N	nano	10^{-9}
5	MY	micro	10^{-6}
6	M	milli	10^{-3}
7	C	centi	10^{-2}
8	D	deci	10^{-1}
9	DA	deca	10^{1}
10	H	hecto	10^{2}
11	K	kilo	10^{3}
12	MA	mega	10^{6}
13	G	giga	10^{9}
14	TA	tera	10^{12}
15	EA	exa	10^{15}
16	PA	peta	10^{18}

2. Commercial prefixes

consecutive no.	abbreviation	name	numeric value
17	H	hundred	10^{2}
18	T	thousand	10^{3}

TABLE 2 (continued)

Set of prefixes for the representation of quantities in natural science, engineering, industry and economy

1. Physical-technical prefixes

consecutive no.	abbreviation	name	numeric value
19	MIO	million	10^6
20	MRD	milliard	10^9
21	BIO	billion	10^{12}
22	BRD	billiard	10^{15}
23	TRO	trillion	10^{18}
24	TRD	trilliard	10^{21}

TABLE 3

Set of elementary units
Selected amount for the representation of physical-technical quantities

consecutive no.	abbreviation of the elementary unit	name of the elementary unit
1	A	ampere
2	ANG	angstrom
3	ANN	year
4	ATM	atmosphere (normal)
5	ATT	technical atmosphere
6	AUT	astronomical unit
7	BAR	bar
8	BARN	barn
9	BQ	bequerel
10	C	coulomb
11	CAL	calorie (International Table)
12	CD	candela
13	CI	curie
14	DEG	degree (angle)

TABLE 3 (continued)

consecutive no.	abbreviation of the elementary unit	name of the elementary unit
15	DI	day (mean solar)
16	DYN	dyne
7	ERG	erg
18	EV	electron volt
19	F	farad
20	G	gram
21	GAL	gal (galileo)
22	GON	grad
23	H	henry
24	HR	hour (mean solar)
25	HZ	hertz
26	INCH	inch
27	J	joule
28	K	kelvin
29	KAR	carat
30	KG	kilogram
31	KNT	knot
32	L	litre
33	LGY	langley
34	LM	lumen
35	LX	lux
36	LY	light year
37	M	metre
38	MIN	minute (mean solar)
39	MNT	minute (angle)
40	MOL	mole
41	MWS	metre of water
42	N	newton
43	OHM	ohm
44	P	pond

TABLE 3 (continued)

consecutive no.	abbreviation of the elementary unit	name of the elementary unit
45	PAR	parsec
46	PAS	pascal
47	PFS	horse-power (metric)
48	POI	poise
49	PRM	per mille
50	PZ	per cent
51	RAD	radian
52	RD	rad
53	ROE	roentgen
54	S	second (time)
55	SEC	second (angle)
56	SEP	week (lat.: septimana)
57	SIE	siemens
58	SM	nautical mile ("seemeile")
59	SR	steradian
60	STO	stokes
61	T	tesla
62	TEX	tex
63	TNE	ton (metric)
64	TORR	torr
65	U	atomic mass unit
66	UNA	1-Einheit
67	V	volt
68	W	watt
69	WB	weber
70	XE	x-unit

TABLE 4

Base units for the set of elementary units according to table 1

consecutive no.	abbreviation of the base unit	name of the base unit
1	M	metre
2	S	second
3	A	ampere
4	KG	kilogram
5	K	kelvin
6	CD	candela
7	RAD	radian
8	SR	steradian
9	BIT	bit
10	ST	piece
11	MR	mark
12	MOL	mole
13	PERS	person

TABLE 5

Base units for the set of elementary units according to table 3

consecutive no.	abbreviation of the base unit	name of the base unit
1	M	metre
2	S	second
3	A	ampere
4	KG	kilogram
5	K	kelvin
6	CD	candela
7	MOL	mole
8	SR	steradian
9	RAD	radian

TABLE 6

Representation of the elementary units according to table 3 as exponential product from base units

consecutive no.	abbreviation of the elementary unit	representation of the elementary unit as quantity with base units
1	A	(base unit)
2	ANG	1 ANG = $1\cdot10^{-10}$ M
3	ANN	1 ANN = $3.1536\cdot10^{7}$ S
4	ATM	1 ATM = $1.01325\cdot10^{5}$ KG/M.S2
5	ATT	1 ATT = $0.980665\cdot10^{5}$ KG/M.S2
6	AUT	1 AUT = $1.49598\cdot10^{11}$ M
7	BAR	1 BAR = 1.10^{5} KG/M.S2
8	BARN	1 BARN = 1.10^{-28} M2
9	BQ	1 BQ = 1 S—1
10	C	1 C = 1 A.S
11	CAL	1 CAL = 4.1868 M2.KG/S2
12	CD	(base unit)
13	CI	1 CI = $3.7\cdot10^{10}$ S—1
14	DEG	1 DEG = $1.745392\cdot10^{-2}$ RAD
15	DI	1 DI = $8.64\cdot10^{4}$ S
16	DYN	1 DYN = 1.10^{-5} M.KG/S2
17	ERG	1 ERG = 1.10^{-7} M2.KG/S2
18	EV	1 EV = $1.60210\cdot10^{-19}$ M2.KG/S2
19	F	1 F = 1 S4.A2/M2.KG
20	G	1 G = 1.10^{-3} KG
21	GAL	1 GAL = 1.10^{-2} M/S2
22	GON	1 GON = $1.5708.10^{-2}$ RAD
23	H	1 H = 1 M2.KG/S2.A2
24	HR	1 HR = $3.6\cdot10^{3}$ S
25	HZ	1 HZ = 1 S–1
26	INCH	1 INCH = $2.54\cdot10^{-2}$ M
27	J	1 J = 1 M2.KG/S2
28	K	(base unit)

TABLE 6 cont'd

Representation of the elementary units according to table 3 as exponential product from base units

consecutive no.	abbreviation of the elementary unit	representation of the elementary unit as quantity with base units
29	KAR	1 KAR = $2 \cdot 10^{-4}$ KG
30	KG	(base unit)
31	KNT	1 KNT = $5.14444 \cdot 10^{-1}$ M/S
32	L	1 L = $1 \cdot 10^{-3}$ M3
33	LGY	1 LGY = $4.1868 \cdot 10^{4}$ KG/S2
34	LM	1 LM = 1 CD.SR
35	LX	1 LX = 1 CD.SR/M2
36	LY	1 LY = $9.46055 \cdot 10^{15}$ M
37	M	(base unit)
38	MIN	1 MIN = 60 S
39	MNT	1 MNT = $2.908882.10^{-4}$ RAD
40	MOL	(base unit)
41	MWS	1 MWS = $9.80665.10^{3}$ KG/M.S2
42	N	1 N = 1 M2.KG/S2
43	OHM	1 OHM = 1 M2.KG/S3.A2
44	P	1 P = $9.80665 \cdot 10^{-3}$ KG.M/S2
45	PAR	1 PAR = $3.0857 \cdot 10^{16}$ M
46	PAS	1 PAS = 1 KG/M.S2
47	PFS	1 PFS = 735.499 W
48	POI	1 POI = 1.10^{-1} KG/M.S
49	PRM	1 PRM = $1 \cdot 10^{-3}$
50	PZ	1 PZ = $1 \cdot 10^{-2}$
51	RAD	(base unit)
52	RD	1 RD = $1 \cdot 10^{-2}$ M2/S2
53	ROE	1 ROE × $2.57976.10^{-4}$ S.A/KG
54	S	(base unit)
55	SEC	1 SEC = $4.848137 \cdot 10^{-6}$ RAD
56	SEP	1 SEP = $6.048 \cdot 10^{5}$ S

TABLE 6 cont'd

Representation of the elementary units according to table 3 as exponential product from base units

consecutive no.	abbreviation of the elementary unit	representation of the elementary unit as quantity with base units
57	SIE	1 SIE = 1 S3.A2/M2.KG
58	SM	1 SM = 1852 M
59	SR	(base unit)
60	STO	1 STO = 1.10^{-4} M2/S
61	T	1 T = KG/S2.A
62	TEX	1 TEX = 1.10^{-6} KG/M
63	TNE	1 TNE = 1.10^{3} KG
64	TORR	1 TORR = $1.33322{\cdot}10^{2}$ KG/M.S2
65	U	1 U = $1.66053{\cdot}10^{-27}$ KG
66	UNA	1 UNA = 1
67	V	1 V = M2.KG/S3.A
68	W	1 W = 1 M2.KG/S3
69	WB	1 WB = 1 M2.KG/S2.A
70	XE	1 XE = $1{\cdot}10^{-13}$ M

WHAT WE CLAIM IS:—

1. An electronic calculating apparatus for automatically processing data corresponding to a variety of physical parameters said apparatus comprising: entry means for successively entering items of data each indicative of a physical quantity and having a first portion representing the numerical part of the data item and a second portion representing the unit of measurement of said data item and hereinafter referred to as homoscribtive data; input transformation means for automatically transforming the homoscribtive data into an internally operable format and hereinafter referred to as autoscribtive data; calculating means for processing the transformed data according to a selected calculating function; output transformation means for automatically transforming the processed autoscribtive data into homoscribtive data suitable for display and having a first portion representing the numerical part of the data and a second portion representing a unit of measurement assigned to said data, wherein the second portion of the output data from said transformation means may represent a unit of measurement which differs from at least one of the units of measurement entered by the entry means.

2. An apparatus as claimed in claim 1, wherein said entry means includes a first selector for designating a desired unit of measurement in which the output from said read out means is to be provided.

3. An apparatus as claimed in claim 1, wherein determining means are provided for automatically selecting the optimum unit of measurement for read out in dependence on the result of the calculation process.

4. An apparatus as claimed in claim 1, 2 or 3, wherein said entry means includes function selectors for selecting addition, subtraction, multiplication, division of two input quantities or for raising the input quantity to a higher power or

for extracting the root of the input quantity when processed by said calculating means.

5. An apparatus as claimed in any one of claims 1 to 4, wherein the entry means comprises: an input keyboard containing digit, letter, symbol and operating keys as well as a coder the letter codes generated thereby differing from the digit and special symbol codes by one special bit and which, via an input discriminator is connected in series either with the input of a numeric value register or the input of a register for a homoscribtive unit thereby controlling the storage of a first partial sequence of characters which represents a number in the numeric value register and the storage of a second partial sequence of characters which represents an alphanumeric character sequence in the homoscribtive unit register, the data in both said registers being available for display.

6. An apparatus as claimed in claim 5, wherein the input transformation means comprises: a logic network which separates the homoscribtive unit from said register available as an exponential product in to stringed units and exponents in cycles for storage in a stringed unit register and exponent register respectively; a check code generator checks this stored data prior to receipt by a calculating assembly which computes the summation in cycles and in dependence thereon controls an address register for addressing read-only memories for elementary units and prefixes respectively to separate a stringed unit or a factor of the exponential product into a prefix and an elementary unit in each case, whereupon the calculating assembly in combination with the numeric value register, a register for an autoscribtive unit, together with a read-only memory for numeric values and a read-only memory for groups of exponents to base units, and the read-only memories for prefixes and elementary units generates the autoscribtive quantity cyclically under the control of a control network.

7. An apparatus as claimed in claim 5 or 6 wherein the input keyboard includes a shift key for the input of quantities, which has to be activated before the setting of a quantity and which continues to be activated until an operational key or another shift key is activated.

8. An apparatus as claimed in claim 6, wherein the calculating assembly determines code sums to letter sequences.

9. An apparatus as claimed in claim 6 or 8, wherein the check code generator generates a check character from a given character sequence according to a predetermined bit pattern mask.

10. An apparatus as claimed in claim 6, 8 or 9, wherein the read-only memory for elementary units contains specific bit sequences for each elementary unit.

11. An apparatus as claimed in claim 6, or any one of claims 8, 9 or 10, wherein the logic network performs a separation of a given character sequence in dependence on the last character transferred and on the next character to be transferred.

12. An apparatus as claimed in any one of claims 1 to 11, wherein said calculating means for processing the transferred data to add, subtract, multiply, divide, raise the power or extract the root of said data comprises: a numerical value register and an autoscribtive unit register connected to a calculating assembly, said calculating assembly in combination with a numerical value accumulator and an autoscribtive unit accumulator providing the desired arithmetic operation under the control of a control network.

13. An apparatus as claimed in claim 12, wherein the numerical value register, the calculating assembly and the autoscribtive register are shared by the input transformation means and said calculating means.

14. An apparatus as claimed in any one of claims 1 to 13, wherein the output transformation means comprise: a calculating assembly in combination with an address register which determines a packed numerator unit and a packed denominator unit for an autoscribtive unit in cycles from the output of said calculating means, which result is compounded in a compounder network whereupon a homoscribtive unit is read out from a homoscribtive unit read-only memory or a homoscribtive unit is generated by a unit generator in combination with a prefix generated by a prefix generator after the separation of a factor dependent on the numeric value of the homoscribtive unit, which homoscribtive unit together with the prefix is stored in a homoscribtive unit register and the numerical value being stored in a numerical value accumulator, the homoscribtive quantity and unit being available for display by a display device.

15. An apparatus as claimed in claim 14, wherein the compounder network

transforms a specified bit sequence for a large number to a specified bit sequence for a small number.

16. An apparatus as claimed in claim 14 or 15, wherein the unit-generator transforms the positive and negative numbers of an autoscribtive unit to a homoscribtive unit in the form of an exponential product of base units.

17. An apparatus as claimed in any one of claims 1 to 13, wherein the output transformation means comprises a calculating assembly in combination with an address register and a unit-generator for generating a homoscribtive unit as an exponential product with a minimum number of factors from the autoscribtive units from said calculating means to provide an optimum, said generated unit being stored in a homoscribtive unit register, combined with the prefix generated by a prefix generator after the separation of a factor from the content of the numeric value of the homoscribtive unit in a register for a homoscribtive unit, the homoscribtive quantity being made available for display in a display device.

18. An apparatus as claimed in claim 17, wherein the unit-generator generates positive and negative numbers for converting an autoscribtive unit to a homoscribtive unit in the form of an exponential product with a minimum number of factors, whereby the individual factors only contain base units and/or independent SI units.

19. An apparatus as claimed in any one of claims 1 to 13, wherein the output transformation means is parameter controlled by a preselected unit of measurement and includes a unit-register which stores this unit of measurement previously converted from a homoscribtive unit to autoscribtive unit and the numeric value of which is stored in a coefficient register, the numeric value being divided by the content of the coefficient register to provide the homoscribtive quantity made available for a display device without generation of a prefix.

20. An apparatus as claimed in any one of claims 1 to 13, wherein the output transformation means is controlled by a preselected unit of measurement and includes a unit register which stores the unit of measurement previously converted from homoscribtive to autoscribtive form and the numeric value of which is stored in a coefficient register, the numeric value being divided by the content of the coefficient register and in combination with a prefix generator after the separation of a factor of the numeric value, a prefix added to the homoscribtive unit in a homoscribtive unit register and the homoscribtive quantity is made available for display by a display device to include a prefix.

21. An apparatus as claimed in any one of claims 1 to 20, wherein a read-only memory and a microprocessor system are provided for realising at least part of said apparatus.

22. An apparatus as claimed in any one of claims 1 to 21, wherein the character transfer and processing are performed in bit-serial or in a bit-parallel manner.

23. An apparatus substantially as described herein with reference to and as illustrated by the accompanying drawings.

24. An apparatus as claimed in claim 1 substantially as hereinbefore described.

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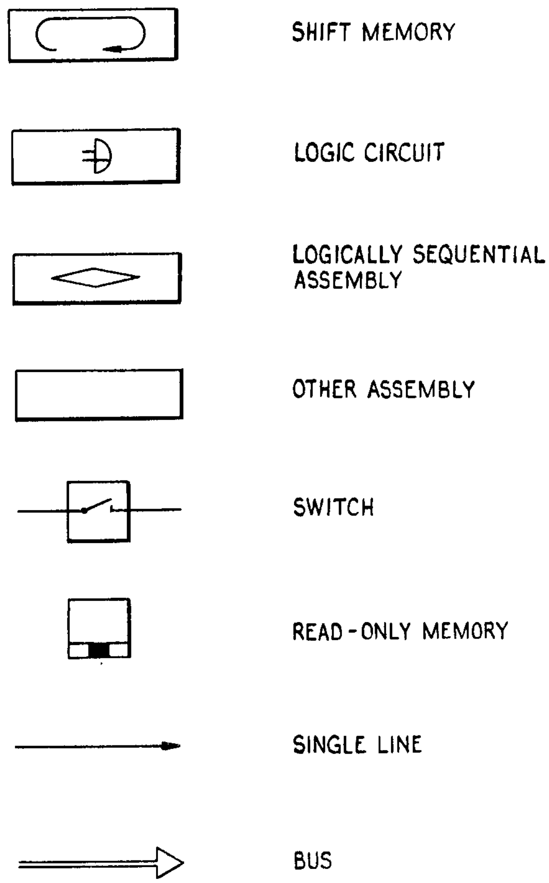
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LOGICALLY SEQUENTIAL ASSEMBLY
OTHER ASSEMBLY
SWITCH
READ-ONLY MEMORY
SINGLE LINE
BUS

FIG. 1

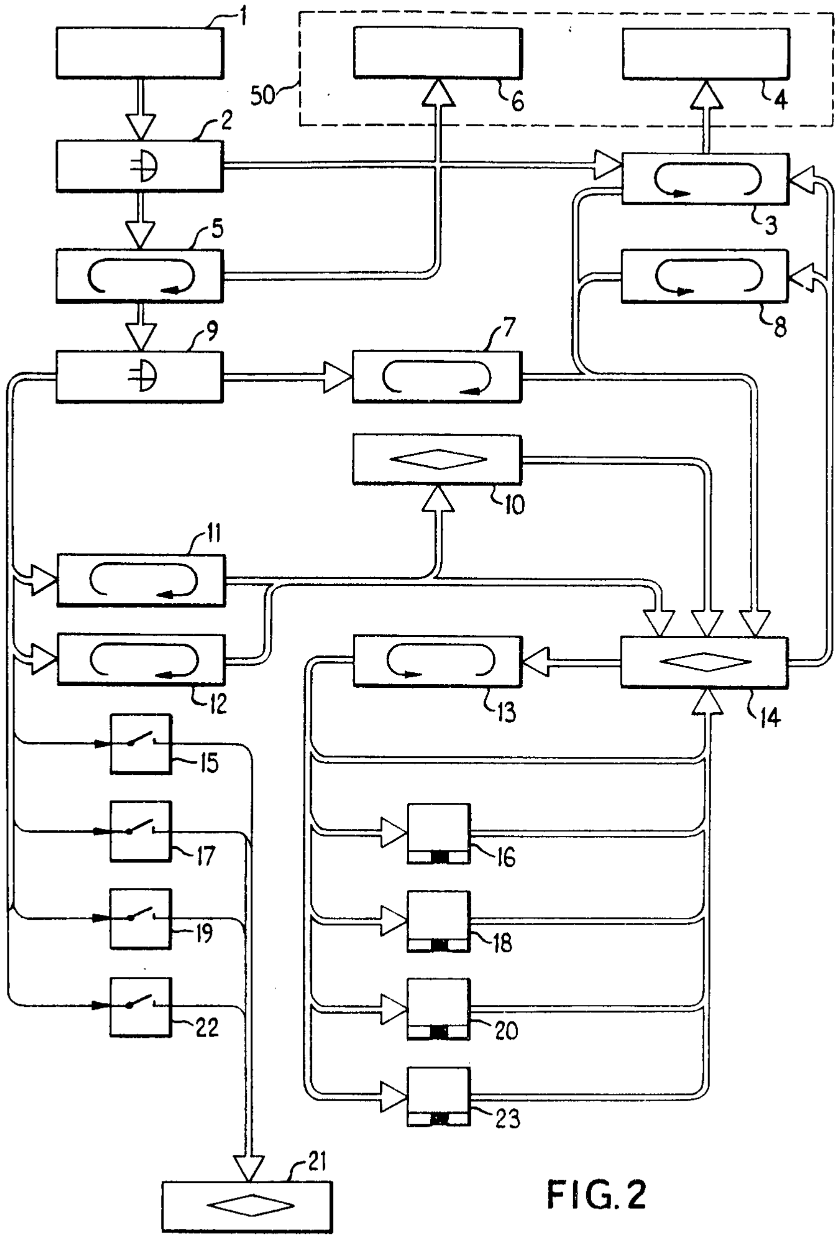

FIG. 2

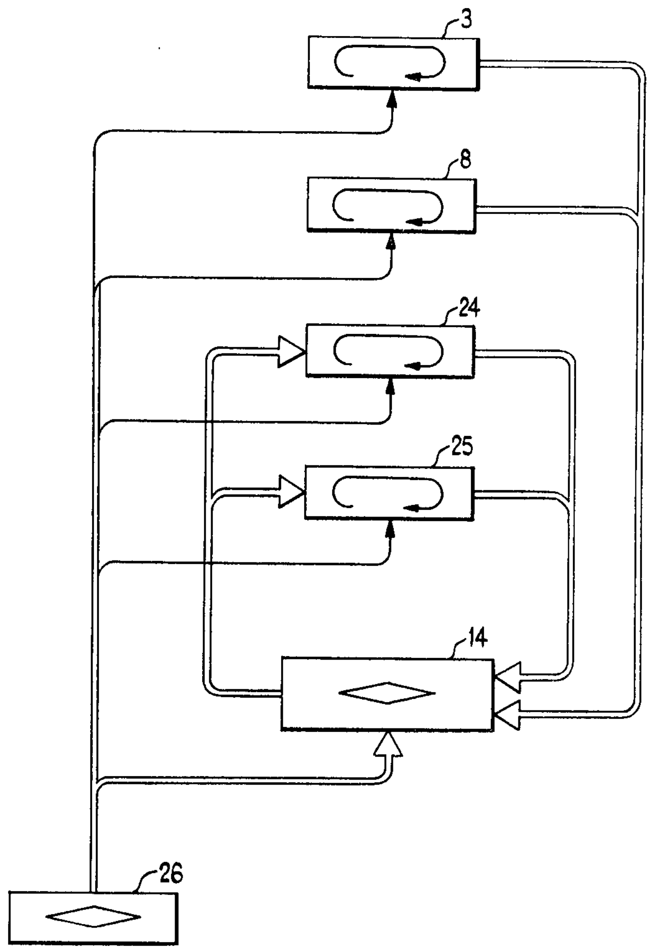

FIG.3

1579589 COMPLETE SPECIFICATION

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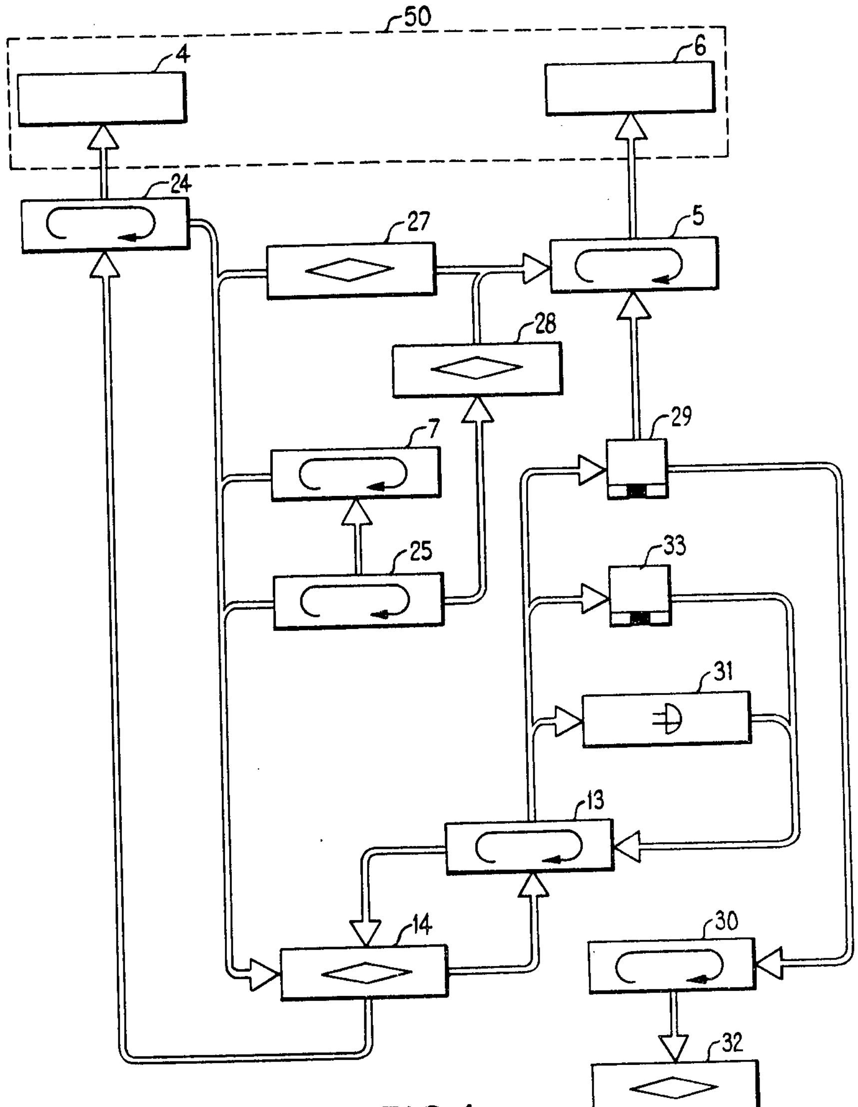

FIG.4

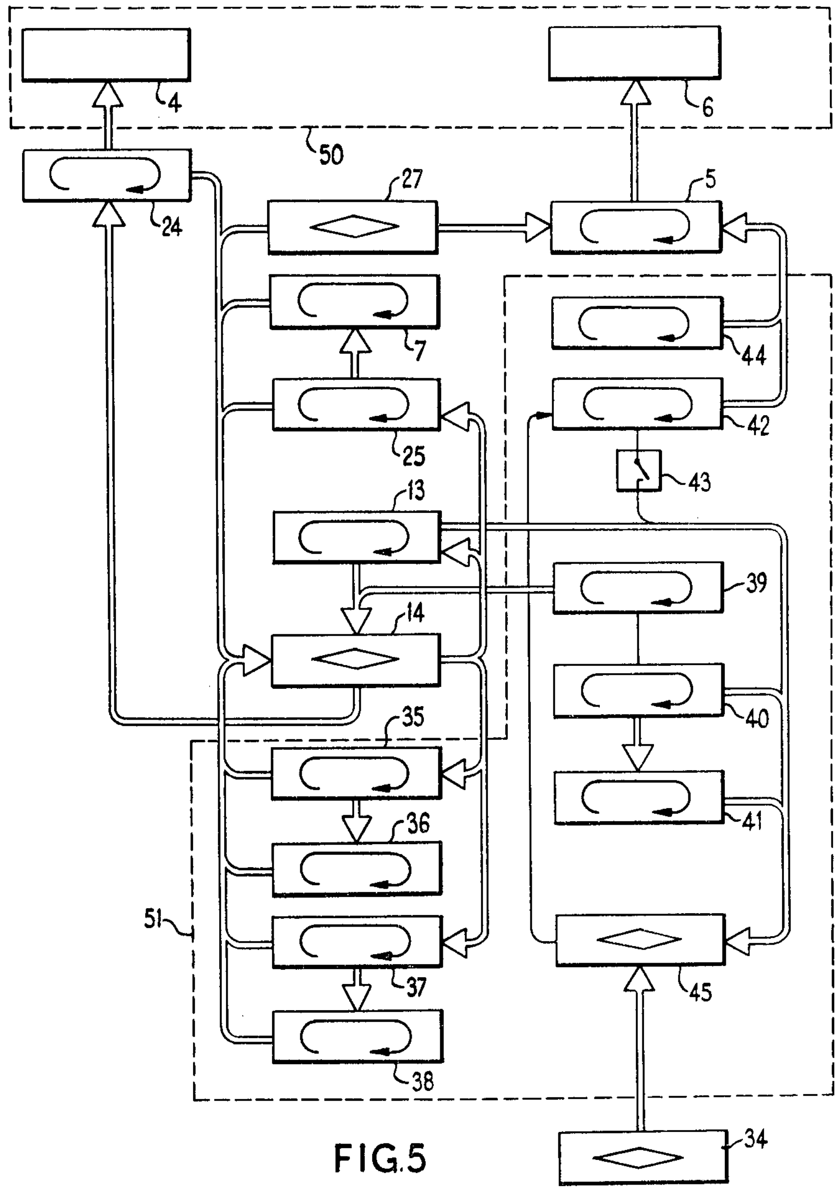

FIG.5

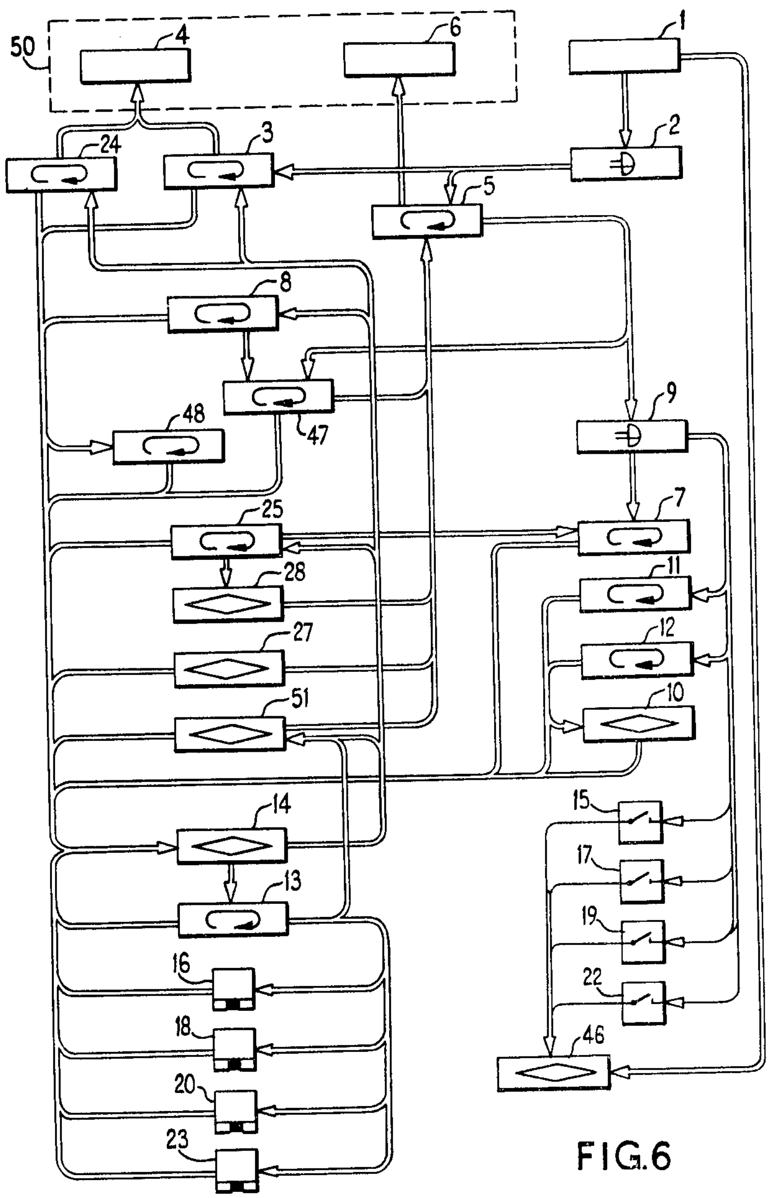
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FIG.6

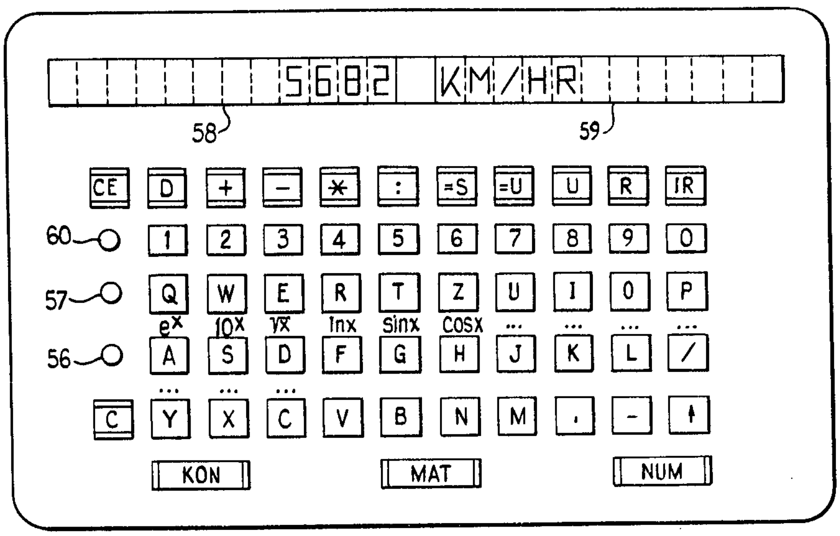
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FIG.7

1579589 COMPLETE SPECIFICATION

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Sheet 8

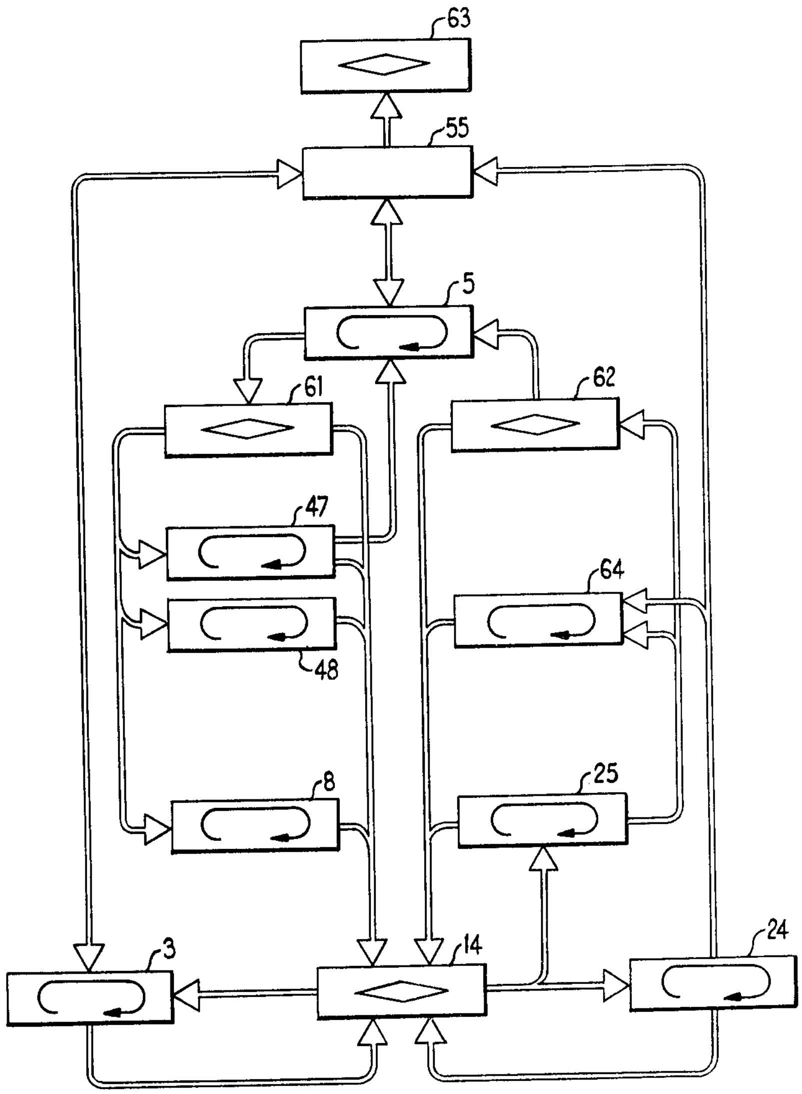

FIG.8