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(54) IMPROVEMENTS IN OR RELATING TO PORTABLE ELECTRONIC CALCULATORS

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company, of 3—4, 4—chome, Ginza, Chuo-ku, Tokyo, Japan,

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:—

This invention relates to portable electronic calculators by which expression is meant in this specification and the claims electronic calculators small and light enough to be conveniently carried on the person.

There has long been need for electronic calculators of small size, low weight and cost and great compactness. In attempts to fulfill this need miniaturisation of circuitry and the use of integrated circuits have been suggested in order to provide convenient electronic calculators or so-called electronic "sorobans" for desk use. However, there has been the difficulty, greatly limiting the degree of compactness achievable, that the size of the keyboard for controlling the action of the calculator cannot be reduced below a certain quite substantial size. Such keyboards are usually mechanically arranged to operate reed switches by means of permanent magnets moved by the keys. Such an arrangement is necessarily of relatively large size, weight and cost. In known calculators the calculating circuit arrangement is usually a combination of interconnected Middle Scale Integrated circuits and with such an arrangement the labour required is costly and, moreover, the use of such interconnected Middle Scale Integrated circuits involves that the resulting calculating circuit arrangement is of substantial volume and of too high power consumption for a simple dry battery to be satisfactory as a power source.

Again in known portable calculators as at present in general use, display devices of the Braun tube, Nixy tube or digitron type have been used and these are not only of relatively large size but are also of relatively high power consumption too high for a simple dry battery to be a practical proposition as the power supply source.

The present invention seeks to avoid or reduce the foregoing disadvantages and defects and to provide improved portable calculators which shall be exceedingly compact and light in weight; which shall be such as to be capable of operating satisfactorily from a power supply constituted by a compact dry battery of low price; and which shall be of low power consumption, high efficiency and relatively low cost.

According to this invention a portable electronic calculator comprises a plurality of magnetically operable switches each adapted to be operated by the application of an externally provided magnetic field thereto, a calculating circuit unit of the L.S.I. circuit type adapted to respond to perform any of a plurality of pre-determined calculations in dependence upon which of said switches or combination of said switches is actuated, and a liquid crystal display unit controlled by said calculating unit and adapted to display the results of the calculations thereof.

In carrying out the invention the switches, which are preferably magnetically operated read switches, are preferably mounted in different pre-determined and indicated positions and are adapted each to be operated by bringing a permanent magnet into the neighbourhood of the position in which it is mounted. Thus, in a preferred construction each switch is attached in a different position to the inner side of the case or housing of the calculator in the neighbourhood of a recess formed in the outer side of said case.

The invention is illustrated in the accompanying drawings in which:—

Figure 1 is a block diagram of a preferred form a calculator in accordance with this invention;

Figure 2 is a schematic sectional diagram of a preferred input circuit unit for use in the calculator of Figure 1; and

Figure 3 is a schematic sectional diagram

of a preferred display unit for use in the calculator of Figure 1.

The calculator represented in Figure 1 comprises an input circuit unit 1, a calculating unit 2 fed with signals supplied from the unit 1; a driving circuit unit 3 fed from unit 2 and driving a display unit 4; and a small low power dry battery 5 which is the power source of the calculator and which supplies power to a voltage translating unit 6 which steps up the voltage and provides an output voltage suitable for operating the calculating driving and display units.

Referring now to Figure 2, 7 represents part of the outer case of the calculator of Figure 1. The surface of this case is formed with a plurality of recesses such as 8, each of which is appropriate to a particular input number or function. Thus there might be fourteen such recesses, ten of which are appropriate each to a different one of the ten numerals 0 to 9, the remaining four recesses being appropriate respectively to + (add), − (subtract), × (multiply) and ÷ (divide). Fixed to the inner surface of the case 7, e.g. by taping, are a plurality of magnetically operable reed switches 9 one under each recess and laterally displaced a little from the centre of the recess with which it is associated. Each switch has terminals 10 and 11. There is provided a movable bar 12 which carries, at or near one end, a small permanent magnet, the poles of which are, as indicated conventionally by the letters N S, located at different points in the length of the bar. By bringing the magnet end of the bar close to a recess, as indicated in Figure 2, the magnetically operable reed switch 9 associated with that recess can be closed and an input signal fed to the calculating unit 2 at a different point in the circuitry thereof. The calculating unit is arranged in any manner known per se to perform whatever calculation is appropriated to the particular switch or combination of switches thus magnetically closed. Because the reed switches are fixed to the underside of the case 7, whereas the magnet and carrier bar arrangement for switch operation is separated from, and does not form part of, the calculator structure mechanically, the said calculator can be made very small indeed for there is no incorporated keyboard. There is, moreover, considerable consequent economy in material and reduction in weight and cost. As will be apparent the functions performed by the reed switches may be the same as those performed by the reed switches of a much larger keyboard actuated calculator so that, despite its small size and economy, a calculator in accordance with this invention can be designed to give as good efficiency, reliability, endurance, freedom from error and performance generally as a larger and more expensive calculator.

The calculating circuit unit 2 employs LSI (Large Scale Integrated circuit) circuitry so that a high degree of miniaturization is attainable together with less cost in materials and labour (especially labour for interconnections), high endurance and high efficiency. Also by using MOS type LSI circuitry, as is preferred, low power consumption and especially low cost are achievable.

The display unit 4 is of the liquid crystal type operating in accordance with known principles by utilizing electric signal control of light scattering effect. The display unit utilizes, in each element thereof, a layer of liquid crystal which is sandwiched between two electrode plates, at least one of which is transparent. When a suitable voltage is applied between the two electrode plates, the direction of arrangement of the molecule group in the liquid crystal is disturbed and there is resultant modification of light scattering whereby a display is given. The display unit is arranged to give a numeric display by arranging electrodes in the different elements to combine and co-operate to display different numerals in dependence upon the input signals from the drive unit 3. The liquid crystal type of display has the following advantages over displays of the luminous diode, nixy tube, Braun tube and digitron types:—

1. The stronger the ambient lighting the clearer is the display.

2. The power consumption per unit area of display is very low only about $100^{mw}/_{cm^3}$ and is very small compared with that of other types of display.

3. The thickness of the liquid crystal layer can be as little as 20μ so that a flat display can be obtained from a very compact display structure. In this respect a liquid crystal type of display is much better than Braun tube or a nixy tube type of display.

4. The cost per unit area of display is substantially lower than that of other types of display.

The sectional view of Figure 3 illustrates the general construction used in the display unit. Referring to Figure 3, 14 is a transparent glass base on the underface (as viewed in Figure 3) of which is coated a thin transparent electrode film 15. 17 is a thin layer of liquid crystal which is confined by edge insulation 16 and is situated between the electrodes 15 and an opposed electrode film or coating on the upper face of a second transparent glass plate 18. 20 is a light reflecting film on the underface of the plate 18 and may conveniently consist of a film of evaporated-on bright metal. 21 and 21′ are leads between which voltage from the driving circuit 3 is applied. On application of a suitable voltage between these leads, the electric field set up in the liquid crystal film 17 produces light scattering and a consequent display. The electrodes are shaped as already

mentioned and in manner known per se to provide a numeric display so that desired members, determined by the signals applied from the drive unit 3 to the display unit, can be displayed.

As will be appreciated, a calculator constructed as above described can be readily miniaturised to such an extent as to be very compact, and low in weight. The power consumption is small, the efficiency is high and the cost is low so that the invention enables a surprisingly low-priced portable and compact electronic calculator to be manufactured.

Attention is directed to our co-pending specification No. 28714/72 (Serial No. 1342137) which relates to similar subject matter.

WHAT WE CLAIM IS:—

1. A portable electronic calculator comprising a plurality of magnetically operable switches each adapted to be operated by the application of an externally provided magnetic field thereto, a calculating circuit unit of the L.S.I. circuit type adapted to respond to perform only of a plurality of pre-determined calculations in dependence upon which of said switches or combination of said switches is actuated, and a liquid crystal display unit controlled by said calculating unit and adapted to display the results of the calculations thereof.

2. A calculator as claimed in claim 1 wherein the switches are mounted in different predetermined and indicated positions and are adapted each to be operated by bringing a permanent magnet into the neighbourhood of the position in which it is mounted.

3. A calculator as claimed in claim 1 or 2 wherein the switches are magentically operable reed switches.

4. A calculator as claimed in any one of the preceding claims wherein each switch is attached in a different position to the inner side of the case or housing of the calculator in the neighbourhood of a recess formed in the outer side of said case.

5. Portable electronic calculators substantially as herein described and illustrated in the accompanying drawings.

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