

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO KEYBOARDS

(71) We, HEWLETT-PACKARD COMPANY, of 1501 Page Mill Road, Palo Alto, California, United States of America, a corporation organised and existing under the laws of the state of California, United States of America, 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 is concerned with improvements in or relating to keyboards.

Previously keyboards for use with computers, calculators, data terminals and the like usually had an array of mechanical switches, one for each key on the keyboard, which were connected to encoding electronics for generating a digital code corresponding to the key. Limitations of such keyboards include wear and corrosion of the switch contacts, erroneous code generation due to contact bounce, high mechanical and electrical complexity, and corresponding high cost and low reliability.

It is an object of the present invention to provide an improved keyboard.

The present invention provides a non-contacting keyboard comprising an array of coreless transformers, each transformer having a primary and a corresponding secondary winding, the primary windings being series connected in one or more first groups and the secondary windings being series connected in one or more second groups, each first group containing an integral number of pairs of the primary windings and there being at least said integral number of second groups, energizing means connected to the first groups for applying signals thereto, the magnitude and polarity of the mutual inductance between the pairs of primary windings in a first group and the corresponding secondary windings being selected for cancellation of signals induced on said corresponding secondary windings in response to signals in the primary windings, an array of push-buttons

arranged in a one to one correspondence with and physically proximate to the array of transformers, a pair of push-buttons corresponding to a pair of primary windings and said push-buttons being supported for movement with respect to the transformers, magnetic flux changing means attached to each push-button for changing the mutual inductance between the primary and secondary windings in one of the transformers when the push-button corresponding to that transformer is moved to change the proximity of the magnetic flux changing means with respect to the transformer, and circuit means connected to the second groups for giving an electrical indication of which push-button was moved, said circuit means including comparator circuitry for determining the polarity of a signal caused by the change in mutual inductance between the primary and secondary windings of a transformer to identify which push-button in a pair of push-buttons was moved and logic means responsive to the comparator circuit for storing a digital indication of the polarity of the change in mutual inductance.

Preferably the energizing means includes a signal source and scanning means for connecting one of said integral number of pairs of the primary windings at a time to the signal source.

Preferably the circuit means includes latching circuitry for halting the scanning means when the circuit means gives an electrical indication that a member has been moved.

The magnetic flux changing means may comprise an element made of ferrimagnetic material. Alternatively it may comprise an element made of metal. Preferably the transformers are provided by metal foil spirals on a printed circuit board, the members are supported above the printed circuit board by spring means, and each member is arranged to be actuated by depression thereof, so as to bring said element of metal attached thereto into close

[Price 25p]

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proximity to the respective transformer.

Preferably the circuit means includes digital coding means responsive to the comparator circuitry and the scanning means, the digital coding means giving a digital output corresponding to the member moved.

Preferably latching means is included for comparing the digital output corresponding to successive scans of the scanning means, the latching means giving an output in response to the same member being moved during at least two successive scans.

There now follows a detailed description which is to be read with reference to the accompanying drawings of several keyboards which are illustrative of the invention, it is to be clearly understood that these keyboards have been selected for description to illustrate the invention by way of example and not by way of limitation.

In the accompanying drawings:—

Figure 1 is a circuit diagram including one pair of keys of a noncontacting keyboard according to the invention;

Figure 2 is a perspective view of a preferred physical configuration of a portion of a keyboard according to the invention;

Figures 3 to 6 are circuit diagrams of several embodiments of noncontacting keyboards according to this invention.

Figure 1 shows a pair 11 of key assemblies 10 and 12. A primary winding 18 of the key assembly 12 is connected in series with a primary winding 14 of the key assembly 10 and with energising means provided by a pulse generator 28. When a pulse 42 from the generator 28 is applied to the primaries 14 and 18, pulses 44 and 46 appear on secondary windings 16 and 20, respectively. The dots near the transformer windings indicate the polarity of the windings, and it can be seen from the position of these dots that the pulse 46 is inverted with respect to the pulse 42 while the pulse 44 is not inverted. The mutual inductance in the transformers is designed to be the same, and, therefore, the pulses 44 and 46 are of the same magnitude, but of opposite phase or polarity, so that they cancel each other. The key assemblies 10 and 12 also include push button members provided by keys 22 and 24 respectively, and each key includes a magnetic flux changing element 26 which may take a number of forms. To increase the mutual inductance between the primary winding and the secondary winding magnetic flux changing means in the form of an element of magnetic material such as ferrite may be attached to the key. The ferrite may be in the shape of a rod or core which moves near the windings when the key is depressed. Alternatively, an element of metal can be used for the element 26 to

decrease the mutual inductance between the primary winding and the secondary winding, the element of metal acting essentially as a shorted turn. The element of metal, brass, for example, could be in the shape of a disc or a washer which almost contacts the transformer windings when the key is depressed. A simple suspension system for the keys 22 and 24 might comprise, for example, a hole in a panel 23 through which the flux changing element 26 can move, a spring 25 to bias the key into its "up" position, and a retainer element 27 to limit the travel of the key. The panel 23 might be that of a calculator, data terminal or other device requiring a keyboard.

If the key 24 is depressed, as indicated by the arrow 40, a pulse 46 will increase in magnitude, assuming for the sake of example that the element 26 is made of ferrite. The pulses 44 and 46 will no longer cancel and a signal will appear at the input of a comparator 48. The comparator 48 comprises two input resistors 34, two amplifiers 30 and 32, and a flip-flop 36 which stores the output of the two amplifiers 30 and 32. Each of the amplifiers 30 and 32 will pass only a positive polarity pulse. The pulse 44 will be positive to the amplifier 30 and will therefore reset the flip-flop 36; the pulse 46 will be positive to the amplifier 32 and will set the flip-flop 36. During the time that the key 24 is depressed, an output 38 of the flip-flop 36 will be a logical "1", the code arbitrarily selected for the key 24 in this example.

Figure 2 shows a preferred practical form of a portion of a noncontacting keyboard according to the invention. The keys 22 and 24 are supported through holes in the panel 23 by the springs 25. The flux changing element is shown as a metallic disc 126, made of, for example, brass or copper, attached to each key. A printed circuit board 100 supports two printed circuit transformers 110 and 112. The key 24 is shown in the "up" position with its disc 126 held above the transformer 112, while the key 22 is shown in its depressed position, as indicated by the arrow 41, with its disc 126 in closer proximity to the transformer 110. It is not necessary for the disc to touch or pass between the windings of the transformer.

Figure 3 shows a simplified keyboard according to the invention with eight pairs 11 of key assemblies. The pairs of primary windings of the pairs of key assemblies are connected in parallel to a pulse generator output bus 66. Each primary winding pair is also connected to terminals 49 of a counter 50. The counter 50, shown as a scale of eight counter, sequentially connects one terminal 49 to earth each time it receives a pulse from the generator 28 through delay means 54 and an AND gate 52. Thus, for

each pulse 42 from the generator 28, a different pair 11 of key assemblies is pulsed. Either the amplifier 30 or the amplifier 32 will have an output when a key is depressed and that signal, coupled to the AND gate 52 through an OR gate 56 and an inverter 57, will halt the counter 50 by turning off the AND gate 52. The delay means 54 prevents the counter 50 from being stepped before the comparator 48 can check for a depressed key. Thus, the elements 52, 54, 56 and 57 serve as a lockout circuit to prevent an output in response to more than one depressed key. Key code information is available to external equipment on the output 58, comprising three outputs from the counter 50 and the output 38 from the flip-flop 36. A "key down" signal is also provided on the output 62. In this example, the counter 50, delay means 54, and the gates 52 and 56 in conjunction with the pulse generator 28 provide a scanner.

One method of expanding the non-contacting keyboard is shown in Figure 4. In this embodiment primary groups 64 of four primary windings connected in series are shown with half of the secondaries series connected to a comparator 68 and the other half to a comparator 70. As in Figure 3, the primary groups 64 are pulsed sequentially by a generator 28 and a counter 50; the remaining circuitry has been abbreviated or omitted for clarity.

Another method of scanning the primaries in a noncontacting keyboard is illustrated in Figure 5. Sixteen keys are illustrated as in Figure 3, but the counter is only a scale of four counter rather than a scale of eight counter. Alternate pairs 11 of primary windings are connected to an output 74 of a flip-flop 80 and the other pairs 11 are connected to a second output 76. The generator 28 drives the flip-flop 80, and therefore the outputs 74 and 76 are alternately energized. Diodes 75 ensure that current flows in only one of the lines connected to the outputs 74 and 76. Adjacent pairs of primary windings are connected to one of the four terminals on a counter 51, and the counter 51 is driven by the flip-flop 80 rather than directly by the generator 28. Thus, the counter 51 earths a different set of primary windings after two pulses from the generator 28. An output 78 comes from the counter 51, the flip-flop 80 and the comparator 48. This method of scanning is known as X-Y scanning.

Figure 6 illustrates an alternative embodiment of circuit to that shown in Figure 3. For the sake of simplicity, only 8 keys are shown in this example. The output 58 is connected to a buffer store 90 which enters a new key code into a memory every time there is a key down pulse on a line 94. Thus the information available on buffer store

output lines 96 represents the key depressed during a given cycle n of a counter 50. The information on the output 58 represents the key depressed during cycle $n+1$ of the counter 50. The information on the outputs 58 and 96 are compared in a digital comparator 92; if they coincide, a key down signal appears on an output 63. Thus a key down signal will appear on the output 63 only if the same key is depressed for two or more cycles of the counter 50. Key code information appears on an output 59.

The keyboard illustrated in Figure 4 can be expanded either by increasing the number of input lines to the counter 50 or the number of pairs of primary windings connected in series and thus the number of comparators. The keyboard of Figure 5 can be expanded either by increasing the number of input lines to the counter 51 or the number of flip-flops 80 driven by the pulse generator 28. Scanning methods other than those illustrated are also possible; for example, all the primary windings could be connected in series and pairs of secondary windings could be connected to an array of comparators.

WHAT WE CLAIM IS:—

1. A non-contacting keyboard comprising an array of coreless transformers, each transformer having a primary and a corresponding secondary winding, the primary windings being series connected in one or more first groups and the secondary windings being series connected in one or more second groups, each first group containing an integral number of pairs of the primary windings and there being at least said integral number of second groups, energizing means connected to the first groups for applying signals thereto, the magnitude and polarity of the mutual inductance between the pairs of primary windings in a first group and the corresponding secondary windings being selected for cancellation of signals induced on said corresponding secondary windings in response to signals in the primary windings, an array of push-buttons arranged in a one to one correspondence with and physically proximate to the array of transformers, a pair of push-buttons corresponding to a pair of primary windings and said push-buttons being supported for movement with respect to the transformers, magnetic flux changing means attached to each push-button for changing the mutual inductance between the primary and secondary windings in one of the transformers when the push-button corresponding to that transformer is moved to change the proximity of the magnetic flux changing means with respect to the transformer, and circuit means connected to the second groups for giving an electrical indication of which

each pulse 42 from the generator 28, a different pair 11 of key assemblies is pulsed. Either the amplifier 30 or the amplifier 32 will have an output when a key is depressed and that signal, coupled to the AND gate 52 through an OR gate 56 and an inverter 57, will halt the counter 50 by turning off the AND gate 52. The delay means 54 prevents the counter 50 from being stepped before the comparator 48 can check for a depressed key. Thus, the elements 52, 54, 56 and 57 serve as a lockout circuit to prevent an output in response to more than one depressed key. Key code information is available to external equipment on the output 58, comprising three outputs from the counter 50 and the output 38 from the flip-flop 36. A "key down" signal is also provided on the output 62. In this example, the counter 50, delay means 54, and the gates 52 and 56 in conjunction with the pulse generator 28 provide a scanner.

One method of expanding the non-contacting keyboard is shown in Figure 4. In this embodiment primary groups 64 of four primary windings connected in series are shown with half of the secondaries series connected to a comparator 68 and the other half to a comparator 70. As in Figure 3, the primary groups 64 are pulsed sequentially by a generator 28 and a counter 50; the remaining circuitry has been abbreviated or omitted for clarity.

Another method of scanning the primaries in a noncontacting keyboard is illustrated in Figure 5. Sixteen keys are illustrated as in Figure 3, but the counter is only a scale of four counter rather than a scale of eight counter. Alternate pairs 11 of primary windings are connected to an output 74 of a flip-flop 80 and the other pairs 11 are connected to a second output 76. The generator 28 drives the flip-flop 80, and therefore the outputs 74 and 76 are alternately energized. Diodes 75 ensure that current flows in only one of the lines connected to the outputs 74 and 76. Adjacent pairs of primary windings are connected to one of the four terminals on a counter 51, and the counter 51 is driven by the flip-flop 80 rather than directly by the generator 28. Thus, the counter 51 earths a different set of primary windings after two pulses from the generator 28. An output 78 comes from the counter 51, the flip-flop 80 and the comparator 48. This method of scanning is known as X-Y scanning.

Figure 6 illustrates an alternative embodiment of circuit to that shown in Figure 3. For the sake of simplicity, only 8 keys are shown in this example. The output 58 is connected to a buffer store 90 which enters a new key code into a memory every time there is a key down pulse on a line 94. Thus the information available on buffer store

output lines 96 represents the key depressed during a given cycle n of a counter 50. The information on the output 58 represents the key depressed during cycle $n+1$ of the counter 50. The information on the outputs 58 and 96 are compared in a digital comparator 92; if they coincide, a key down signal appears on an output 63. Thus a key down signal will appear on the output 63 only if the same key is depressed for two or more cycles of the counter 50. Key code information appears on an output 59.

The keyboard illustrated in Figure 4 can be expanded either by increasing the number of input lines to the counter 50 or the number of pairs of primary windings connected in series and thus the number of comparators. The keyboard of Figure 5 can be expanded either by increasing the number of input lines to the counter 51 or the number of flip-flops 80 driven by the pulse generator 28. Scanning methods other than those illustrated are also possible; for example, all the primary windings could be connected in series and pairs of secondary windings could be connected to an array of comparators.

WHAT WE CLAIM IS:—

1. A non-contacting keyboard comprising an array of coreless transformers, each transformer having a primary and a corresponding secondary winding, the primary windings being series connected in one or more first groups and the secondary windings being series connected in one or more second groups, each first group containing an integral number of pairs of the primary windings and there being at least said integral number of second groups, energizing means connected to the first groups for applying signals thereto, the magnitude and polarity of the mutual inductance between the pairs of primary windings in a first group and the corresponding secondary windings being selected for cancellation of signals induced on said corresponding secondary windings in response to signals in the primary windings, an array of push-buttons arranged in a one to one correspondence with and physically proximate to the array of transformers, a pair of push-buttons corresponding to a pair of primary windings and said push-buttons being supported for movement with respect to the transformers, magnetic flux changing means attached to each push-button for changing the mutual inductance between the primary and secondary windings in one of the transformers when the push-button corresponding to that transformer is moved to change the proximity of the magnetic flux changing means with respect to the transformer, and circuit means connected to the second groups for giving an electrical indication of which



push-button was moved, said circuit means including comparator circuitry for determining the polarity of a signal caused by the change in mutual inductance between the primary and secondary windings of a transformer to identify which push-button in a pair of push-buttons was moved and logic means responsive to the comparator circuitry for storing a digital indication of the polarity of the change in mutual inductance.

2. A keyboard according to claim 1 wherein the energizing means includes a signal source and scanning means for connecting one of said integral number of pairs of the primary windings at a time to the signal source.

3. A keyboard according to claim 2 wherein the circuit means includes latching circuitry for halting the scanning means when the circuit means gives an electrical indication that a push-button has been moved.

4. A keyboard according to any one of the preceding claims wherein the magnetic flux changing means comprises an element made of ferri-magnetic material.

5. A keyboard according to any one of claims 1 to 4 wherein the magnetic flux changing means comprises an element made of metal.

6. A keyboard according to any one of claims 1 to 5 wherein said integral number is one.

7. A noncontacting keyboard according to any one of claims 2 to 6 wherein the circuit means includes digital coding means responsive to the comparator circuitry and the scanning means, the digital coding means giving a digital output corresponding to the push-button moved.

8. A non-contacting keyboard according to claim 7 including latching means for comparing the digital output corresponding to successive scans of the scanning means, the latching means giving an output in response to the same push-button being moved during at least two successive scans.

9. A keyboard according to claim 5 wherein the transformers are provided by metal foil spirals on a printed circuit board, the push-buttons are supported above the printed circuit board by spring means, and each push-button is arranged to be actuated by depression thereof, so as to bring said element of metal attached thereto into close proximity to the respective transformer.

10. A keyboard according to claim 1 substantially as hereinbefore described with reference to the accompanying drawings.

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