United States Patent

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[54] **NONCONTACTING KEYBOARD**

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[52] **U.S. Cl.** ....**340/365**, 178/17 C

[51] **Int. Cl.** **G08c 1/00**

[58] **Field of Search** ....340/365; 179/90 K; 178/17 C; 197/98

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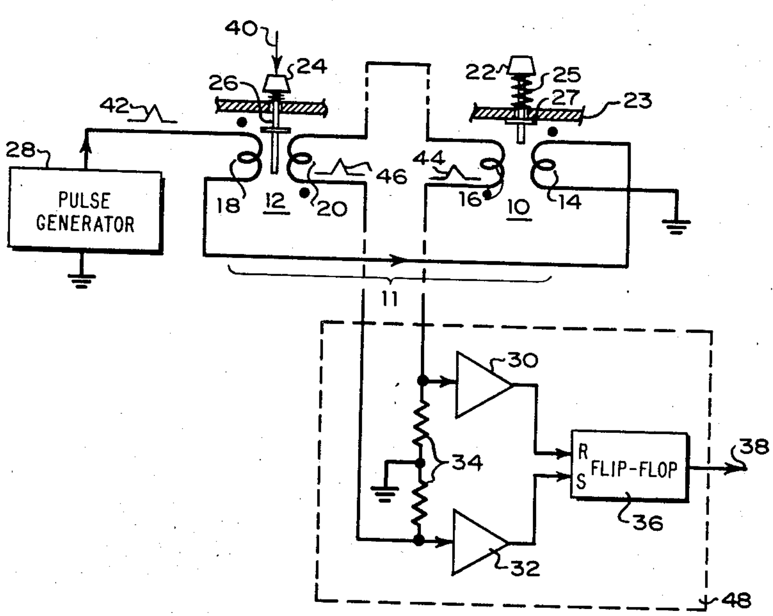
[57] **ABSTRACT**

An array of keys is suspended over an array of transformers. The transformer secondaries are series connected together and the primaries are arranged in series connected pairs, the transformers of each pair being oppositely poled. A ferrite core is attached to each key. The primary pairs are electrically energized one at a time by a scanner, and the series connected secondaries are connected to a comparator. When a key is depressed the ferrite core on the key changes the mutual inductance between the primary and secondary of the corresponding transformer, causing the comparator to register a depressed key. An information output available from the scanner and comparator tells which key is depressed, and the scanner halts when a key is depressed to prevent an erroneous output due to more than one simultaneously depressed key.

9 Claims, 6 Drawing Figures



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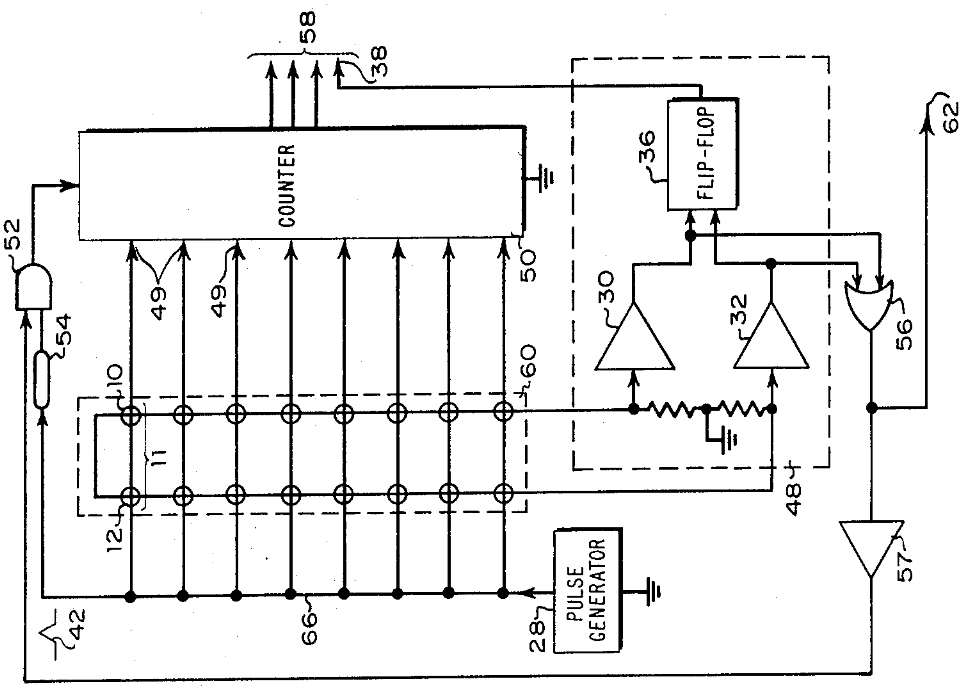

Figure 3

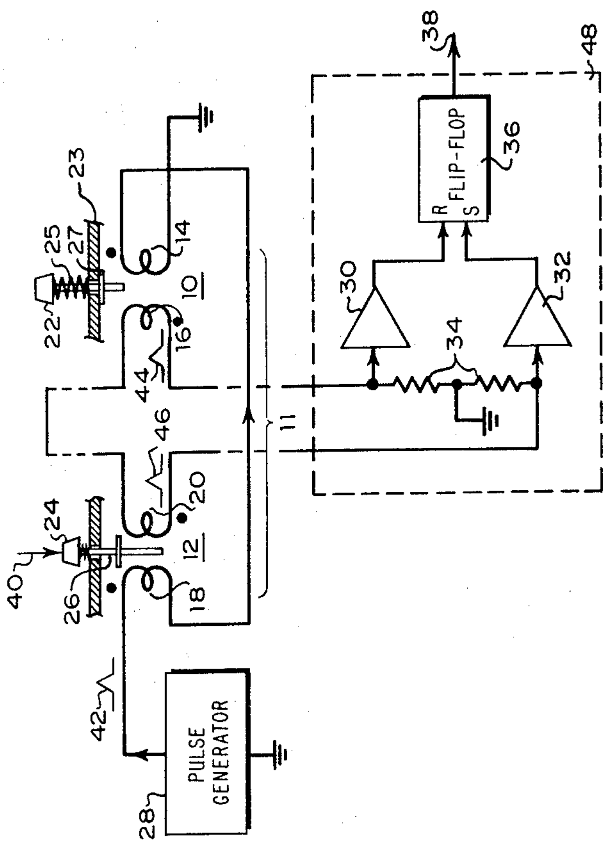

Figure 1

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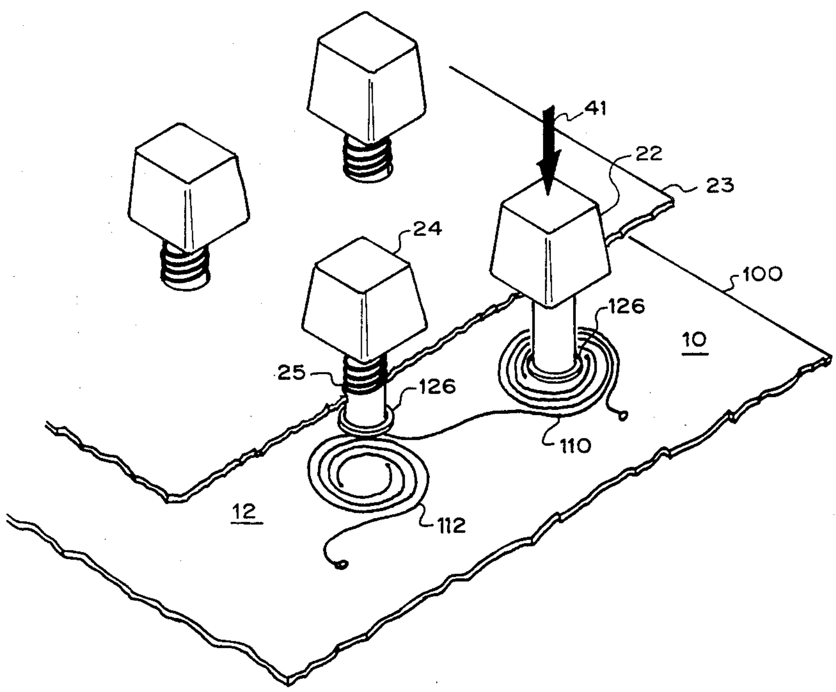

Figure 2

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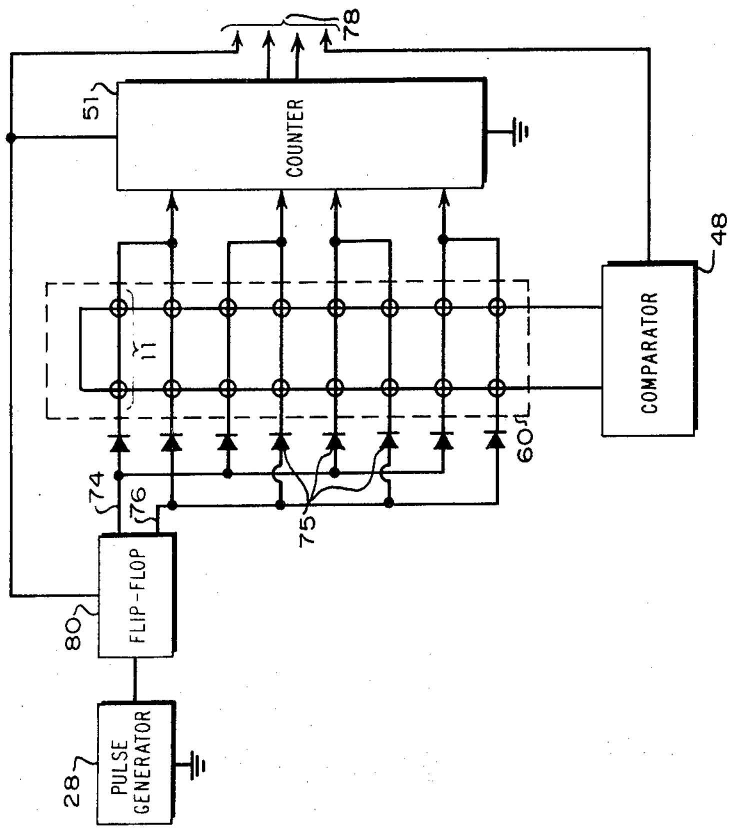

Figure 5

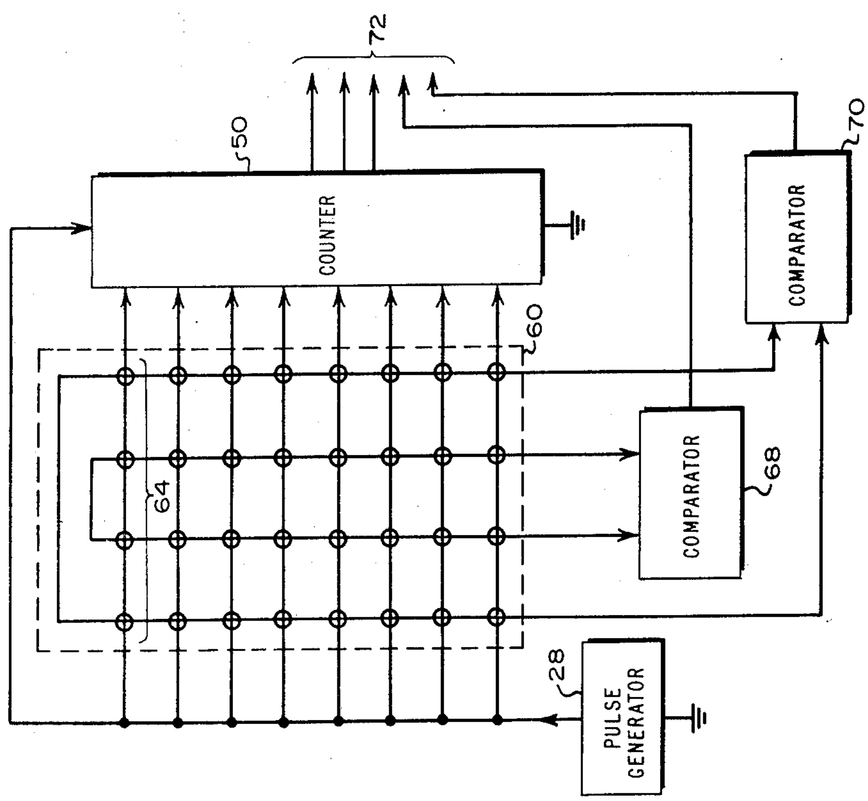

Figure 4

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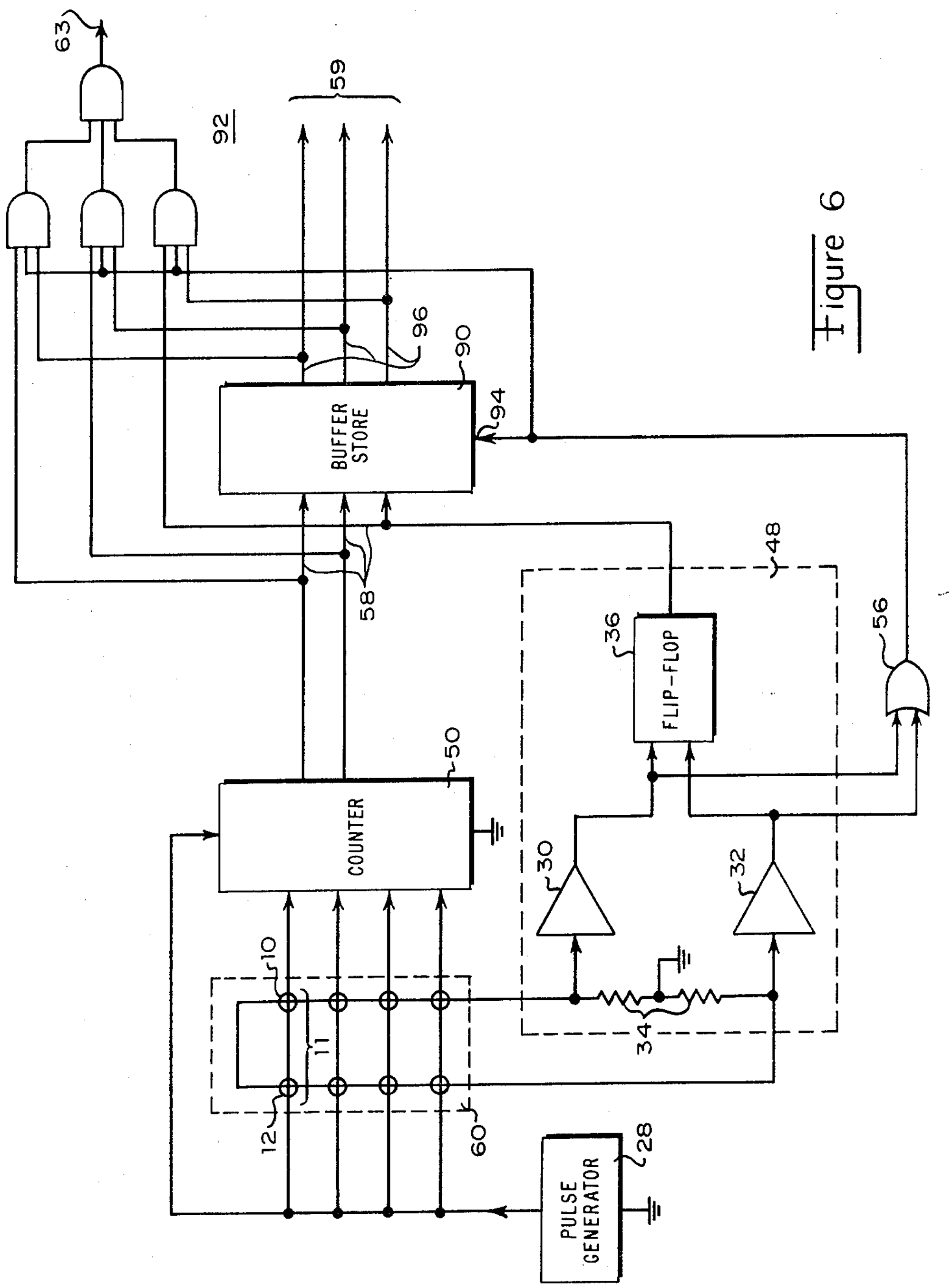

Figure 6

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NONCONTACTING KEYBOARD

BACKGROUND AND SUMMARY OF THE INVENTION

In the prior art 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.

In a preferred embodiment of the present invention the keyboard is comprised of an array of printed circuit transformers with a key or button for each transformer. All of the transformer secondaries are connected together in series and the series combination is connected to comparator amplifiers. The transformer primaries are grouped in series connected pairs and the pairs are sequentially energized by a scanner. The transformers in any one pair are oppositely poled. The polarity of a transformer is determined by the phase of a signal at the transformer's secondary compared with the phase at its primary. Depending upon the sense of the primary and secondary windings, and therefore the polarity of the mutual inductance, the phase of a signal may be either unaltered or inverted by a transformer. Since each pair of transformers is oppositely poled and the transformers are otherwise identical, the signals on the series connected secondaries normally cancel. Each key has a magnetic flux changing element such as a ferrite rod or core on it, and when a key is depressed, the ferrite element is brought closer to the transformer. The mutual inductance between the primary and secondary of the transformer is changed (in this example increased) by the presence of the ferrite, and the previously mentioned cancellation is upset, producing a signal at the comparator. The polarity of the signal tells which transformer of the pair was actuated, and the scanner tells which pair was energized when a signal appeared at the comparator. An interlock is provided to stop the scanner when a key is depressed to prevent the detection of more than one depressed key at a time. The entire keyboard is scanned in a few milliseconds so, to human perception, the response to a depressed key is instantaneous. Thus, a keyboard is realized which does not require the mechanical closure of contacts.

DESCRIPTION OF THE DRAWINGS

FIG. 1 shows one pair of keys of a noncontacting keyboard.

FIG. 2 shows a preferred physical configuration of the keys and keyboard.

FIGS. 3–6 show different simplified embodiments of a noncontacting keyboard according to this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a pair **11** of key assemblies **10** and **12**. A primary winding **18** of key assembly **12** is connected in series with a primary **14** of key assembly **10** and pulse generator **28**. A pulse **42** from generator **28** is applied to primaries **14** and **18**, and pulses **44** and **46** appear on secondaries **16** and **20**, respectively. The dots near the transformer windings indicate the polarity of the windings, and it can be seen that pulse **46** is inverted with respect to pulse **42** while **44** is not inverted. Since the mutual inductance in the transformers is designed to be the same, pulses **44** and **46** are of the same magnitude, but of opposite phase or polarity, so they cancel. Key assemblies **10** and **12** also include keys **22** and **24**, respectively, and each key includes a magnetic flux changing element **26**. Element **26** may take a number of forms. To increase the mutual inductance between the primary and secondary, a 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, a piece of metal can be used for element **26** to decrease the mutual inductance between the primary and secondary, the piece of metal acting essentially as a shorted turn. The metal, brass, for example, could be in the shape of a disc or washer which almost contacts the transformer coils when the key is depressed. A simple suspension system for keys **22** and **24** might comprise, for example, a hole in panel **23** through which flux changing element **26** moves, a spring **25** to bias the key in the "up" position, and a retainer **27** to limit the travel of the key. Panel **23** might be that of a calculator, data terminal or other device requiring a keyboard.

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

FIG. 2 shows a preferred physical embodiment of a portion of a noncontacting keyboard. Keys **22** and **24** are supported through holes in panel **23** by spring **25**. The flux changing element is shown as a metallic disc **126** such as brass or copper attached to each key. A printed circuit board **100** supports printed circuit transformers **110** and **112**. Key **24** is shown in the up position with its disc **126** held above transformer **112**, while key **22** is shown depressed, as indicated by arrow **41**, with its disc **126** in closer proximity to transformer **110**. It is not necessary for the disc to touch or pass between the windings.

FIG. 3 shows a simplified keyboard with eight pairs **11** of key assemblies. The pairs of primaries are connected in parallel to pulse generator output bus **66**. Each primary pair is also tied to terminals **49** of a counter **50**. Counter **50**, shown as a scale of eight counter, sequentially connects one terminal **49** to ground each time it receives a pulse from generator **28** through delay **54** and AND gate **52**. Thus, for each pulse **42** from generator **28**, a different key assembly **11** is pulsed. Either amplifier **30** or **32** will have an output when a key is depressed and that signal, coupled to AND gate **52** through OR gate **56** and inverter **57**, will halt counter **50** by turning off AND gate **52**. Delay **54** prevents counter **50** from being stepped before comparator **48** can check for a depressed key. Thus, 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 output **58**, comprising three outputs from counter **50** and output **38** from flip-flop **36**. A "key down" signal is also provided on output **62**. In this example, counter **50**, delay **54**, and gates **52** and **56** in conjunction with pulse generator **28** comprise a scanner.

One method of expanding the noncontacting keyboard is shown in FIG. 4. In this embodiment primary groups **64** of four primaries connected in series are shown with half of the secondaries series connected to comparator **68** and the other half to comparator **70**. As in FIG. 3, the primary groups **64** are pulsed sequentially by generator **28** and 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 FIG. 5. Sixteen keys are illustrated as in FIG. 3, but the counter is only a scale of four counter rather than a scale of eight counter. Alternate pairs **11** of primaries 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 flip-flop **80**, and therefore outputs **74** and **76** are alternately energized. Diodes **75** ensure that current flows in only one of the lines connected to outputs **74** and **76**. Adjacent pairs of primaries are connected to one of the four terminals on counter **51**, and counter **51** is driven by flip-flop **80** rather than directly by generator **28**. Thus, counter **51** grounds a different set of primaries after two pulses from generator **28**. Output **78** comes from counter **51**, flip-flop **80** and comparator **48**. This method of scanning is known as X–Y scanning.

FIG. **6** illustrates an alternative embodiment of a lockout circuit from that shown in FIG. **3**. For the sake of simplicity, only eight keys are shown in this example. Output **58** is connected to a buffer store **90** which enters a new key code into memory every time there is a key down pulse on line **94**. Thus the information available on buffer store output lines **96** represents the key depressed during a given cycle *n* of counter **50**. The information on output **58** represents the key depressed during cycle *n*+1 of counter **50**. The information on 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 output **63** only if the same key is depressed for two or more cycles of counter **50**. Key code information appears on output **59**.

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

We claim:

1. A noncontacting keyboard comprising:

an array of coreless transformers, each transformer having a first and a corresponding second winding, the first windings being series connected in one or more first groups and the second windings being series connected in one or more second groups, each first group containing an integral number of pairs of the first 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 first windings in a first group and the corresponding second windings being selected for cancellation of signals induced on said corresponding second windings in response to signals on the first windings;

an array of buttons arranged in a one to one correspondence with and physically proximate to the array of transformers, a pair of buttons corresponding to a pair of first windings and said buttons being supported for movement with respect to the transformers;

magnetic flux changing means attached to each button for changing the mutual inductance between the first and second windings in one of the transformers when the 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 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 first and second windings of a transformer to identify which button in a pair 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 noncontacting keyboard as in claim **1** wherein the energizing means includes a signal source and scanning means for connecting one of said integral number of pairs of the first windings at a time to the signal source.

3. A noncontacting keyboard as in claim **2** wherein the circuit means includes latching circuitry to halt the scanning means when the circuit means gives an electrical indication that a button was moved.

4. A noncontacting keyboard as in claim **2** wherein the magnetic flux changing means is a piece of ferrimagnetic material.

5. A noncontacting keyboard as in claim **2** wherein the magnetic flux changing means is a piece of metal.

6. A noncontacting keyboard as in claim **2** wherein said integral number is one.

7. A noncontacting keyboard as in claim **2** 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 button moved.

8. A noncontacting keyboard as in 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 button being moved during at least two successive scans.

9. A noncontacting keyboard as in claim **5** wherein the transformers are metal foil spirals on a printed circuit board, the buttons are supported above the printed circuit board by spring means, and a button is actuated by depressing it, bringing said piece of metal in closer proximity to the corresponding transformer.

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