United States Patent

[11] 3,594,487

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[21] Appl. No. 852,590
[22] Filed Aug. 25, 1969
[45] Patented July 20, 1971
[73] Assignee Navcor, Inc.

[54] CONTACTLESS ELECTRONIC KEYBOARD ARRAY

5 Claims, 5 Drawing Figs.

[52] U.S. Cl. 84/1.1, 84/1.15
[51] Int. Cl. G01h 3/00
[50] Field of Search 84/1.01, 1.1, 1.14, 1.15; 197/19, 98

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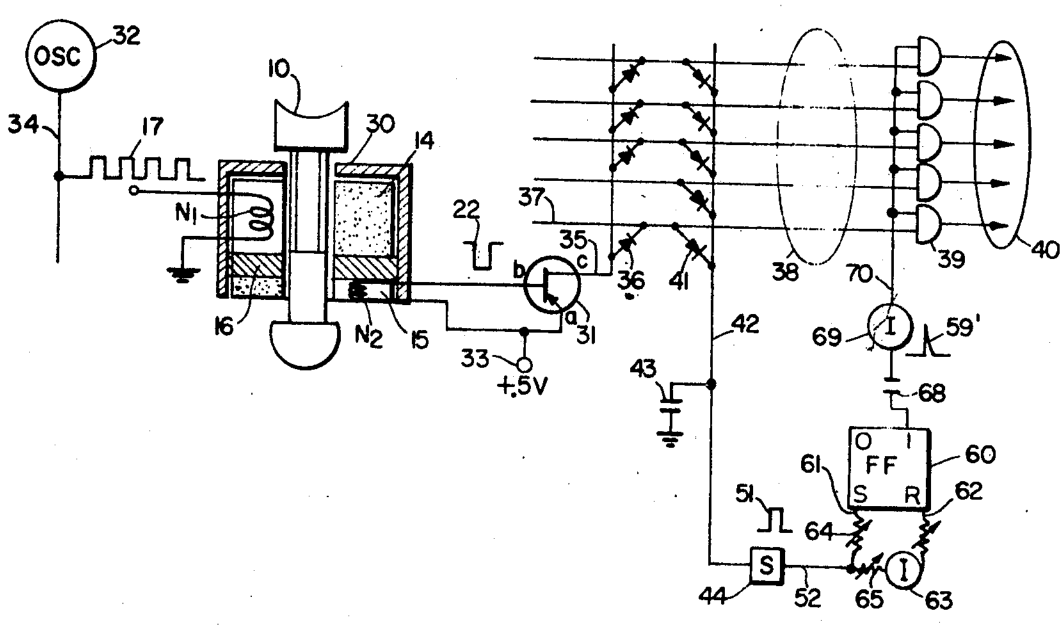
ABSTRACT: An electronic keyboard system includes a key structure comprising primary and secondary coils coupled together by a magnetic shaft when moved to produce primary signals from a pulse train in the secondary. A magnetic shield between the coils produces a sharp transistor between no-signal and signal condition in the secondary winding as the shaft is moved past a critical position. Electronic circuitry provides for converting the pulse train into a single output pulse for each key depression, by use of a single Schmidt trigger circuit coupled into an encoding matrix to produce a coded signal for each separate key.



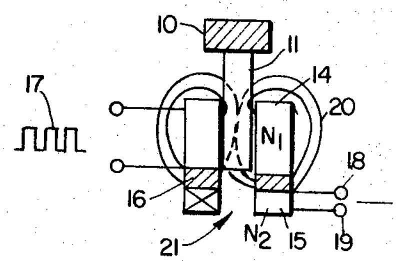


FIG. 1

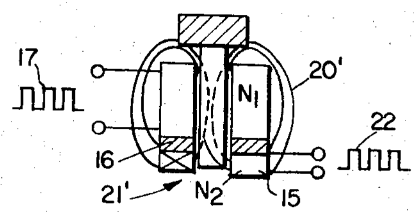


FIG. 2

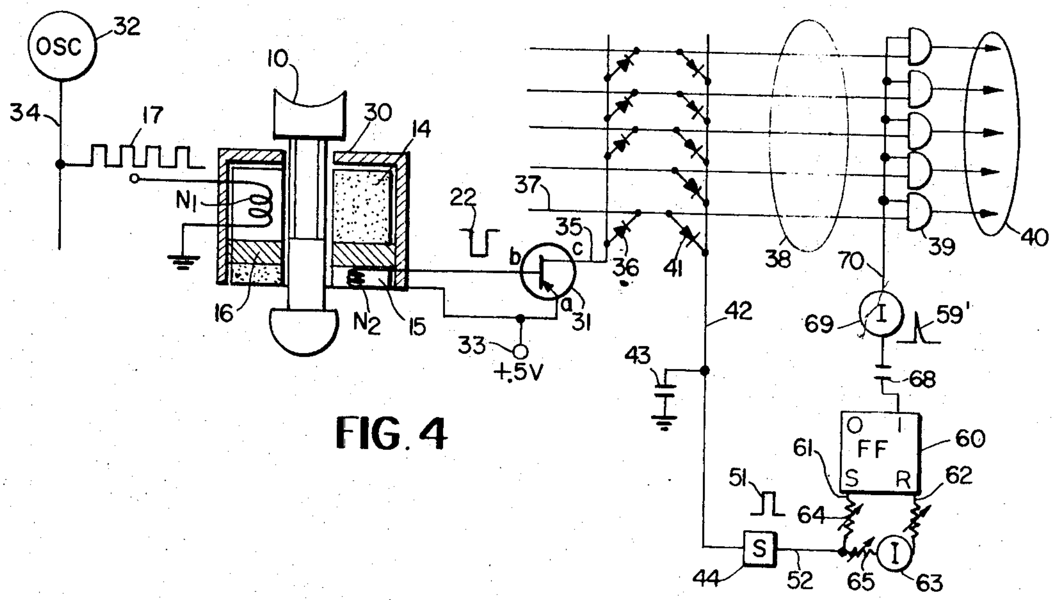


FIG. 4

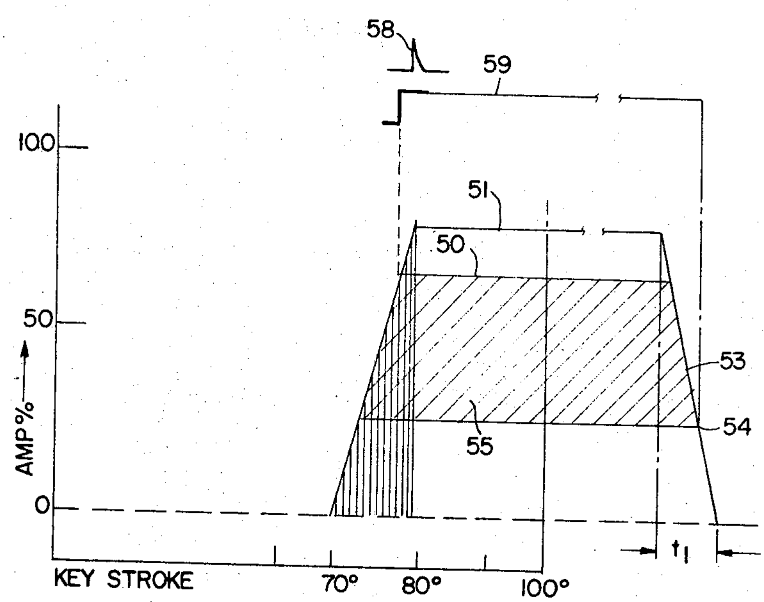


FIG. 5

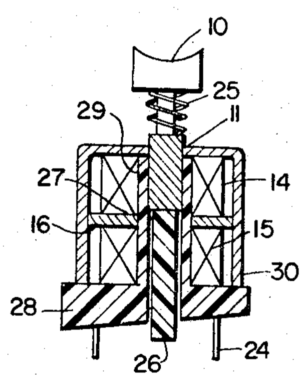


FIG. 3

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CONTACTLESS ELECTRONIC KEYBOARD ARRAY

This invention relates to electronic keyboard systems, and more particularly to keyboard arrays with contactless keys.

Electronic keys in the prior art have primarily incorporated mechanical switching contacts of various types. All of these have suffered from the general problem of switch bounce which in electronic systems tends to introduce false signals and errors. Also some mechanical contacts have limited life spans. Critical applications of electronic keyboard system in military, traffic control or digital systems require higher performance standards that will not tolerate mechanical switch bounce deterioration or other associated problems. Wherever switches are subjected to vibrations the mechanical contacts become even less reliable. Also environmental conditions such as humidity or temperature changes can cause variations in contact performance. For these reasons switchless contacts involving photoelectric devices and the like may fail even if their added cost is permissible.

It is therefore a general object of this invention to provide improved contactless electronic keyboard arrays.

Another object of the invention is to provide a rugged and inexpensive keyboard array which provides a high degree of uniformity and which can be made simply with noncritical techniques.

Therefore in accordance with the invention a keyboard switch employing magnetic coupling techniques such as those defined in my U.S. Pat. No. 3,249,199 are employed in a system providing from a train of pulses coupled through the actuation of the key to electronic utilization means a single defined output pulse of known characteristic for each key depression. The key design is an improved design providing for a sharp signal transition as the key shaft is moved past a critical position.

The equipment afforded by this invention is defined in more detail with reference to the accompanying drawing, in which:

FIG. 1 is a section view sketch of a magnetically coupled key in its rest position,

FIG. 2 is a section view sketch of a magnetically coupled key in its operated position,

FIG. 3 is an elevation view in cross section of a key assembly constructed in accordance with this invention,

FIG. 4 is a schematic diagram of a keyboard system operable to produce a single pulse of known characteristics from each key stroke, and

FIG. 5 is a waveform diagram illustrating operation of the system of FIG. 4.

In FIG. 1, the electronic key device comprises a finger rest key button **10** coupled to a longitudinally oriented shank or shaft **11** of magnetic material of low reluctance such as soft iron extending axially part way into the core of a pair of coils **14**, **15** wound about the axis of shank **11**. In accordance with this invention a magnetic shield washer **16** of low reluctance material separates the primary coil **14** at which pulse train **17** is continuously coupled from the secondary coil **15** having output terminals **18**, **19**. As seen from FIG. 1 this washer **16** works as a flux gate to confine the magnetic field lines **20** within the region of primary coil **14** when the key is in its rest position shown with the shank **11** terminating at a position **21** on the primary coil side of the magnetic washer **16**.

This construction provides a sharp transition characteristic as the shank **11** is moved through a critical position at magnetic washer **16** so that input pulse train **17** couples into the secondary winding **15** to provide a corresponding output pulse train **22** as the modified flux lines **20'** cut through both the primary **14** and secondary **15** from the modified end position **21'** of the magnetic shank **11**.

As may be seen in FIG. 3, the key is normally biased into its rest position by means such as spring **25** about shank **11**. The shank **11** may be provided with an extension **26** of nonmagnetic material such as nylon having high reluctance which will adapt it to operate a standard keyboard in the manner described in the aforesaid patent. This shank extension **26** may have a keyed extension **27** mating with a keyed slot in the base portion **28** which extends part way through a cylindrical shaft **29** to define the upper rest position of key button **10**, and thus confine it from rotation. The tapered construction of base member **28** adapts to a standard keyboard panel slant. Pins **24** extend through base member **28** to provide electrical access terminal connections for the coils **14** and **15**.

To enhance the magnetic coupling characteristic of the key structure a hood **30** of low reluctance magnetic material envelops both coils and extends to the vicinity of shank **11** at the top to provide a return path for flux passing through secondary coil **15**.

This key structure in FIG. 4 is coupled to a system for utilizing the pulse train passed through secondary winding **15** into the transistor amplifier **31**. An oscillator **32** may provide the pulse train **17** of pulses having a duration of 35 microseconds and a duty cycle of 1 to 10, for example, of enough magnitude to produce output pulses **22** from the secondary winding **15** of enough amplitude to overcome a bias voltage of 0.5 volts for example at the emitter terminal **33** of transistor **31**. The oscillator **32** may be connected by a bus connector **34** to a plurality of separate keys in a keyboard array (not shown). Each separate key has an individual output lead **35** which is coupled to a selected set of output lines **37** by a corresponding set of diodes **36**. Each output line **37** may include an amplifier **38** and a gate **39** so that the output code of any key is uniquely defined by a combination of signals at one or more output leads **40**.

To assure that a single output pulse is defined for each key depression several precautions are taken in the circuit of FIG. 4. An envelope of pulses **17**, for example 35 microsecond pulses at a 3 kilocycle repetition rate, is passed from one or more of lines **37** through OR diodes **41** into lead **42**. The capacitor **43** accumulates these pulses with the help of an integration circuit **44** to produce a pulse waveform **51** built up from the successive 3 kc. pulses as shown in FIG. 5.

Flip-flop circuit **60** is operated as a Schmidt trigger circuit to fire once from input waveform **51** to produce output pulse **59'** which is differentiated from pulse **59** (FIG. 5) at capacitor **68**. Pulse **59'** is amplified through inverter **69** to produce at lead **70** a pulse of sufficient length to open gates **39** for passing a single pulse **17** from oscillator **32** through each of the leads **40** connected by diodes **36** to the transistor output lead **36**, provided key **10** is depressed to gate pulses **22** into the transistor circuit **31**.

The firing and reset points of flip-flop **60** are set up by the adjustable input resistors **64** and **65** respectively to drive the flip-flop input **61** directly and input **62** through inverting amplifier **63**. In practice the adjustable resistor **65** is set to make the inverter **63** conduct to ground at the threshold level **54** of input waveform **51** (FIG. 5). This removes the reset voltage at flip-flop terminal **62**. As the waveform continues to build up at lead **42**, and is integrated, the conduction point of the flip-flop at lead **61** is reached at a level selected by setting resistor **64**. When the flip-flop **60** fires the gate pulse **59'** will be produced to gate a single following pulse **17** of the pulse train passed while the key **10** is depressed.

Only when key **10** is released does the pulse train fall off in amplitude as the shank **11** extremity nears the critical point at washer **16**, to thereby cause a steep falloff slope **53** in amplitude of the input pulses at lead **42**. When the amplitude falls below threshold level **54** the inverter **63** will fire flip-flop **60** at lead **62** to terminate pulse **59** in a reset operation for the Schmidt trigger circuit.

This described mode of operation is important to avoid any stuttering or double firing of a key such as provided when it is in the critical region with the extremity of shank **11** near washer **16**. Also it affords synchronization of timing with oscillator **32** for output pulses at leads **40**. Of particular importance is the hysteresis portion **55** of the waveform **51** as employed in this carrier detection operation to assure that the key **10** can pass through the critical region without firing more than once.

In this respect transistor 31 plays a role in detecting and amplifying the pulse train and producing the firing threshold. A silicon transistor may be employed having an input conduction level between base and emitter of about 0.75 volts. This means that shank 11 must pass the gating washer 16 and provide enough flux in coil N_2 to build up 0.75 volts before output pulses are afforded at transistor output lead 35. This affords noise immunity to prevent spurious triggering possibilities, and operates the transistor amplifier as a threshold comparator greatly sharpening the transition from no pulse to full pulse amplitude in response to the depression of the key.

What I claim is:

1. Structure operable in an electronic keyboard comprising in combination, an electronic key device manually actuable from a key button having a longitudinally oriented shank coupled to the key button and movable axially over a confined span of longitudinal movement, magnetic material of low reluctance in at least a portion of said shank extending a predetermined distance along the axis of movement and movable with the shank, biasing means holding the shank in a nominal return position, a first coil wound about said shank to permit its axial movement through the coil and extending in the region of said magnetic material to substantially the terminal end of the magnetic material at the end of the shank remote from the key button, a second coil wound about the axis of said shank to permit its axial movement through the coil and placed substantially adjacent said first coil beyond the terminal end of the magnetic material in said shank, and a magnetic plate of low reluctance material placed between the coils and closely enough surrounding said shank to establish a low reluctance flux path return from said remote end of the magnetic material when the magnetic material is confined within the first coil as the key button is in said return position, whereby said two coils are mutually magnetically coupled with a low reluctance path through the magnetic material of said shank only when the shank is moved enough to pass the end of the magnetic material in the shank through said magnetic plate to enter the second coil.

2. Structure as defined in claim 1 wherein a hood of low reluctance magnetic material surrounds said coils, said plate and said shank to provide a low reluctance return path for magnetic flux extending from said remote end of said magnetic material in the shank.

3. Structure as defined in claim 1 including a source of continuous pulses coupled to said first coil, means coupled to said second coil for receiving a plurality of pulses from said source whenever the shank is moved from said return position, and means converting said plurality of pulses to a single output pulse comprising a hysteresis circuit responsive to two selected threshold valves encountered intermediate in a range of amplitudes of pulses from said source encountered as the magnetic material of said shank enters the second coil during shank movement to produce only one output response pulse for each shank reciprocation, said single output pulse being derived from said output response pulse.

4. Structure as defined in claim 3 wherein said hysteresis circuit comprises a flip-flop circuit, and structure integrating pulses from said source of pulses to set the flip-flop at one threshold level and to reset the flip-flop at a different threshold level from the integrated pulses.

5. Structure as defined in claim 1 having a source of pulses connected for transfer between said two coils when the magnetic material of said key shank is axially moved into a position encompassing both said coils, including hysteresis circuit means responsive to pulses transfered from said source at the coils to provide a single indication of a reciprocation cycle of said shank including means integrating said pulses and means detecting two different threshold levels of the integrated pulses to define therebetween a hysteresis band where variations of pulse amplitude due to variations of coupling between said coils are made ineffective.