

Feb. 10, 1970

F. MATHAMEL

3,495,236

TRANSDUCER

Original Filed Feb. 17, 1965

3 Sheets-Sheet 1

Fig. 1

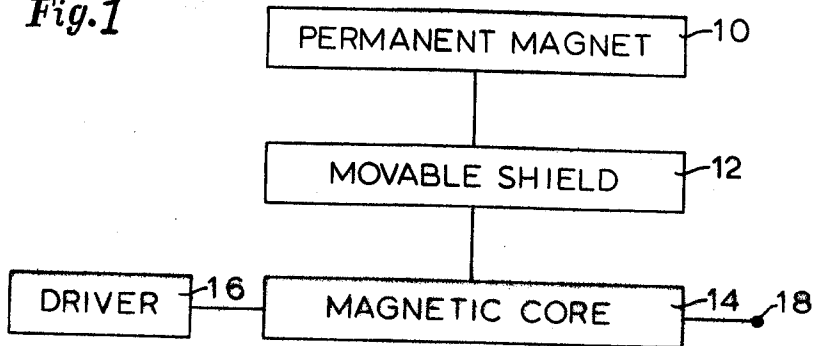
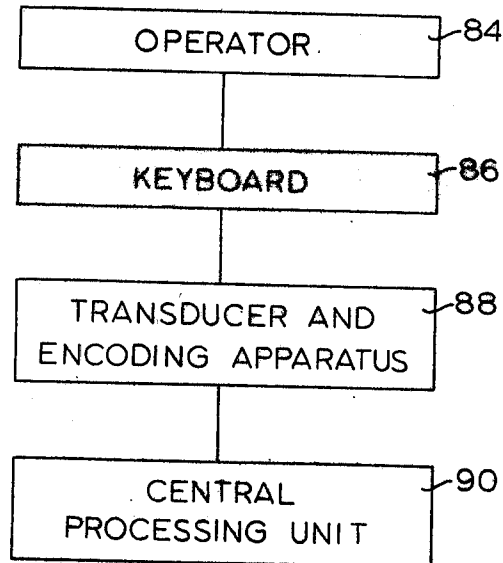


Fig. 8



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Fig. 9

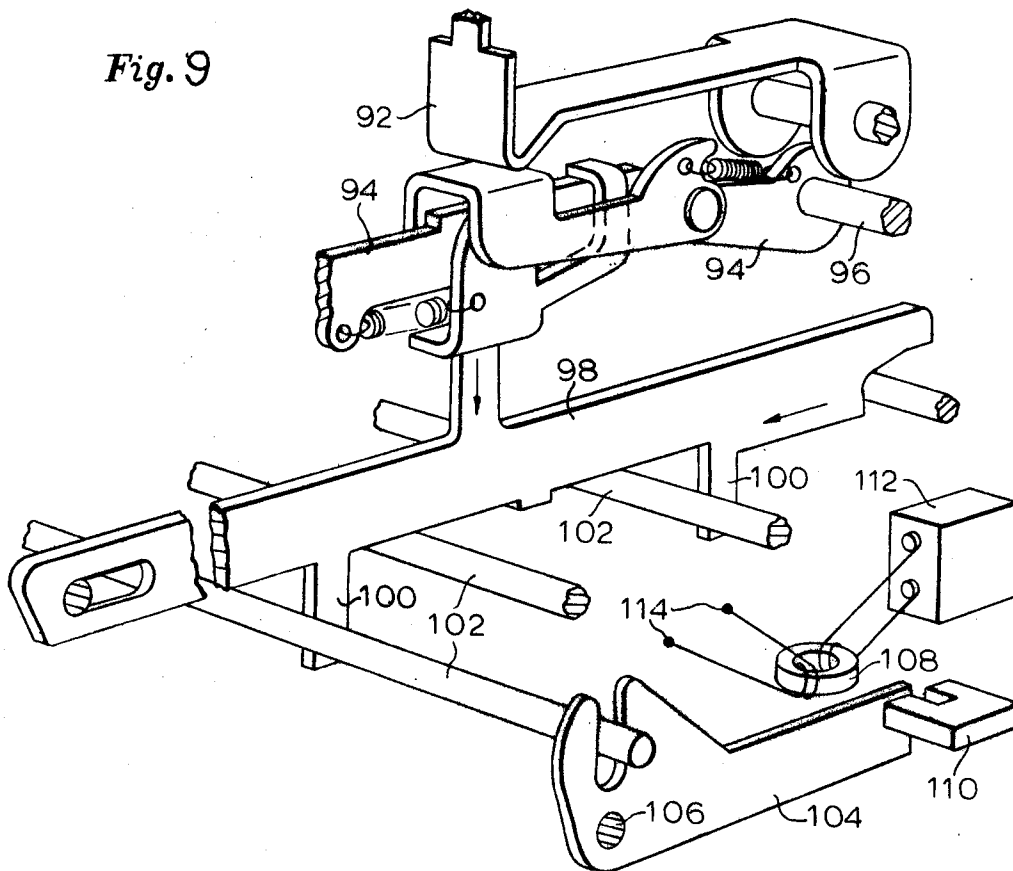
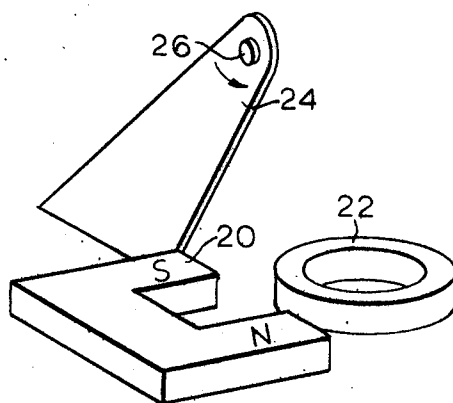


Fig. 2



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Fig. 3

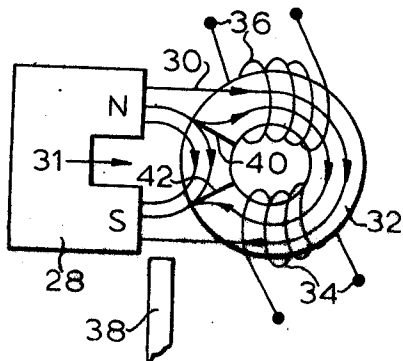


Fig. 4

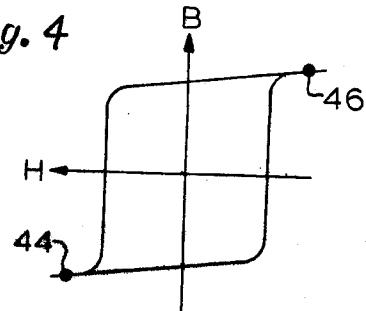


Fig. 5

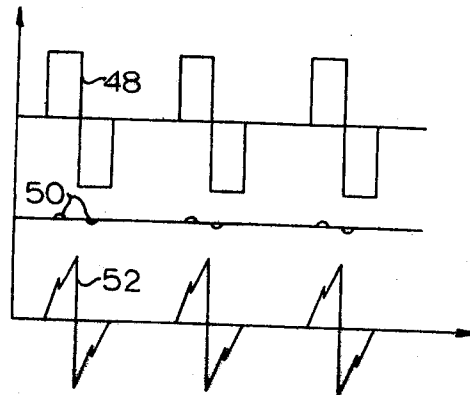


Fig. 7

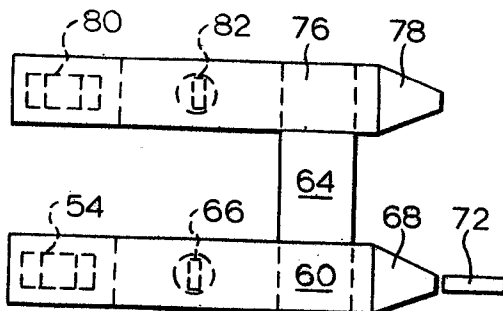
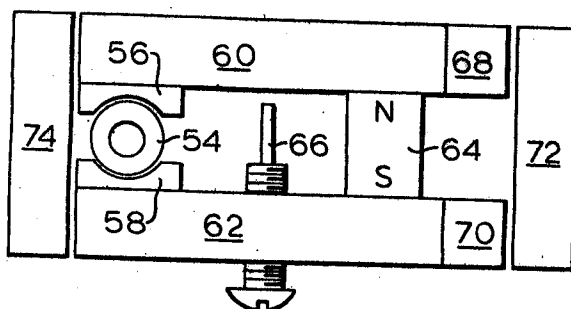


Fig. 6



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TRANSDUCER

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Continuation of application Ser. No. 433,359, Feb. 17,
1965. This application Apr. 16, 1969, Ser. No. 816,643

Int. Cl. G08c 11/00; H03k 13/00; H04l 3/00

U.S. Cl. 340—347

7 Claims

ABSTRACT OF THE DISCLOSURE

A depressible key of a business machine keyboard and a transducer including a permanent magnet and a current control device magnetically influenced thereby which is activated by a key of a keyboard to effect an electrical signal representative of a character to be recorded. Depression of the key depresses and moves an interposer which through a movable bail moves a magnetic shunt which controls activation of the transducer. In one form of the invention, the shunt is movable into and out of the space between a permanent magnet and a magnetic core having a square-shaped hysteresis characteristic, and in another form a movable shunt is positionable to overlap the corresponding ends of a pair of flux distributors between which a magnetic core and a permanent magnet are located. In the latter embodiment of the invention, a movable adjustable shunt is positioned between the flux distributors having a low reluctance and having one end spaced from one of the flux distributors so that the resultant air gap may be adjusted to achieve a low but effective reluctance at the core.

This is a continuation of application for patent Ser. No. 433,359, filed Feb. 17, 1965.

This invention relates to transducers, and more particularly to transducers which are to be used for converting a mechanical displacement to an electrical signal.

It is frequently desirable to convert a mechanical force or mechanical motion to an electrical signal. In business machines, for example, displacement of a key button of a keyboard is converted to an electrical signal to indicate a letter or a number for use in the business operations. It is desirable that the transducers used for this conversion be simple and economical. They must have great reliability and be able to withstand continuous use for long periods of time. The electrical output from the transducer must be of a nature that can be conveniently used in the business machine. It should be sensitive to displacement rather than velocity. Many prior art transducers are deficient in one or more of the above factors. Accordingly, it is an object of this invention to provide an improved transducer.

It is a further object of this invention to provide an inexpensive and reliable transducer.

It is a still further object of this invention to provide a transducer which converts a mechanical displacement to an electrical signal having a sufficient amplitude and a sufficiently narrow time-width for use in the keyboard of a business machine.

It is a still further object of this invention to provide a transducer that is capable of bi-directional dynamic readout and of static readout.

In accordance with the above objects, a transducer is provided having an electrical switching device in the form of a magnetic core with square loop hysteresis characteristics, a driver for switching the core between saturation levels, a permanent magnet adjacent to the core, and a movable shunt for the magnetic. The permanent magnet biases the core so that it normally is not switched by the

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driving source of electrical energy attached to it. The shunt is attached to a key in the keyboard so that when the key is depressed the shunt moves with respect to the permanent magnet to thereby change the effect of its flux on the core. This enables the core to be switched from one hysteresis level to the other by the driving source so that it provides an output signal indicating that the selected key in the keyboard has been depressed.

The invention and the above and other features thereof will be understood more clearly and fully from the following detailed description considered with reference to the accompanying drawings in which:

FIG. 1 is a block diagram illustrating the elements of a transducer which comprise an embodiment of the invention;

FIG. 2 is a simplified perspective drawing of a transducer which is an embodiment of the invention;

FIG. 3 is a front view of an embodiment of the invention illustrating its principle of operation with superimposed flux lines;

FIG. 4 is a graph of the hysteresis curve for a ferromagnetic core which may be used in an embodiment of the invention;

FIG. 5 is a graph having three curves illustrating the input and possible outputs of a core when used in an embodiment of the invention;

FIG. 6 is an elevational view of an embodiment of the invention;

FIG. 7 is a top view of the embodiment of the invention shown in FIG. 6;

FIG. 8 is a block diagram illustrating the use of the invention in a business machine; and

FIG. 9 is a partial, perspective view of a keyboard including a transducer which is an embodiment of the invention.

In FIG. 1 a block diagram of a transducer is shown having a permanent magnet 10, a movable shield 12, a magnetic core 14, a driver 16, and an output terminal 18. The magnetic core may be composed of any high permeability material, but it is desirable for it to have square-loop hysteresis characteristics. With these characteristics it provides the high-amplitude pulses having a time width in the microsecond range even when it is controlled by mechanical motion which has a short stroke and which lasts for milliseconds. Ferrite cores are desirable because they are inexpensive.

The driver 16 provides a periodic driving current to the magnetic core 14, which current is sufficient to saturate the core 14 alternately in each of its two possible directions. The permanent magnet 10 applies a field to the magnetic core 14 which biases this core to prevent it from being switched by the driver 16. The movable shield 12 is moved between the permanent magnet 10 and the magnetic core 14 shielding the magnetic core 14 from the field of the permanent magnet 10 and thereby releasing the magnetic core 14 so that it can be switched from one saturation state to the other by current from a driver 16. This causes the voltage to be induced in an output winding on the core that is connected to the output terminal 18. In this way the motion of the movable shield 12 in response to a mechanical force upon it results in an electrical output on the transducer output terminal 18.

In FIG. 2 a simplified perspective view is given of a transducer having a permanent magnet 20, a ferrite core 22, and a shield 24 adapted to be rotated about a pin 26 to move between the permanent magnet 20 and the core 22. When the shield 24 is between only one pole of the magnet 20 and the ferrite core 22, the ferrite core 22 is biased by the magnetic field so that it is not switched from one state to the other. As the shield 24 rotates directly between the magnet 20 and the core 22, the flux from the magnet 20 is prevented from reaching the ferrite core 22

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so that this core is now free to act as a switching element providing an output voltage in response to an alternating current. Approximately 10° of rotation of the shield 24 are sufficient to change the bias of the ferrite core 22 from an inhibiting bias to a non-inhibiting bias.

In FIG. 3 an elevational view of a transducer is shown having a permanent magnet 28 which provides flux 30 to a ferrite core 32 which as shown is of toroidal shape. An input winding 34 provides alternating current to the core 32 which current is sufficient to switch the ferrite core 32 from one state to the other in the absence of the flux 30 from the permanent magnet 28. An output winding 36 has a voltage induced in it whenever the core is switched. A shunting or shielding device 38 is positioned so that it may be moved between the permanent magnet 28 and the ferrite core 32. This shunting device 38 provides a low reluctance path for the flux lines 30 removing them from the core 32.

When the shunting material 38 is not between the permanent magnet 28 and the core 32 the flux lines 30 link the ferrite core 32 magnetizing a portion of the core. This causes the magnetized portion of the core to act as a separate magnet with fixed polarity which resists the switching of the remainder of the core under the influence of current applied through the winding 34. It is heuristically thought of as a fractured core in which the portion of the core indicated as being the narrower portion between the lines 40 and 42 is a separated magnet.

In FIG. 4 a hysteresis curve is shown for a ferrite core such as 32 having abscissas of magnetomotive force and having ordinates of flux density. The point 44 on the curve indicates the saturation level of zone 31 (FIG. 3) of the ferrite 32 due to the influence of the field from the permanent magnet 28. When the magnetic field from the magnet 28 is removed, the ferrite core 32 is switched from the saturation level 44 to the opposite level indicated at the point 46 by current through the winding 34. When the magnet 28 is providing its full magnetic field to the ferrite core 32, the ferrite core 32 remains at the saturation level indicated at point 44 so as to not provide an output voltage.

In FIG. 5 a graph is shown having three curves with common abscissas of time and individual ordinates of voltage or current. The curve 48 indicates a series of alternating current pulses applied to the input winding 34 of the ferrite core 32 by a driver. When the flux lines 30 are linking the ferrite core 32 with their full strength, the output voltage induced in the winding 36 has a very low amplitude as shown by the curve 50. When the shielding or shunting device 38 is moved between the permanent magnet 28 and the ferrite core 32, the core is switched from one hysteresis level to the other resulting in output voltage pulses 52 of comparatively larger amplitude occurring in response to the input driving pulses 48.

In FIG. 6 an elevational view is shown of a transducer having a ferrite core 54 in contact with the relatively high reluctance pole pieces 56 and 58 which pole pieces have arcuate surfaces contacting and mating with opposite outer surfaces of the toroidal ferrite core 54. The opposite surfaces of the pole pieces 56 and 58 are flat and each contacts a different surface of a different rectilinear flux distributor 60 and 62. A bar magnet 64 is positioned between the two flux distributors 60 and 62 with its north pole in contact with the flux distributor 60 and its south pole in contact with the flux distributor 62.

The magnet 64 provides a flux which passes through the flux distributor 60, through the pole piece 56, through the ferrite core 54, through the pole pieces 58, through the flux distributor 62, and back to the south pole of the permanent magnet 64. The magnetic field conducted to the ferrite core 54 is greater than the field necessary to saturate the ferrite core 54. However, a low reluctance shunting screw 66 is threaded through the flux distributor 62 from its outer surface in the direction of the flux distributor 62 which is between the ferrite core 54 and the permanent magnet 64. This screw provides an alternate

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path for the flux from the north pole of the permanent magnet 64 through the distributor 60 through an air gap between the flux distributor 60 and the adjustable screw 66, through the screw 66, through the flux distributor 62 and back to the south pole of the permanent magnet 64. This alternate path for the flux from the magnet 64 reduces the biasing magnetic field on the ferrite core 54. Since the air gap has a high reluctance and the screw has a low reluctance, the amount of flux shunted away from the ferrite core 54 is determined by the adjustment of the air gap. This provides a convenient means for critically adjusting the biasing field so that it is just sufficient to inhibit the ferrite core 54.

Tapered pole pieces 68 and 70 are each connected to ends of different ones of the flux distributors 60 and 62. They are connected at the opposite ends of the flux distributors from the pole pieces 56 and 58. A shunting device 72, which is the moving element of the transducer that responds to a mechanical force that is to be converted to electrical output, is capable of being moved across the narrow ends of the tapered pole pieces 68 and 70 to provide an alternate path for flux from the magnet 64. A shunt 74 may, in the alternative, be moved across the other ends of the flux distributors 60 and 62 nearer to the ferrite core 54 to provide this alternative flux path. The low reluctance path provided by either of these shunts reduces the field from the permanent magnet 64 which links the ferrite core 54 so that the ferrite core 54 is no longer inhibited.

In FIG. 7 a top view of the transducer of FIG. 6 is shown including two cores and only one shunt 72 operating on the preferred end of the flux distributors. The bar magnet 64 has the flux distributor 60 positioned on its north pole and the flux distributor 76 positioned in a spaced-apart parallel location on the same pole of the permanent magnet 64. The bottom flux distributors are not shown in this view. Similarly the top pole piece 68 has a top pole piece 78 positioned parallel to it but on the flux distributor 76. A ferrite core 80 with its accompanying pole pieces and an adjustable screw 82 are shown under the flux distributor 76 positioned in a manner corresponding to the ferrite core 54 and the adjustable screw 66 under the flux distributor 60. This view illustrates the use of two transducers sharing a common magnet.

It can be seen that the ferrite cores 54 and 80 are aligned to be easily threaded by a common drive wire passing through their centers linking both of them with one turn. As the shunt 72 is moved laterally it may contact the transducer which includes the pole pieces 68 or the transducer which includes the pole piece 78 so as to provide an output signal indicating the position of the shunt. Of course, additional transducing elements may also share the same permanent magnet to provide a larger array of transducers at a lower cost than would be possible if each transducer had an individual permanent magnet.

In FIG. 8 a block diagram is shown which illustrates the manner in which the transducer of this invention is used in the keyboard of a business machine. An operator of the business machine, indicated by the block 84, depresses keys in the keyboard 86 which actuates individual transducers and their associated encoding apparatus 88 to provide output signals to the central processing unit 90 of the business machine. These signals identify the keys that have been depressed. The transducer and encoding apparatus 88 may be combined in various ways. Each key may actuate a different transducer which provides signals to an electrical encoding apparatus such as a diode matrix to obtain coded signals for the central processing unit. On the other hand the keyboard may be connected to a mechanical encoder which selects a plurality of transducers which in turn

provide the coded output. The key buttons of the keyboard may include letters as in a typewriter, numbers as in a calculator and control signs.

In FIG. 9 a partial perspective view of a mechanical encoding apparatus is shown including a transducer according to this invention. A key button is selected and pressed causing the key lever 92 to pivot. The key lever 92 is linked to a key lever 94 which pivots about the pin 96 depressing the interposer 98. The interposer 98 moves downward so that projections 100 located along the length of its bottom side, are inserted between code bails 102 representing in mechanical fashion the desired output code corresponding to the key lever 92. The key lever 92 also actuates the bail interlock mechanism (not shown) to prevent other keys from moving. The interposer 98 is driven forward pushing the code bails which have been selected by the projections 100. The code bails are each connected to a shunting device such as shown as 104.

The shunting device 104 is pivoted about a pin 106 to move from a position beneath the ferrite core 108 and the permanent magnet 110 to a position directly between the core 108 and the permanent magnet 110. A driver 112 continuously provides alternating current pulses to the core 108. When the shunt 104 is moved between the core 108 and the permanent magnet 110 in response to the pushing of the key lever 92 an output signal is provided to the output terminals 114 by the core 108. This happens because the inhibiting field from the magnet 110 is shielded from the core 108 by the shunt 104.

Each of the selected code bails 102 is connected to a separate transducer so as to cause an individual output pulse. The combined output pulses from the depression of the selected key lever 92 results in a binary output code which is characteristic only of the key lever 92. This binary output code is used by the central processing unit in a manner known to the art for storage or for the printing out of an individual character.

It can be seen that the transducer of this invention is inexpensive and reliable. It does not require that the shunting element be in frictional contact with the core. The core itself and the permanent magnet are inexpensive and durable. The use of the core with square loop characteristics provides the desired high-amplitude, short-duration output pulse.

Of course many modifications and variations of the invention are possible in the light of the above teachings.

What is claimed is:

1. A transducer comprising:

- a ferrite core having an input winding adapted to be electrically connected to a source of alternating current and having an output winding;
- a first pole piece having an arcuate surface adjacent to one portion of said ferrite core and having a second flat surface;
- a second pole piece having an arcuate surface adjacent to another portion of said ferrite core and having a second flat surface;
- a first elongated flux distributor having a flat surface one portion of which is adjacent to said flat surface of said first pole piece;
- a second elongated flux distributor having a flat surface one end of which is adjacent to said flat surface of said second pole piece;
- a permanent magnet having one pole adjacent to a second portion of said flat surface of said first flux distributor and having its other pole adjacent to a second portion of said flat surface of said second flux distributor, whereby said ferrite core, said first and second pole pieces, said first and second flux distributors and said permanent magnet form a continuous loop through which flux may flow from one pole to another pole of said permanent magnet;
- a screw of low-reluctance material threaded through said second flux distributor in a direction toward

said first flux distributor so as to form an adjustable alternate path for flux from one pole of said permanent magnet to the other, which path includes an adjustable air gap; and

movable shunting means for forming an additional path for flux between one pole and another of said permanent magnet in response to a mechanical force, whereby an electrical output is obtained from said output winding of said ferrite core in response to said mechanical force.

2. A keyboard comprising:

- a key button adapted to be selected and pressed by an operator;
- a plurality of toroidal ferrite cores each having a square loop hysteresis and having an input winding adapted to be connected to a source of alternating current sufficient to drive said ferrite core from one saturation state to the other and having an output winding adapted to provide electrical signals;
- a key lever mechanically connected to said key button and pinned so as to pivot when said key button is pressed;
- an elongated interposer having selected projections along one side perpendicular to its longitudinal axis; said interposer being mechanically connected to said key lever and being pinned at one end so as to be moved in the direction of said projections when said key button is pressed;
- a plurality of code bails positioned in juxtaposition with and perpendicular to said interposer such that said projections pass between said code bails when said key button is pressed pivoting said interposer; driving means for driving said interposer in a direction parallel to said longitudinal axis when said key button is pressed;
- a plurality of permanent magnets each placed in juxtaposition with a different one of said plurality of ferrite cores so that each of said ferrite cores is inhibited by the magnetic field from one of said permanent magnets; and
- a plurality of shields each being operatively connected to a different one of said plurality of code bails and each being positioned so as to pivot between a different one of said pairs of ferrite cores and permanent magnets when said code bails are driven by said interposer, whereby said ferrite cores provide output currents through said output windings indicative of said selected and pressed key button.

3. A transducer comprising:

- a toroidally shaped magnetic core having a square-loop hysteresis characteristic;
- means inductively coupled to said core and operable to switch the core from one magnetic saturation level to the other saturation level;
- a first elongated flux distributor having one side in juxtaposition with said core;
- a permanent magnet having one pole in juxtaposition with another side of said first flux distributor;
- a second elongated flux distributor having a first side in juxtaposition with another portion of said core and having a second side in juxtaposition with the other pole of said permanent magnet;
- the flux of said permanent magnet acting through said first and second flux distributors and sufficiently permeating the core to prevent it from switching; and
- an elongated low reluctance magnetic shunt movable to a position across a common end of said first and second flux distributors to divert sufficient magnetic flux therefrom to permit the core to be switched by said inductively coupled means for producing a sensible change in the core.

4. A keyboard including a plurality of actuatable

key members each adapted to be selected and actuated by an operator;

a plurality of magnetic cores each having similar square-loop hysteresis characteristics and further having winding means adapted to be connected to a source of electrical current sufficient to drive said core from one saturation state to the other and to provide an electrical signal upon such change in state;

an elongated code bar operatively connected to each key member and being movable in response to the actuation of its key member, each code bar having one or more projections along one side thereof extending perpendicular to its longitudinal axis;

a plurality of code bails positioned in juxtaposition to each code bar and perpendicular thereto such that when the code bar is moved its projections move a distinctive combination of one or more of said code bails;

a plurality of permanent magnets each placed in juxtaposition with a different one of said magnetic cores so that the switching capability of each core is inhibited by the magnetic field of the magnet with which it is paired; and

a plurality of magnetic shunts each being operatively connected to a different one of said plurality of code bails and each being mounted and positioned so as to pivot between a different one of said pairs of juxtaposed cores and magnets when said code bails are moved by said code bar, whereby certain of said cores are capable of generating output currents in their respective winding means indicative of a selected and actuated key member when switched from one to the other of said saturation states.

5. A keyboard including a plurality of actuatable key members each adapted to be selected and actuated by an operator;

a plurality of electrical switching elements each having an input and an output and being capable of assuming two operating conditions either providing an electrical signal on its output in response to the reception of an electrical signal on its input or being incapable of such action;

an elongated code bar operatively connected to each key member and being movable in response to the actuation of its key member, each code bar having one or more projections along one side thereof extending perpendicular to its longitudinal axis;

a plurality of code bails positioned in juxtaposition to each code bar and perpendicular thereto such that when the code bar is moved its projections move a distinctive combination of one or more of said code bails;

a plurality of permanent magnets each placed in juxtaposition with a different one of said switching elements so that each switching element is retained in one of its two operating conditions by the magnetic field of the magnet with which it is paired; and

a plurality of magnetic shunts each being operatively connected to a different one of said plurality of code bails and each being mounted and positioned so as to pivot into and out of the space between a different one of said pairs of juxtaposed switching elements and magnets;

the distinctive combination of code bails responding to the actuation of the selected key member being operable to pivot their respective shunts to positions altering the magnetic fields of the juxtaposed magnets so that the switching elements paired therewith assume the other of their operating conditions whereby a coded pattern of electrical signals indicative of the actuated key member can be derived from the outputs of those switching elements which are capable of responding to electrical signals received on their respective inputs.

6. A keyboard including a plurality of actuatable key members each adapted to be selected and actuated by an operator;

a plurality of stationary electrical switching elements each having an input and an output and each being capable of assuming two operating conditions either enabling an electrical signal to be produced on its output in response to the reception of electrical current on its input or being inhibited from doing so;

an elongated code bar operatively associated with each key member and being movable in response to the actuation of its key member, each code bar having one or more projections along one side extending perpendicular to its longitudinal axis;

a plurality of code bails positioned in juxtaposed crosswise relation to each said code bar such that the projections of the code bars move a distinctive set of one or more of said code bails when a selected key member is actuated;

a plurality of stationary permanent magnets each placed in close but spaced apart relation with a different one of said switching elements so that each switching element is retained in one of said operating conditions by the magnetic field of the magnet with which it is paired;

a plurality of magnetic shunts each associated with an individual one of said magnets, each of said shunts being operatively connected to a different one of said plurality of code bails and capable of being swung thereby about an axis into and out of the space between its associated magnet and the switching element with which it is paired;

the distinctive set of code bails responding to the actuation of the selected key members being operable to pivot their respective magnetic shunts to positions altering the magnetic fields of the associated magnets so that the switching elements paired therewith assume the other of said two operating conditions; and means for connecting the inputs of each of said switching elements to a source of electrical energy for providing electrical signals on the outputs of those switching elements in enabling condition whereby a coded pattern of electrical signals indicative of the selected actuated key member can be derived.

7. In keyboard mechanism, a transducer for converting motion of a key member to an electrical signal comprising:

a stationary electrical switching device sensitive to a relatively strong magnetic field and having an input and an output, said switching device being capable of assuming one or the other of two operating conditions either transmitting an electrical current signal on its output in response to the receipt of an electrical current signal on its input or being incapable of so doing;

an elongated code bar operatively associated with a key member of the keyboard and being movable in the direction of its longitudinal dimension in response to the actuation of the key member, said code bar having one or more projections along one side of its longitudinal dimension;

a code bail positioned in juxtaposed crosswise relation to said code bar such that one of the projections of the code bar will engage and move the code bail when the key member is actuated;

a stationary permanent magnet placed sufficiently close to but spaced from said switching device so that its magnetic field is capable of influencing the operation of the switching device;

a magnet shunt operatively associated with said code bail and responding to the movement of the bail by swinging through an arcuate path from one position to another position, in one position the magnetic shunt being disposed in the space between the magnet

and the switching device thereby reducing the effectiveness of the magnetic field of the magnet on the switching device and causing it to assume one of its two operating conditions, and in the other position the magnetic shunt being withdrawn from said space 5 thereby increasing the effectiveness of the magnetic field on the switching device and causing it to assume the other of its two operating conditions; and means for connecting the input of said switching device to a source of electrical energy for providing an 10 electrical signal on the output of the switching device when it is enabled to do so by the position of the magnetic shunt thereby providing an electrical signal indicative of the actuation of the key member.

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J. GLASSMAN, Assistant Examiner

U.S. Cl. X.R.

235—145; 335—205, 301; 340—365