# United States Patent [19]

**Wood**

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[54] **AIR DRIVE KEYBOARD TESTER**


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[52] **U.S. Cl.** ..... **197/19,** 73/37, 137/830, 197/15

[51] **Int. Cl.** ..... **B41j 23/22**

[58] **Field of Search** ..... 73/37, 432 R; 137/608, 602, 612.1, 596.16, 830; 251/61; 197/15, 98, 19; 235/201 PF, 145, 146; 84/423; 46/44; 234/123



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[57] **ABSTRACT**

The invention is a method and apparatus for driving or exercising keys or buttons on a keyboard utilizing a jet of fluid as the driving medium. An improved valve structure utilizing a flexible, perforate diaphragm is used to control the fluid jets and is the operative portion of the apparatus used in the method employed.


**5 Claims, 5 Drawing Figures**

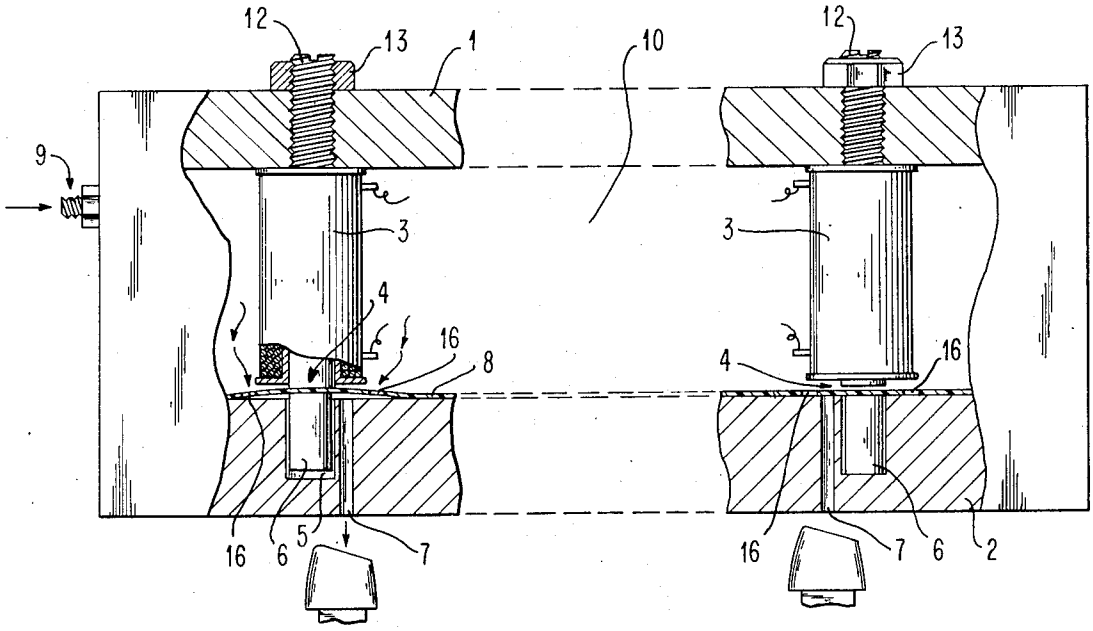


FIG. 1

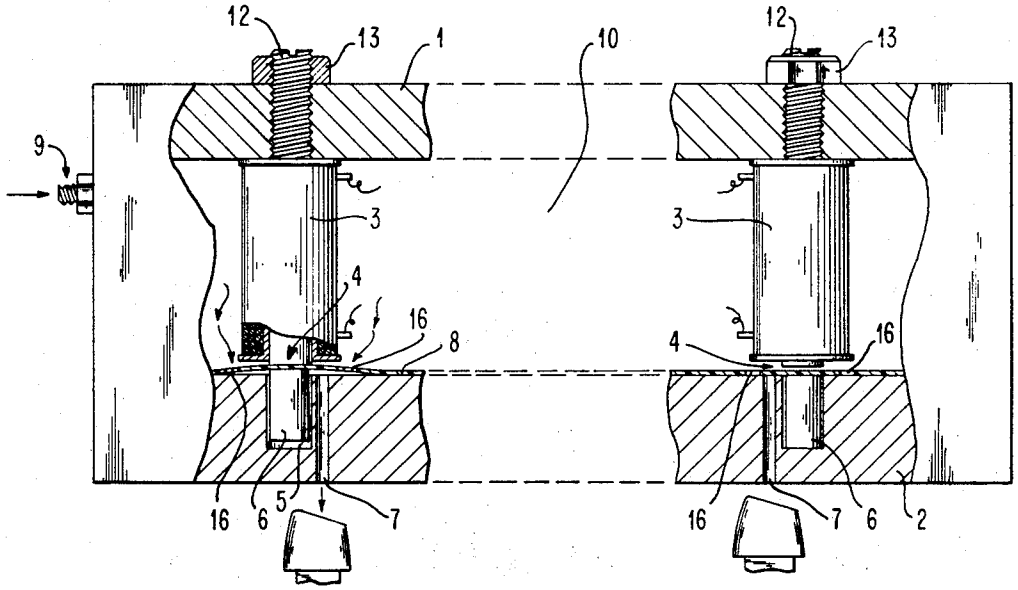
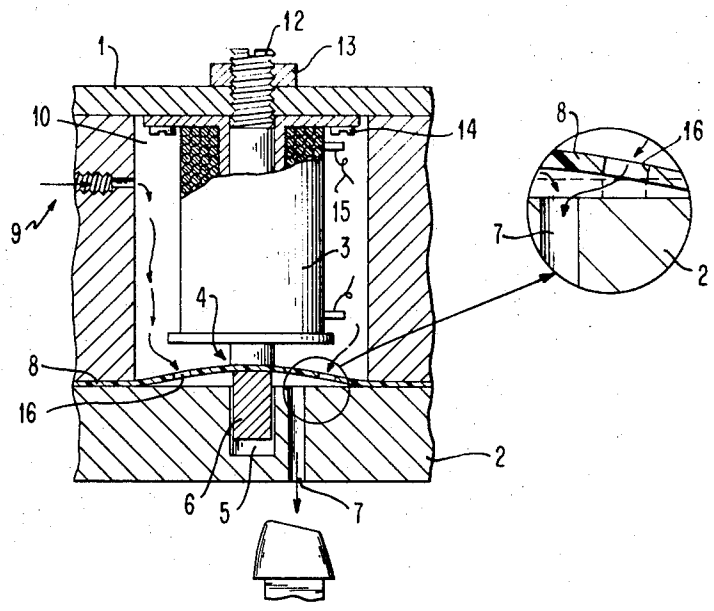



FIG. 2




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FIG. 4

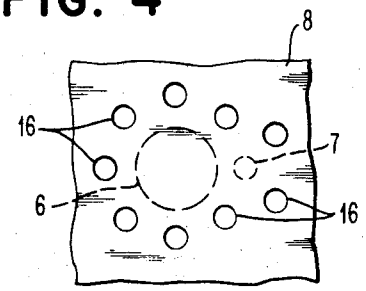



FIG. 3

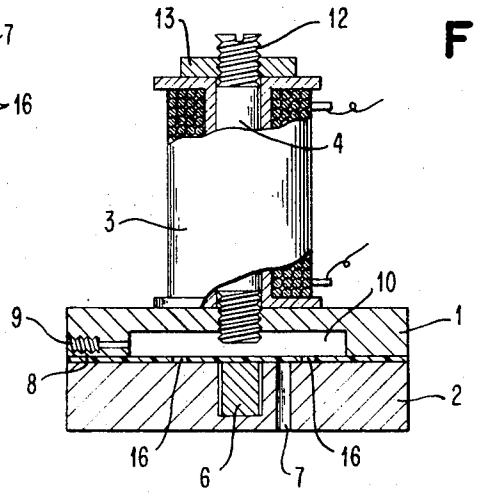
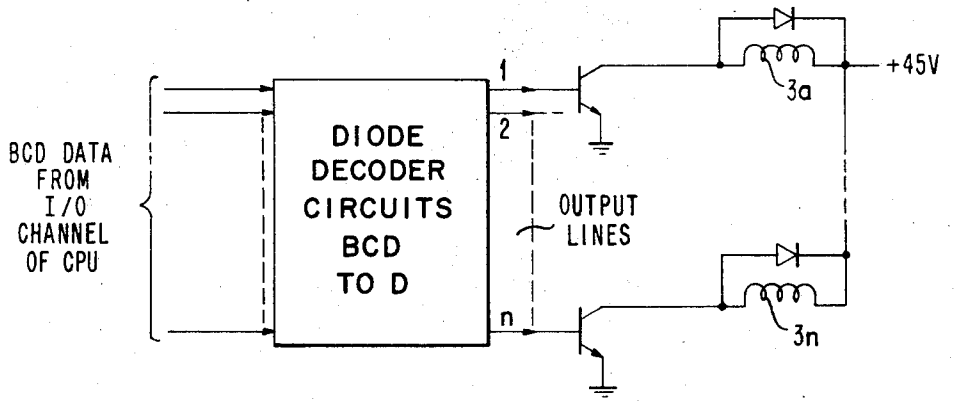



FIG. 5



# AIR DRIVE KEYBOARD TESTER

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to means for actuating keys, buttons, levers and the like by remote control to repetitively and/or sequentially actuate these members in the course of testing them. Alternatively, such a device is useful in adapting a keyboard assembly for automatic operation. More specifically, this invention relates to keyboard adapter or test unit which is utilized to interface between a keyboard and a high-speed data communication device. The invention also finds utility as a method and apparatus for testing assembled keyboards for proper operation by a high-speed repetitive cycling of the keys under test.

2. Prior Art

While prior devices for adapting keyboards for automatic operation have been built, they have mainly relied on electrical devices such as solenoids and plungers to drive the key buttons. These devices, when mounted on slanted and irregularly shaped keyboards, require careful individual adjustment of the various solenoid plunger actuators, both in position and in length of stroke, in order to achieve proper operation of the keys. Such a process with such a device is laborious, time consuming, and is ill-adapted to suit a wide variety of configurations of keyboard and key spacings and exterior design aspects. A recurrent problem in this type of device is the necessity of carefully adjusting the solenoid stroke in order to achieve proper actuation of the keys. Since keytops on an ordinary keyboard, and especially on a slanted keyboard, are not all at the same elevation, laborious hand fitting or special individualized design of the tester or adapter unit for the specific keyboard is required. In today's high-speed automated production environment, such delay in fitting a tester to a keyboard cannot be tolerated. If a keyboard adapter is to be truly versatile, it must be capable of fitting a large variety of shapes and sizes of keyboards without difficult adjustment procedures. The prior art devices have not been this versatile in operation.

A further difficulty with these prior devices is that the numerous solenoids are subject not only to the usual mechanical problems of binding, sticking, etc. which require continuous lubrication and other maintainance, but the mechanical impact of the solenoid plungers on the keytops produces unnecessary and undesirable wear on the mechanical components of the keyboard and of the testing unit. Additionally, it is extremely difficult to produce a consistent force with a varying plunger stroke by using a solenoid, particularly when repetitive, high speed operation is required. Since keys generally require both a uniform stroke and pressure, improper actuation of a key can result in many ways when the inconsistent solenoid and plunger type of exercise unit is utilized.

Finally, the solenoid and plunger type of adapter or tester structure is mechanically complex. Numerous brackets, holders, spacers and other adjusting mechanisms are required for positioning each individual solenoid both vertically and horizontally in order to position the plungers in the proper position above each keytop. This complicated structure, which is a necessity in this type of device, makes the production of such a unit an expensive and time consuming operation. In addition, such complexity invariably leads to lower reliability and life of the unit as a useful entity since one or more of the numerous parts will eventually fail or malfunction. This leads not only to a decreased utility of the unit, but increases the amount of maintainance and supervision required in order to utilize such a unit.



## OBJECTS OF THE INVENTION

In light of the above difficulties and problems in the prior art, it is an object of this invention to improve the means of driving keys on a keyboard with a testing or exercise unit.

It is another object of this invention to simplify the design and structure of the testing or adapter unit to improve the reliability, adaptability, and serviceability of the unit.

It is also an object of this invention to improve the speed capability of exerciser devices.

Still another object of this invention is to eliminate laborious hand fitting and adjustment of the individual key drivers required in the prior art by improving the means of driving the individual keys.

Yet another object of this invention is to improve the utility of the testing unit by making it adaptable to a wide variety of keyboard designs and structures.

It is a further object of this invention to improve over known keyboard test units by making a test unit which is simpler and easier to manufacture.

Finally, it is an object of this invention to improve on keyboard drive and adapter mechanisms by making the individual key drive units easily adjustable to individual force requirements for the various keys.

## SUMMARY OF THE INVENTION

The invention achieves the foregoing and other objects and overcomes the problems inherent in the prior art by utilizing a compressed fluid in a manifold and multiple valve structure. The fluid in the manifold is selectively valved to form numerous individual fluid jets. The fluid jets directly actuate the keys or buttons. An improved and simplified valve structure makes possible individual adjustment of fluid flow to vary the force applied to each key without any mechanical repositioning of the test unit. The valve structure utilizes a thin, flexible diaphragm which can be moved quickly and at high speed to achieve high speed repetitive operation.

## DRAWINGS

FIG. 1 illustrates a sectional view of a preferred embodiment of the apparatus utilized in this invention.

FIG. 2 illustrates a single valve of the type depicted in FIG. 1 as it would appear when actuated.

FIG. 3 illustrates an alternate embodiment of the invention.

FIG. 4 illustrates a preferred plan of perforations in the diaphragm surrounding each slug and outlet.

FIG. 5 illustrates a schematic wiring diagram for a preferred embodiment of the invention as shown in FIG. 1.

As shown in the drawing, the preferred embodiment of the apparatus utilized in this invention consists of a simplified manifold and multiple valve assembly. As shown in FIG. 1, the manifold, or main body, consists of a first body portion 1 which forms the upper half of the valve manifold structure. Body portion 1 serves as a base for mounting the numerous solenoid coils 3. It also serves as a base for a mounting and adjusting means for solenoid cores 4. A second body portion 2

contains numerous recesses 5 for containing magnetic slug means 6 and outlets 7. Body portion 2 also serves, in combination with body portion 1, to clamp the edges of flexible, perforate diaphragm means 8 at its extremities to hold it firmly in position.

Inlet means 9 for admitting pressurized fluid to the cavity 10 formed in body portion 1 is shown at the left of FIGS. 1, 2, and 3.

As shown in FIGS. 1, 2, and 3, magnetic slug means 6 consists of a cylindrical piece of soft iron which is positioned in bore 5 in body portion 2 in a freely slideable dimensional fit. While it is not shown in the figures, slug means 6 is provided with a 0.020 inch radius on the end which contacts diaphragm means 8 so that it will not cut, chaffe, or otherwise unduly wear diaphragm 8. Fluid pressure in cavity 10 formed in body portion 1 forces perforate diaphragm means 8 against the surface of body portion 2 and seals the perforations 16 against said surface. However, special raised sealing projections or surfaces could be formed on body portion 2's contact surface where it meets the diaphragm means, if desired.

As shown in the Figures, magnetic slug means 6 is in contact with the lower surface of perforate diaphragm means 8. Furthermore, as is clear in FIGS. 1 through 3, solenoid core means 4 is spaced slightly above diaphragm means 8 and directly opposite the position which is occupied by magnetic slug means 6. The gap separating the perforate diaphragm means and core means 4 may be regulated by screw thread mount and lock nut 12 and 13 as illustrated. Mounting means 14 holds solenoid 3 in position and leads 15 are selectively supplied with electric current by, for example, the circuit shown in FIG. 4.

When a given solenoid has electric current flowing in its windings, solenoid core 4 will be magnetized and will attract magnetic slug 6 which will deflect perforate diaphragm means 8 as shown in FIG. 2 and its magnified view. As shown, only the area immediately overlying magnetic slug means 6 and nearby adjacent portions of perforate diaphragm means 8 are deflected. This permits fluid in cavity means 10 to escape through the perforations 16 surrounding the area of slug means 6 and outlet means 7 in body portion 2 which forms a jet of fluid utilized to drive the key as shown in FIGS. 1 and 2. The volume of fluid exiting from outlet means 7 can be easily adjusted by adjusting the gap between core means 4 and perforate diaphragm means 8. This is done by regulating the position of core 4, since the displacement produced by the magnetic attraction of slug means 6 against perforate diaphragm means 8 is thereby regulated and the free apertures exposed in the perforations of diaphragm means 8 are therefore also adjusted. This makes individual regulation of the force produced on the keytops a simple matter requiring few tools, little effort, and virtually no laborious readjustment.

As shown in FIG. 5, a typical means for operating the various solenoids 3 is an electrical gating system which includes a digital computer (CPU) which is programmed as desired to send binary coded decimal (BCD) electrical signals through its input-output (I/O) channel to a normal diode decoding matrix. This matrix arrangement, and other types of electronic signal decoding devices, e.g., transistorized logical decoders, is well-known to those of skill in the art. It converts the BCD signals into decimal signals which appear sequentially as received on individual ones of the outputs of the matrix. The converted decimal signals are used, for example, as gating signals to drive the base of a transistor to turn it on and, through it, to operate the particular solenoid with which it is connected.

Another typical means for actuating the various solenoids in a sequence is an electrical stepper switch or rotary contactor of the type well-known in the art which connects a source of electricity sequentially to a series of outputs which may be connected to solenoids as desired. This alternative is felt to be so clear and obvious that further explanation and description of it is unnecessary, and no illustration of such a device is provided.

The perforate diaphragm means shown in the figures consists of a sheet of flexible plastic, such as a polyester or polyimide, but could just as easily be formed of flexible non-magnetic metal, rubber, or the like. The pattern of perforations surrounding the position of each magnetic slug means is chosen to seal the perforations against second body portion 2 when the diaphragm is undeflected and yet near enough to the slug means and outlet means to prevent the escape of fluid to outlets other than the one adjacent said slug.

As shown in FIG. 4, the pattern of perforations 16 on diaphragm 8 is chosen to surround the position occupied by slug means 6 and outlet means 7 in relatively close proximity thereto, but with no perforations being aligned with outlet means 7. The relative positions of slug 6 and outlet 7 are indicated in dashed lines in this figure because, in the view shown, these elements lie below diaphragm 8.

In the preferred embodiment, these repetitive perforation patterns are formed by a standard photo-etching process to save labor and to assure the elimination of burrs, etc. which could be formed by mechanical punching of the perforations and which would then require a separate step of removal of burrs.

If only a single outlet means and slug were utilized, i.e., if only a single valve for the actuation of a single button were desired, the only requirement would be that perforations 16 in diaphragm means 8 should be close enough to the position occupied by slug means 6 to be freed from sealing relationship with the body portion upon actuation of the solenoid. To prevent leakage, it is, of course, obvious that the perforations in diaphragm 8 must not align with any of the exit means or outlets 7 when the diaphragm is in its undeflected position. If numerous solenoids and valve structures are required within the same manifold, internal ribs or bosses could be added to either body portion 1 and/or body portion 2 to further seal the perforate diaphragm means 8 against body portion 2 in the area surrounding each solenoid. This, however, has been found to be unnecessary when the perforation pattern illustrated is utilized. Slug-to-slug (and outlet) spacings of approximately three-fourths of an inch are easily attainable and little or no leakage out the unactuated outlets is experienced. In fact, if fluid pressures of approximately 30 psig are employed, even closer outlet spacings can be achieved and ⅜ inch spacings are easily attainable. The lower limit on such spacing is controlled by the size of the solenoids and the thickness of the diaphragm which must be deflected and by fluid pressure which dictates diaphragm thickness.

For purposes of testing a keyboard assembly, electronic selection switches are utilized to apply current to the solenoids. The source of electrical current regu-

lated thereby can be applied sequentially and selectively to chosen solenoids for high speed repetitive operation of the valve assembly to drive the independent keys or buttons. Operative repetition rates are primarily limited by the operating characteristics of the keyboard keys, but the valve apparatus is capable of repetitive operation at speeds in excess of 45 operations per second. However, if it is desired to utilize the apparatus as a keyboard adapter for deriving meaningful data from the keyboard, such as by driving a typewriter to print a meaningful message, the individual solenoids may be driven by a data communication device and automatic selection or decoding circuits known in the art. (These do not form a part of this invention and thus are not shown.)

Because the volume of fluid exiting from the various outlet means **7** upon actuation of the independent solenoid means can be easily regulated, the distance between the outlet means and the keytop to be driven is not crucial. In operation, a driving force of approximately 200 grams has been achieved at separations of 1 to 2 inches. This has been with outlets of 0.100 inch diameter for the jets and using compressed air as a driving fluid at a pressure of approximately 65 psig within the manifold. Significantly, this means that quick and effective positioning of the adapter or test unit over a variety of keyboards, even the slanted or variously configured ones, can be quickly effected without laborious adjustment since no mechanical contact between the tester and the keyboard is necessary.

In order to utilize the apparatus of this invention, it is only necessary to position the tester unit above a keyboard to be driven. Telescoping mount arms, pivoting arms, and a variety of clamps and overhead external mounting means may be utilized to hold the tester or adapter unit in proper location an inch or so above the keyboard. A center-to-center spacing of approximately three-fourths of an inch is generally utilized in the keyboard art for manual keyboards, however, slight variations in center-to-center distance of keys may be easily accommodated since the narrow jet of fluid exiting from the outlet means is effective whether it strikes a keytop in the center thereof or on any portion of it. Adjacent keys are not actuated by a jet which is slightly off-center. All that is required is that mechanical positioning of the device be sufficiently accurate to assure that each jet hits at least some portion of the keytop which is desired to be operated.

## MODE OF OPERATION

The method of this invention is clear from the Figures. All that is necessary is that a jet of fluid impinge on a keytop with sufficient force to actuate the key. This force is regulated by the volume and velocity of fluid striking the keytop. Fluid is supplied by some suitable source such as the preferred embodiment of apparatus shown in the drawings. Assuming that it is desired to actuate a given key utilizing the apparatus of this invention, it is only necessary to apply a current to the solenoid positioned above that key. Energization of a given solenoid **3** results in magnetization of solenoid core **4** and the attraction of freely movable slug means **6** towards core **4**. This results in the deflection of perforate diaphragm means **8** by the movement of slug means **6**. This, in turn, permits fluid held confined in cavity means **10** to exit via outlet means **7** forming a jet which impinges on the desired keytop. As previously explained, the volume and velocity of the jet of fluid regulates the amount of force applied to the keytop. The volume may be regulated by adjusting the position of solenoid core **4** above perforate member **8**. The velocity of exiting fluid is also regulated by the design of the outlet means **7** and by the pressure of fluid within the cavity. In practical application, it has been found that air at a pressure of 30 psig is perfectly satisfactory to provide a jet which will actuate keys requiring a force of up to 75 grams. Operation of such a device has been easily achieved under such conditions at a distance of 1.0 to 1.5 inches separation between the outlet means and the keytop using an outlet size of 0.100 inches diameter and a polyimide diaphragm 0.005 inches thick.

While the invention has been illustrated and explained with reference to a preferred embodiment thereof, numerous modifications thereof will be apparent to those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

**1.** A method of exercising individual keys on a keyboard, comprising:
- positioning, over each of said keys, an individually actuable means for directing a jet of gas against said keys;
- pressurizing each said directing means with a source of compressed gas;
- actuating said directing means associated with said key to be exercised; and
- impacting said key with a kinetic jet of gas from said directing means, thereby exercising said key.

**2.** The method as described in claim **1**, further comprising the step of:
- actuating said directing means individually and selectively to produce a sequence of outputs from said keyboard.

**3.** Apparatus for exercising keys on a keyboard by directing jets of fluid against them, comprising:
- a body;
- said body being divided into first and second body portions;
- cavity means defined by said first and second body portions for confining fluid under pressure therein;
- inlet means for admitting pressurized fluid to said cavity means;
- a plurality of output means for passing fluid from said cavity through said second body portion to the outside of said body;
- a flexible, perforate diaphragm means in said cavity means and separating said first and second body portions;
- said perforate diaphragm means contacting a surface carried on said second body portion to close said perforations under the urging of said pressurized fluid in said cavity to confine said fluid in said cavity means;
- a plurality of individually movable magnetic slug means for contacting the side of said diaphragm means which is in contact with said surface carried by said second body portion;
- said slug means each being located adjacent to an individual one of said outlet means;
- a plurality of individually actuable magnet means for magnetically attracting said slug means;
- said magnet means being located on said first body portion and spaced from the surface of said dia-

phragm means and opposite the location of said diaphragm means behind which said magnetic slug means reside; and

means for selectively magnetizing said magnet means to attract said slug means opposite therefrom, , whereby said slug means is magnetically attracted and moved toward said magnet means and into contact with said flexible diaphragm means to deflect a portion of said diaphragm means out of contact with said surface carried by said second body portion whereby fluid in said cavity means of said first body portion is permitted to pass through said perforations in said diaphragm means which are nearest to said slug means and from there through said outlet means in proximity with said slug means and out of said body to kinetically impact said keys to exercise them.

**4.** Apparatus as described in claim **3,** wherein:

said fluid is a gas;

said magnet means comprises a plurality of individually wound solenoids having adjustable position magnetizable cores therein; and

said means for selectively magnetizing said solenoids comprises an electrical gating means for directing current to selected solenoids.

**5.** Apparatus as described in claim **4,** wherein:

said gas is air;

said electrical gating means comprises a means for sequentially generating coded solenoid drive signals;

decoder means for converting said signals into signals at unique individual outputs thereof;

said generating means being connected to said decoder means;

individual electrical gate means for directing drive signals to solenoids; and

said decoder means having said outputs connected to said individual electrical gates to drive said solenoids.

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