

July 7, 1970

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3,519,009

FLUIDIC-ELECTRO TRANSDUCER

Filed Sept. 10, 1968

2 Sheets-Sheet 1

FIG. 1

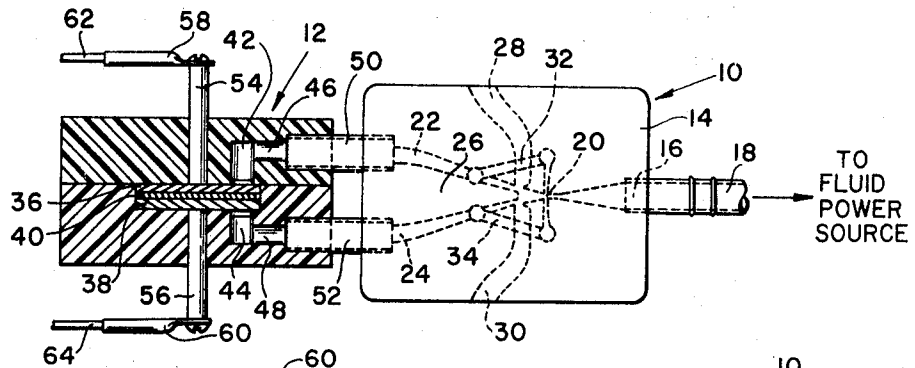
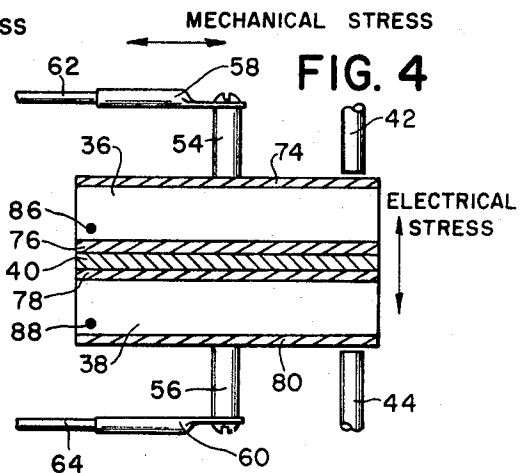
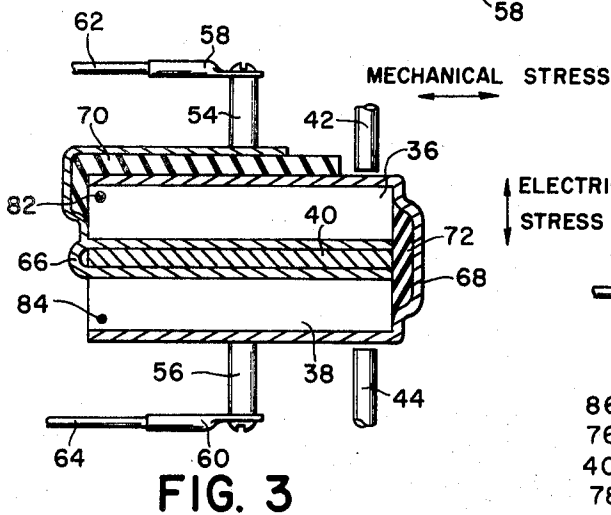
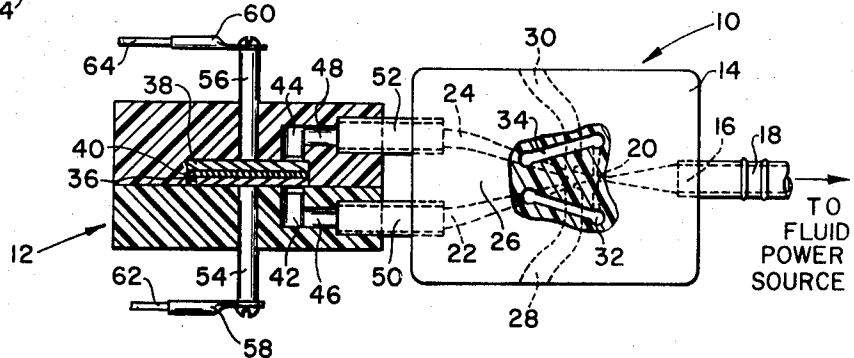


FIG. 2



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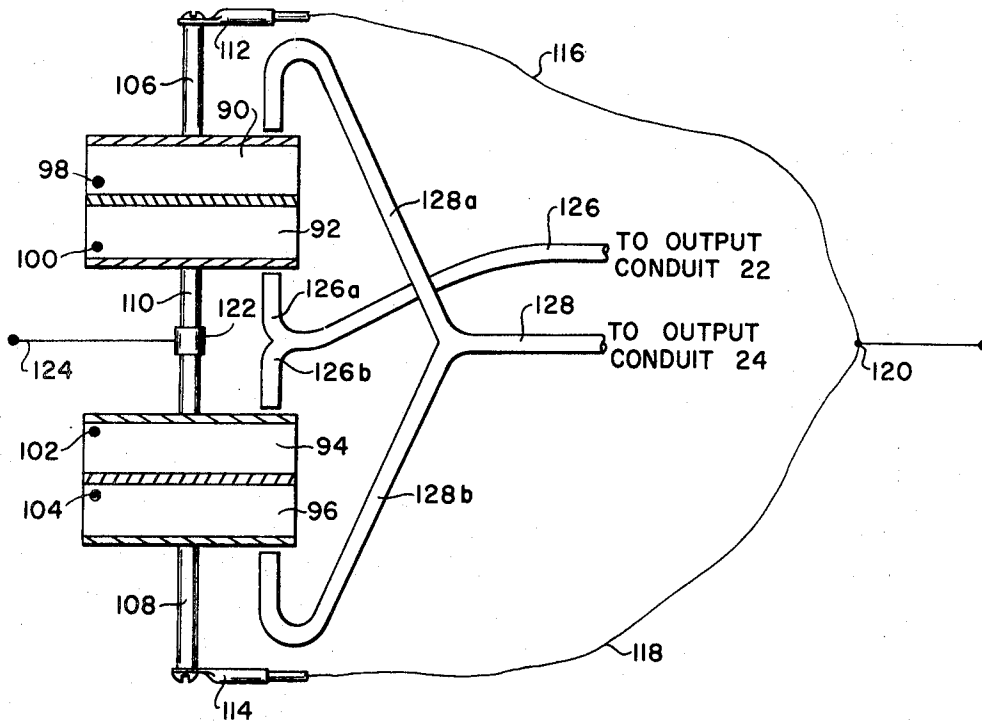


FIG. 5

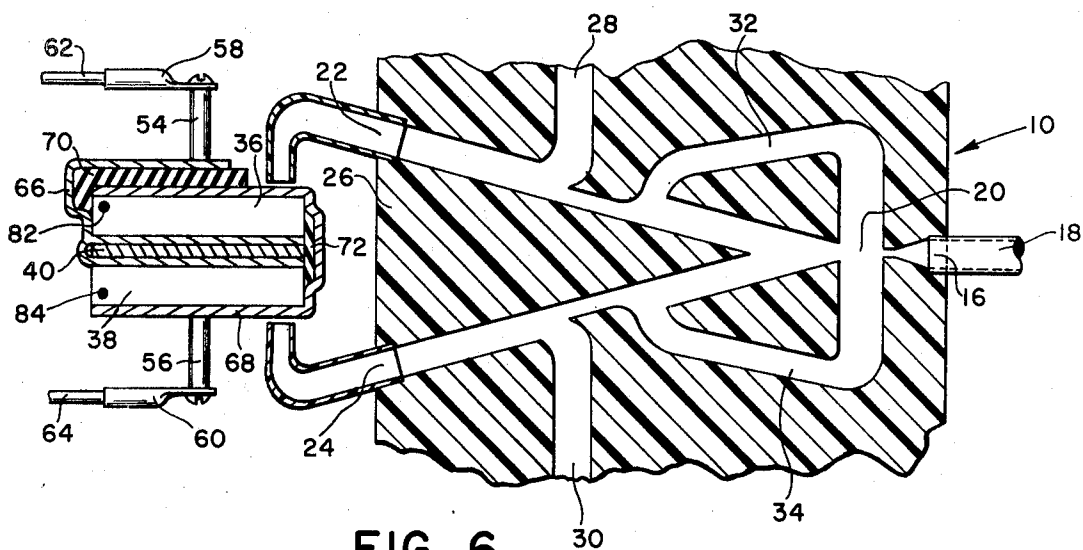


FIG. 6

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FLUIDIC-ELECTRO TRANSDUCER

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10 Claims

ABSTRACT OF THE DISCLOSURE

This disclosure relates to a fluidic-electro transducer utilizing a fluid digital-output element of the wall attachment type, having feed back paths from the outputs back to the control inputs respectively, so as to produce alternating fluid jet stream outputs. The dynamically changing fluid output pressures are applied alternately to a plurality of flexural-piezoelectric elements, stressing them by virtue of the pressure differential created, thereby generating electrical energy which may be usefully recovered by suitable electrical terminals positioned along the electrical axes of the elements.

The plurality of flexural-piezoelectric elements may be connected either in series, or in parallel, or a combination of both serial and parallel connections.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a fluidic-electro transducer, and more specifically to a fluidic-electro generator for deriving electrical energy using a fluidic source as a prime mover.

Description of the prior art

There is a perennial requirement for electrical energy sources that are readily available and provide trouble free operation over extremes of temperature, humidity, atmospheric contamination, acceleration, shock and vibration.

The instant invention proposes to satiate these exacting and variegated demands by producing a fluidic-electro generator for deriving electrical energy from flexural-piezoelectric elements using a fluidic source as a prime mover.

The use of piezoelectric crystals in conjunction with fluidic digital devices is broadly known in the art. For example, U.S. Pat. 3,269,419 to Dexter discloses fluid amplifiers using a piezoelectric crystal, electrically excited and physically embedded in one wall of the amplifier to enable bistable switching. Here, the piezoelectric crystal is employed as a control element; there has been no teaching in the art to utilize piezoelectric elements for power generation.

SUMMARY OF THE INVENTION

This invention relates to fluidic-electro transducer means. A fluid amplifier means of the wall attachment type, comprising a power inlet, two control inputs, two output conduits and an interaction region, is connected as a self-sustaining oscillator by fluidic feed back paths connected between the control inputs and outputs respectively. The alternating fluidic pressure outputs are connected to provide force along the mechanical axes of a plurality of flexural-piezoelectric elements (which may be ceramic disks or Curie strips), and the electrical output is taken from the respective electrical axes, the elements being electrically connected in series or parallel or combinations thereof.

Accordingly, it is an object of this invention to provide a fluidic electro transducer means in which electrical

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energy from flexural-piezoelectric elements is generated from any pressurized fluid available.

Another object of this invention is to provide an electric generator which will operate successfully over extreme environmental changes, such as temperature, humidity, atmospheric contamination, acceleration, and mechanical shock and vibration.

The novel features of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation together with objects and advantages thereof may best be understood by reference to the description to follow considered in connection with the accompanying drawings.

Brief description of the drawings

FIG. 1 is a schematic view, partially in section, of a top view of the fluidic-electro transducer means in accordance with the invention;

FIG. 2 is a schematic view, partially in section, of a bottom view, of the fluidic-electro transducer means in accordance with the invention;

FIG. 3 is a schematic cross sectional view showing the arrangement for connecting flexural-piezoelectric elements in parallel;

FIG. 4 is a schematic cross sectional view showing the arrangement for connecting the flexural-piezoelectric elements in series;

FIG. 5 is a schematic cross sectional view showing the arrangement for connecting the flexural-piezoelectric elements in series parallel combination; and

FIG. 6 is a schematic diagram of the fluidic-electro transducer means, utilized in explaining the operation of the device.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. 1 and 2, the fluidic-electro transducer in accordance with the invention, comprises a bistable element indicated generally at 10, and a housing indicated generally at 12. The bistable element 10 includes an epoxy or other plastic housing 14, internally recessed to provide a plurality of fluidic passages. The housing 14 is provided with a power nozzle at 16 to which is suitably connected a plastic or other flexible tubing 18 which is connected to a fluid power source (not shown). The power nozzle 16 presents a gradually tapered or restricted opening which terminates in an interaction region indicated at 20, from whence it branches into output conduits 22, 24. A splitter is indicated at 26, and bleeds or vents are indicated at 28, 30. Feed back loops or paths, identified at 32, 34, convey a portion of the fluid stream in output conduits 22, 24 back to the interaction region 20.

The housing 12 may include a plurality of flexural-piezoelectric elements, supported in a plastic medium, and here for convenience illustrated only by means of two piezoelectric ceramic disks 36, 38, forming a sandwich with a plate 40, and having their electrical axes properly oriented with respect to their mechanical axes so as to realize a useful electrical output. The elements 36, 38 are polycrystalline ceramic disks polarized by the manufacturer by being electrically stressed in the vicinity of the Curie temperature. Additionally the elements 36, 38 may be Curie strips selected from piezoelectric crystals. The plate 40 is conductive, (although conductivity is optional) and may be selected from: copper, phosphor bronze, beryllium bronze etc.

The housing 12, also includes fluid pressure conduits 42, 44 which are cast in the plastic and adapted to convey fluid pressure directly to the surface of the flexural-piezoelectric elements 36, 38 respectively. The conduits 42, 44 make fluid connection with passageways 46, 48,

the latter being connected with output conduits 22, 24 by any other convenient means such as flexible tubing 50, 52.

Terminals 54, 56 are adapted to make electrical contact in the direction of the electrical axes of the piezoelectric disks, 36, 38 respectively as shown. The terminals 54, 56 are provided with connectors indicated at 58 and 60 to which are secured electrical output wires 62, 64 respectively.

The flexural-piezoelectric elements may be connected in series or in parallel or in combinations of both. As shown in FIG. 3 the ceramic disks 36, 38 are connected in parallel by means of conductive straps 66 and 68 as shown. The conductive straps 66, 68 are separated from the piezoelectric elements 36, 38 by means of insulating materials 70, 72, as shown. The conductive strap 66 in the parallel connection of FIG. 3, may be conveniently fabricated as a separate strip or by deposition. Similarly, conductive strip 68 may be a separate strip or may be arranged by deposition techniques. The insulating material 68, 70 may be silicon monoxide laid on by means of vacuum deposition.

In FIG. 4 the piezoelectric ceramic disks 36, 38 are connected in series by means of a plurality of conductors 74, 76, 78 and 80 connected as shown.

In both the configurations FIG. 3 and FIG. 4, the dots 82, 84, 86, 88 indicate the direction of (+) positive polarization identified by the manufacturer. Care must be taken in assembling the disks 36, 38 to properly orient the markings 82-88 to produce the desired electrical effect.

In FIG. 5, four disks 90, 92, 94 and 96 are connected in series-parallel combination. The polarity to be observed is indicated by the dot markings at 98, 100, 102 and 104. Terminals 106, 108 are electrically connected to disks 90 and 96 respectively, while terminal 110 is electrically common with disks 92 and 94 observing the orientation dictated by the dot markings 100 and 102. Terminals 106 and 108 are connected by connectors 112, 114 to wires 116, 118 respectively which are electrically joined at 120. Terminal 110 is connected by means of connector 122 to wire 124. Fluidic pressure is applied to the flexural-piezoelectric elements by means of flexible tubing 126, 128 connected to conduits 22 and 24 respectively of the bistable element 10. The tubing 126 is forked to provide fluid pressure branch outlets 126a and 126b for applying fluidic pressure to disks 92 and 94, respectively. Similarly tubing 128 is forked to provide fluid pressure branch outlets 128a and 128b for applying fluidic pressure to disks 90 and 96 respectively.

OPERATION OF THE DEVICE

In explaining the operation of the fluidic-electro transducer, reference will be had to FIG. 6 where the flexural-piezoelectric elements are illustrated in the parallel configuration of FIG. 3; however, it should be understood that the operation is the same and the explanation applies equally where the flexural-piezoelectric elements are electrically arranged in the configurations of FIG. 4 or FIG. 5.

The operation of the bistable element 10 per se is fairly well known in the art. A fluid supply or power stream is introduced by means of tubing 18 and power nozzle 16 to the interaction region 20. The fluid passes through a restricted channel or nozzle which serves to convert a good deal of the stream's potential energy into kinetic energy. The resulting jet stream enters the interaction region at reduced pressure but at high speed. The bistable element 10 is a wall attachment device producing a digital output by the Coanda effect. Normal manufacturing tolerances insure that the jet stream is initially switched so that it is totally attracted to either output conduit 22 or 24, deflection being accomplished by the entrainment properties of the jet stream. Suppose for example the stream is switched to output conduit 24, then a part of this pressurized output will be conveyed by feed back passage 34 back to the interaction region 20,

causing the fluid stream to be switched to output conduit 22. Again part of the pressurized output is conveyed from output conduit 22 by means of feed back 32 back to the interaction region 20, causing switching of the fluid stream back to output conduit 24. The result is that fluidic oscillator action is obtained, and the fluid stream alternately switches between output conduits 22 and 24. The fluidic pressure in the output conduits 22, 24 is then conveyed by means of the passages 46, 48 and the conduits 42, 44 alternately to the surfaces of ceramic disks 36, 38. The disks 36, 38 are therefore subjected to pressure on the mechanical axes which results in an electrical potential output along the electrical axes. The flexure of a ceramic disk in the direction of its mechanical axis places each surface alternately under compressive and tensile stress producing thereby electric polarization of opposite polarities. The disks 36, 38 are assembled, properly oriented with respect to the dot markings, so that these electric effects are additive in accordance with voltage and/or current requirements for the particular application. Since the fluidic pressure is alternating, the resulting electrical output wave obtained is an alternating current wave approximating a square wave.

The fundamental frequency of the electrical output depends on the fundamental frequency of the fluidic oscillator provided by the bistable element 10. The fundamental frequency of the oscillator can be changed by shortening or lengthening the feed back path so that the frequency of the electrical output will be increased or decreased respectively.

The electrical A.C. wave is out of phase with the fluidic pressure wave except at the resonant frequency of the flexural-piezoelectric elements.

The vents 28, 30 are utilized down stream of the interaction region 20 to decrease the sensitivity of the elements to loading effects.

It is within the scope of the invention to also use an analog element to provide the fluidic pressures to be applied to the flexural-piezoelectric elements. However, the analog element cannot realize the differential pressures afforded by the full on-full off action of the digital element. Accordingly, the invention has been illustrated and described in the best mode of operation utilizing a digital element to provide the alternating fluidic pressures.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

I claim:

1. A fluidic electro transducer comprising:

- (a) piezoelectric means for producing an electrical potential when subjected to mechanical stress, the polarity of said electric potential depending on the direction of said mechanical stress;
- (b) fluidic oscillator means for providing alternating fluid pressures across said piezoelectric means so as to produce alternately directional stress thereacross, whereby an electrical potential of alternating polarity is produced by said piezoelectric means; and
- (c) electrical output terminals connected across said piezoelectric means for receiving said electrical potential, whereby said alternating electrical potential is delivered to said output terminals.

2. A fluidic electro transducer according to claim 1 in which said piezoelectric means comprises at least one polycrystalline ceramic disk.

3. A fluidic electro transducer according to claim 2 in which there are at least two of said polycrystalline ceramic disks and they are connected electrically in series.

4. A fluidic electro transducer according to claim 2 in which there are at least two of said polycrystalline ceramic disks and they are connected electrically in parallel.

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5. A fluidic electro transducer according to claim 2 in which there are at least two of said polycrystalline ceramic disks and they are connected electrically in series-parallel combination.

6. A fluidic electro transducer according to claim 1 in which said piezoelectric means comprises at least one Curie strip. 5

7. A fluidic electro transducer according to claim 6 in which there are at least two of said Curie strips and they are connected in series.

8. A fluidic electro transducer according to claim 6 in which there are at least two of said Curie strips and they are connected electrically in parallel. 10

9. A fluidic electro transducer according to claim 6 in which there are at least two of said Curie strips and they are connected electrically in series-parallel combination. 15

10. A fluidic electro transducer comprising.

(a) flexural-piezoelectric means having a mechanical axis and an electrical axis for producing an electrical potential along said electrical axis when subjected to 20

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mechanical stress along said mechanical axis, the polarity of said electrical potential depending on the direction of said mechanical stress;

(b) fluidic oscillator means for providing alternating fluid pressures across said flexural-piezoelectric means so as to produce alternately directional stress thereacross; and

(c) electrical output terminals connected across said electrical axis.

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