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Mohr

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[54] **PIEZOELECTRIC LIGHTER WITH IMPACT MECHANISM**

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[51] **Int. Cl.** **F23q 3/00**

[58] **Field of Search** .... 310/8.3, 8.7; 317/81, 96, 317/DIG. 11; 200/67 F; 431/132, 255

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[57] **ABSTRACT**

A piezoelectric igniter with an impact mechanism particularly suitable for lighters. The igniter includes a piezoelectric transducer including a hammer movable toward the transducer. The hammer cooperates with an energy storage spring which is compressible by an actuation member and which is retained in a rest position by one or more magnets.

5 Claims, 6 Drawing Figures

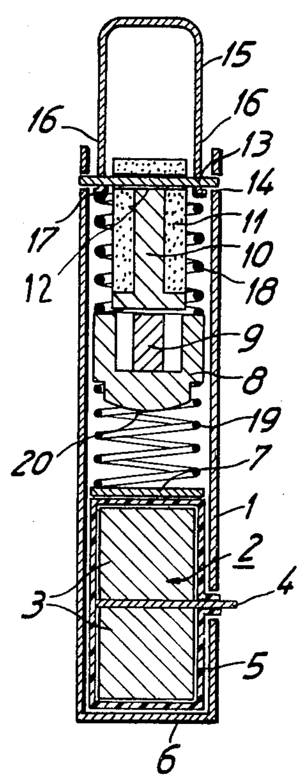

Fig.1

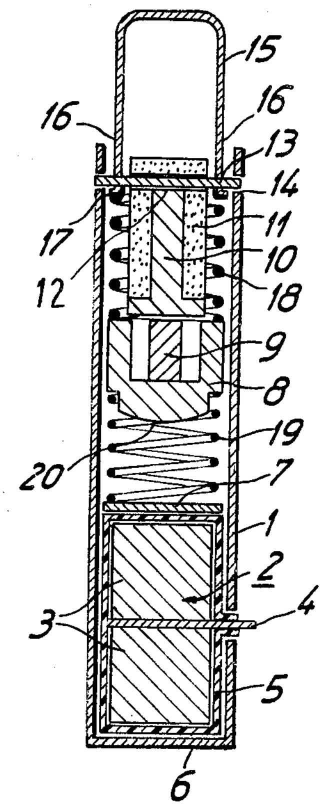

Fig.2

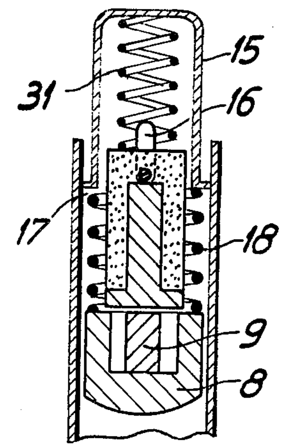

Fig.3

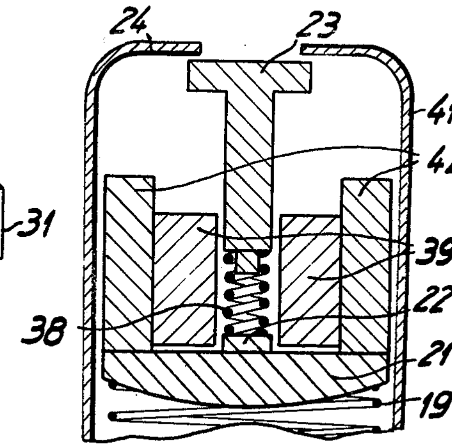

Fig.4

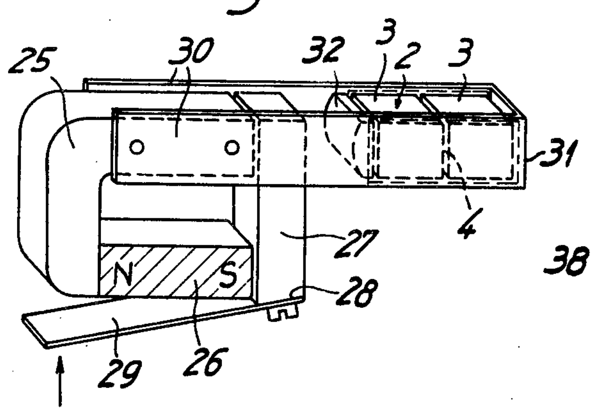

Fig.5

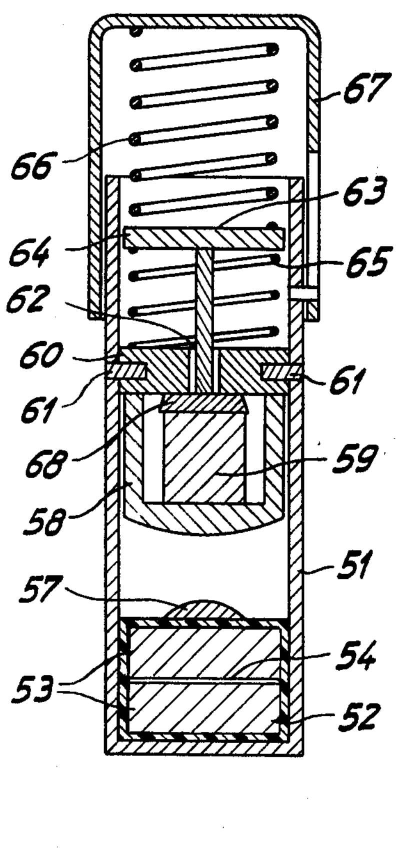
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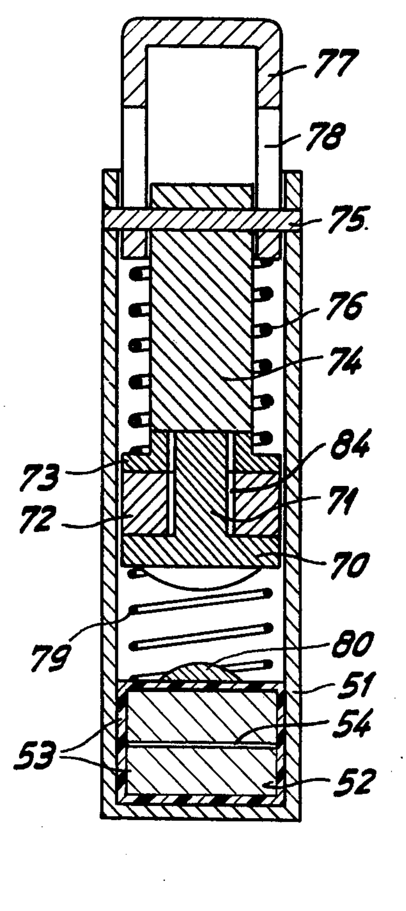
Fig.6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PIEZOELECTRIC LIGHTER WITH IMPACT MECHANISM

BACKGROUND OF THE INVENTION

This invention relates generally to an igniter particularly for lighters and specifically relates to such an igniter including a piezoelectric transducer and an impact mechanism therefor.

Such piezo electric igniters are generally known. They include a fixed permanent magnet to which adheres a hammer consisting of a ferromagnetic material in the rest position of the mechanism. Such a piezoelectric igniter has the drawback that a relatively large magnet must be used in order to generate the necessary holding forces. Furthermore, there is a disadvantage that the hammer after it has been removed from the magnet remains very long in the region of its attraction so that a large portion of the energy stored in the energy storage spring cannot be used for accelerating the hammer but must be used to overcome the attractive force between magnet and hammer.

Piezoelectric igniters for lighters are mass produced articles which cannot be too expensive in manufacture. Permanent magnets, which are presently available in the trade which can be used for this purpose, considering their price, do not generate the necessary holding force.

It is accordingly an object of the invention to provide a piezoelectric igniter of the type discussed herein which does not have the disadvantages of the prior art, which requires a relatively low actuation force and which may be made in a compact form.

SUMMARY OF THE INVENTION

This aim of the invention is solved in that the hammer and the magnet form part of a magnetic circuit closed in the rest position. In this manner it is achieved that a holding force is generated which is high compared to the size of the magnet.

Preferably, a magnetically-conductive member is disposed at both poles of each magnet.

According to a special embodiment, the hammer forms a pot-shaped magnetically-conductive member in which is disposed a magnet. During the rest position of the hammer a fixed magnetically-conductive yoke or frame is disposed adjacent to the open side of the pot-shaped magnetically-conductive member. This construction has the advantage that there is no need to provide an additional heavy metal part for the hammer so that the weight of the piezoelectric igniter is reduced. The pole surface of the magnet adjacent to the magnetically-conductive yoke may carry a magnetically-conductive plate.

The pot-shaped magnetically-conductive member may be guided in a housing which is magnetically non-conductive.

According to a further expansion of the invention means are provided by means of which the fixed magnetically conductive yoke is secured to a bushing. In this manner a simple construction of the piezoelectric igniter is achieved.

In a further extension of the embodiments of the invention the magnet consists of two individual members shaped like a parallelepiped, two sides of which are provided with magnetically conductive plates, the plates being longer than the parallelepiped blocks of the magnet. This unit is secured to a housing. At the lower side of the plates there is provided a disk-shaped hammer, the lower side of which is convex while its upper side carries a guide pivot which may slide in the free space between the magnets.

According to another embodiment the magnetic circuit includes a permanent magnet, a magnetically-conductive member adjacent to the magnet and a magnetically-conductive yoke, the yoke being relatively movable with respect to the other two parts of the magnetic circuit.

The magnetically-conductive member and the permanent magnet may form the hammer.

According to a further embodiment of the invention the magnetically-conductive member and the permanent magnet may be fixed so that the yoke forms the hammer. In this case, however, the yoke must have a sufficiently large mass, but this construction may be relatively easily achieved.

Such an embodiment consists preferably in that the yoke is tiltably arranged with respect to a unit consisting of the magnetically-conductive member and the permanent magnet. Additionally, an energy storage spring may be secured to the yoke.

Preferably, the energy storage spring is arranged as a leaf spring, one end of which is secured to the yoke while the other end operates as an actuation element.

It is advantageous to arrange the elements of the magnetic circuit axially symmetrically with respect to the axis of motion because this avoids the occurrence of forces acting at an angle and preventing canting of the hammer.

A further preferred embodiment includes a permanent magnet and a magnetically-conductive element having an axial opening in which is disposed the energy storage spring and a ram serving as the actuating element.

According to a further extension of the invention, the magnetic circuit includes a shunt circuit including at least one air gap, the magnetic resistance of which is at least three times as large as the magnetic resistance of the closed magnetic circuit.

The shunt circuit may also be formed by an air gap between the magnet and the magnetically-conductive member.

A special embodiment consists in that the hammer is formed by a magnetically-conductive member having a T-shaped cross section. At the side faces of the member there is provided at least one axially polarized magnet.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view of a piezoelectric igniter according to the present invention;

FIG. 2 is a longitudinal sectional view through the upper portion of a modified piezoelectric igniter, the section being rotated through 90° with respect to that of FIG. 1;

FIG. 3 is a longitudinal sectional view on enlarged scale of the upper portion of another embodiment of the piezoelectric igniter of the invention;

FIG. 4 is a side elevational view in perspective of a preferred embodiment of the piezoelectric igniter of the invention;

FIG. 5 is a longitudinal sectional view through another piezoelectric igniter embodying the invention; and

FIG. 6 is a longitudinal sectional view through a modified construction of a piezoelectric igniter.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The piezoelectric igniter illustrated in FIG. 1 includes a cylindrical housing which consists of a material which is magnetically non conductive. In the lower portion of the housing there is provided a piezoelectric transducer 2 hereinafter referred to as a transducer. The transducer includes two piezoelectric crystals 3 between which is disposed a high voltage electrode 4. Within the transducer there is also disposed an impact plate.

The surface of the transducer is surrounded by an insulating layer 5. Its lower surface is disposed adjacent to the bottom 6 of the housing 1. Above the plate 7 there is disposed a pot-shaped magnetically-conductive member 8 in the interior of which is secured a permanent magnet 9 spaced from the side walls of the magnetically-conductive member 8. The pot-shaped magnetically conductive member 8 and the permanent magnet 9 form the hammer of the piezoelectric igniter.

Above the hammer there is disposed a yoke 10 which is magnetically conductive and which is formed as a plate adjacent the hammer and which extends into a pin-shaped extension. The yoke 10 consists of a ferromagnetic material. The lower plate-like region of the yoke 10 covers the upwardly open surface of the pot-shaped magnetically-conductive member 8 and in the rest position rests on the member 8 so that the magnetic circuit is closed consisting of the magnetically-conductive member 8, the permanent magnet 9 and the yoke 10. This means that there is essentially no air gap in the magnetic circuit.

The shaft of the yoke 10 is fixedly connected with a pot-shaped body preferably of a synthetic material or resin 11. The body 11 is provided with a transverse bore 12 in its upper region through which extends a holding pin 13 which in turn extends through openings 14 in the housing 1 and which fixes the yoke 10 and the synthetic resin body 11 with respect to the housing.

Above the yoke there is provided an actuation cap 15 which is provided with at least two diametrically opposite longitudinal apertures 16 which are traversed by the holding pin 13 and which limit the movement of the actuation cap. The lower edge 17 of the actuation cap 15 serves as a support for an energy storage spring 18, the other end of which rests against the pot-shaped magnetically-conductive member 8.

The piezoelectric igniter further includes a return spring 19 which is disposed between the plate 7 and a shoulder-like recess in the bottom of the pot-shaped magnetically-conductive member 8.

Such a piezoelectric igniter operates as follows: When the actuation cap 15 is depressed the energy storage spring is compressed and tensioned so that a force is exerted on the pot-shaped magnetically-conductive member 8. As soon as the reactive force generated in the energy storage spring by means of the actuation cap exceeds the holding force of the hammer consisting of the magnetically-conductive piece 8 and the permanent magnet 9 by the yoke, the hammer suddenly moves away from the yoke and is accelerated by the liberation of the energy stored in the energy storage spring 18 in the direction toward the pivot of the transducer 2. The hammer only has to overcome the attractive force which rapidly decreases with distance from the yoke as well as the force necessary for compressing the return spring 19.

When the head 20 of the magnetically-conductive member 8 impacts the plate of the transducer 2 a short duration pressure is exerted on the transducer whereby a high voltage impulse is generated at the high voltage electrode 4.

This high voltage impulse may, for example, be utilized for generating a spark in a spark gap. The spark in turn may be used for igniting the fuel of an igniter.

When the actuation cap 15 is released the energy storage spring 18 expands into its neutral position. Thereafter, the hammer 8 and 9, the energy storage spring 18 as well as the actuation cap 15, are lifted by the return spring 19 into the rest position where the hammer 8 and 9 is again held by magnetic force against the yoke 10.

FIG. 2 shows a longitudinal sectional view of the piezoelectric igniter of FIG. 1 in a plane rotated through 90° and illustrates a slightly modified embodiment. As shown the return spring 31 is not disposed between the hammer and the transducer but is disposed in the interior space of the actuation cap 15. The actuation cap 15 consists of a ferromagnetic material so that a magnetic shunt circuit is formed by the pot-shaped magnetically-conductive member 8 through the energy storage spring 18 and the actuation cap 15 which is sufficient to lift the hammer 8 and 9 again into its rest position. The energy storage spring 18 is fixedly connected with the magnetically-conductive member 8, for example, by means of one or several pins disposed in a circular recess of the magnetically-conductive member 8. Furthermore, the energy storage spring 18 is fixedly connected at its upper end with the actuation cap 15 in the same or similar manner. Otherwise, the construction corresponds to that illustrated in FIG. 1.

FIG. 3 illustrates the upper part of a further embodiment of a piezoelectric igniter according to the invention. The magnet consists of two individual blocks shaped like a parallelepiped 39 which is surrounded on two sides by plates 42 of magnetically-conductive material, the plates being longer than the parallelepiped blocks 39 of the magnet. The thus formed unit is secured to the housing 41, for example, by pressing. A disk-shaped hammer 21 rests against the lower surface of the plates. The lower surface of the hammer is convex as shown while its upper portion carries a guide pivot 22 which can slide in the free space between the magnets.

It is feasible to provide a disk, not illustrated, having a lower convex surface and disposed between the guide pin 22 and the energy storage spring 38. This disk ensures that the force of the energy storage spring 38 acts against the guide pin 22 along the axis of movement.

At the lower surface of the disk shaped hammer 21 which forms the hammer and which at the same time forms the yoke of the magnetic circuit, there rests a return spring 19.

In the central space between the two blocks 39 of the magnet there is disposed the energy storage spring 38, the lower end of which rests against the disk 21 while its upper end bears against an actuation stem **23** which is prevented from falling out of the housing by a radially inwardly directed flange **24** of the housing **41**.

When the actuating stem **23** is depressed the energy storage spring **38** is tensioned. Since the reactive force of the spring is greater than the holding force of the disk-shaped hammer **21**, the hammer moves easily from the magnetically-conductive plates **42** and is accelerated in the direction of the transducer whereby the return spring **19** is compressed. When the actuation stamp **23** is released, the energy storage spring **38** returns into its neutral position. Thereafter the disk **21**, the energy storage spring **38** and the actuation stem **23** are returned to their rest position by the force of the return spring **19**. Because the parts of the magnetic circuit are formed axially symmetrically with respect to the axis of motion of the movable plates, in this case the disk **21**, there are no forces acting on the hammer at an angle so that the hammer is not substantially twisted from its axially symmetrical orientation during its accelerated motion.

FIG. **4** illustrates a simple embodiment of a piezoelectric igniter according to the invention. The magnetic circuit includes an L-shaped magnetically-conductive member **25**. At one leg of the member **25** a permanent magnet **26** shaped like a parallelepiped is secured in such a manner that the two elements form a U. At the free ends of the magnetically-conductive member **25** and the permanent magnet **26** there are disposed a yoke **27** of a ferromagnetic material which also serves as the hammer. At the end of the yoke **27** adjacent the permanent magnet **26** there is disposed a leaf spring **29** at an inclined surface **28** of the yoke.

At the free leg of the L-shaped magnetically-conductive member **25** there is secured a U-shaped holding sheet **30** consisting of a magnetically-nonconductive material. In the base region **31** of the holding sheet **30** there are arranged the piezoelectric transducer **2** in such a manner that its impact plate **32** is opposite the hammer **27**. The piezoelectric igniter of FIG. **4** operates in the following manner. In order to actuate the igniter the leaf spring **29** is pressed in the direction indicated by the arrow so that the spring is bent. As soon as the bending moment of the leaf spring exceeds the holding moment of the hammer **27** of the magnetic circuit consisting of the magnetically-conductive member **25** and the permanent magnet **26**, the hammer **27** lifts off the free leg of the magnetically-conductive member **25** and is accelerated by the force of the leaf spring **29** in the direction toward the impact plate **32** of the transducer **2**. When the hammer **27** impacts the plate of the transducer a pressure wave is generated in the transducer **2** which generates a high voltage impulse at the high voltage electrode **4**.

When the leaf spring **29** is released the hammer **27** is returned into its rest position illustrated in FIG. **4** by the leakage field lines of the magnetic circuit. In order not to impede this return motion the leaf spring **29** should consist of a material which is magnetically-nonconductive or should be sufficiently far removed from the permanent magnet **26** in its actuated position.

The piezoelectric igniter illustrated in FIG. **5** includes a cylindrical housing **51** consisting of a material which is magnetically nonconductive. In the lower portion of the housing there is disposed a piezoelectric transducer **52** containing two piezoelectric crystals **53** between which is disposed a high voltage electrode **54**. At the upper surface of the transducer there is disposed a semispherical impact plate **57**. Above the impact plate **57** there is disposed a pot-like magnetically-conductive member **58** in the interior of which is secured a permanent magnet **59** spaced from the side wall of the magnetically-conductive member. The potshaped magnetically-conductive member **58** and the permanent magnet **59** form the hammer of the piezoelectric igniter.

Above the hammer is disposed a magnetically conductive yoke plate **60** which is secured by pins **61** to the wall of the housing **51**. The yoke plate **60** is provided with a central bore **62** through which extends the shaft of a mushroom-shaped pressure transfer member **63**, the head **64** of which can slide within the housing **51** with a certain play.

Between the lower surface of the head **64** and the yoke plate **60** there is anchored a return spring **65**. At the upper surface of the head **64** is disposed the energy storage spring **66** disposed in the actuation cap **67**.

In accordance with the invention the permanent magnet **59** is provided at the pole surface adjacent the yoke plate **60** with a magnetically-conductive plate **68** into which is secured the end of the shaft **62** of the mushroom-shaped pressure transfer member **63**. The thickness of the permanent magnet **59** and of the magnetically-conductive plate **68** are so selected that the free upper surface of these elements is disposed in the plane of the edge of the potshaped magnetically-conductive member **58** adjacent the yoke plate **60**.

In the rest position this edge and the magnetically-conductive plate **68** adhere to the yoke plate **60** so that the magnetic circuit does not have an air gap. In that case the permanent magnet **59** develops its maximum holding force.

When the actuation cap **67** is depressed the energy storage spring **66** is tensioned so that the force exerted on the pressure transfer member **63** increases. As soon as the force exerted by the energy storage spring **66** becomes larger than the holding force of the permanent magnet **59**, the unit consisting of the members **58, 59**, 68 and **63** are removed from the yoke plate **60** and moved with acceleration against the pressure plate **57**. As soon as the pot-shaped magnetically-conductive member **58** impacts the plate **57**, a pressure wave is created in the piezoelectric transducer **52** which results in a high voltage impulse at the high voltage electrode **54**.

In the actuated state, that is when the pot-shaped magnetically conductive member **58** is in contact with the plate **57**, the magnetic resistance of the magnetic surface is increased because the circuit now contains an air gap between the magnetically-conductive plates **68** and the magnetically-conductive member **58**. The magnitude of this air gap, however, may be so selected that only a small leakage flux extends outwardly beyond the housing **51**. In the rest state and shortly after the magnetically-conductive plate **68** is separated from the yoke plate **60**, the latter causes a rapid deflection of the field lines to the edge of the pot-shaped magnetically-conductive member **58** compared to other proposed constructions.

The embodiment illustrated in FIG. **6** utilizes instead of a pot-shaped, a mushroom-shaped magnetically-conductive member **70**, the shaft **71** of which is surrounded by an annular magnet **72** in such a manner that an air gap **84** remains between the two parts. This air gap may be filled with a magnetically-nonconductive material.

Disposed on the surface of the pole of the permanent magnet not connected with the mushroom-shaped magnetically-conductive member **70** there is disposed a magnetically-conductive conductive annular member **73**, the face of which is flush with the face of the shaft **71**.

In the rest position the magnetically-conductive annular member or ring **73** and the shaft **71** adhere to the magnetically-conductive yoke **74** so that the field lines emanating from the annular magnet do not have to bridge an air gap. The holding force of the magnet is therefore at a maximum.

The yoke **74** is secured in its upper region by a pin **75** to the housing **51**. The yoke **74** is so formed that an annular space is provided between it and the housing **51**. In this annular space there is provided an energy storage spring **76**, one end of which rests against the magneticallyconductive ring **73** and the other end against the face of an actuating cap **77**. The actuating cap fits into the annular space and is provided at diametrically opposite points with longitudinal apertures **78** through which the pins **75** extend. The actuating cap **77** can accordingly be moved only to a limited extent which is defined by the length of these apertures.

Between the piezoelectric transducer **52** and the mushroomed-shaped magnetically-conductive member **70** there is further provided a return spring **79**. When the actuating cap **77** is depressed the energy storage spring **76** is tensioned. Accordingly, it exerts an increasing force on the magnetically-conductive ring **73** and the parts connected thereto. As soon as the force developed by the energy storage spring **76** is greater than the holding force of the magnet and the force of the return spring **79**, the unit consisting of parts **70, 72** and **73**, that is the socalled hammer, moves away from the yoke **74** and impacts the impact plate **80** of the transducer **52**.

In this actuated state only a small linkage flux exists from the hammer because the magnetically-conductive ring **73** collects the field lines emanating from the adjacent pore face of the ring magnet **72** and concentrates them in the air gap between the magnetically-conductive ring **73** and the shaft **71**.

The described piezoelectric igniters have the advantage that they develop a relatively large holding force. On the other hand, the attractive force rapidly reduces even at a small distance of the hammer from the yoke **74** so that the energy stored in the energy storage spring **76** can be transformed to a major portion into kinetic energy of the hammer.

What is claimed is:

1. A piezoelectric igniter of the type normally used in a lighter comprising

a magnetically non-conductive housing;

a piezoelectric transducer and an impact mechanism disposed in said housing and including a hammer movable between a normal rest position and an impact position away from said rest position and whereat said hammer has an impact with said transducer;

an electric circuit including electrical leads and electrodes connected to the piezoelectric transducer for ignition purposes;

spring means being operable to exert a force against said hammer in a direction toward said transducer when the potential energy of the spring means is increased;

resilient retraction means for said hammer of smaller force than said spring;

an actuating member operable to increase the potential energy of said spring means; and

a magnetic circuit comprising a fixed part, a movable part, one of said parts including a magnet having pole faces and both said parts being magnetically-conductive, said parts being sufficiently closely adjacent each other in the rest position of the hammer for closing the magnetic circuit substantially free from any air gap, said movable part being connected to the hammer and being movable therewith and being operable due to the magnetic force exerted between said parts to hold said hammer in said rest position against the force of said spring means throughout that portion of the increase in potential energy of said spring means which is at least inferior to said magnetic force;

said hammer including a pot-shaped magnetically-conductive member disposed in said hammer and having an open side, said movable part being a magnet disposed in said member, said fixed part comprising a magnetically-conductive yoke, the open side of said magnetically-conductive member being disposed next to said yoke in the rest position of said hammer.

2. Piezoelectric igniter as claimed in claim **1** wherein a magnetically-conductive member is disposed adjacent each of the poles of said magnet during said predetermined rest position but not at other times.

3. Piezoelectric igniter as claimed in claim **1** wherein the magnetically-conductive yoke is secured to said housing.

4. Piezoelectric igniter as claimed in claim 1 wherein said hammer is formed by said magnetically-conductive member and said permanent magnet.

5. a Piezoelectric lighter as claimed in claim **1** said movable part including said magnet and an additional magnetically-conductive member in contact with said magnet at all times and movable therewith together with said hammer, said magnet being a permanent magnet.

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