

March 10, 1970

M. BAERMANN
MAGNETO-ELECTRIC PULSE GENERATOR ESPECIALLY FOR
IGNITING GAS-OPERATED DEVICES

3,500,086

Filed Feb. 1, 1967

2 Sheets-Sheet 1

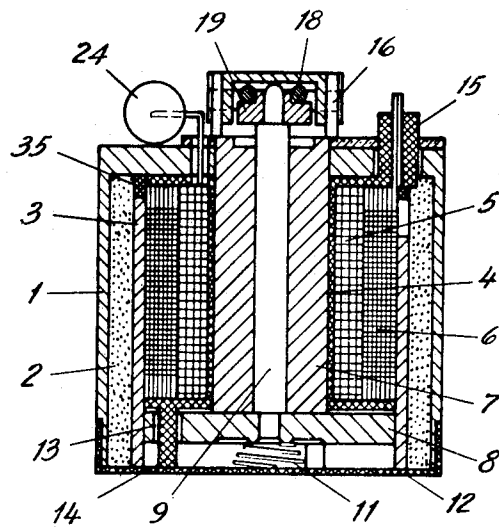


FIG. 1

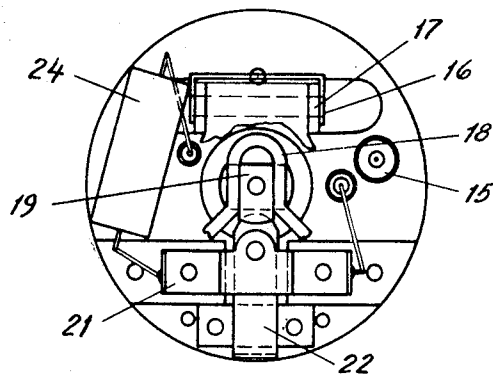


FIG. 2

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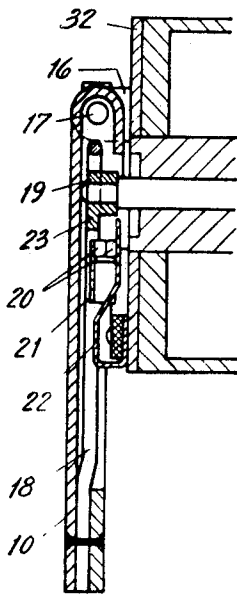


FIG. 3

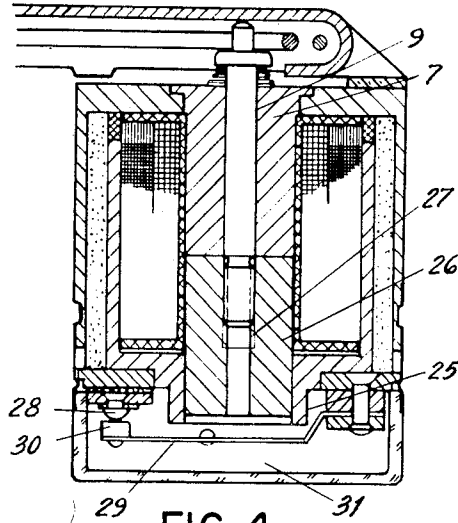


FIG. 4

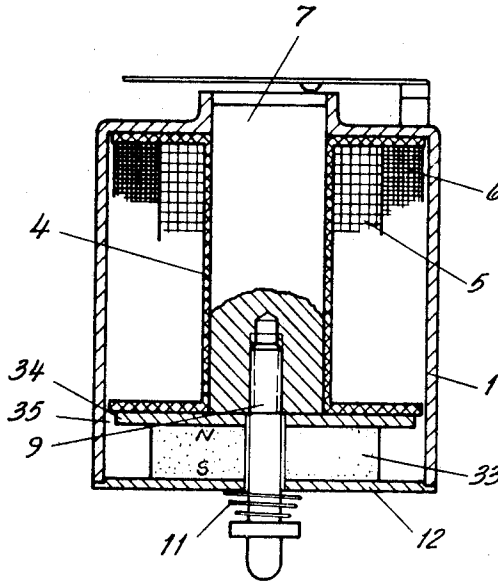


FIG. 5

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**MAGNETO - ELECTRIC PULSE GENERATOR
ESPECIALLY FOR IGNITING GAS-OPERATED
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U.S. Cl. 310-69

9 Claims 10

ABSTRACT OF THE DISCLOSURE

A magneto-electric pulse generator having a magnetic circuit design which enables obtaining maximum voltage pulses with a minimum physical size and relatively cheap plastic bound permanent magnet material.

The invention pertains to a magneto-electric pulse generator which, independent of an electric source of current, when operated produces an electric spark, especially for igniting gas-operated devices such as gas stoves, gas lighters, gas heaters, welding devices, etc.

The magneto-electric pulse generator according to the present invention is, however, not only appropriate for igniting gases, but can by use of the generated current also be used very well for igniting explosive charges of any type.

Magneto-electric pulse generators hitherto known have been provided with one or several multi-turn windings or coils and a magnetic circuit through the winding having at least one permanent magnet, which the magnetic circuit can be suddenly opened so that the magnetic flux in the coil is suddenly changed which change is used for generating a high voltage pulse which forms an ignition spark across an air gap. In many cases, the armature is of cylindric shape and is shifted along a path of movement transverse or normal to the lines of magnetic force. By the sudden shifting of the armature, the magnetic circuit is opened and a voltage pulse corresponding to the change of the magnetic flux is generated in the winding. If a higher voltage is required for producing an ignition spark, still a second so-called low voltage winding has been provided.

When the armature is shifted, simultaneously a switch across the low voltage winding arc is opened which causes thus a more sudden breakdown of the magnetic flux, whereby an accordingly higher voltage is induced in the high voltage winding, which voltage is high enough so that a spark flashes over the spark gap which is sufficient for igniting the escaping gas.

The known constructions have the disadvantage that they require much space due to the design of the magnetic circuit including the permanent magnet arranged inside the same circuit. Therefore, it is desirable to reduce the size of such pulse generators as far as possible, especially if they are to be incorporated in a gas-operated device and arranged near the gas outlet nozzle for igniting the gas. These endeavors meet with difficulties because permanent magnets of sufficient strength and size and a corresponding core cross section must be provided in order to produce a flux density of at least 8,000 Gauss inside the winding core and because it is difficult to arrange the movable parts in a way that the flux produced by the permanent magnet flows by a short flux path to the air gap produced by shifting the armature without leakage.

SUMMARY OF INVENTION

The invention shows how to overcome this difficulty and how to build a magneto-electric pulse generator of small size which is of simple and cheap construction but

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produces strong ignition sparks and can even be incorporated in especially small gas-operated devices such as cigarette lighters. Such a pulse generator is characterized by: an exterior cup or shell-shaped ferromagnetic body; a permanent magnet against the interior wall of the ferromagnetic body; and an interior ferromagnetic body against the opposite side of the permanent magnet; together with a coil body arranged inside this system carrying the coil windings and having a central ferromagnetic core which is in magnetically conductive relationship between the exterior and the interior ferromagnetic bodies, the central core being adjacent to a movable armature or being designed as a movable armature itself so that the magnetic circuit can be readily broken.

It is the essence of this invention that in case of a permanent magnet material of high coercive force and low permeability of nearly one, a ratio of dimensions which is unusual to anyone skilled in the art, has been chosen for the permanent magnet, i.e. L:F is more than 1:200 and L:D is more than 1:20, where: L means the length of the lines of magnetic force extending inside the magnet from the north to the south pole, which according to the axis of magnetization usually corresponds to the length or the thickness of the magnet; F means the area of the effective magnetized surface; and, D the corresponding diameter. In other words, the magnetic circuit for the pulse generator according to the invention shall be so designed that the thickness of the permanent magnet is as small as possible, while the area of the magnetized surface against which the ferromagnetic bodies are positioned which conduct the flux to the central core shall be as large as possible.

Thus, it is possible to produce strong ignition sparks by means of cheap permanent magnet materials (e.g. barium ferrite) of a relatively low remanence and a high coercive force and at the same time create a magneto-electric pulse generator of small dimensions. For such materials in the literature a ratio of L:D of 1:1 to some 1:5 is indicated. Preferably, such permanent magnets will be used which are composed of a mixture of a powdered permanent magnet material such as barium ferrite and a plastic binder which has been manufactured by extruding, rolling or injection molding, then magnetizing.

Due to this design of the magnet system, it is possible to achieve a small diameter and to arrange inside same the coil body and the coil windings.

According to another characteristic of the invention the interior ferromagnetic body has been so arranged in respect of the exterior ferromagnetic body that between the two bodies there is an air gap smaller than that created by moving the armature which gap conducts the lines of magnetic force in a different direction whenever the magnetic circuit is opened. Thus, it has been achieved that at the instant of operation the magnetic flux suddenly breaks down so that a high voltage is induced, which in turn generates strong ignition sparks.

The ferromagnetic bodies are preferably produced by cold pressing or stamping.

The permanent magnet is preferably magnetized in the direction of its smallest thickness, which in the case of a cylinder is radially magnetized.

The ferromagnetic bodies can be provided with slots for avoiding the formation of eddy currents.

OBJECTS OF INVENTION

The principal object of the invention is the provision of a new and improved magneto-electric pulse generator that is small in size and yet generates a maximum voltage.

Another object is a new and improved pulse generator having dimensions of the magnetic circuit so arranged as to produce a maximum flux density with plastic bound magnets of relatively cheap magnetic material.

Still another object is the provision of a pulse generator having a first magnetic circuit through the windings when the generator is ready for operation and a second magnetic circuit not through the windings when the generator is operated so that the rate of flux change of the coil is a maximum on operation of the generator.

PREFERRED EMBODIMENTS

The invention may take physical form in certain parts and arrangements of parts, preferred embodiments of which will be described in detail in this specification and illustrated in the accompanying drawings which form a part hereof and wherein:

FIGURE 1 is a longitudinal cross section through a magneto-electric pulse generator illustrating a preferred embodiment of the invention;

FIGURE 2 is a top elevational view of FIGURE 1 but showing only a part of the operating lever;

FIGURE 3 is a partial cross-sectional view of the magneto-electric pulse generator of FIGURE 1 from which the interrupter situated under the operating lever is visible;

FIGURE 4 is a view similar to FIGURE 1 showing an alternative embodiment of the invention; and,

FIGURE 5 is a cross-sectional view similar to FIGURE 1 showing a still further alternative embodiment of the invention wherein the central ferromagnetic core has been designed as a movable armature.

Referring now to the drawings wherein the showings are for the purposes of illustrating a preferred embodiment of the invention only and not for the purposes of limiting same, FIGURE 1 shows a magneto-electric pulse generator comprised of an exterior cup-shaped ferromagnetic body 1 tightly surrounding a radially magnetized cylindrical permanent magnet 2, in turn tightly surrounding a cylindrical-shaped ferromagnetic body 3. The length of the interior ferromagnetic body 3 is such in respect to the length of the exterior ferromagnetic body 1 that there is formed an air gap 35 between one end of the body 3 and the bottom of the cup-shaped body 1.

Inside this magnet system there is a coil form 4 in the shape of a hollow spool supporting an inner low voltage winding 5 and an outer high voltage winding 6. The center of the coil form 4 contains a cylindrical ferromagnetic core 7 which at the upper end is in magnetically conductive relationship with the bottom of the cup-shaped exterior magnetic body 1. Adjacent to the free or lower end of the ferromagnetic core 7 there is a movably arranged ferromagnetic armature 8 in the shape of a disk, which disk at its edges is in magnetically conductive relationship with the inner wall of the ferromagnetic body 3. It will be noted that this armature 8 is axially slidable relative to the ferromagnetic body 3. The armature 8 is fastened to the lower end of a plunger 9 of non-magnetic material slidably supported in a central opening in the core 7. The open end of the cup-shaped body 1 is closed by a cover 12. The armature 8 and the plunger 9 are biased upwardly by a spring 11 positioned between armature 8 and the cover 12. The upper end of the plunger 9 extends above the upper end of core 7 where it can be engaged by an operating lever 10 pivoted at one end on a shaft 17 such that movement of the lever 10 downwardly will force the plunger 9 and armature 8 downwardly.

The armature 8 has several small openings 13 therethrough, the diameter of which is so small that the flux density in the armature 8 is not unduly increased. The coil form 4 has spacer members 14 extending through these openings 13 and bearing at their lower end against the cover 12 so that the coil form 4 with its windings thereon is held in position. These openings 13 also serve to permit the passage of air therethrough when the armature 8 moves, thus avoiding any damping action due to air pressures building up inside of the device.

The coil form 4 also has an insulating bushing 15 extending upwardly through the bottom of the cup-shaped body 1 and one end of the high voltage winding 6 extends through this bushing where it can be connected to one terminal of a spark gap, not shown.

The operating lever 10 is pivoted on a bearing block 16 by means of the shaft 17 as can be clearly shown in FIGURES 2 and 3. Inside the operating lever 10 there is a cantilevered spring 18 fastened at one end to the outer end of the handle 10 and pressing at the other end against a switch block 19 mounted on the upper end of the plunger 9.

A normally closed switch is provided in operative relationship with this switch block 19, which switch consists of a contact bridge 21 mounted on a baseplate 32 of electrically insulating material and a contact spring 22 also mounted on the baseplate 32. The bridge 21 and the spring 22 have switch contacts which are normally biased into engagement. A condenser 24 is provided which is connected across these contacts of the switch. The spring 22 extends toward the plunger 9 so as to be engaged by the switch block 19 when the armature 8 and plunger 9 are moved downwardly such that the contacts will be opened by such movement. The bearing block 16 is supported on this baseplate 32 and the baseplate 32 is in turn mounted on the upper side of the cup-shaped ferromagnetic member 1.

One end of the low voltage winding 5 is connected to ground which in this case is the ferromagnetic body 1. The other end is connected to one of the switch contacts. The other switch contact is connected to the body 1. One end of the high voltage winding is connected to the one end of the low voltage winding which is connected to the switch contact. The other end of the high voltage winding extends through the insulating bushing 15 and forms one pole of a spark gap. The other pole of the spark gap will, of course, be connected to the body 1.

The permanent magnet 2 is preferably formed from a mixture of a plastic binder and a relatively cheap, permanent magnet material of a relatively low remanence and a high coercive force such as barium ferrite, or like known materials. The barium ferrite in finely divided form is thoroughly mixed with the plastic binder and the mixture is then either extruded, rolled or injected into the desired final cylindrical shape. The cylindrical magnet is then radially magnetized such that the inner cylindrical surface is one magnetic pole and the outer cylindrical surface is an opposite magnetic pole.

Dimensions of the cylindrical permanent magnet 2 in accordance with the invention are such that the ratio of the radial thickness, D, of the cylinder wall to the surface area, F, of the cylinder wall is more than 1:200 and the ratio of the thickness, D, of the cylindrical wall to the diameter, D, is more than 1:20. In the preferred embodiment the radial thickness of the wall is $\frac{3}{32}$ of an inch, the internal diameter is one inch, and the axial length of the cylinder is one inch. The length of the air gap 35 is $\frac{3}{32}$ of an inch.

The spring 18 normally biases the lever arm 10 upwardly so that the lever 10 is slightly spaced from the upper end of the plunger 9. Movement of the lever 10 downwardly first compresses the spring 18. Further movement brings the lever 10 into contact with the upper end of the plunger 9 and continued movement starts to move the armature 8 downwardly such that a tiny air gap is created between the lower end of the core 7 and the upper surface of the armature 8. At this point, the magnetic attraction between the core 7 and armature 8 is reduced to a point where it is less than the force of the spring 18 and the plunger 9 and armature 8 are quickly forced downwardly with a snap action to thus create a large air gap between the lower end of the core 7 and the upper surface of the armature 8. The magnetic flux immediately shifts to air gap 35. Thus, the magnetic flux in the windings 4 and 5 is very rapidly reduced which

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change of flux as is known generates a voltage in both of these windings. Simultaneously with the rapid opening of the air gap, the switch block 19 engages the contact spring 22 which opens the contacts and thus opens the circuit through the low voltage winding 5. The magnetic field in the winding 5 is collapsed, creating an even greater rate of change of flux in the high voltage winding 6 with the result that a high voltage appears at the terminal extending through the bushing 15 sufficient to break down the spark gap and create a spark.

It will thus be seen that by means of a spring 18 a sudden opening of the magnetic circuit is achieved independent of the speed of the operating lever and a maximum rate of change of flux in the winding 6 can be readily achieved.

It used to be noted that in a normal position, the magnetic circuit is from the outer radial surface of the permanent magnet 2 to the shell 1, thence through the core 7 to the armature 8 to the inner shell 3 and thence to the inner radial surface of the permanent magnet 2. However, when the armature 8 moves away from the core 7 there is a substantial air gap created greater than the air gap 35 such that the magnetic circuit is then principally from the shell 1 through the air gap 35 to the shell 3 and the flux of the permanent magnet 2 is not through the windings 4, 5 as it was when the armature 8 was in engagement with the core 7.

It is in part this change of the magnetic circuit rather than the increase in the reluctance of the magnetic circuit by the enlarged air gap created by movement of the armature 8 away from the core 7 which creates the rapid change of flux in the windings 4, 5. Axial slots, not shown, are provided in the inner and outer bodies 3, 1 to prevent eddy currents.

In the embodiment of the pulse generator shown in FIGURE 4 the design of the magnetic circuit and the way of action differ from the embodiment shown in FIGURE 1 to 3 only by the fact that the contacts have been arranged on the side of the device which is remote from the operating lever, and by a different design of the armature.

In this embodiment the interior ferromagnetic body is cup-shaped like the exterior ferromagnetic body, whereby the two bodies are telescoped into each other with the cylindrical permanent magnet between them. In the bottom of the interior ferromagnetic body there is a cylindrical bearing 25 in which the armature 26, which is of cylindric shape, is slidably supported. The armature 26 penetrates so far into the coil body that the place of separation is about in the middle of the coil body. The lower end of the plunger 9 is provided with a threaded portion which is screwed into a threaded bore 27 in the armature 26. The low voltage winding switch is comprised of a stationary contact 28 and a movable contact 30 fastened to a contact spring 29.

When the operating lever 10 is operated, the plunger 9 with the armature 26 is forced downwardly away from the ferromagnetic core 7. It then snaps against a rivet 31 on the spring 29 so that the contacts are opened.

The embodiment of the magneto-electric pulse generator shown in FIGURE 5 differs from the preceding embodiments mainly in that the ferromagnetic core 7 forms the movable armature. Thus, the pulse generator consists of the cup-shaped ferromagnetic body 1. The coil body carrying the coil windings 5, 6 is positioned in the interior. The open side of the cup-shaped body is closed by a cover 12 of ferromagnetic material on the interior side of which a permanent magnet 22 is positioned. This magnet is axially magnetized. An interior ferromagnetic body 34 is positioned adjacent to the opposite surface of the permanent magnet. Between the outer edges of the interior ferromagnetic body 34 and the exterior ferromagnetic body 1 an air gap 35 is provided through which the lines of magnetic force are conducted when the principal magnetic circuit is opened. This guarantees a

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sudden break-down of the flux at the place of separation between the ferromagnetic core 7 and the interior ferromagnetic body 34.

The ferromagnetic core 7 is movably arranged inside the coil body and on one end is in magnetically conductive relationship with the exterior ferromagnetic body 1 and on the other end with the interior ferromagnetic body 34. The cover 12, the permanent magnet 33, and the interior ferromagnetic body 34 have a central bore into which the plunger 9 extends and is thus attached to the ferromagnetic core.

One end of the plunger 9 protrudes from the exterior cup-shaped ferromagnetic body 1, as already shown in the other figures, where it can be engaged by the operating lever 10 (not shown).

The switch can either be mounted on the end where the operating lever is mounted or on the opposite end.

When the operating lever 10 is depressed, the plunger 9 is moved in an axial direction whereby the ferromagnetic core 7 is separated from the interior ferromagnetic body 34 so that the magnetic circuit is opened and a corresponding voltage is induced in the windings and an ignition spark is generated.

After the operation, the pressure spring 11 brings the plunger back again to its neutral position.

Thus, it will be seen that a magneto-electric pulse generator has been provided which is small in size, uses relatively cheap, easily fabricated permanent magnets, and which for the size and the strength of the magnets will produce a pulse of maximum voltage.

The invention has been described with reference to preferred embodiments. Obviously, modifications and alterations will occur to others upon a reading and understanding of this specification and it is my intention to include all such modifications and alterations insofar as they come within the scope of the appended claims.

Having described my invention, I claim:

1. Magneto-electric pulse generator including in combination an exterior cup-shaped ferromagnetic body, a cylindrical permanent magnet positioned inside of said body and an interior ferromagnetic body positioned inside of the permanent magnet, portions of said interior ferromagnetic body being slightly spaced from the base of said exterior cup-shaped ferromagnetic body to provide an air gap, a coil form positioned inside of the interior ferromagnetic body and having coil windings thereon, a ferromagnetic member extending through said coil form and including an armature, said member and armature being in magnetically conductive relationship between the exterior and interior ferromagnetic bodies, said armature being movable from said member to break said magnetic circuit whereby to create a change of flux in said windings.

2. The pulse generator of claim 1 wherein the permanent magnet is dimensioned such that $L:F$ is more than 1:200 and $L:D$ is more than 1:20, where L is the length of the lines of magnetic force extending inside the permanent magnet from north to south, F is the area of the effective magnetized surface of the magnet, and D is the diameter of the cylinder.

3. Pulse generator of claim 1 wherein the air gap between the interior ferromagnetic body and the exterior ferromagnetic body is less than the air gap created between the member and the armature when the armature is moved away from the member such that in such position, flux is conducted through the air gap between the interior and exterior ferromagnetic bodies.

4. Pulse generator of claim 1 wherein the ferromagnetic bodies have axial slots to prevent eddy currents being induced therein.

5. Pulse generator of claim 1 wherein said armature is in the shape of a disk abutting against one end of the member and having its edges in flux conducting relationship with the interior ferromagnetic body.

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6. Pulse generator of claim 5 wherein said armature has passages therethrough to permit the passage of air therethrough when said armature is moved.

7. Pulse generator of claim 1 including a non-magnetic plunger slidably mounted in said member and supporting said armature on one end, said plunger extending out of the exterior ferromagnetic body and a lever pivoted on said body and engageable with said plunger, movement of said lever separating said armature from said member.

8. Pulse generator of claim 7 wherein said lever has a spring engageable with said plunger and compressible as said lever is moved toward said plunger whereby as said armature starts to move away from said member, said spring moves said armature independent of the speed of the operating lever.

9. The generator of claim 7 including normally closed contacts and means on said plunger for opening said con-

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tacts when said armature is moved away from said member.

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15 J D MILLER, Primary Examiner

U.S. Cl. X.R.

310—15, 155; 317—92