SYSTEM FOR GENERATING NONPERIODICAL ELECTRIC SPARKS

Filed March 13, 1968

Fig. 1

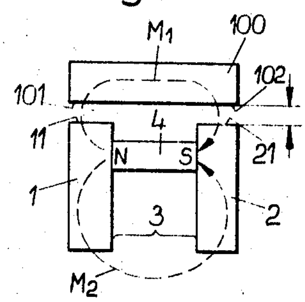
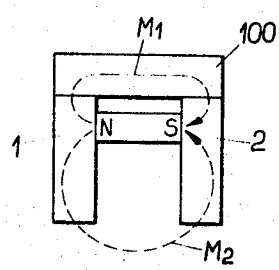


Fig. 2



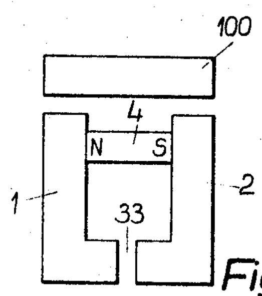
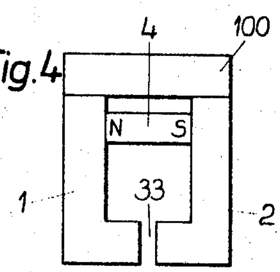


Fig. 3

Fig. 4



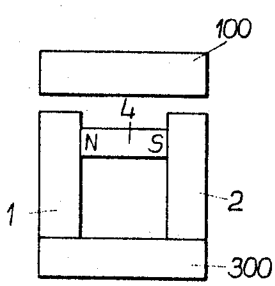


Fig. 5

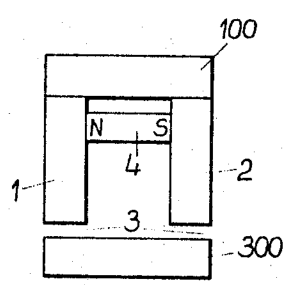


Fig. 6

Inventor:
Klaus Dieter Wosylus,

By

His Attorney

June 10, 1969 K. D. WOSYLUS 3,449,636

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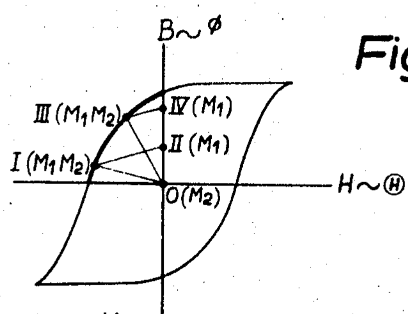

Fig. 7

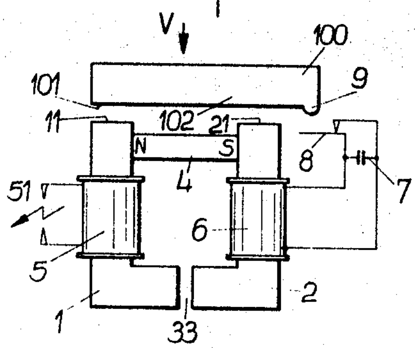

Fig. 8

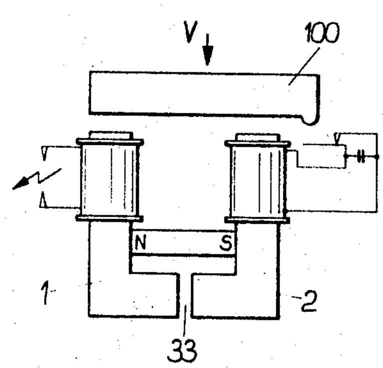

Fig. 9

Inventor:
Klaus Dieter Wosylus

By [signature]
His Attorney

United States Patent Office

3,449,636

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3,449,636

SYSTEM FOR GENERATING NONPERIODICAL ELECTRIC SPARKS

Klaus Dieter Wosylus, Frankfurt am Main, Germany, assignor to Braun Aktiengesellschaft, Frankfurt am Main, Germany, a corporation of Germany

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U.S. Cl. 317—81 5 Claims

ABSTRACT OF THE DISCLOSURE

A system for mechanically generating nonperiodical electric sparks has a permanent magnet, two soft iron conductors each in contact with a pole of the magnet, and at least one armature that is movable between a position in contact with the ends of the conductors and a position spaced therefrom. The other ends of the conductors for at least a time period define an air gap. A low voltage coil surrounds one conductor and is arranged in parallel with a condenser and a normally closed switch that is opened by the armature as the armature moves into the contact position, and a high voltage coil that surrounds the other conductor and is in series with a spark gap arrangement.

The invention relates to the mechanical generation of nonperiodical electric sparks by means of magnetic induction, and more particularly to a system that includes a permanent magnet, soft iron conductors, a high voltage coil, a low voltage coil that has in parallel a condenser and a shunting switch, and a movable armature that operates to open the shunting switch.

Magnetoelectricaly generated high voltage sparks are widely used for igniting combustible mixtures of gases, vapors or mists, particularly in connection with lighters. All generators for these type sparks have in common that they change in as short a period as possible the magnetic flux, the latter being in connection with coils. The mathematical expression for the voltage produced, namely $d\phi/dt$ becomes so large, that the voltage

$$U=-N\frac{d\phi}{dt}$$

wherein N is the amount of windings of the coils, surpasses the value necessary for the spark formation.

The aforesaid arrangements are known in various forms of execution. Thus systems are known wherein an air gap within a magnetic flux path, that consists of a permanent magnet and a yoke of soft iron with a coil, is opened by means of a soft iron armature, it being necessary, however, that the armature is pulled out of the flux path as rapidly as possible Systems of this type have the disadvantage, however, that the change of flux $d\phi$ has its maximum at the instant when during the aforesaid pulling-out movement the air gap is first formed. In that instant, however, the speed of the armature is small, so that due to the large value of dt the expression $d\phi/dt$ will remain small.

In accordance with another system, an increase in the rate change is achieved by closing, rather than opening, the magnetic flux path. By this arrangement, the aforesaid drawback of a too slow speed of the armature near the point of closing is avoided.

In accordance with all these arrangements, the change in flux is brought about by introducing, eliminating or changing air gaps within the permanent magnetic flux path by means of a mechanical action; by either adding magnetic resistances in series to the existing magnetic resistances, or by subtracting magnetic resistances from the existing magnetic resistances. This arrangement is disadvantageous, however, because due to the characteristics of permanent magnets only limited induction changes are possible.

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It is accordingly among the principal objects of the invention to provide a system for mechanically generating non-periodically electric sparks, that avoids the aforesaid drawbacks of the prior art.

It is another object of the invention to provide such a system that is simple to make and easy to maintain.

Further objects and advantages of the invention will be set forth in part in the following specification and in part will be obvious therefrom without being specifically referred to, the same being realized and attained as pointed out in the claims hereof.

In accordance with one embodiment of the invention, a permanent magnet is provided with two magnetic parallel flux paths; one of these paths includes a constant air gap and includes soft iron conductors that carry the induction coils; and the other flux path includes soft iron conductors and a movable armature that may be accelerated towards the soft iron conductors and is operative to shunt the permanent magnet through the soft iron conductors.

In accordance with another facet of the invention, a permanent magnet is again provided with two magnetic parallel flux paths; one of these paths includes again soft iron conductors and has a constant air gap; and the second path includes soft iron conductors and the induction coils are mounted on the soft iron conductors of the second flux path, and the second flux path includes again a movable armature that may be accelerated towards the soft iron conductors and by means of these will shunt the permanent magnet.

In accordance with yet another facet of the invention, a permanent magnet is again provided with two magnetic parallel flux paths; one of these paths is shorted by means of a first movable armature and includes soft iron conductors that carry the induction coils; and the second flux path may be closed by means of a second armature, and the second armature may be accelerated in the direction towards the soft iron conductors and shortly before making an air gap free contact with the soft iron conductors separates the first armature from the soft iron conductors.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a schematic view of a system for mechanically generating nonperiodical electric sparks in accordance with an embodiment of the invention, the induction coils and their circuits having been omitted for the purpose of clarity and simplicity, both flux paths having an air gap;

FIG. 2 is a schematic view, similar to FIG. 1, but showing one of the flux paths without air gap;

FIG. 3 is a schematic view, similar to FIG. 1, with both flux paths having an air gap, the air gap of one of the flux paths, however, being comparably small and permanent;

FIG. 4 is a schematic view, similiar to FIG. 3, but showing the air gap of the other flux path eliminated;

FIG. 5 is a schematic view, similar to the preceding views, but embodying a modification, one of the flux paths having an air gap and the other one being without air gap;

FIG. 6 is a schematic view, similar to FIG. 5, but showing a different position in that the flux path that in FIG. 5 has a gap is now without air gap, and the flux path that in FIG. 5 did not have any air gap now shows an air gap;

FIG. 7 is a graph showing the hysteresis graph of a permanent magnet;

FIG. 8 is a schematic view, similar to FIGS. 3 and 4, but showing the induction coils and the electric circuits for the induction coils, and having the permanent magnet between the induction coils and the variable air gap; and

FIG. 9 is a schematic view, similar to FIG. 8, but showing a further modification, the permanent magnet being disposed between the induction coils and the permanent air gap.

In carrying the invention into effect in the embodiments which have been selected for illustration in the accompanying drawings and for description in this specification, and referring now particularly to FIGS. 1–4, a permanent magnet **4** is shown that has two poles "N" and "S," respectively. To each pole there is applied a soft iron conductor **1** and **2**, respectively. A movable armature **100** is spaced for a distance x (FIG. 1) from the receiving surfaces **11** and **21**, respectively, of the soft iron conductors **1**, **2**. The armature **100** has corresponding receiving surfaces **101** and **102**, respectively, for interengaging the surfaces **11** and **21** while the armature **100** is in shorting position (FIG. 2).

Near the other ends of the conductors **1** and **2**, there is provided an air gap **3**. Thus, the permanent magnet **4** forms part of two magnetic flux paths as follows: It forms a path of the first flux path M_1 that includes the parts **4, 1, 11, 101, 100, 102, 21, 2,** and **4**; and partakes in the second flux path M_2 that includes the parts **4, 1, 3, 2,** and **4.**

Turning to the graph of FIG. 7, the permanent magnet **4** of FIG. 1 is disposed approximately in the magnetic condition that is represented by the point I (M_1, M_2), in which the outermost magnetizing graph, plotted in the B–H diagram for the permanent magnet **4**, is shown.

Turning now to FIG. 2, when the armature **100** is positioned on the end surfaces **11** and **21** of the soft iron conductors **1** and **2** and thereby eliminates the air gap x, the induction B of the permanent magnet will increase to the value II (MM) in FIG. 7. As the arrangement of the flux path M_2 has not changed, the increase of B has taken place solely in the flux path M_1 the induction B in the path M_2 therefore will be approximately O (M_2). The arrangements of the prior art made use of the change in induction between I (M_1, M_2) and II (M_1).

The arrangement of FIGS. 3 and 4 constitutes an advance over the arrangement of FIGS. 1 and 2. In FIGS. 3 and 4, the air gap **33** of the second flux path has been reduced as compared to the air gap **3** of FIG. 1. Due to this change, the permanent magnet **4** in the constellation of FIG. 3 assumes approximately the position III (M_1, M_2) in FIG. 4, and in the shorting position of FIG. 4 will assume the position IV (M_1) when the armature **100** will be positioned on the end surfaces **11**, **21** of the soft iron conductors **1**, **2**, respectively. There will therefore result for the first flux path the change in induction for the permanent magnet **4** from the point III (M_1, M_2) to the point IV (M_1), similarly to existing arrangements. The change in induction of the second flux path M_2, however, will be reflected by the change from the point III (M_1, M_2) to the point O (M_2). The last named change in the induction is markedly larger than that of the permanent magnet **4**. The increased change in induction may be utilized when the induction coils are connected with the flux path M_2.

A further increase in the induction change may be achieved by connecting the induction coils with the flux path M_1. The induction change is then comparable to a change between the points O (M_2) and IV (M_1).

The choice of the point III of the magnetizing curve (FIG. 7) thus the arrangement of the air gap, depends on the magnitude of the energy required for generating the spark.

The available induction change can be further increased when two armatures **100** and **300**, respectively, are used in accordance with FIGS. 5 and 6. In this arrangement, the armature **100** shortly before the shorting of the flux path M_1 will move the armature **300** from the soft iron conductors **1**, **2** of the flux path M_2, and therefore eliminates the shorting of the second flux path M_2. In this arrangement, the stray currents are reduced, though mechanical effort is markedly increased.

The steep increase of the induction changes in all the embodiments of the system in accordance with the instant invention results in a reduction in size of the structure and thereby permits to utilize the instant system for instance in connection with pocket lighters.

In FIGS. 8 and 9, the soft iron conductors **1** and **2** define again the permanent air gap **33** and are in contact with the poles of the permanent magnet **4**. A high voltage coil **5** surrounds a portion of the conductor **1**, and has electrodes **51** for a spark gap. A low voltage coil **6** surrounds a portion of the conductor **2** and is connected to a spark exterminator condenser **7**, and a switch **8**. The armature **100** carries a cam or nose **9**, and is movable between the position shown in FIG. 8 in which there is an air gap between the ends **11** and **21** of the conductors **1** and **2** and, respectively, the receiving surfaces **101** and **102** of the armature **100**, and a position (see FIG. 4) in which the armature **100** makes contact with its receiving surfaces **101** and **102** with the end surfaces **11** and **21**, respectively, of the conductors **1** and **2** thereby shorting the first flux path of the permanent magnet **4**.

When the armature **100** is accelerated in the direction V towards the end surfaces **11** and **21** of the conductors **1** and **2**, it will reach maximum speed immediately before making impact with the end surfaces **11** and **21**. The air gap **101–11–102–21** during that movement will be reduced until upon the aforesaid impact it will be eliminated entirely.

Initially, the air gap **33** is small as compared to the air gap **101–11–102–21**, and the magnetic flux predominantly will proceed along the second flux path **4–1–33–2–4** that is connected with the induction coils **5** and **6**.

When the air gap **101–11–102–21** upon impact is eliminated, however, the magnetic flux will proceed along the first flux path, namely through parts **4–1–100–2–4**.

In this manner, in the system shown in FIG. 8, the flux that is connected with the coils **5** and **6** will be reduced from its maximum as determined by the sizes of the air gap **33** and of the conductors **1** and **2**, down to a value of about zero, while for the permanent magnet **4** the flux will be increased from the minimum that is determined by the air gap **33** to an absolute maximum upon shorting by the impact of the armature **100**. Towards the end of the movement of the armature **100**, the nose **9** will open the switch **8**. By this opening, there will be an additional change of field by the interruption of the shorting electric circuit in the coil **6**. The condenser **7** serves for spark extinguishing.

In FIG. 9 the first flux path **4–1–100–2–4** includes the coils **5** and **6**.

In operation, in the embodiments of FIGS. 5 and 6 as well as FIGS. 8 and 9, the impact of the armature **100** with the end surfaces **11** and **21** of the conductors **1** and **2** will cause a spark to be formed between the electrodes **51**.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

Having thus described the invention, what I claim as new and desired to be secured by Letters Patent, is as follows:

1. In a system for generating nonperiodical electric sparks, the combination of a permanent magnet, two soft iron conductors each intermediate its ends being positioned adjacent a pole of said permanent magnet, at least one armature positioned near one end of each of said conductors, a high voltage circuit including in series a spark gap arrangement and a high voltage coil surrounding one of said conductors, a low voltage circuit including a low voltage coil surrounding the other conductor and a normally closed switch and a condenser in parallel with said low voltage coil, whereby there will be formed two flux paths, one of said paths comprising said permanent magnet, said armature and portions of said conductors near said armature, and the other path comprising said permanent magnet and the remaining portions of said conductors and having for at least a time period an air gap defined between the other ends of said conductors, said armature being movable between a first position wherein it is spaced for a predetermined distance from said one end of said conductors and a second position wherein it makes contact with said one end of said conductors, an actuating cam driven from said armature, said switch being disposed in the path of said cam, whereby when said armature is driven from said first towards said second position said cam will near the end of the movement of said armature open said switch and thereby will interrupt said low voltage circuit, and said armature will terminate its movement near its maximum speed upon making contact with said one ends of said conductor thereby shorting said permanent magnet.

2. In a system, as claimed in claim **1**, said air gap being constant at all times.

3. In a system, as claimed in claim **2**, said permanent magnet being disposed between said coils and said one ends of said conductors.

4. In a system, as claimed in claim **2**, said permanent magnet being disposed between said coils and said air gap.

5. In a system, as claimed in claim **1**, a second armature disposed near the other ends of said conductors and being movable between a first station wherein it makes contact with said other ends and a second station spaced apart from said other ends thereby establishing said air gap, said one armature at least shortly before reaching its second position being operable to move said second armature from the first to the second station.

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VOLODYMYR Y. MAYEWSKY, *Primary Examiner.*

U.S. Cl. X.R

317—92, 96; 336—105; 431—255