Dec. 19, 1967 E. J. SMITH 3,359,459

IGNITION APPARATUS

Filed Nov. 13, 1964

Fig. 1.

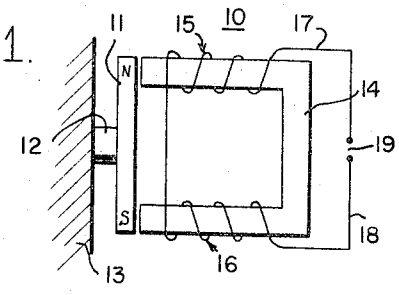


Fig. 3.

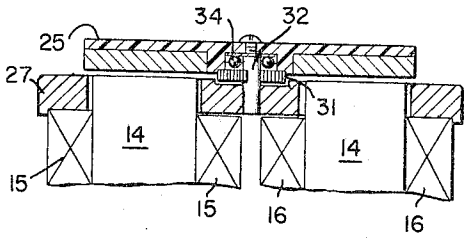


Fig. 2.

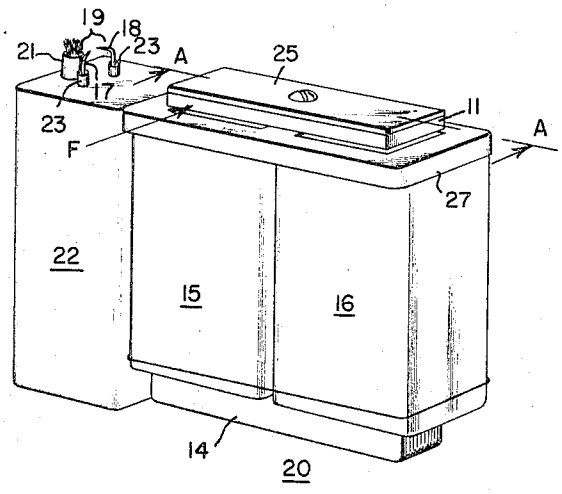
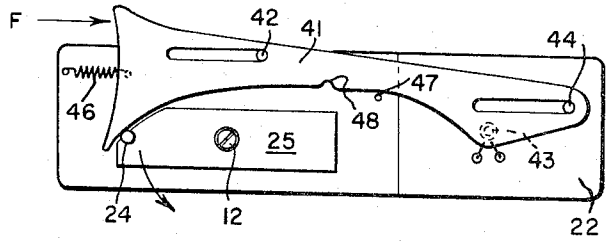


Fig. 4.



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IGNITION APPARATUS

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ABSTRACT OF THE DISCLOSURE

An ignition device which includes a permanent magnet, a permeable magnetizable core member which is adapted to form a closed flux loop for the magnet, and inductive coil surrounding the core member and a second magnetizable member positioned adjacent the core and adapted to provide a closed loop flux path for the permanent magnet and means for rapid moving the magnet to transfer the flux from one path to the other. Switching the flux paths results in substantial changes of flux through the coil element thereby generating a substantial voltage difference which is applied to a spark gap adjacent a fuel supply which may be ignited by a spark.

This invention relates to a system for igniting a combustible and, more particularly, to a self-contained, portable, electro-mechanical, spark-producing system.

The prior art has known many systems for igniting combustiles. Such systems have been used for accomplishing any of a number of purposes in which ignition is required. For example, flint and steel have long been used as a spark source. In the refined arrangement of present day cigarette lighters, the principal of mechanical ignition by striking flint to steel has reached its apex. However, as all users of cigarette lighters are well aware, such a system requires the constant replacement of parts. Not only is this an undesirable inconvenience and a somewhat expensive bother, but the necessity for providing arrangements which allow consumer replacement of parts substantially increases the expense of such a device.

The pilot lights used on gas stoves, ovens, and many furnaces are present day examples of systems for igniting gaseous combustibles. As is well-known, such systems most often require a continuous source of gas to maintain a small flame burning. Such an expense is minimal; however, the necessity of a continuous flame substantially negates portability as a feature of the arrangement and offers explosive possibilities.

Other ignition systems are known. For example, ignition systems are used for welding torches. A system is used for igniting flashbulbs and another for providing an electronic flash of high intensity. In general, such systems require a substantial source of voltage.

There has long been a need for an improved ignition system which is substantially impervious to wear, safe to use, and capable of generating a high energy output. Many attempts at such a system have been made of late. For example, U.S. Patent No. 2,867,753 issued to H. H. Quandt, illustrates a lighter with an electric ignition system, another attempt at realizing an efficient ignition system. Through the valuable and efficient energy of electricity is uytilized, the system requires a battery which is subject to replacement; the system also is arranged with a catalytic agent which may exhibit wear under combustion.

It is therefore an object of this invention to enhance the safety of ignition systems.

Another obpect of this invention is to provide an effective ignition system which require substantially no replaceable parts.

An additional object of this invention is to provide a

portable system for igniting a combustible which provides a small but efficient source of igniting energy.

A more particular object of this invention is to increase the spark gap energy available in an electro-mechanical combustion-generating system.

These and other objects are accomplished in accordance with the features of my invention by a system for igniting a combustible fuel which includes a permanent magnet mounted for rotation, a spring or other member for providing a high energy impetus to the magnet when displaced from an original position, a high permeability core associated with opposite ends of the magnet, a multi-turn output winding upon the core, and a pair of leads from the winding providing a spark gap. A source of combustible fuel is associated with the gap so that the production of a spark ignites the fuel.

In one particular embodiment, the magnet is rotated to provide a bias upon the spring or torsion member and then released. The rapid release of the magnet causes it to pass the core quite rapidly, producing a first and a second high rate of change of flux in the core. These two changes generate first and second high voltage sparks across the gap which can be used to light the combustible. The arrangement is especially useful in cigarette and cigar lighters since the rapid flux change produces a high energy discharge. Thus, no energy storage arrangement is required. Furthermore, the double spark produced across the gap insures the ignition of the combustible.

Other objects and features of the invention will be better understood by reference to the drawings and the specific description which refers thereto. In the drawings, like numbers have been used for designating like items throughout the various figures.

FIG. 1 is a partially-schematic, partially-block diagram useful in illustrating the principals of operation of the invention;

FIG. 2 is a perspective view of a system for igniting a fuel contained upon a wick, such as a cigarette lighter;

FIG. 3 is a partial cross-sectional view taken along line A—A of FIG. 2; and

FIG. 4 is a plan view of a modification of the arrangement shown in FIG. 2 for igniting a gaseous fuel ejected from a nozzle, as in a butane cigarette or cigar lighter.

In FIG. 1, there is shown an arrangement **10** illustrative of the basic concept of the invention. The arrangement **10** includes a permanent magnet **11** mounted by a spring member **12** to a plate or other fixture **13**. The magnet **11** may be selectively chosen to provide an appropriate flux for the generation of the spark desired. The spring member **12** may advantageously comprise to torsion mounting spring. Alternatively, a coil spring may be used for mounting the magnet **11** by positioning it such that it provides an appropriate torque for rotating the magnet **11** in a plane perpendicular to the plane of the paper. The plate **13** may comprise a selected mounting piece and will depend upon the particular igniting arrangement. Various examples of such arrangements are presented in the following description.

The magnet **11** has its magnetically opposed ends positioned closely adjacent a high-permeability magnetic core **14**. The positioning is accomplished such that the magnet **11** may rotate near the ends of the core **14** without touching and so that the core **14** will, in the unstressed position of the magnet **11**, provide an easy flux path for the magnet **11**. Various cores may be used and such are well known in the art. In at least one arrangement, I prefer to use a laminated core to provide a high permeability flux path with a negligible eddy current loss. It is especially important to note that FIG. 1 is somewhat distorted and the gaps provided between the magnet **11** and the ends of the core **14** are actually quite small with respect to the length

of the flux path. Typical gaps range between .005 to .010 inch. By this arrangements, the flux must cross only a very small air gap so that a substantial value of electromotive force may be derived from the output means associated with the core **14**.

The means for deriving an output comprise a pair of windings **15** and **16** joined in series and mounted upon the core **14**. A pair of leads **17** and **18** extend from the cores **15** and **16**, respectively, and have their ends placed adjacent one another to form a spark gap **19**. The coils **15** and **16** are designed connected in series, and wound in a well-known manner to provide sufficient turns upon the core **14** for generating a voltage across the gap **19** in response to flux changes in the core **14** such that a spark of selected intensity will be produced.

In operation, the magnet **11** is rotated about the axis of the torsion spring **12** by an appropriate mechanically provided force. This rotation stores an energy sufficient that, upon release of the force, the magnet **11** rotates rapidly past the positions of the core **14** thereby rapidly changing the flux therein in first one sense and then in the other sense. This change in flux in accordance with the equation

$$E = N\frac{d\phi}{dt}$$

provides a pair of voltages in aiding series across the windings **15** and **16**. Since no resistance other than the incidental resistance of the windings and leads **17** and **18** appears in the circuit, the total voltage drop appears across the spark gap **19**. This voltage may be made sufficient to generate a spark discharge across the gap **19** having first one polarity and then the other.

It is a special note that the magnetic flux path provided by the core **14** contains substantially no air gap for dissipating the magnitude of the electromotive force. This allows for the use of the device shown in arrangement **10** without the necessity of connecting a storage capacitor in circuit with the gap **19** for storing the charge developed by a number of flux variations in order to produce sufficient energy to generate a spark across the gap **19**. This lack of a requirement for capacitor allows the device to be simpler, lighter in weight, and more reliable. Quite obviously, a capacitor could be used with the invention if desired.

In FIG. 2, there is shown another illustration of the invention. The device to illustrate is a feasible embodiment for a cigarette lighter. The device **20** includes a container **22** for a fuel. The container **22** may have a wick **21** projecting therefrom for sampling the liquid fuel placed within the container **22** and for thus providing a combustible adjacent the spark gap **19**. The container **22** may be filled with fuel in a well-known manner through a filling opening, not shown, and may contain a package if desired for easy retention of the liquid fuel, if such be the form of the fuel. Mounted adjacent the projecting wick **21** are two leads **17** and **18** which form the spark gap **19**.

The leads project from the interior of the container **22** through insulated projections **23**. Quite obviously, the leads might as well run around the outer portion of the container **22**. The gap **19** formed by the pointed ends of the leads **17** and **18** is shown in a somewhat distorted form (for effect) adjacent but not quite over the projecting wick **21**. Actually, only enough distance need be left between the two ends so that the wick may be withdrawn from the container **22** as it is used in maintaining a flame. The correct positioning of a wick is well-known to those skilled in the art, especially to those skilled in designing and manufacturing cigarette lighters.

Adjacent the container **22** is a laminated core of high-permeability material **14** formed in the shape of U. Wound upon the core are two windings **15** and **16** having a number of turns sufficient such that when connected in series as shown, their aiding voltage generated by the change of flux within the core **14** will initiate a high voltage spark across the gap **19**. The number of turns required for such windings **15** and **16**, the size of the wire used in those windings, and the insulating material for separating the adjacent turns of the coils are all matters of choice depending on the intensity of the spark desired and the difficulty of ignition of the fuel presented by the wick **21**. Though these are matters of choice, in one embodiment the core **14** had placed thereon a pair of windings **15** and **16** of number 43 wire each having 16,000 turns. The length of these coils was 1" and the voltage generated across the gap **19** was approxiamtely 1050 volts.

To assist in the generation of a particularly high voltage spark, the device **20** has a magnetic shield **27** placed over the ends of the coils **15** and **16** so that the ends of the core **14** project therethrough. As is noted below, the shield **27** serves to maintain the permanent magnet **11** in a closed magnetic circuit. The permanent magnet **11** is connected by the spring member **12** to the magnetic shield **27**. In the particular embodiment, a non-magnetic material **25** was placed over the magnet **11** in such a manner as to provide for maintaining the internal structure of the spring member **12** separated from the magnet **11**, and to avoid shunting the flux (magnetic path).

FIG. 3 shows a section taken at AA of the device **20** wherein it is clear that the member **25** contains a hole through which is placed a shaft **32** which is journalled to the magnetic shield **27**. On the shaft, one end of a coil spring **31** is affixed. The coil spring **31** winds about the shaft and has its other end affixed to a portion of the non-magnetic material **25** which projects downwardly through a hole in the magnet **11**. This non-magnetic material has a set of bearings, for example ball-bearings **34** carried in retaining grooves in the hole therethrough so that the entire assembly of the magnet **11** and the non-magnetic material **25** rotate freely about the shaft **32** restrained only by the force generated by the coil spring **31**.

The ends of the magnet **11** are (in the unconstrained position of the coil spring **31**) placed closely adjacent to and immediately over each of the projecting ends of the U-shaped core **14**. When a pressure is applied along a line of force F (shown in FIG. 2), the material **25** and the magnet **11** affixed thereto are rotated from their position adjacent the core **14**. The flux generated by the magnet **11** in the position rotated away from the core **14** is then directed by the magnetic shield **27** such that substantially no flux flows through the core **14**.

In one particular embodiment, the shield **27** comprises a high-permeability magnetic material which itself forms an easy flux path to divert all of the flux generated by the magnet **11** away from the core **14**, when the magnet **11** is displaced from its rest position. Other forms of magnetic shielding are known and would be feasible depending upon the particular embodiment. For example, the magnet and the core could be held stationary and a moving shield used to change the flux. In this case, the flux in the core would vary from some maximum to some minimum value.

If the force holding the magnet **11** away from the ends of the core **14** is suddenly released, then the material **25** and the magnet **11** rapidly rotate away from the shield back to the position over the ends of the core **14**. This rotation causes the flux in the core **14** to go from essentially zero to some substantially greater value. Since the change in flux takes place in an extremely short period of time, a high voltage is generated in the windings **15** and **16** causing a spark discharge to appear across the gap **19**.

As the magnet **11** continues in its rotation under the urging of the coil spring **31**, it swings away from the ends of the core **14** and again crosses the magnetic shield **27** thereby generating a second rapid change in flux within the core from a high value to a value sub-

stantially equal to zero. This causes a high voltage in the opposite sense to be induced in each of the coils **15** and **16**, thereby generating another spark discharge across the gap **19**.

It should be especially noted that the arrangement of the embodiment shown in FIG. 2 provides a particularly high voltage across the coils **15** and **16** (and thus across the gap **19**) because of the arrangement whereby the rotating magnet is caused to generate flux which first tends to intersect substantially none of the core **14**, then substantially all of the core **14**, and finally none of the core **14**. This effect is enhanced, of course, by the provision of the shield **27** which substantially diverts all of the flux from the core **14** during the rotation of the magnet **11** away from its unbiased position.

This rapid change from no flux to total flux to no flux in a very short period provides much higher output voltages than would normally be expected from a rotating permanent magnet. These high voltages avoid the necessity of a capacitor for storing the charge generated by the swing of the magnet **11** and thus reduced the size, weight, and the sensitivity to wear of the device **20**. However, a capacitor, if used, could provide higher voltage.

During experiments with the invention, moving a magnet past a pair of coils without the easy path provided by the flux shield **27**, could generate only approximately one-sixth the output voltage of the device suggested herein. The present device is therefore called a closed flux arrangement because of the nature of the direct flux path formed by the core **14** and the closed flux path provided by the magnetic shielding device **27**. This is essentially a flux linking device rather than a flux cutting device which other mechanisms have used, not employing a shield.

In the device in which the aforementioned constants were used in the coils **15** and **16**, semi-horseshoe magnets having a size of ½" x 5/16" x ⅛" have been used.

In FIG. 4, there is shown a linkage arrangement which may be used with the invention in order to obtain a quick release of the magnet thereby enhancing the voltage generated at the output coils. The arrangement includes the non-magnetic material **25** which is connected by spring and bearing member **12** to the magnetic insulating material **27**. The material **25** has a pin **24** projecting upwardly at the left end thereof, as shown in FIG. 4, to provide a cam-like surface against which a linkage member **41** may bear. The bearing surface of the linkage member **41** projects downwardly and is guided by a pair of pins **42** and **44** which protrude through slots in the linkage member **41**. When a force is applied in a sense as shown by the arrows F, the linkage member **41** moves toward the right-hand side thereby uncovering a nozzle **43** from which in an alternative embodiment a fuel may be ejected. The fuel ejected from the nozzle **43**, for example, may be a fuel such as butane which can be maintained within the container **22** in a liquid form under pressure and is ejected in a gaseous form. Alternatively, the nozzle may merely be the wick **21** of FIG. 2.

The nozzle **43** is uncovered as the member **41** slides to the right. Upon applying pressure in the thumb crevice of the member **41**, pressure is applied on the pin **24** of the member **25** forcing it to rotate in the direction shown. As the member **41** continues until the point where the pin **24** allows the member **25** to release and travel upwardly, the lower extremity of the member **41** passes the pin **24** allowing its immediate release and rotation of the material **25** and the magnet **11** connected thereto. The undersurface of member **41** may be grooved to allow the pin **24** to swing freely. A spring **46** is affixed to the member **41** to the magnetic shield **27** to provide for moving the member **41** back to its initial position.

As the lower tip of the member **41** slides past the pin **24** and releases the material **25**, the rapid swing of the magnet **11** induces the high voltages across the gap **19**. In the embodiment illustrated, the conductors **17** and **18** are displaced from the nozzle **43** so that they will not

interfere with the movement of the member **41**. Such a displacement is obviously feasible in view of the fact that a gaseous fuel is to be ejected from the nozzle **43** and will necessarily be lighted by the spark appearing between the conductors **17** and **18** due to the close positioning thereof.

In a particular embodiment it might be desirable to provide a delay mechanism for holding the member **41** in the forward position until the flame provided by the gas ejected from the nozzle **43** has been utilized. This is also accomplished by not releasing the thumb pressure. For example, pin **47** can be torsionally urged upwardly into a notch **48** upon the forward movement of the member **41** to retain that member in the forward position until a releasing pressure is applied.

Quite obviously, a number of other arrangements may be devised by those skilled in the art. However, these arrangements will be readily apparent to others upon reading the description of this specification and should therefore be considered to lie within the spirit and scope of the invention. In view of the foregoing, the invention should be restricted only within the spirit and scope of the appended claims.

What is claimed as new is:

1. A spark-generating device including electrodes defining a spark gap and comprising a permanent magnet, means including an armature for providing a first substantially closed-loop flux path for said magnet, means for providing a second substantially closed-loop flux path, means for rapidly moving said magnet between said first and second flux paths to vary the flux in said first flux path, and coil means mounted on said armature and connected to the electrodes for generating a spark in the spark gap in response to flux changes in said first flux path of a preselected level.

2. A spark-generating device as in claim **1** wherein said means for providing said second flux path comprise a magnetic shielding member for shunting virtually all magnetic flux from said first flux path into said second flux path with small movements of said magnet.

3. A spark-generating device as in claim **1** in which said means for rapidly moving said magnet include a spring member mounting said magnet for rotation, and a means for rapidly releasing said magnet to rotate under urging by said spring member.

4. A lighter comprising a source of fuel, electrodes defining a spark gap, means for placing fuel from said source adjacent said gap, a magnet, torsion means biasing said magnet to a neutral position, means including an armature for providing a first easy path for flux between the opposite poles of said magnet in the neutral position thereof, means for providing a second easy path between the opposite poles of said magnet in all other positions thereof, a coil surrounding said armature to detect flux changes in said first easy path, and means connecting said coil to said electrodes defining the spark gap.

5. A lighter as in claim **4** in which the means for placing fuel adjacent said gap comprises a wick, and said torsion means includes a coil spring having one end affixed to said magnet.

6. A lighter as in claim **5** wherein the source of fuel and the magnet are mounted together in a portable arrangement.

7. A lighter as in claim **4** in which said means for providing said first easy flux path comprises a U-shaped armature member of magnetic material having its ends adjacent the pole of said magnet.

8. A lighter as in claim **7** wherein said second easy path comprises magnetic shielding means positioned adjacent and about the ends of said U-shaped member to enhance flux changes therein caused by movement of said magnet.

9. A lighter as in claim **8** further comprising a member for urging said magnet to a second position and releasing it therefrom to move rapidly toward said first position.

10. A spark-generating device including a pair of elec-

trodes defining a spark gap, comprising a permanent magnet, means including an armature for providing a first substantially closed-loop flux path for said magnet, means for providing a second substantially closed loop flux path means for rapidly diverting flux from said first flux path to said second flux path and means including a coil surrounding said armature and coupled to said pair of electrodes for generating a spark in response to flux changes of a preselected level in said first path.

11. The apparatus of claim **10** in which said means for providing said second flux path include a magnetic shielding member adapted to be interposed in said first flux path and said means for diverting flux include means for interposing said magnetic shield member.

12. The apparatus as in claim **10** wherein said means for providing a first substantially closed-loop flux path for said magnet include a first magnetizable armature member positioned to complete the flow of flux to said permanent magnet and said means for providing said second closed loop flux path include a second magnetizable member adapted to be interposed between said permanent magnet and said first magnetizable member and said means for diverting include means for interposing said second magnetizable member between said permanent magnet and said first member to shunt said permanent magnet flux onto said second path.

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