

March 29, 1960

W. H. FLEMING ET AL

2,930,910

MANUALLY OPERABLE IMPULSE GENERATOR

Filed Dec. 24, 1956

2 Sheets-Sheet 1

Fig. 1

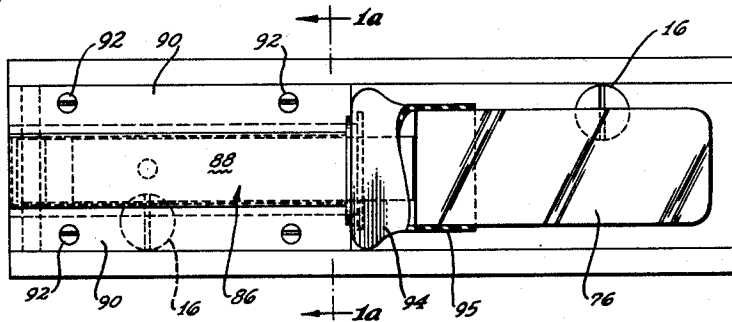


Fig. 2

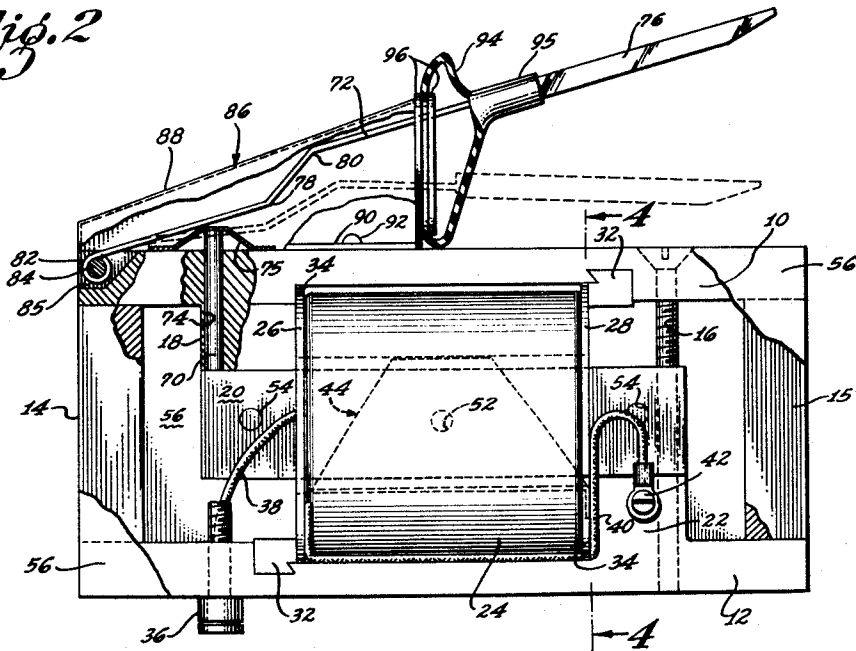
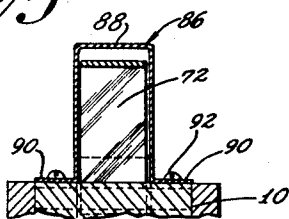


Fig. 1a



INVENTORS:
Walter H. Fleming
Victor H. Matson

By *Smith & Roston*
Attorneys

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Fig. 3

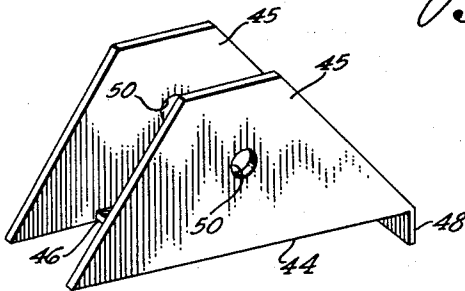


Fig. 4

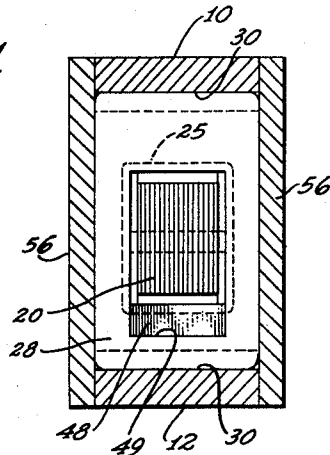


Fig. 5

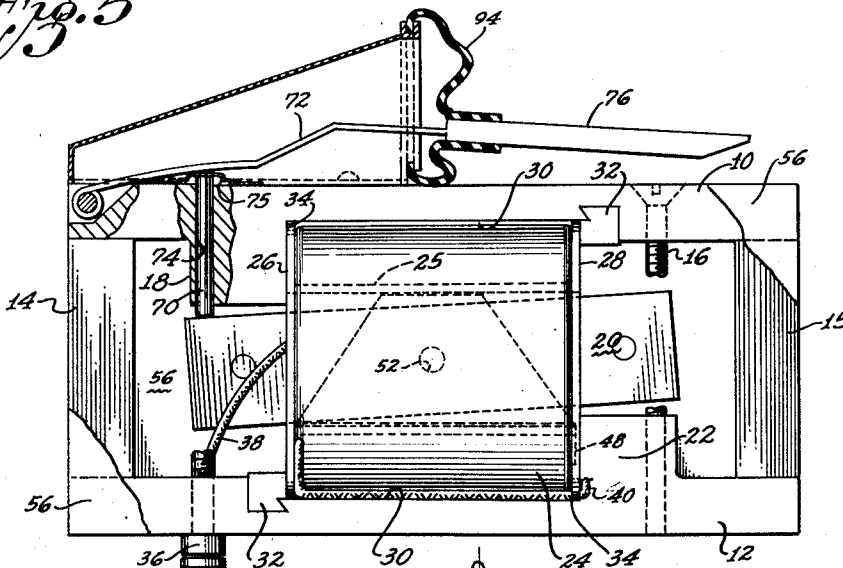


Fig. 6

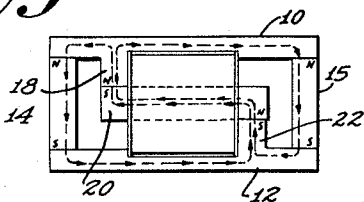
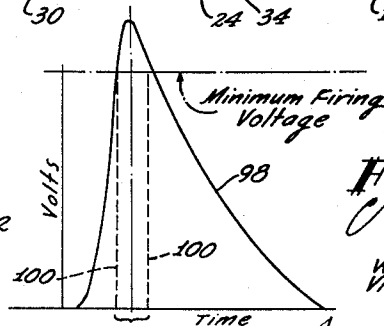


Fig. 7

INVENTORS:
Walter H. Fleming
Victor H. Matson

Required duration
of Current Flow

By *Smith & Roston*
Attorneys

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MANUALLY OPERABLE IMPULSE GENERATOR

Walter H. Fleming and Victor H. Matson, Jr., Los Angeles, Calif., assignors to Microloc Corporation, Los Angeles, Calif.

Application December 24, 1956, Serial No. 630,156

8 Claims. (Cl. 310—15)

This invention relates to a manually operable device for generating a pulse of electric current. The invention is applicable to a wide range of purposes in various arts since it is capable of generating sufficient current to actuate relays and solenoids. The invention is also capable of igniting combustion-type photographic flashbulbs. The invention is being initially employed, however, to detonate an explosive charge on an airplane for the ejection of jettisonable fuel tanks, bombs and other disposable stores and to detonate explosive charges of artillery. This particular embodiment of the invention is described herein by way of illustration and will provide adequate guidance for those skilled in the art who may have occasion to apply the same principles to other specific purposes.

An impulse generator of the general type to which the invention pertains comprises at least one permanent magnet, an electric coil, and a core or armature that cooperates with the permanent magnet to complete a magnetic circuit linked with the coil and that is movable from a normal first position to a second position to change the magnetic linkage and thereby generate a pulse of current in the coil. It is essential that the device not only create a pulse of electric current, but also automatically reset to permit the pulse-creating operation to be repeated. Thus, two successive operations are involved; first, what may be termed the firing operation in which the core is moved from its normal first position to its second position, and, second, the resetting operation in which the core is restored to its initial normal position.

A successful prior art impulse generator for this purpose incorporates two pairs of poles for cooperation with a core that is mounted for rocking or tilting movement about a central transverse axis, the two pairs of poles making contact with the core at its two positions respectively. When the core is rocked out of contact with a first pair of poles at its normal position into contact with a second pair of poles at its second position, the magnetic flux through the core is completely reversed, with consequent creation of the desired electrical pulse. Thus, the firing operation involves overcoming the magnetic attraction between the core and the first pair of poles and the resetting operation involves overcoming magnetic attraction of the same magnitude between the core and the second pair of poles. A manually operable lever is actuated to cause the core to snap from its first position to its second position, and the lever acts against the resistance of spring means to store sufficient energy for the subsequent resetting operation.

This prior art arrangement has certain inherent disadvantages. In the first place, the manual force required for total actuation is at least twice the force necessary for the firing operation alone. In the second place, the necessity for high magnitude actuating force makes it necessary to employ a relatively long actuating lever to achieve a high leverage advantage. In the third place, it has been found that certain critical relationships are encountered in the fabrication of the prior art device.

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The four pole faces are all inclined with respect to the longitudinal axis of the impulse generator, and these four poles must be accurately sloped and accurately located.

The present invention is directed to the problem of eliminating these disadvantages of the described prior art device. The solution to this problem by the invention is based on certain discoveries.

The first discovery is that completely reversing the magnetic flux through the core merely prolongs the duration of the pulse without adding to the voltage amplitude of the pulse. A second discovery is that the duration of the pulse that is obtained by merely collapsing the initial normal magnetic circuit is ample for the detonation of an explosive charge. Therefore, only one set of poles is necessary, this set cooperating with the core at the normal first position of the core. A third discovery is that, with one of the two pairs of poles omitted, the magnetic attraction between the core and the remaining pair of poles provides sufficient magnetic attractive force for resetting the core. A fourth discovery is that, in a compact impulse generator of a given size, the omission of two of the usual four poles cuts down the magnetic flux leakage at the normal first position of the core with consequent increase in the normal amount of flux linked with the coil. Thus, eliminating one of the two pairs of poles actually increases the voltage of the pulse of electric current that is created by the movement of the core from its normal first position to its second position.

In accord with these discoveries, the invention provides a single pair of poles in contact with the opposite ends of the core at the initial normal position of the core. The core may be rocked about its transverse axis to a second position for breaking the magnetic circuit, and thus create an electrical pulse, but the magnetic attraction between the core and the two poles at this second position is sufficient to return the core to its first position. Thus, only sufficient actuating force is required to carry out the firing operation.

A feature of the preferred practice of the invention is the use of a leaf spring for the actuating lever so that initial depression of the lever causes flexure of the leaf spring to store energy. Further depression of the lever increases the operating pressure against the core until the pressure is sufficient to overcome the magnetic attraction between the core and the pair of poles, whereupon the energy stored in the leaf spring is released to rock the core to its second position with a snap action.

The reduction in the magnitude of the actuating force that is necessary for operation of the device makes it possible to use a relatively short actuating leaf spring lever. A feature of the invention in this regard is that the device may be constructed for hand-grip operation, it being unnecessary to exert the actuating force against an anchored support structure. Thus, the impulse generator may be designed to be held in the hand and squeeze for actuation.

A further advantage of the new construction is that no critical relationships or dimensions are involved. The pole faces may be parallel with the longitudinal axis of the structure to make the fabrication of the device comparatively simple.

The various features and advantages of the invention will be apparent from the following detailed description considered with the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

Fig. 1 is a plan view of the presently preferred embodiment of the invention with a portion of the structure broken away;

Fig. 1a is a transverse section through a guard mem-

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ber of the device taken as indicated by the line 1a—1a of Fig. 1;

Fig. 2 is a side elevation of the device with one of the side plates removed and with portions shown in section, the core being shown at its normal first position;

Fig. 3 is a perspective view of a bracket that is employed to pivotally mount the core inside the electrical coil;

Fig. 4 is a transverse section taken as indicated by the line 4—4 of Fig. 2;

Fig. 5 is a side elevational view similar to Fig. 2, showing the core in its second position;

Fig. 6 is a diagram showing the two magnetic circuits through the core at the normal initial position of the core; and

Fig. 7 is a graph showing the general character of the electrical pulse created by the device.

The selected embodiment of the invention shown in the drawings includes a rectangular frame of ferromagnetic material having two longitudinal members 10 and 12 and two end members 14 and 15. The two end members 14 and 15 are permanent magnets which are both oriented in the same manner. In this instance, for example, the two bar magnets 14 and 15 are positioned with their north poles uppermost. This rectangular frame may be held together in a rigid manner by a pair of screws 16 which are offset on opposite sides of the longitudinal center of the device, as may be seen in Fig. 1.

The upper longitudinal member 10 is formed with a laterally inward extension 18 which serves as a pole adjacent one end of a core 20, this pole being directly connected to the north poles of the two permanent magnets 14 and 15. In like manner, the lower longitudinal member 12 forms a second pole 22 at the other end of the core 20 and on the opposite side of the core, this second pole being in direct communication with the two south poles of the permanent magnets 14 and 15. The frame structure including the two poles 18 and 22 and the permanent magnets 14 and 15 may be termed magnetic flux-creating means. Fabrication of the structure is simplified by the fact that the faces of the poles 18 and 22 are parallel with the longitudinal frame members 10 and 12.

An electric coil 24 that loosely surrounds the core 20 is wound on a spool made of suitable nonconducting material. The spool has a body shell 25 and two opposite end flanges 26 and 28. The body shell 25 is of rectangular cross-sectional configuration to house the core 20 with adequate clearance for the core to rock or tilt between its normal first position shown in Fig. 2, and its second position shown in Fig. 5.

Each of the longitudinal members 10 and 12 is formed with an inner longitudinal recess 30 to clear the coil, and each of the longitudinal members carries a transverse key 32 of brass or other nonmagnetic material for anchoring the coil 24 in the rectangular frame. As may be seen in Fig. 2, the two keys 32 abut the end flanges 28 of the coil spool at diagonally opposite points, and shoulders 34 formed by the two longitudinal recesses 30 also abut the end flanges of the coil spool at diagonally opposite points.

A two-wire cable (not shown) may be connected to the rectangular frame by a fitting 36 which grounds one of the cable wires to the rectangular frame. A wire 38 from the fitting 36 is connected to one end of the winding of the coil 24, and the other end of the winding is connected by a wire 40 with a screw 42 of the pole 22 to ground the second side of the coil winding.

The core 20 may be pivotally mounted inside the coil 24 for rocking movement by means of a bracket 44, the construction of which is best shown in Fig. 3. The bracket 44, which is made of suitable nonmagnetic material such as brass and is suitably anchored in position, has two upstanding wings 45 interconnected by a transverse web 46 and is formed with a downwardly extend-

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ing flange 48 at one end. The bracket 44 fits snugly in the rectangular body shell 25 of the coil spool, and, preferably, the end flange 28 of the spool is formed with a recess 49 (Figure 4) to seat the end flange 48 of the bracket with the outer faces of both flanges flush with each other. It can be seen in Fig. 2 that the immediately adjacent pole 22 will lock the end flange 48 in the recess 49 to immobilize the bracket 44.

The two upstanding wings 45 of the bracket 44 have aligned bores 50 therein to receive a suitable pivot pin 52 for rotatably supporting the core 20. The core 20 is preferably of laminated construction, with the laminations secured together by suitable fastening means 54. The core has a transverse bore to receive the pivot pin 52. Preferably the two wings 45 are resilient to permit an assembly procedure in which the pivot pin 52 is first mounted in the core 20 to form pivot trunnions and then the core is forced between the two wings to snap into place in the two bores 50.

With the core 20 mounted in this manner, it may be rocked longitudinally between its normal position shown in Fig. 2 and its second position shown in Fig. 5. In Fig. 2, the core is in longitudinal alignment with the rectangular frame and rests flat against the faces of the two poles 18 and 22. In Fig. 5, the core 20 is inclined with its two ends spaced away from the poles 18 and 22, but close enough to the poles to be attracted thereby for restoration of the core to its normal first position.

In the construction shown, the two sides of the rectangular frame are closed by two side plates 56. Thus, the rectangular frame, together with the two side plates, forms a rectangular box or housing that completely encloses the coil 24, the core 20 and the two poles 18 and 22. Preferably, all of the joints of this box structure are sealed in a fluid-tight manner, for example, by applying solder or other adhesive material to the various joints.

Various actuating arrangements for shifting the core 20 from its normal first position to its second position may be employed in various practices of the invention. In this instance, the actuating arrangement includes a plunger 70 and a cooperating actuating lever 72.

The plunger 70 is slidably mounted in a bore 74 in the longitudinal side member 10 of the rectangular frame, the bore extending through the pole 18. For an installation where a hermetically sealed unit is required, a suitable sealing diaphragm 75 covers the upper end of the bore 74, the diaphragm extending over the upper end of the plunger 70.

The actuating lever 72 is in the form of a leaf spring provided with a suitable handle 76. Preferably, the leaf spring is bent, as shown at 78 and 80, to form an upward offset, thereby to provide adequate freedom for downward flexure of its outer end. The end of the leaf spring lever is formed into a loop 82 to embrace a pivot pin 84, and, preferably, the pivot pin 84 is mounted in a recess 85 in the end of the upper longitudinal frame member 10.

Preferably, a suitable guard, generally designated 86, covers the inner end portion of the actuating lever 72. This guard, which may be made of suitable plastic material, has an inclined top wall 88 and two longitudinal side flanges 90, and is anchored to the top longitudinal frame member 10 by suitable screws 92 in engagement with the side flanges. The end of the guard 86 is open to clear the path of movement of the lever 72, but this end may be closed, if desired, by a suitable boot 94 of rubber-like material. One end of the boot 94 is in the form of a sleeve 95 that embraces the handle 76. The other larger end of the boot 94 resiliently engages the guard 86 in a groove formed by two closely spaced end flanges 96 of the guard.

The manner in which the impulse generator operates may be readily understood from the foregoing description. With the core 20 in its normal initial position

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shown in Fig. 2, depression of the handle 76 to flex the actuating lever 72 approximately to the extent indicated by dotted lines in Fig. 2 merely results in progressive storing of energy in the leaf spring lever and progressive rise in the pressure exerted against the plunger 70 through the diaphragm 75. This pressure against the plunger 70 then reaches a magnitude sufficient to overcome the magnetic attraction between the core 20 and the two poles 18 and 22, whereupon the core is snapped to its second position shown in Fig. 5, the snap action resulting from release of the energy stored in the flexed leaf spring.

The collapse of the magnetic field created by the normal magnetic circuit through the core 20 results in creation of the desired electrical pulse. As may be understood by reference to Fig. 6, there are actually two magnetic circuits through the core 20 at the normal first position of the core, each of the two permanent magnets having its own magnetic circuit. When the handle 76 is released after the creation of an electrical pulse, the core 20 is returned automatically to its normal first position by the magnetic attraction between the core and the two poles 18 and 22, and the leaf spring lever 72 springs back to its normal position. Thus, the actuating mechanism is automatically reset in preparation for a new operating cycle.

The character of the pulse of current that is generated is indicated by the curve 98 in Fig. 7. The curve rises abruptly to a peak that is of higher amplitude than can be achieved by an embodiment of the previously described prior art device of the same size. Thus, the invention provides a voltage pulse that is higher than usual above the minimum firing voltage required for igniting an explosive charge. As indicated by the two spaced dotted lines 100, the duration of the minimum firing voltage that is required for ignition of an explosive charge is substantially less than the duration of high voltage spanned by the curve 98.

It is apparent that the invention provides a liberal safety margin both with respect to the voltage amplitude of the pulse and the duration of the pulse. The amplitude of the voltage curve 98 is exceptionally high because the use of only the single pair of poles 18 and 22 minimizes flux leakage paths when the core is in its normal position, and thus increases the proportion of the total available flux that is actually linked with the coil winding 24 through the core 20. Flux leakage is minimized by the relatively large air gap in Fig. 2 between the ends of the core 20 and the two permanent magnets 14 and 15, and by the liberal air gaps between the ends of the core 20 and the two longitudinal frame members 10 and 12. Thus, the end of the core 20 that lies against the pole 22 is spaced by a relatively wide air gap from the longitudinal frame member 10, and the other end of the core that lies against the pole 18 is spaced by the same liberal distance from the longitudinal frame member 12.

Our description in specific detail of the presently preferred embodiment of the invention will suggest various changes, substitutions and other departures from our disclosure that lie within the spirit and scope of the appended claims.

We claim:

1. In a pulse generator, the combination of: coil means; ferromagnetic structure extending through said coil means, said ferromagnetic structure forming only one pair of magnetic poles and including an armature normally at a position in contact with said poles to complete at least one magnetic circuit through the coil means, said pair of poles comprising one pole on one side of said armature at one end thereof and a second pole on the other side of the armature at the other end thereof, said armature being pivoted to rock about a transverse axis from said normal position to a second position to break contact with said poles, the ends of

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said armature at the second position of the armature being close enough to said poles for the armature to be magnetically rotated from its second position to its normal position in the absence of restraining force; and actuating means to snap said armature from its normal position to its second position.

2. A combination as set forth in claim 1 in which said actuating means comprises an operating member and spring means operatively connecting said operating member to said armature for progressive stressing of the spring means by the operating member with consequent application of progressively increasing force to the armature until the rising applied force overcomes the magnetic attraction for the armature at said poles.

3. In an impulse generator having a coil, means to create a normal magnetic field with flux lines linked with said coil and to vary said magnetic field abruptly, said means comprising: a core extending through said coil and being pivoted to rock about a transverse axis between a first normal position and a second position; a frame of ferromagnetic material surrounding said coil longitudinally thereof, said frame including at least one permanent magnet and having only two poles, said two poles being for contact with the two ends respectively of said core at only the normal position of the core to complete a magnetic circuit including the core, said poles comprising one pole on one side of the core at one end thereof and a second pole on the other side of the core at the other end thereof; means positioned transversely of said frame and extending from the exterior of the frame to the interior of the frame to force said core from its first position to its second position in opposition to the magnetic force exerted on the core at said poles; and manual means to actuate said forcing means.

4. An impulse generator as set forth in claim 3, which includes means to seal off said coil and core from the atmosphere, said sealing means including a diaphragm for the transmission of actuating force therethrough to said core.

5. An impulse generator as set forth in claim 1, in which said actuating means comprises a spring lever and means to fulcrum the lever and to transmit force from the lever to said armature, whereby manually swinging the lever against the fulcrum means results in flexure of the lever with progressively increasing force against the fulcrum means until the increasing force reaches a magnitude to overcome the magnetic force holding the armature at its normal position.

6. An impulse generator as set forth in claim 3, in which said manual means is a spring lever fulcrumed on said forcing means, whereby initial manual movement of the lever with consequent stressing thereof stores energy in the lever for forcing the core to said second position with a snap action.

7. In an impulse generator wherein a coil is provided with end walls and has an axial passageway through the end walls, means to create a normal magnetic field linked with said coil and to vary the linkage abruptly, said means comprising: a core extending through said passageway; a bracket mounted in said passageway, said bracket having two wings straddling said core and a flange for abutment against one of said end walls of the coil to position the bracket accurately in the passageway; means pivotally connecting said core to said wings of the bracket to permit the core to rock between a first normal position and a second position; magnetic flux-creating means including at least one permanent magnet and providing only two poles, said two poles being located to contact the opposite ends of said core only at said normal position of the core to form a magnetic circuit through the core, said core being spaced from said flux-creating means at its second position, whereby the core is normally magnetically held at its normal position and magnetic force tends to return the core from its second position to its normal position; and actuating means to shift

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said core from its normal position to its second position in opposition to the magnetic force.

8. A combination as set forth in claim 7, in which said bracket is made of resilient material whereby said wings of the bracket may be resiliently spread apart temporarily to receive the core-pivoting means in the course of fabrication of the impulse generator.

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