July 9, 1946. N. B. WALES, JR 2,403,567

ELECTRICALLY ENERGIZED FUSE

Filed Jan. 13, 1942 2 Sheets-Sheet 1

Fig. 1,

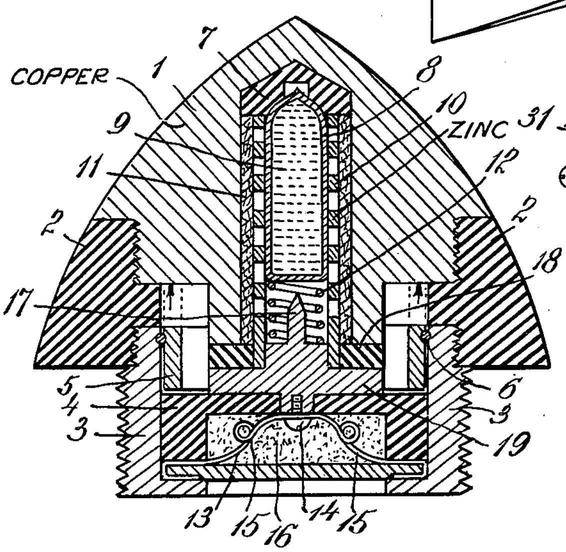

Fig. 3,

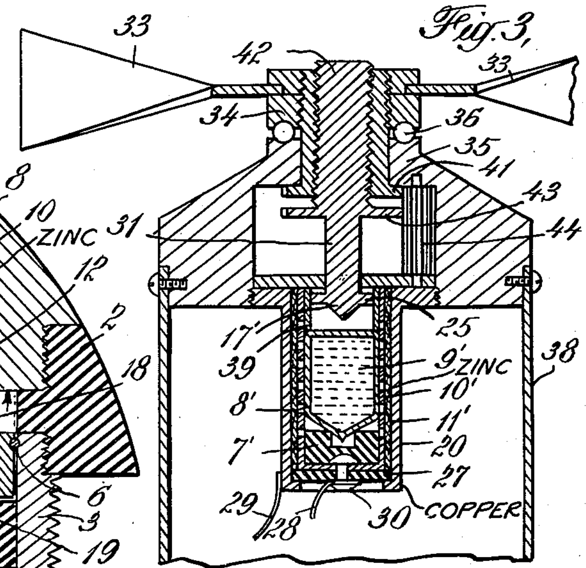

Fig. 1a,

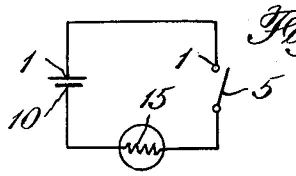

Fig. 2,

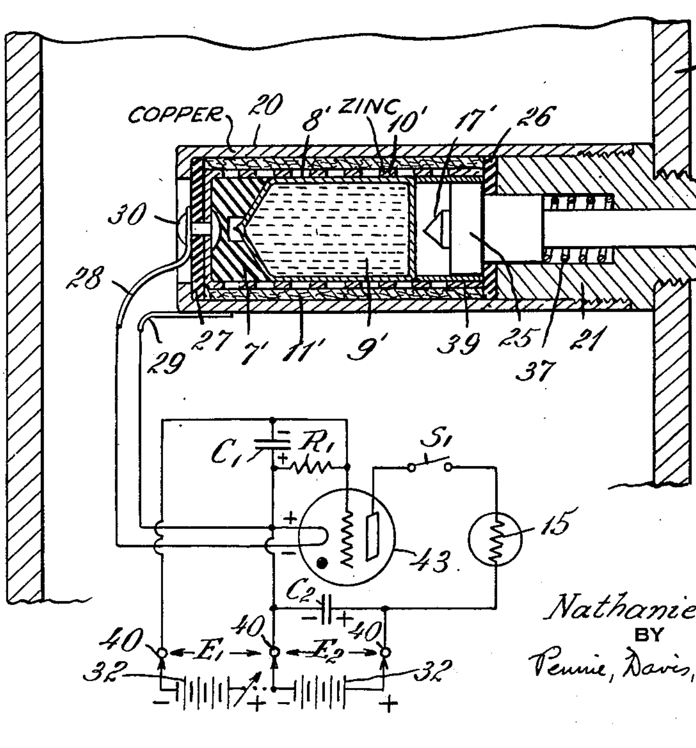

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Fig. 4.

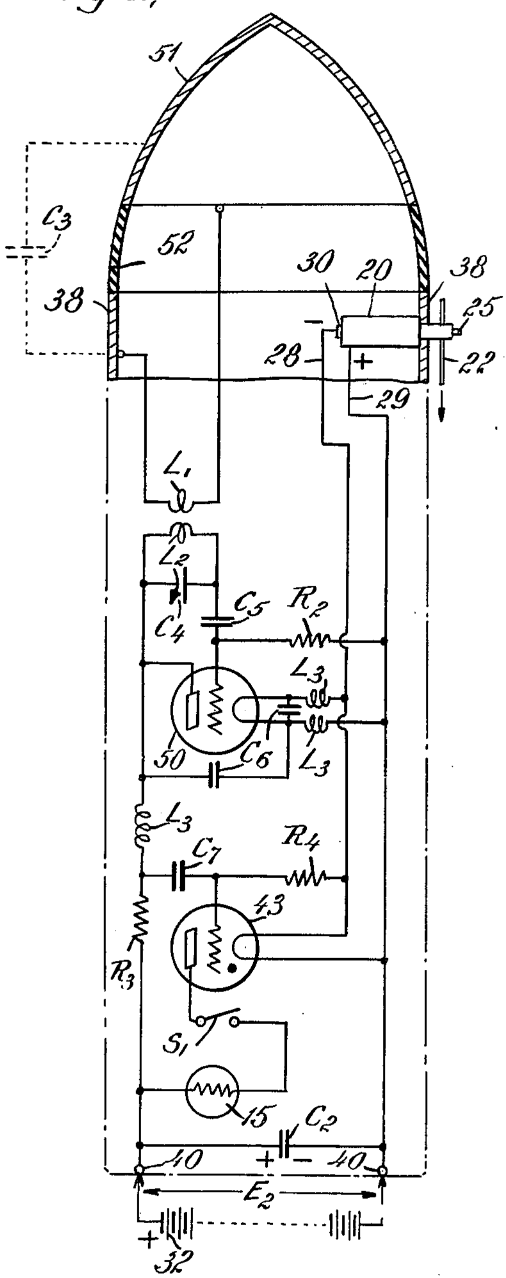
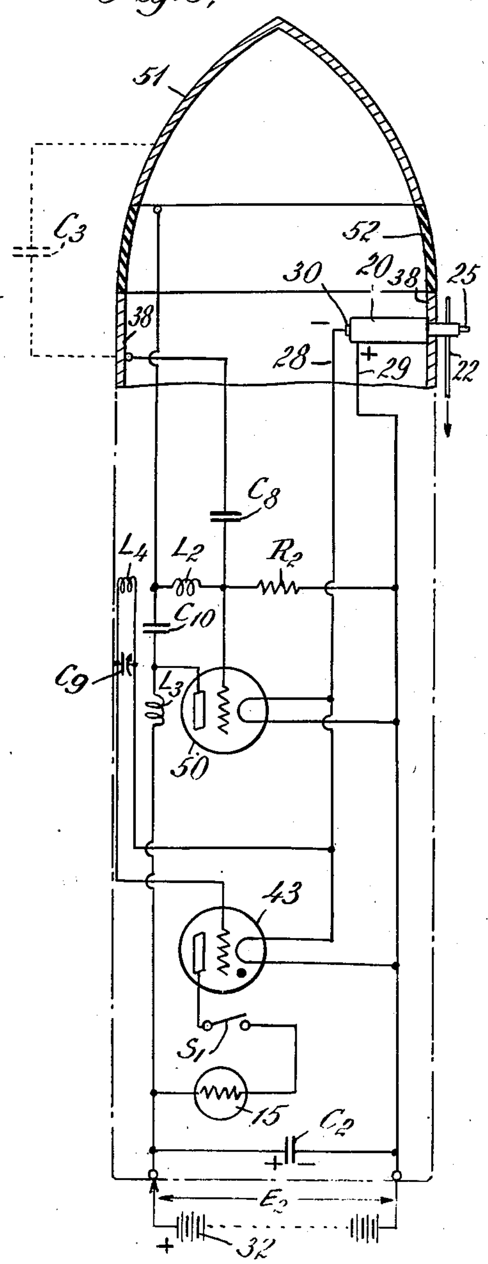


Fig. 5.



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Patented July 9, 1946

2,403,567

UNITED STATES PATENT OFFICE

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ELECTRICALLY ENERGIZED FUSE

Nathaniel B. Wales, Jr., New York, N. Y.

Application January 13, 1942, Serial No. 426,580

4 Claims. (Cl. 136—90)

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The present invention relates to projectiles and more especially to projectile fuses actuated electrically.

The development of electric fuses for projectiles, especially those employing electrically operated or electronic devices, has heretofore been impeded by lack of a satisfactory source of electric operating current. By means of the present invention an adequate source of primary current may be included within the projectile with assurance of complete reliability and safety and without appreciably increasing the normal size or weight of the projectile.

It has been proposed to furnish the required electric current for the purposes above mentioned from electrostatic condensers which are suitably charged before the projectile is released. When such condensers are properly chosen as to type and when suitable components, circuit connections, and mechanical features, are included, satisfactory electric fuses may be produced. Such fuses are described in my copending U. S. patent application Serial No. 405,570, filed August 6, 1941. However, in certain classes of projectiles it has been found desirable to include electric or electronic devices which for their operation require more electric current than can be feasibly furnished from an electrostatic condenser charged, as it must be, before release of the projectile. To supply this need it has been proposed to employ batteries of the dry-cell type, but these have not proved satisfactory in practice, chiefly because of excessive bulk and weight and because the characteristics thereof change markedly with age and with changes of temperature and humidity.

The present invention contemplates the use of a primary battery cell fundamentally of a well-known type. The novel features of the present invention reside in the structure and mechanism by which the battery cell is formed and by which it is applied to the several different types of ordnance projectiles. The term "projectile" as employed in the present specification and claims is intended to include shells, bombs, rockets and like ordnance devices.

By means of this invention it becomes possible to employ in connection with projectile fuses, electronic devices of the filament or heater type, these devices frequently being preferred not only because they are more compact than corresponding devices of the cold-cathode type for the same output, but also because they are more uniform and reliable. The electric cell of the invention, being unformed until the occasion for its actual

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use occurs, has an unlimited "shelf life," and when put into service according to the invention may be depended upon to supply the required electric current at its rated voltage regardless of climatic conditions. This invention, consequently, comprises suitable systems and circuit arrangements employing hot-cathode type electronic devices in connection with time fuses and proximity fuses in which the required sources of electric energy are derived from the combination of a primary cell according to the present invention and, if required, also a precharged electrostatic condenser. As an example of an application of the invention wherein a condenser is not required, there is described below an electric contact fuse for which the detonating energy is derived wholly from a primary cell which is not formed until final release of the projectile.

A better understanding of the present invention may be had from consideration of the drawings, wherein:

Fig. 1 illustrates a cell structure according to the present invention applied to a contract fuse especially adapted to shells;

Fig. 1*a* is a diagram of the fundamental electric circuit of Fig. 1;

Fig. 2 is a second form of the invention applied to a time fuse especially adapted for aircraft bombs and for anti-aircraft rockets;

Fig. 3 is an alternative form of the device of Fig. 2 more particularly adapted to aircraft bombs; and

Figs. 4 and 5 illustrate two different types of proximity fuses, each of which is adapted for use in projectiles of various types such as aircraft bombs, anti-aircraft shells and anti-aircraft rockets.

The contact fuse illustrated in Fig. 1 is shown as applied to a shell, and the construction is such that it is adapted for use in shells even as small as those employed with machine guns. The drawings represent the nose of such a shell and shows a copper shell nose **1** to which a section of insulating material **2**, such as Bakelite, is screwed. To the underside of this insulating section is screwed a fuse base **3** which may be of brass or steel, for example, and which carries suitable external threads to which a shell casing may be screwed.

In the center of the shell nose **1** a chamber is formed of suitable dimensions to receive the components which make up the primary cell in accordance with the present invention. This cell comprises a rupturable vessel or vial **8**, of suitable material to contain an electrolyte **9** such as dilute sulfuric acid of specific gravity of approximately 1.2 for example. Glass and lead are suitable materials for such a vial. Surrounding the vial 8 is a cylindrical sleeve 10 of electronegative material such as zinc, perforated to form apertures therethrough, which comprises one electrode of the cell. Surrounding sleeve 10 is a cylindrical sleeve of absorbent or capillary material which is a non-conductor when dry. Suitable materials for this absorbent sleeve are glass fabric and soft blotting paper. The absorbent sleeve 11, which may be perforated if desired, is in contact with the walls of the chamber formed in the copper shell nose 1 which, being electropositive metal thus forms the other electrode of the electric cell.

Below the vial 8 is a rupturing pin 17 mounted on a suitable metallic base 19. Around the pin 17 is a retaining compression spring 12 sufficiently strong to hold the vial 8 away from the pin 17 during normal handling or accidental dropping of the device after assembly. Below the base 19 is a detonating cup 4 of insulating material, such as Bakelite, which holds a detonating or explosive compound 16 in its cavity, as shown. This cavity is closed by a combustible retaining disc or diaphragm 13. A screw or rivet 14 electrically connects to the metallic base 19 suitable lengths of detonating or heater filament 15 which pass through the detonating compound, thence around the edge of the retaining disc 13 to make contact with the fuse base 3 as illustrated.

Above the cup 4 is provided a space accommodating a metal annulus 5 in which a groove is formed around the outside surface. A corresponding groove is also formed on the inside surface of fuse base 3 as shown. In these two grooves is placed a ring of spring wire 6 which tends to retain the annulus in its normal position as shown.

A thick washer 18 of insulating material separates the lower portion of the copper shell nose 1 from the opposite surface of the metallic base 19. Another piece of insulating material 7, such as suitably shaped rubber, is inserted in the closed end of the central chamber of the copper shell nose 1 before the electric cell is inserted, in order to cushion the end of the vial and to prevent a shortcircuit across the end of the electric cell when formed.

The operation of the electric cell according to the invention as illustrated in Fig. 1 is as follows: When the shell is released, thus initiating its path of flight, the force of inertia or "setback" forces vial 8 back against the pressure of spring 12 to collide with rupturing pin 17. The rupture of the vial allows electrolyte to flow therefrom and to pass through the apertures or perforations in zinc sleeve 10. The electrolyte is forced to flow positively and very quickly through these perforations due to the centrifugal force acting upon it as the result of the rotation of the projectile. Due to the construction of the device, such force is sufficient to be entirely independent of gravity and positively controls the direction of flow of the electrolyte into electrochemical contact with both electrodes irrespective of the position of the projectile during flight. The means cooperating with the rotation of the shell to apply this force on the electrolyte and thus to control its direction of flow, include the base 19 which closes the end of sleeve 10 to form a chamber, the dimensions of the chamber permitting the electrolyte to rotate away from the axis, and the perforations in the sleeve 10. The electrolyte is absorbed due to capillary action by the spacing sleeve 11 and thus is conveyed to be in electro-chemical contact with a surface of zinc sleeve 10 and a surface of copper shell nose 1, forming an electrical cell which generates approximately 1 volt.

As shown in Fig. 1*a*, the electric detonating circuit includes electric cell 1—10, detonating device 15 and switch 1—5 connected in series. Hence, even though the cell may be formed as above described, detonation cannot occur until this switch is closed. The construction illustrated provides a sensitive, yet safe, inertia switch. The spacing between the upper surface of annulus 5 and the opposite surface of nose 1 is such that when the forward motion of the projectile is suddenly impeded, as by coming into contact with or penetrating a fairly dense substance, the inertia of annulus 5 will cause it to move forward, as indicated by the arrows, until it contacts the surface of the nose 1 indicated at the heads of the arrows, to close the detonator circuit. The contacting surfaces may be silver plated to reduce contact resistance, and, if necessary, spring or self-locking contacts may be here employed.

Fig. 2 illustrates an electric cell generally similar to that of Fig. 1, but modified so as to be adapted for use in connection with an electric time fuse. The drawings illustrate a time fuse such as may be employed in an aircraft bomb or in an anti-aircraft rocket, for example.

In this figure the projectile casing 38 is shown to support an end bushing 21 of suitable metal, such as brass, which screws into a hole through the case. To this bushing is screwed a cylindrical copper casing 20 which encloses the elements of the electric cell according to the invention, and which acts also as one electrode (positive) thereof. As before, the negative electrode comprises a perforated zinc cylinder 10′ in which is inserted a sealed vial or vessel 8′ filled with an electrolyte 9′, such as a dilute sulfuric acid solution. A plug or cushion 7′ of insulating material separates the end of the vial from the end of the cell proper. In the construction shown in Fig. 2 the zinc electrode cylinder is formed with one end closed, this being a convenient construction for the present modification because it enables a connection from the negative electrode to be made through a hole in the end of the copper casing 20 by means of a rivet or screw 30 passing through an insulating terminal disc 27 which serves to separate the end of the casing 20 from the end of the zinc cylinder 10′.

On the opposite end of the electric cell is a plunger 25 on one side of which is a rupturing pin 17′ normally spaced away from the end of the vial, as shown. Surrounding the plunger 25 is a cylindrical insulating spacer 39 which serves to retain the vial in position and also functions as a cylinder wall for the plunger 25.

A coil spring 37 acts against a shoulder on end bushing 21 and against the bottom of plunger 25, urging plunger 25 and rupturing pin 17′ toward the vial 8′. Plunger 25 terminates in a shaft 31 which slides through a suitable hole in bushing 21. Two holes are shown to have been drilled diametrically through the end bushing 21 and shaft 31. Through one of these holes 46 a cotter pin 23 is inserted, after assembling of the device as a safety measure. Hole 45 receives an arming wire which is commonly employed in connection with aircraft bombs, such an arming wire being withdrawn just before or at the instant the bomb is released from the aircraft. At the time the bombs are loaded on the aircraft, and after the arming wire is inserted in place, the cotter pin would be removed. Pin 24 which passes through a suitable hole in shaft 31 and presses against the end of bushing 21 is used in connection with the assembly of the device, and would be removed after cotter pin 23 is inserted, previous to shipment.

Operation of the electric cell illustrated in Fig. 2 is generally similar to that of Fig. 1. It differs from the operation of the cell of Fig. 1 in that upon release of shaft 31, plunger 25 is urged toward the vial 8′ by spring 37 with sufficient force to cause pin 17′ to rupture the vial. The piston action of plunger 25 tends to force the electrolyte through the apertures or holes in sleeve 10′ to be absorbed by absorbent spacer 11′ and thus conveyed to and held in contact with the electrodes 10′ and 20 to form an electric cell. Thus the action of the plunger 25 in combination with the perforated sleeve 10 and the spacer 11 is equivalent to the above-mentioned action of the rotation of the projectile in combination with the base 19, perforated sleeve 10 and spacer 11 in the form of Fig. 1, because in both forms of the invention the direction of flow of the electrolyte is automatically and positively controlled so as to be in electrochemical contact with both electrodes irrespective of the position of the projectile during flight. More specifically, when plunger 25 is forced to move into vial 8, the resulting piston action positively and quickly forces the electrolyte out of the vial, through the holes or perforations in sleeve 10, as above described, and thus replaces the similar effect of centrifugal force as described in connection with the form of Fig. 1.

The elements comprising the time fuse of Fig. 2 are shown diagrammatically below the electric cell just described, and comprise a gaseous discharge tube 43 of the Thyratron type which includes the usual heated filament type cathode, anode and control electrode or grid. The timing resistance R_1 and timing condenser C_1 are connected in parallel between the control electrode and cathode. The output circuit of tube 43 includes in series a safety switch S_1 and ignition element 15. It is not necessary that a switch be included in the cathode circuit because the cell is not formed and hence no current flows in the cathode circuit until the vessel 8′ is ruptured. However, as an added safety precaution switch S_1 actuated after release of the projectile, is included. Such a safety switch may be operated, for instance, by means of an airvane and gear reduction mechanism as shown in my mentioned copending application.

Those skilled in the art will appreciate the advantage of a reliable and stardardized voltage supply for furnishing heating current for the cathode. Inasmuch as the timing of the timing circuit depends in part upon the electron emission from the cathode, it is necessary that the heating current be in excess of a minimum value. This requirement is met by means of the present invention which furnishes current from a standardized electric cell which, because it is formed immediately before use, is always fresh and reliable.

The operation of the fuse system of Fig. 2 is as follows: Shortly before the projectile is to be released, voltage sources E_1 and E_2 (here represented as batteries 32) are connected through separable connectors 40 to charge condensers C_1 and C_2, respectively. The voltage impressed across condenser C_1 should be variable to control the quantity of the charge in C_1. This is the timing voltage. The voltage E_2 applied across condenser C_2 may usually be fixed so long as it charges C_2 with sufficient energy to furnish anode potential to the tube 43, and also to furnish ignition energy to actuate the electric device 15, here represented as an ignition element or detonator. At the time of release of the projectile, or as a result thereof, the arming wire 22, or its equivalent, is withdrawn and the electric cell is automatically formed as above described. The resulting current heats the cathode of thyratron tube 43 and this tube 43 is then capable of thermionic conduction.

It will be seen that the voltage of C_1 initially biases the control electrode of tube 43 negatively, this bias being sufficient to prevent discharge of the tube. Upon expiration of a time period predetermined by the product of R_1 and C_1 and by the preselected value of E_1, the ratio of the decaying negative grid voltage to the positive anode voltage reaches a value which permits the discharge of condenser C_2 through the ignition element 15 and the discharge path of tube 43. This, of course, will occur after C_1 has discharged itself sufficiently through the leak resistor R_1. The timing action commences at the instant the separable connectors 40 are detached from the charging source 32.

The modification of the invention shown in Fig. 3 is particularly adapted for use with aircraft bombs and flares, and is so constructed that the electric cell is formed automatically a predetermined interval after release of the projectile and during its trajectory. To this end the bomb, for example, is fitted with a mechanism driven by an airvane which begins to operate immediately upon release from the aircraft. This mechanism, known in the art as an arming vane, is here arranged to rupture a vessel holding electrolyte as in Fig. 2 and thus to form an electric cell in accordance with the invention.

The elements of the cell of Fig. 3 being similar to those correspondingly numbered in Fig. 2, require no further description. In the device of Fig. 3, however, the plunger 31 and rupture point 17′ are caused to move toward the vessel 8′ by the force initially derived from an air driven propeller usually mounted on the nose of the bomb. This propeller includes two airvanes 33 secured to bushing 34 which is journaled axially in casing 35 so that thrust bearing balls 36 receive the thrust of air pressure on the vanes. Rotation of vanes 33 due to the free fall of the bomb or flare to the nose of which they are attached rotates a driving spur gear 41 which is secured to bushing 34.

Axially threaded in the bushing 34 is a shaft 42 which is integral with a driven gear 43. This driven gear differs by one tooth from driving spur gear 41. Pinion gear 44 engages both of gears 41 and 43 and is arranged to revolve freely on a fixed axis. Thus the rotation of bushing 34 will slowly revolve screw shaft 42 by reason of the epicyclic gear action resulting from the gear train just described. Since this screw shaft 42 is threaded into bushing 34, as shown, the rotation of the sleeve will progressively move the shaft downward, causing rupture point 17′ to collide with vessel 8′ and release the electrolyte. Further movement of the plunger 25 tends to force the electrolyte through the perforations in sleeve 10′, as in Fig. 2, independent of other forces such as gravity, for example.

The control and ignition circuits connected to be energized by the rupture cell just referred to may, for example, be those of the time fuse of Fig. 2 or those of the proximity fuses of Figs. 4 and 5. In employing a device like that of Fig. 3 it is usually not necessary to include a safety switch S_1 shown connected in the ignition circuits of Figs. 2, 4 and 5 because of the fact that this electric cell is not formed until an appreciable interval after release of the projectile, before which time there is no energy available by which the fuse can operate. However, in my mentioned copending application Ser. No. 405,570, there is shown and described an arming vane capable of actuating a safety switch S_1.

Figs. 4 and 5 illustrate the electric cell of Fig. 2 of the present invention employed to energize proximity fuses for projectiles, the form of cell represented being especially adapted to use with bombs. When applied to a anti-aircraft shell or rocket the form of electric cell shown in Fig. 1 is more suitable. The proximity fuse of these figures is housed in a part of the case thereof. The case includes a metallic nose **51** spaced and insulated from the remainder of the case portion **38** by insulating section **52**. The nose portion **51** and the case portion **38** are utilized as two elements of a dipole which have a fixed free-space electrostatic capacity C_3 therebetween. Either or both of these metallic portions may be separated from the case, but it is usually convenient that at least one forms a part of the projectile case. This free-space capacity increases when the nose of the projectile approaches a solid object, and it is this change in capacity which by changing the frequency of a tuned circuit, ultimately actuates the fuse. A proximity fuse of this nature is disclosed in my U. S. application Ser. No. 196,116, filed March 16, 1938, now abandoned.

The elements of the electric proximity fuse of Fig. 4 include an inductance L_1 connected to the two poles of dipole **51—38** and coupled to inductance L_2 which, together with adjustable tuning condenser C_4 connected across it, comprises an oscillator tank circuit. One terminal each of condenser C_4 and inductance L_2 is connected through grid coupling condenser C_5 to the grid of thermionic tube **50** which is an oscillator tube. A grid leak R_2 is connected from the grid of oscillator tube **50** to the cathode thereof. Each leg of the cathode is connected through a radio-frequency choke coil L_3 to the remainder of the circuit. The two condensers C_6, one connected from the anode to the cathode and the other across the terminals of the cathode, are radio-frequency bypass condensers. The remaining terminals of condenser C_4 and inductance L_2 are connected in common to the anode of tube **50**, thus completing the anode circuit, except for the anode voltage supply which is furnished to the plate of tube **50** through radio-frequency choke L_3 and oscillator plate-load resistor R_3 from a charge impressed on condenser C_2 which, functionally, corresponds to condenser C_2 of Fig. 2.

The anode of oscillator **50** is coupled to the control grid of the gaseous discharge tube **43**, of the Thyratron type, through coupling condenser C_7. Connected between the control grid and cathode of tube **43** is a grid leak R_4. The polarity of the connections to the cathode from the electric cell **20—30** (which is constructed as in Fig. 2) are such that a negative grid bias substantially equal to that of the cathode heating potential is impressed on the control electrode of tube **43** with respect to its cathode.

As in Fig. 2 the anode circuit of discharge tube **43** includes in series a safety switch **1**, ignition element **15** and energy storage condenser C_2. The safety switch should be arranged to close automatically after discharge of the projectile. In the case of an aircraft bomb this switch may be operated by an airvane as shown in my mentioned copending application.

The distributed capacity C_3 effective across the dipole **51**, **38** is that measured in free space. This capacity effectively connected across inductance L_1 determines the natural frequency of the circuit C_3, L_1 which may be termed an "absorption circuit." Such frequency may be of the order of magnitude of 100 megacycles, for example, and the natural "free space" frequency of C_3, L_1 may be, say, 105 megacycles.

The proximity fuse of Fig. 4 operates as follows: Assuming that oscillator tube **50** is tuned by condenser C_4 to a frequency slightly lower than the frequency of the absorption circuit, when the projectile approaches an object such as the surface of the earth, a building, or an aircraft, the effective capacity C_3 (sometimes known as the "phantom capacity") increases, and the absorption circuit C_3, L_1 will fall into resonance with the oscillator tank circuit L_2, C_4.

This sudden resonance of the absorption circuit causes a sudden dip in the anode current and in the accompanying anode voltage of the oscillator tube **50**. Such sudden change in voltage produces a transient in the oscillator load resistor R_3, and this transient is passed through coupling condenser C_7 to the control electrode of the gas-discharge tube **43** on which it appears as a positive pulse. This positive pulse on the control electrode of tube **43** is sufficient to "fire" the tube and to establish a current flow between the cathode and anode thereof. In other words, the transient effectively closes the cathode-anode circuit of tube **43** which acts as a relay and allows current to flow from ignition storage condenser C_2 through ignition element **15** (switch S_1 having been closed), which energizes the ignition element and detonates the charge.

Prior to the instant when the positive transient pulse is impressed on the control electrode of tube **43**, as just described, that electrode is biased to an inoperative point on the characteristic curve of the tube, at the anode potential provided by condenser C_2 (potential E_2), because of the fact that the grid resistor R_4 is connected to the ungrounded negative terminal **30** of the cell **20—30**. It is understood that the potential of condenser C_2 results from a charge given to that condenser from an external battery **32**, or fuse-setter as described in my mentioned copending application, connected through separable connectors **40** prior to release of the projectile.

The alternative arrangement of the proximity fuse of Fig. 5 differs from that of Fig. 4 by including an oscillator, the frequency of which is varied by changes in the effective capacity C_3 of the dipole so that, for example, the approach of the projectile to an object will lower the oscillating frequency, the frequency of the absorption circuit being fixed. Thus, broadly speaking, the circuit arrangement of Fig. 5 operates in a manner opposite to that of Fig. 4.

In the system of Fig. 5 the absorption circuit L_4, C_9, of which condenser C_9 is adjustable, is pretuned to a lower frequency than the "free space" frequency of the oscillator circuit which includes oscillator tube **50**. It will be clear that the frequency of this oscillator is determined by a tank circuit including inductance L_2 in parallel with which capacity C_3 is connected through radio-frequency bypass condenser C_8. Condenser C_{10} is also a radio-frequency bypass condenser, resistor R_2 being a grid-leak resistor, as in the case of Fig. 4.

A rupturable cell **20—30**, as in Figs. 4 and 2, is connected, as shown, to furnish heating current for the cathodes of tubes **50** and **43**, the connections being such that a negative bias substantially equal to that of the cell is impressed on the control electrode of the discharge tube with respect to its cathode, rendering it inoperative until the instant of intended operation. The circuits of discharge tube **43** are similar to those above described in connection with Fig. 4, except that the input to tube **43** is effected through tuned absorption circuit L_4, C_9 as above indicated.

When a projectile including a proximity fuse in accordance with Fig. 5 approaches an object, the frequency of the oscillator is decreased, bringing it into resonance with the fixed frequency of absorption circuit L_4, C_9 which, as above noted, has previously been tuned to a lower frequency than the "free space" frequency of oscillator **50**. This oscillator frequency may, for example, be of the order of magnitude of 105 megacycles, in which case the natural "free-space" frequency of C_3, L_2 may be, say, 100 megacycles. This resonance relation impresses a high-frequency voltage on the control grid of discharge tube **43**, which, as before, has been biased to an inoperative point on its characteristic curve. The result of thus energizing the control electrode of tube **43** is, as previously explained, to "fire" the tube and effectively to close the anode circuit thereof, which results in operation of the ignition or detonating device **15**.

What is claimed is:

1. In a fused projectile, adapted to be rotated during flight, an electrolyte, a rupturable container therefor, electrodes adapted to form an electric cell when in electrochemical contact with said electrolyte, means responsive to the force of inertia incident to the discharge of said projectile for rupturing said container whereby said electrolyte may flow therefrom, and means utilizing centrifugal force resulting from the rotation of said projectile effectively to force said electrolyte into electrochemical contact with said electrodes irrespective of the position of said projectile during flight.

2. In a fused projectile adapted to be rotated during flight, a sealed vessel containing an electrolyte, a perforated metallic sleeve surrounding said vessel forming a first electrode of a certain polarity, a second electrode of opposite polarity surrounding said first electrode, a spacer of absorbent material separating said electrodes and in contact therewith, means operable by the initiation of the flight of said projectile for rupturing said vessel thereby permitting said electrolyte to be released within said sleeve, and means utilizing centrifugal force resulting from the rotation of said projectile to force said electrolyte through said perforations and thence to said spacer to be conveyed thereby into electrochemical contact with said electrodes irrespective of the position of said projectile during flight, whereby to form an electric cell.

3. In a fused projectile adapted to be rotated during flight, a sealed vessel containing an electrolyte, a metallic sleeve adjacent said vessel forming a first electrode of a certain polarity, a second electrode of opposite polarity adjacent said first electrode, a spacer of absorbent material separating said electrodes and in contact therewith, means operable by the initiation of the flight of said projectile for rupturing said vessel and thereby releasing said electrolyte, and means utilizing centrifugal force resulting from the rotation of said projectile to force said electrolyte into said spacer to be conveyed and retained thereby in electrochemical contact with said electrodes irrespective of the position of said projectile during flight, whereby to form an electric cell.

4. In a fused projectile adapted to be rotated during flight, a sealed vessel containing an electrolyte, a metallic element forming a first electrode of a certain polarity, a second electrode of opposite polarity adjacent said first electrode, a spacer of absorbent insulating material separating said electrodes and in contact therewith, means operable by the initiation of the flight of said projectile for rupturing said vessel and thereby releasing said electrolyte, and means positioned between said vessel and said spacer to constrain said electrolyte to flow into said spacer under the pressure on said liquid resulting from centrifugal force due to the rotation of said projectile, said electrolyte being conveyed and retained by said spacer in electrochemical contact with said electrodes irrespective of the position of said projectile during flight, in order to form an electric cell.

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