

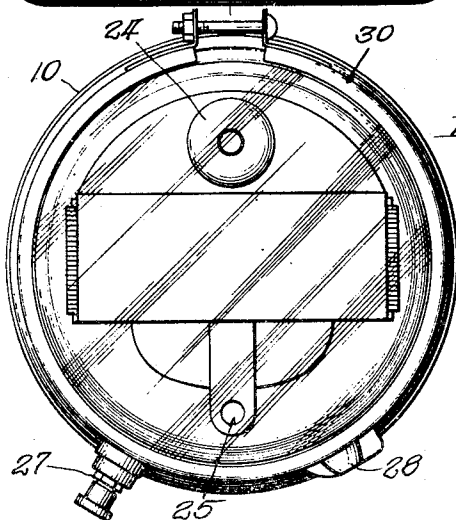
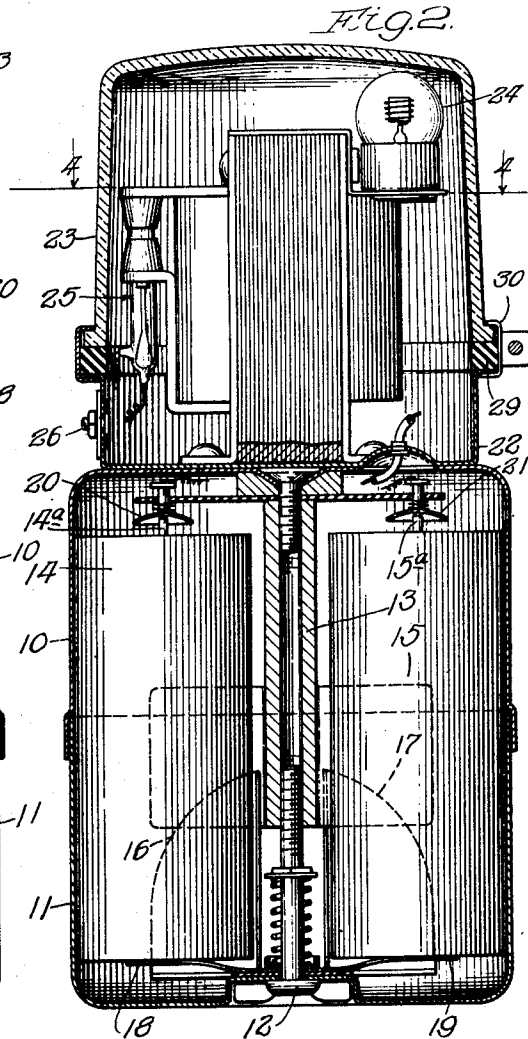
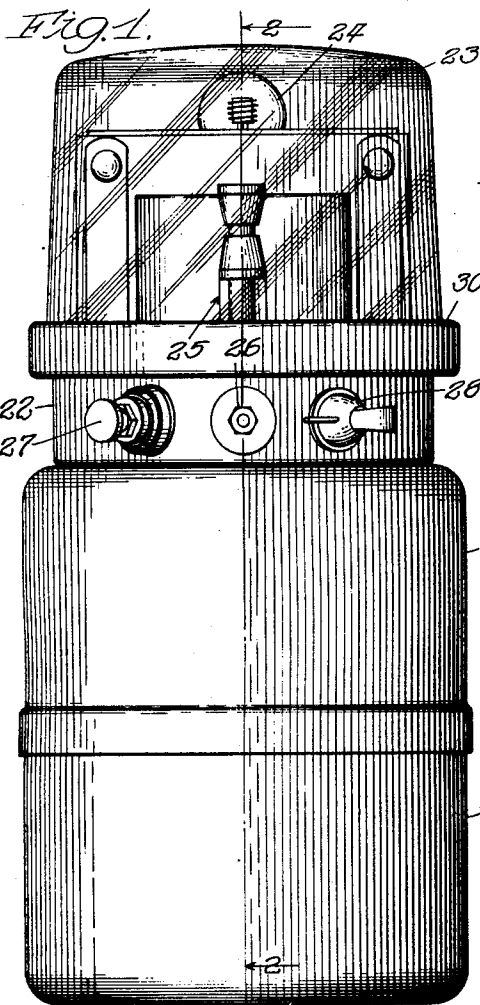
July 8, 1952

L. J. SCHILLING
ELECTRIC FENCE ENERGIZER

2,602,844

Original Filed Nov. 26, 1945

3 Sheets-Sheet 1



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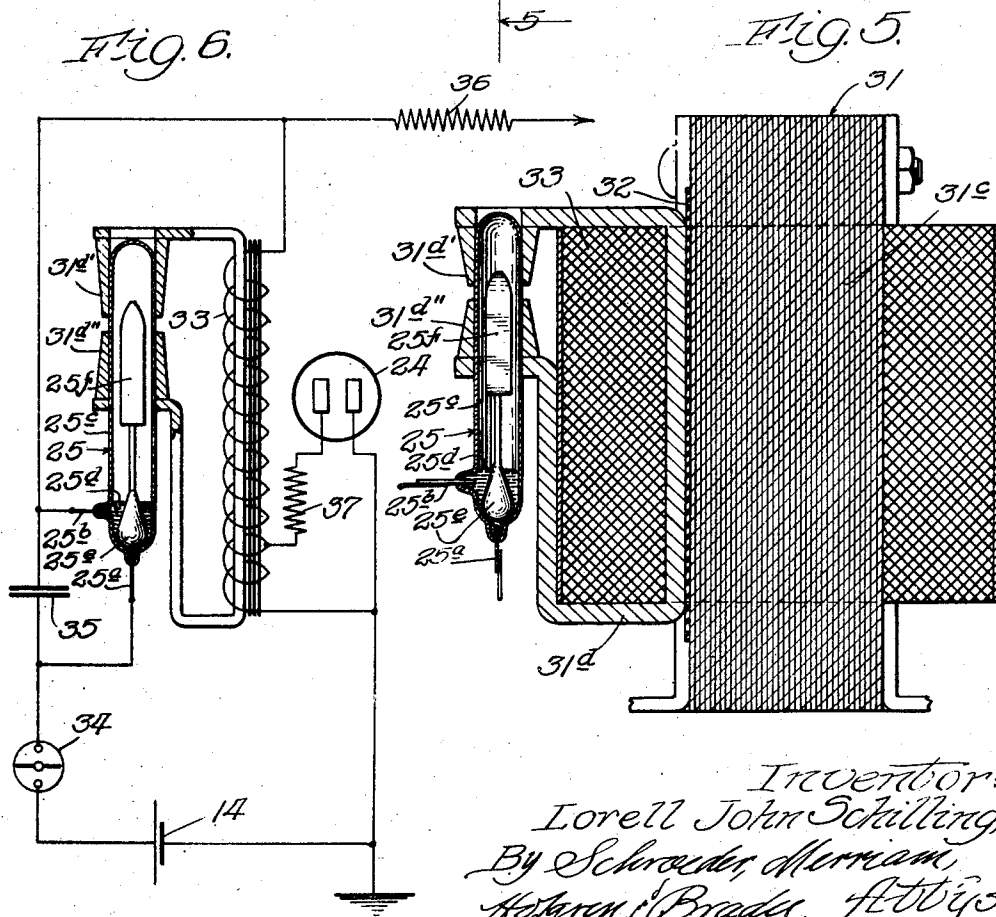
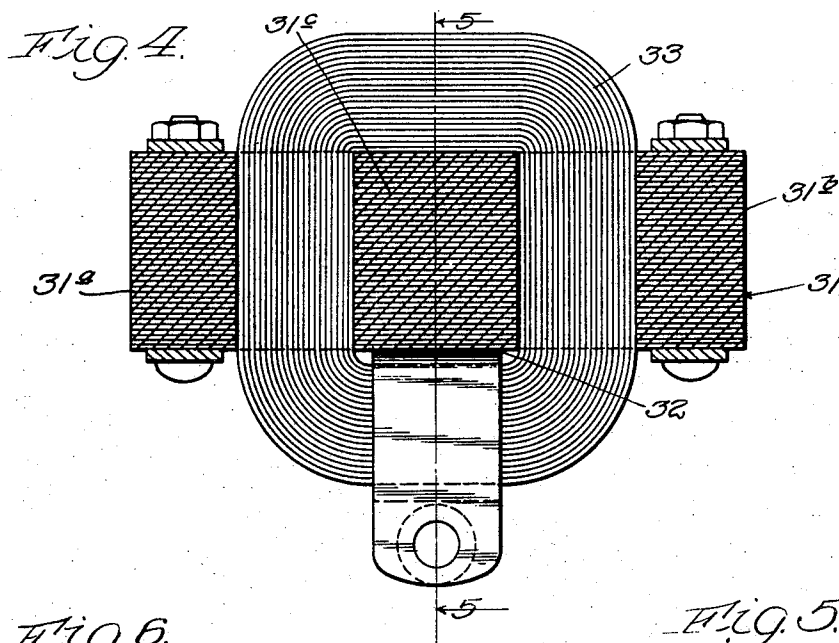
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ELECTRIC FENCE ENERGIZER

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3 Sheets-Sheet 2



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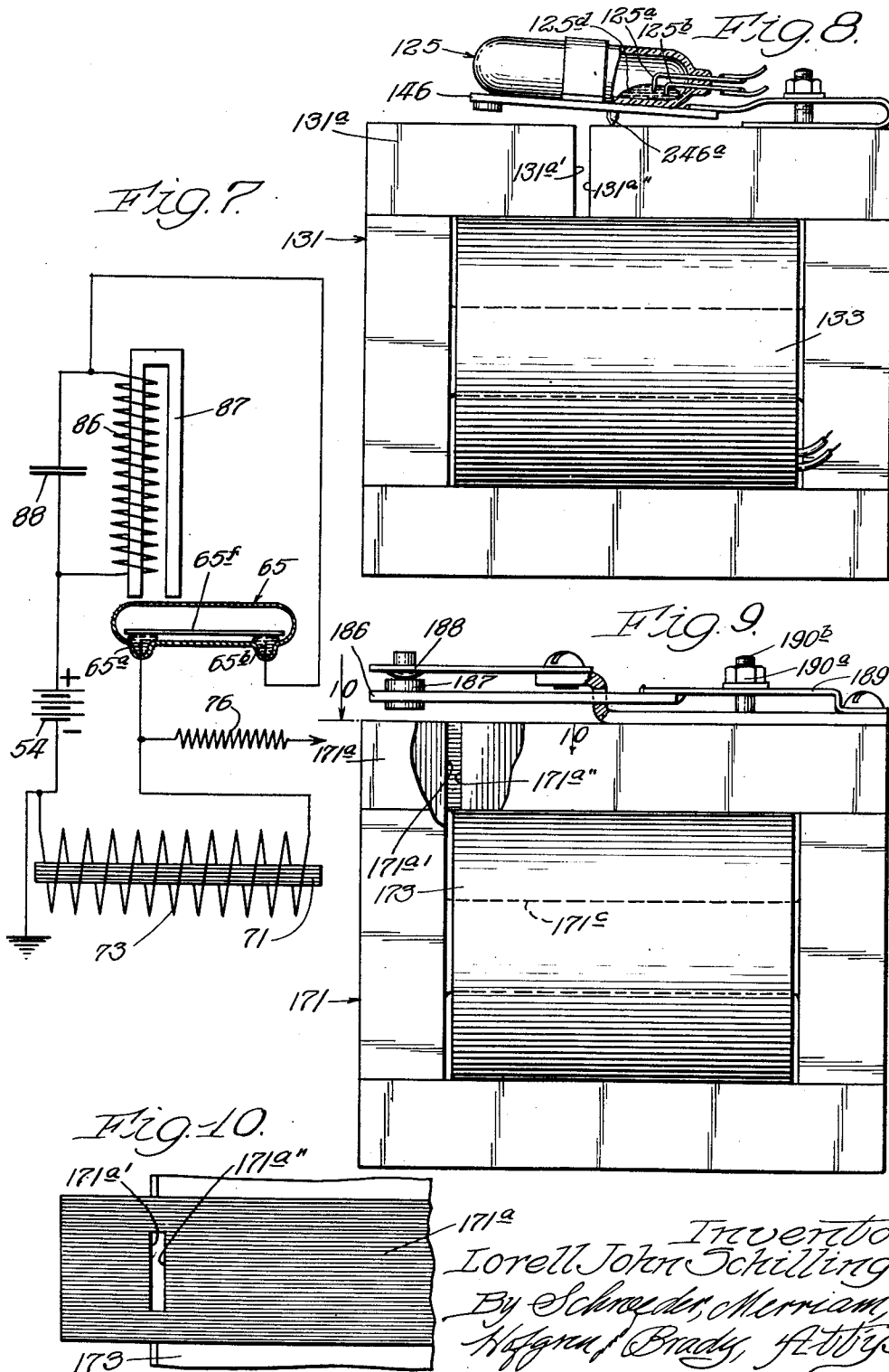
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ELECTRIC FENCE ENERGIZER

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,602,844

ELECTRIC FENCE ENERGIZER

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Original application November 26, 1945, Serial
No. 630,811. Divided and this application
December 14, 1949, Serial No. 132,880

2 Claims. (Cl. 175—373)

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This invention relates to an electric fence energizer, and more particularly to an improved battery operated arrangement for periodically energizing an electric fence wire.

This application is a division of my copending application entitled "Electric Fence Energizer," filed November 26, 1945 as Serial No. 630,811, now abandoned.

Electric fences are intended to stop animals, and keep them within a desired enclosure, by the effect of electrical shocks rather than by sheer mechanical strength, the shock used being strong enough to cause the animal to avoid the fence after it has been shocked once or twice, but not strong enough seriously to injure the animal or anyone accidentally coming in contact with the fence wire. Where the fence wire is briefly periodically energized it has been determined that, for reasons of safety, the maximum current deliverable to the fence should not exceed 25 milliamperes at any time, and the shock impulse duration should not exceed $\frac{1}{10}$ of a second nor be more often than once a second; and certain states have incorporated these and similar requirements in their codes. Accordingly, fence energizing devices for providing a brief periodic impulse to the fence incorporate a circuit interrupter or switch actuated by timing means in such manner that the shock impulse has less than $\frac{1}{10}$ second duration and occurs less than sixty times per minute, usually in the neighborhood of 50 impulses per minute.

Previous electric fence energizers of the periodic type designed for battery operation have almost without exception incorporated a mechanical timing arrangement using a moving mechanical mass of considerable inertia (as a pendulum or a large balance wheel) briefly to close a pair of open contact points periodically with a cycle determined by the natural period of the mechanical mass. Such arrangements have had a number of defects and objections. One of the principal defects is that the open contact points have been subject to pitting, corrosion, interruption due to dirt getting between them, and the like; and the very nature of the timing actuation arrangement has been such that contacts hermetically sealed in an appropriate glass tube or other envelope could not be used.

I have devised and am here disclosing an electric fence energizer particularly designed for battery operation which incorporates a novel timing system adapted, where desired, to use hermetically sealed contacts; and which relies on electrical rather than mechanical factors for

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regulation of the timing. In general, this phase of my invention comprises the use of a transformer with a winding of a large number of turns on a magnetic core structure of considerable weight and size, so that the inductance of the winding is large enough to require more than a second for current build-up to maximum when the winding is connected to the D. C. source, as a battery; and then by providing actuating means (as an armature acted upon by a portion of the flux in the core structure) operable as a function of the current and field strength build-up briefly to open the switch. As may be readily apparent, this makes timing substantially entirely a function of design of the winding and core structure (factors which do not vary in the field); and provides an arrangement which can readily make use of hermetically sealed contacts in small, light switches.

Another important feature of the electric fence energizing system here disclosed is that it provides means for delivering a very high peaked, steep wave front, relatively slowly decreasing voltage shock impulse to the fence, having excellent stock stopping power for a given quantity of electricity (some states limit the impulse to 3 milliampere-seconds).

Still another feature of this invention is that I make use of an auto-transformer having the above and other desirable characteristics, and associate with it means for preventing variations in load conditions on the fence (as contact of the fence by wet weeds or the like) from having any substantial effect upon the current drain on the battery. Other features and advantages will be apparent from the following specification and the drawings, in which:

Fig. 1 is a side elevational view of one embodiment of a battery fence energizer incorporating my inventions; Fig. 2 is a vertical sectional view of the device shown in Fig. 1, along the line 2—2 of such figure; Fig. 3 is a top plan view of the device; Fig. 4 is a horizontal sectional view along the line 4—4 of Fig. 2; Fig. 5 is an enlarged vertical view, partly in section, of certain of the apparatus shown in the upper part of Fig. 2; Fig. 6 is a schematic diagram illustrating the circuit used in the device; Fig. 7 is a schematic drawing illustrating still another system embodying my inventions; Fig. 8 is a side elevational view of the operating portion of another fence energizing system incorporating my inventions; Fig. 9 is a side elevational view, partly broken away, of still another operating portion embodying my inventions; and Fig. 10 is a fragmentary horizontal sectional view along the line 10—10 of Fig. 9.

In the particular embodiment of my invention illustrated in Figs. 1-6 inclusive, the electric fence energizer comprises a lower battery casing portion consisting of an upper section 10 and a lower section 11 held together in any suitable manner, as by threading a stud 12 into an internally threaded central member 13 attached to the upper casing section 10. The particular arrangement here shown is designed to accommodate four $1\frac{1}{2}$ volt dry cells of the so-called No. 6 size, two of these cells being identified as 14 and 15; and proper separation between the cells is ensured by four spacer members at right angles to each other, the two shown in dotted lines in Fig. 2 being identified as 16 and 17. In the particular arrangement here being disclosed the cells are all connected in parallel by a contact system arrangement including the lower leaf spring contacts (as those identified as 18 and 19) and the upper spring-pressed cup contacts (as those identified as 20 and 21) adapted to make contact with the central terminals of the cells, as the terminals 14a and 15a. While this arrangement is shown as representative and as illustrating one which I have actually built and used, it will be understood that any desired source of relatively low voltage direct current can be used, normally either a $1\frac{1}{2}$ volt or 6 volt battery arrangement. My inventions reside primarily in the operating apparatus energized by the direct current source, and the apparatus can be designed to operate with any convenient predetermined battery arrangement. I prefer this particular arrangement because my apparatus is fully capable of operating on $1\frac{1}{2}$ volts (in fact I have operated it satisfactorily with a single small flashlight cell) and this battery arrangement results in exceedingly long life of the battery since, as will become apparent later, there is an almost continuous but exceedingly low current drain on the batteries.

The upper portion of the electric fence energizer now being described comprises a lower casing section of metal or similar suitable material here identified as 22, and an upper casing section 23 which I prefer to make of glass, as illustrated, as this enables the indicator lamp 24 to be mounted within the casing and also enables the user to watch the operation of the switch indicated in general as 25. While it is possible to develop the shocking voltage between two parallel insulated wires strung as a fence it is conventional to develop the energizing voltage between a single insulated fence wire and ground. In the particular system shown here one side of the output is grounded by a ground wire connected to the terminal 26 and the other side of the output is delivered to the "hot" terminal 27 supported by a suitable insulator such as porcelain and the like. While a fixed indicator arrangement is shown in the circuit diagram for simplicity of illustration, an indicator arrangement of the kind shown in Pfanstiel Patent 2,304,954, of December 15, 1945, may be used, the rotatable knob 28 being for this purpose. The upper glass casing part 23 is adapted to seat on a gasket 29 of rubber or other suitable material, and the casing parts 22 and 23 are held together by suitable means, as by a clamping ring 30.

Referring now more particularly to Figs. 4-6, the operating portion of this particular electric fence energizer will be described. In order to provide a satisfactory shock impulse on the fence it is necessary to step the low voltage of the

source up to a very much higher voltage for the shock impulse, preferably a voltage reaching a peak in the neighborhood of 500-1,500 volts and tapering off relatively slowly. While other battery fencers on the market do this by use of a high ratio step-up transformer, I find that much improved voltage curve characteristics of the shock impulse can be obtained by delivering the impulse from the "surge" effect incident to the sudden collapse of a field around a coil having a large number of turns, as from several hundred turns up to a couple of thousand turns or more. Accordingly I provide an auto-transformer or single winding transformer here shown as comprising the core structure 31 having two outer leg portions 31a and 31b and a central leg portion 31c. Adjacent one side of this central leg portion 31c, and preferably separated therefrom by a thin sheet of insulating material 32, is an auxiliary core structure portion comprising a single piece of strap metal 31d having an air gap therein between hollow generally conical pole face portions 31d' and 31d''. The main core structure portion is comprised of a substantial set or stack of laminations of metal of suitable magnetic permeability; and the auxiliary portion 31d is also of magnetically permeable material as soft iron. Around the central leg 31c of the main core structure portion and the vertical leg of the strap iron portion 31d is a winding or coil 33 of at least several hundred turns and of a resistance of the order of at least several ohms.

Referring now more particularly to the circuit diagram comprising Fig. 6, the relatively low voltage direct current source (illustrated as the single battery 14 for simplicity) has one side thereof connected to ground and to one end of the winding 33 (the lower end as illustrated in the figure here being described). The other side of the battery 14 is connected through an "on-off" switch 34 to one terminal 25a of the switch 25, the other terminal 25b being connected to the other end of the winding 33. In order to prevent arcing a condenser 35 is shunted across these terminals; and the circuit between these terminals is made and broken within a hermetically sealed glass tube or envelope 25c by the rise and fall of level of a pool of mercury 25d. This rise and fall of mercury level is effected by movement of a displacement member 25e attached to a core 25f of magnetically permeable metal, as soft iron. The core 25f and displacement member 25e drop to the position shown in Fig. 6 by gravity, causing connection between the terminals 25a and 25b and completion of a circuit through the winding 33. When the current in this winding, and the flux conditions in the magnetic structure which are a function thereof, have reached a predetermined value, the force developed by the flux passing between the core portions or pole faces 31d' and 31d'' is sufficient to start upward movement of the core 25f, such upward movement (once started) continuing until the core member 25f is centered with respect to the gap between the pole faces. This movement, of course, raises the displacement member 25e up out of the mercury pool and causes the mercury level to drop to a point breaking the connection between the terminals 25a and 25b. This causes a sudden collapse of the field around the winding 33 and develops a surge impulse of relatively high peak voltage and sharp wave front characteristics, providing an improved shock impulse. The particular switch shown and described here

has a number of advantages in itself, but it will not be fully described and claimed here as it forms the subject matter of my copending application Serial No. 597,991, filed June 7, 1945, now abandoned.

In order to prevent short circuit conditions on the fence, or load conditions providing a relatively low resistance path between the fence wire and ground, from drawing current unduly from the battery during the "charging" portion of the cycle of operation, I connect the "hot" end of the winding 33 to the fence wire through a resistor 36. While a neon lamp with suitable voltage breakdown characteristics could be used, I find that this has a tendency to cause a rounding over of the top of the voltage wave; and accordingly I prefer to use a resistor of several hundred ohms, as 500 ohms. Also, to provide the desired indication by flashing of the glow lamp 24, I tap off from a portion of the winding 33 to provide an indicating circuit comprising the lamp 24 and a current limiting resistor 37 of suitable value, as for example 6,000 ohms. While the condenser 35 may be of any suitable value I find .02 microfarads satisfactory.

As will be readily apparent, the time interval between closing of the circuit between the battery 14 and winding 33 and the time when the magnetic pull between the pole pieces 31d' and 31d'' has reached a value causing movement of the core piece 25f and breaking of the circuit is a function of the rise in current in the winding and magnetic densities in the core structure.

These in turn, of course, are substantially entirely a function of the number of turns of the winding and its resistance, and of the amount of permeable metal in the core structure, more turns and more metal providing a longer time interval before the circuit reopens. In order to ensure breaking of the circuit I prefer to so construct the switch and associated pole pieces that opening of the switch takes place well before the current and flux densities have leveled off at their maximum. For example, I find that if I design an auto-transformer in relation to the 1½ volt source here illustrated such that current flow and magnetic conditions do not reach their maximum and level off until about 1.3 seconds, very satisfactory and reliable operation is secured with the switch having its parts so proportioned that the circuit is opened at slightly over one second, as about 1.1 second, after it is closed. A satisfactory transformer providing the desired output impulse and having appropriate delay characteristics in the build-up of current flow and field density values, for example, comprises a winding of 1,000 turns of No. 20 enameled wire on a core structure of the type illustrated having 6 lbs., 5 oz. of iron. I have found that this provides about 1,400 volts peak output with a switch set to open when the current flow has reached about 130 milliamperes, with suitable voltage for the indicating lamp 24 being provided by tapping off at about 150 turns. This arrangement provides a very stable and satisfactory timing system for electric fence energizing equipment, provides an improved sharp wave front shocking impulse of the order of a few hundredths of a second or so duration about 50 or 52 times a minute, under conditions which provide the utmost in battery life and which maintains stability of timing from initial battery voltages clear on down to half voltage conditions or thereabouts. The particular winding specifications given immediately above are for copper

wire and an energizing voltage provided by a single dry cell, nominally 1½ volts; and it will be understood that suitable conditions require higher resistances where higher voltages are used.

For example, a transformer design which I have found very satisfactory for use with a 6-volt direct current source of the type comprising four large dry cells grouped together in a single unit comprises 2,000 turns of No. 24 copper wire on a 1½" x 2½" core structure of approximately 7 lbs. in weight. The winding in this case has a resistance of about 46 ohms as contrasted with a resistance of only 4 or 5 ohms in the winding given above as a suitable example of an auto-transformer for use from a 1½ volt source. Inasmuch as the batteries in the 6 volt unit are in series rather than in parallel, I prefer to use a good deal more than four times the resistance in order to keep the current drain per cell within desirable limits.

Referring now more particularly to Fig. 7, another embodiment of my invention will be described. In order to simplify the specification and keep the description as brief as possible reference numerals 40 higher than those used in the description of the first form will be applied to analogous parts in Fig. 7 so that reference back to the preceding description may readily be made to supplement this.

In Fig. 7 the auto-transformer comprising the winding 73 and core structure 71 serve solely to provide the high voltage shock impulse for the fence wire, through the resistor 76 when the energizing circuit is broken; but actuation of the switch is completely independent of the flux in the main coil, although still a function of the current through its winding. In this form of my invention the battery 54, which may be of the six-volt dry-cell type, has one end connected to ground and to one end of the winding 73, and the circuit from the other end of the winding 73 is completed through a switch 65 and a winding 86 back to the other side of the battery. The winding 86 is completely separate from and not magnetically coupled to the winding 73, but is wound about the leg of a U-shaped separate magnetic core structure 87. The rate at which the inductance of these coils and principally the inductance of the coil 73, enables the current in the series circuit to rise determines the magnetic force created at the pole faces of the U-shaped member 87. The switch 65 is herewith shown as provided with two droplets of mercury in engagement with the contact portions 65a and 65b, these droplets being bridged by the combined circuit closing and armature member 65f. When the magnetic pull developed by the pole faces of the U-shaped member 87 has reached a predetermined value, the armature member 65 is lifted up at one end, breaking the circuit. While different types of switch arrangements are being illustrated and described to show the flexibility of use of my inventions, this particular embodiment is being illustrated in Fig. 7 primarily to show the use of a condenser 88 in parallel with the coil 86 as means for preventing undesirably rapid reclosing of the switch. During the charging period of a second or slightly over the condenser 88 accumulates a voltage, which as soon as the switch 65 opens, discharges through the winding 86 in a direction tending to continue to hold the switch contacts open. This comprises a specific way of maintaining the switch open for a sufficient period to permit com-

plete discharge of the energy stored in the main auto-transformer winding 73.

Still another embodiment of my invention is illustrated in Fig. 8, reference numerals 100 higher than those used in the description of Figs. 1-6 being applied to analogous parts. In this embodiment of my inventions the main magnetic core structure 131 again has the winding 133 on its central leg. In this case, however, the switch 125 is of the moving mercury-droplet type, adapted to be actuated between open and closed conditions by tilting of its axis. It is mounted on a combined armature and lever member here identified as 146, this member being spring mounted so as to be rockable about the axis provided by the knife edge portion 246a. In this particular form of my inventions the flux leakage to actuate the member 246 is provided by a slot with the faces 131a' and 131a'' in the leg 131a of the core structure. When the flux leakage has reached a predetermined value the left-hand end of the member 146 (speaking with respect to the position of the parts as shown in Fig. 8) is pulled down against the core structure, the switch tube tilts to the left, and the mercury droplet 125d runs to the left end of the tube, opening the circuit. The desirable delay in reclosing is provided by the mechanical inertia of the returning of the mechanical parts and the time required for the mercury droplet 125d to run back down into engagement with the terminals 125a and 122b.

In order to get sufficient inductance and time delay to have a period of a second or more before the switch reopens, however, it is desirable to have a magnetic core structure which is well closed, so that a complete transverse slot across one leg, as shown in Fig. 8, requires more iron and more turns than would otherwise be necessary. In order to enable actuation of the switch by leakage flux in a portion of the main core, and yet to keep the magnetic circuit provided by the main core of as low reluctance as possible, I prefer the alternative arrangement shown in Figs. 9 and 10 to that shown in Fig. 8. This embodiment of my inventions shown in Figs. 9 and 10 will be described with the use of reference numerals 140 higher than those used in the description of Figs. 1-6 applied to analogous parts.

In this electric fence energizing arrangement a magnetic core structure 171 again has its central leg 171c surrounded by a winding 173 of at least several hundred turns, as is the case in all of the embodiments shown in this application. The leg 171a of the core is provided with a slot which extends only part away across the full width of this leg to provide pole faces 171a' and 171a'' defining an air gap in the structure therebetween. Immediately above this air gap is a movable armature member 186 here shown as carrying a contact member 187 adapted to engage a fixed contact 188, although it will be understood that a mercury switch of the type shown in Fig. 8, or any other suitable hermetically sealed switch arrangement, may be employed. The member 186 is mounted on the leaf spring member 189 and adjusted by means of the nut 190a on the threaded stud 190b. As before, the timing is regulated by the inductance of the coil provided by the large number of turns on the winding and the considerable weight of magnetically permeable metal in the core structure; and when the current in the

winding has reached a predetermined value the magnetic force at the partial air gap in the core leg 171a attracts the armature member 186 to break the circuit energizing the winding 173 and cause the collapse of the field therearound, providing the desired impulse on the fence wire.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. In an electric fence system, energizing apparatus including: an autotransformer having a winding of the order of a thousand turns or more; a magnetic core structure of permeable material of a weight of the order of six pounds or more, said core having a leg upon which said winding is mounted and an external leg having a leakage air gap extending at least partially therethrough; an armature mounted in bridging relationship to said air gap and biased away from said core; first and second switch contact members, at least one being operatively connected to said armature to be moved thereby, a circuit connection being completed between said contact members in the de-energized position of said armature; a low voltage direct current source with one terminal connected to one end of said autotransformer and the other end connected through the normally closed contacts to the other end of said autotransformer, one end of said transformer being connected to the output terminal of the apparatus, said armature and switch contact members being operated directly by flux in said core produced solely by current from said source flowing through said winding, whereby the timing of the operation of said fence energizing apparatus is a function of the slow build-up of current in said winding of the order of a second in time and is relatively independent of variable factors in the use of the device.

2. Apparatus of the character claimed in claim 1, wherein the connection between one end of the transformer and the output terminal of the apparatus is completed through a resistance of the order of several hundred ohms.

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