United States Patent

Malme

[15] **3,655,994**

[45] **Apr. 11, 1972**

[54] ELECTRIC FENCE CHARGER

[72] Inventor: **Elmer K. Malme**, St. Charles, Ill.

[73] Assignee: **Wire Sales Company**, Chicago, Ill.

[22] Filed: **Feb. 8, 1971**

[21] Appl. No.: **113,477**

[52] U.S. Cl. .....**307/132 R**, 256/10, 340/254, 307/106

[51] Int. Cl. **H01h 47/00**

[58] Field of Search.....307/132 R, 132 M, 132 E, 132 ER, 307/106, 112, 96; 256/10; 340/253, 254

[56] **References Cited**

UNITED STATES PATENTS

3,392,285 7/1968 Olson.....307/132 R

3,378,694 4/1968 Griffeth.....307/132 M

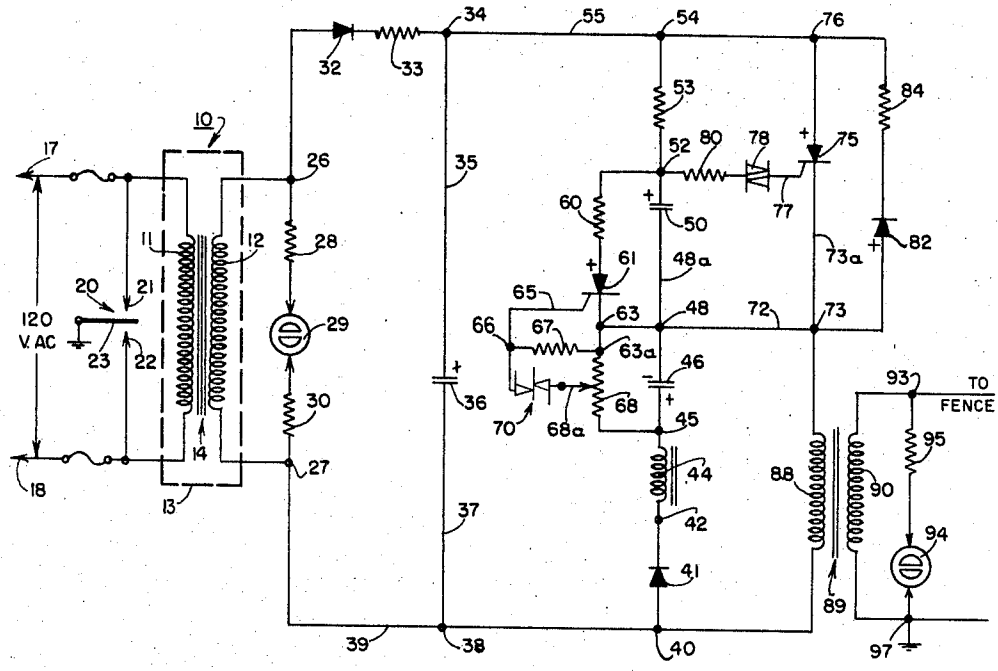
Primary Examiner—Herman J. Hohauser

Attorney—Robert L. Kahn

[57] **ABSTRACT**

A device for periodically applying a high potential on an electric fence has means for applying such potential for very short times at periodic intervals. The time between successive charging intervals depends upon whether the fence is "loaded" (where an animal grounds such fence) or is "unloaded". If the fence is "unloaded", the repetition rate of charging pulses is minimized and if the fence is "loaded", the pulse repetition rate is increased. The change in pulse repetition rate is determined by the fence "loading" reflected into the fence charger system and determines the discharge level of a timing capacitor.

8 Claims, 9 Drawing Figures



Patented April 11, 1972

3,655,994

3 Sheets-Sheet 1

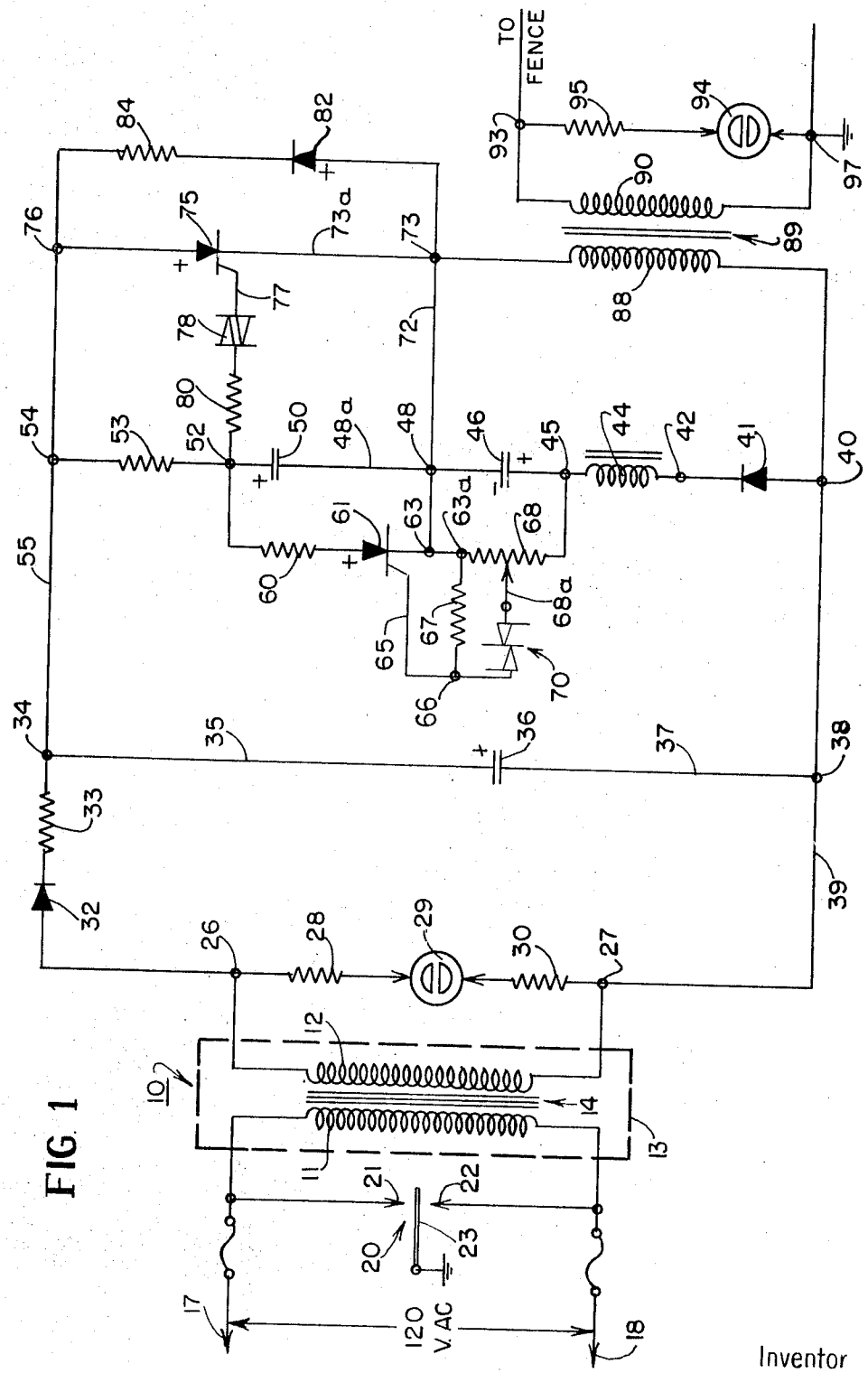


FIG. 1

Inventor

ELMER K. MALME

BY

Robert S. Kahn

ATTY.

FIG. 3

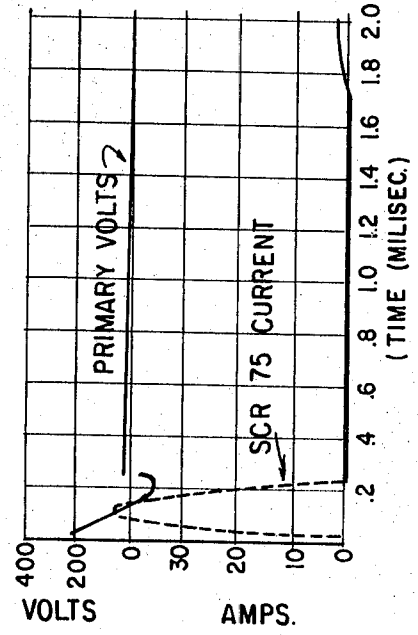


FIG. 5

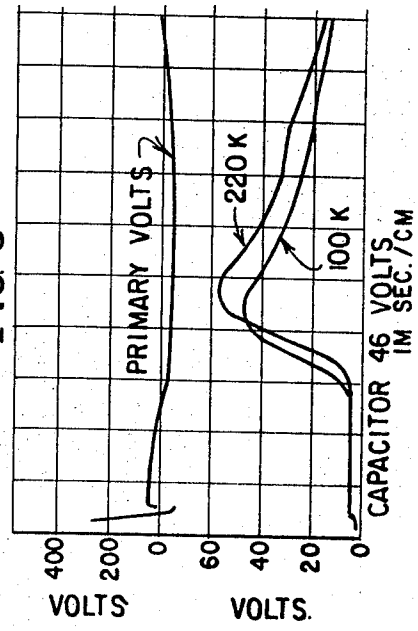


FIG. 2

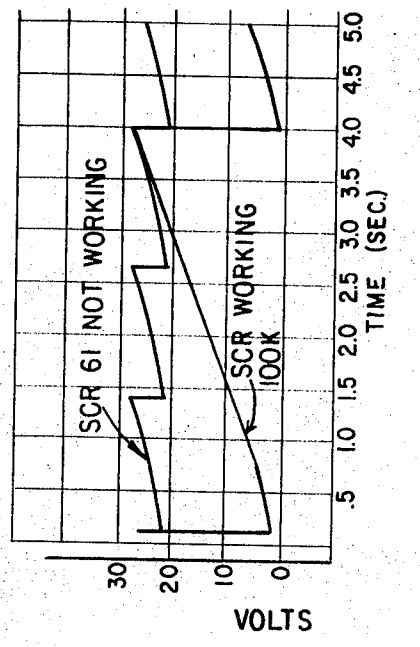


FIG. 4

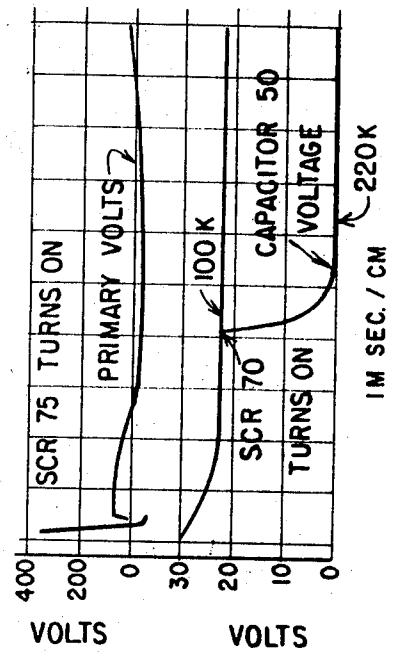


FIG. 7

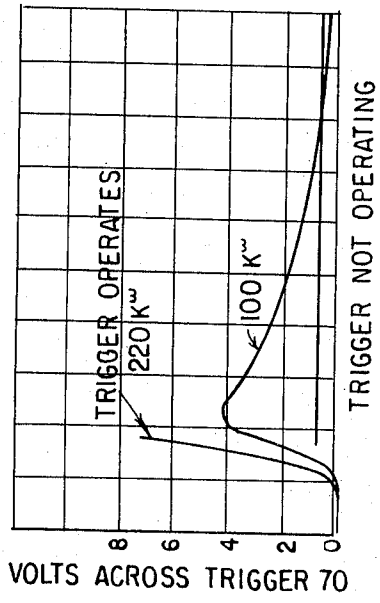


FIG. 9

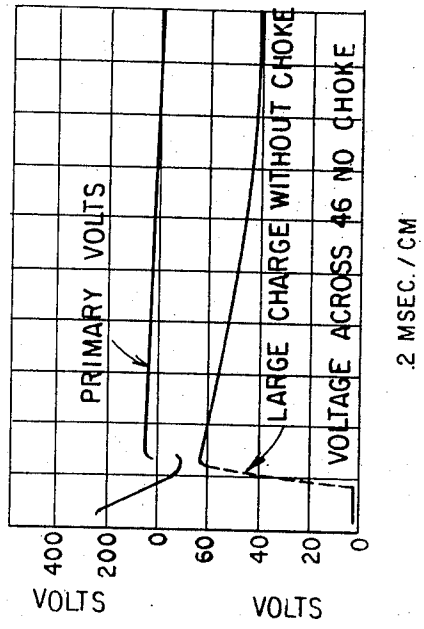


FIG. 6

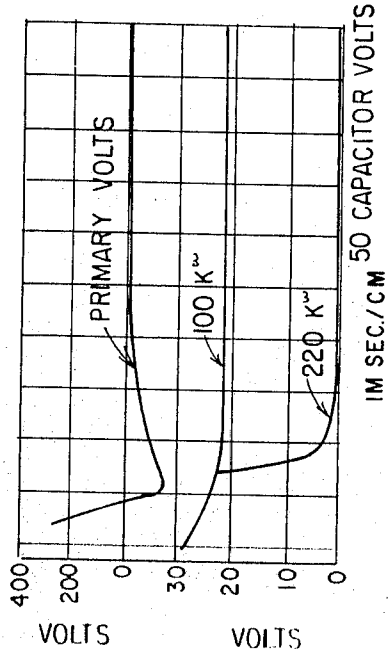
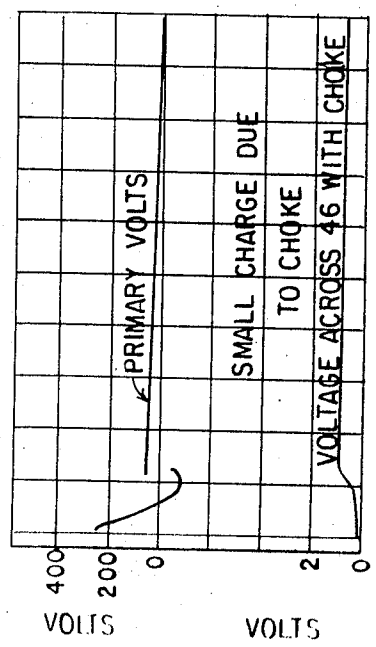


FIG. 8



ELECTRIC FENCE CHARGER

INTRODUCTION

This invention relates to a fence charger and provides a device which is simple, efficient and safe. As is well known, fence chargers have been known and used for many years to impress shocking potentials on wire fences to train cattle or animals generally from straying beyond predetermined boundaries. As a rule, such chargers apply at periodic intervals potentials of the order of several thousand volts but at low currents. Generally the power output of a charger is low so that cattle, while given a mild shock, will not be injured and will learn to remain clear of a fence.

Because of possible dangers of electrocution from fence chargers, governmental agencies have imposed requirements on the characteristics of such chargers. For example, it is important that a fence charger operate to charge a fence intermittently. As an example, many chargers will impress short pulses on a wire fence for less than about one one-thousandth of a second every few seconds. In addition, such a charger must operate at a power level too low to be lethal to animals and must have insufficient energy storage to create an arc, which might start fires.

Where a charger is energized from a battery, economy of power for charger operation is important, this determining servicing of a charger. Chargers may be operated from a 115 volt 60 cycle power line. Apart from minimizing the amount of power required for operating a fence charger from a power line is the added necessity for protection against impressing power line voltages accidentally on a fence.

As a rule, fence chargers have poor voltage regulation. Current drawn from a fence charger following the initial electric shock will be at greatly reduced voltage. In general, a fence charger has each shocking cycle independently of preceeding or subsequent cycles, assuming of course that a charger is operating properly.

GENERAL DESCRIPTION OF INVENTION

The present invention to be hereinafter disclosed provides a fence charger which will normally operate at what might be termed a predetermined stand-by repetition rate when unloaded, as when no cattle are contacting a fence and will operate at a higher repetition rate when the fence is loaded as when some creature is against the fence and is grounding the metal of the fence. As examples, a fence charger operating in conjunction with an unloaded fence may have a repetition rate of about one shocking cycle every three seconds (such a rate may be specified frequently) and a repetition rate of about one per second when operating with a loaded fence. The actual duration of a shocking or charging pulse is in the microsecond range.

Fence chargers powered from batteries or from a power line, operate under severe conditions. Operating conditions may vary from one extreme, in the winter where temperatures and moisture in the form of snow or ice is present to another extreme where high temperatures because of exposure to direct sun. The various parts making up a charger must maintain their operational characteristics within a limited range in regard to both repetition rate and voltage output. The stability of the entire system therefore is important. A system embodying the present invention utilizes capacitors, resistors, solid state components (diodes, transistors) and ferro-magnetic devices such as chokes and transformers.

The new fence charger embodying the present invention provides circuitry which insures improved operating stability and provides response to changes in fence conditions — between loaded and unloaded — and insures a high degree of reliability. A system embodying the present invention has what might be termed a basic fence charging system operating under the control of a timing circuit which in turn may be modified by an auxillary control circuit responsive to the load conditions of a fence being charged.

The changes in fence conditions between load and no load are such that there is a variation not only in the character of the load but also in the quantitative nature of the load. A fence to be charged may range from a comparatively short length of the order of several hundred feet or less to as much as 15 or more miles. When such a fence is unloaded, and assuming substantial absence of moisture and plant life at the fence, the nature of the load faced by a fence charger output terminals is generally capacitive. There is ohmic resistance with a great length of iron wire but this is negligible. The fence resistance to ground is generally great but is greatly reduced when an animal shorts a fence to ground. A resistive load may range from several hundred to may thousand ohms. Apart from the load characteristics, when considerable water is present as in winter so that a bridge of water is between the fence and ground, the resistive load may drop to a low value.

THE INVENTION GENERALLY

The invention provides a transistorized fence charger whose normal repetition rate is controlled by a timing circuit of the resistor-capacitor type. So long as a fence is unloaded, the operation of the charger continues at its normal repetition rate of the order of about one cycle per 3 seconds as an example. During such operation, the charger embodying the present invention senses the fence condition for change from a normal unloaded condition.

The sensing portion of the system includes auxiliary or monitor circuits including resistors and capacitors. So long as the fence remains unloaded, the sensing portion of the system is operating and affects the repetition rate of the charger. However, if the sensing portion of the system detects a loaded fence condition, then a speed-up in the repetition rate of the fence charger occurs. As an example, from a standby repetition rate of one operating cycle during a three second time period, the repetition rate may be tripled so that a charging rate will be increased to one operating cycle per second. It is understood that these repetition rates are given by way of example and may have different values depending upon desired conditions.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows in diagrammatic form a fence charging system embodying the present invention.

FIGS. 2 to 9 inclusive show oscillographic traces taken from the screen of a double display oscilloscope at various positions in the charger system, each of the traces being more fully described later.

DETAILED DESCRIPTION OF THE NEW FENCE CHARGER

Step-up transformer **10** has primary winding **11** and secondary winding **12** magnetically linked through iron core **14** of the high leakage type generally used in fence chargers. Transformer **10** has electrostatic shield **13** disposed over primary winding **11** to prevent build-up of dangerous potentials in the primary winding. Primary winding **11** has its terminals normally connected through fuses to power line wires **17** and **18** of a conventional 115 volts, 60 cycle power line. Lightning arrester **20** is connected across primary winding **11**, the arrester having electrodes **21** and **22** on opposite sides of grounded electrode **23**.

Transformer secondary winding **12** has terminals **26** and **27** between which are connected respectively in series resistor **28**, neon light **29** and resistor **30**. Resistors **28** and **30** are generally of equal value and as one example may each be 220 K ohms. Transformer **10** is of a suitable type and in the case of a 115 volt supply line may have a step-up ratio of the order of about 2.

Terminal **26** is connected to the positive terminal of diode **32** whose negative terminal is connected through resistor **33** to junction point **34**. As an assumed example, resistor **33** may be about 1500 ohms. From junction **34**, wire **35** goes to one

terminal of storage capacitor **36**, the other terminal of which is connected by wire **37** to junction point **38**. Capacitor **36** must be able to withstand the full voltage across secondary winding **12** and accordingly, should be capable of withstanding a voltage of 450 as an example and preferably have a capacity of about 16 microfarads (mf). Capacitor **36** is of the non-polarized, and may be of the electrolytic type. Junction point **38** is connected by wire **39** back to terminal **27**.

Wire **39** continues beyond junction **38** to and beyond junction point **40**. Junction point **40** is connected to the positive terminal of rectifying diode **41**, whose negative terminal is connected to terminal **42** of choke **44**. This choke may have a rather low inductance value such as about 300 millihenries and tends to stabilize the effects of some fence capacitance in long fences (as 15 miles). The exact value of this choke is not critical. Choke **44** has terminal **45** connected to one terminal of auxiliary capacitor **46**. Capacitor **46** need not have a high value of capacitance and, as an example, may be a 0.4 mf 600 volt capacitor. Capacitor **46** has its remaining terminal connected to junction point **48**. From junction point **48**, a connection goes to one terminal of timing capacitor **50**, the remaining terminal of this capacitor being connected to junction point **52**. Junction point **52** is connected to one end of resistance network **53**, the other end of this resistance network being connected to junction point **54** on wire **55** connected to junction point **34**.

Resistance network **53**, while shown as a single resistor, usually has four substantially equal resistors in series. The purpose of such an arrangement of resistors is to insure that if any one of the resistors shorts out, the remaining will still function. Each of the equal resistors may be substantially about 360 K ohms, making a total of about 1440 K ohms.

Referring back to timing capacitor **50**, this is a rather large capacitor such as about 20 or 22 mf but in the example given need only withstand about 35 volts. Such a capacitor may be of the polarized type but should be accurate to about 10 percent plus or minus of the predetermined value.

Connected to junction point **52** is resistor **60** whose value may be quite low, such as about 10 ohms. Resistor **60** has its other terminal connected to the positive terminal of SCR (Silicon Controlled Rectifier) device **61**. SCR **61** has its negative terminal connected to junction point **63** which in turn is connected to junction point **48**. The gate electrode of SCR **61** is connected by wire **65** to junction point **66**. Junction point **66** in turn is connected through resistor **67**, having a comparatively low value such as about 100 ohms, to junction point **63*a*** which is connected to or may be at junction point **63**. Junction point **63*a*** has connected thereto one terminal of resistance element **68** forming part of a potentiometer, the other terminal of the resistor being connected to junction point **45**. Forming part of the potentiometer and cooperating with resistor **68** is wiper **68*a*** connected to one terminal of diac **70**, whose remaining terminal is connected back to junction point **66**.

A diac is a two-electrode, three layer bi-directional avalanche diode which can be switched from the OFF state to the ON state for either polarity of applied voltage. For further details on a diac and its characteristics and structure, reference is made to RCA book entitled Transistor, Thyristor and Diode Manual published by Radio Corporation of America in 1969, pages 43 and 44. The potentiometer and diac (in this instance a simple diode having a predetermined breakdown value may be used) with resistor network will determine the breakdown potential or firing of SCR **61**.

Wire connection **72** between junction points **63** and **48** continues to junction **73**. From junction point **73** wire **73*a*** goes to the negative electrode of SCR **75**, the positive terminal of which is connected to junction point **76** on wire **55**. The gate electrode for SCR **75** is connected by wire **77** to one terminal of diac **78**, the other terminal of which is connected through resistor **80** to junction point **52**. Resistor **80** has a comparatively low value, such as for example about 68 ohms.

Providing a shunt between junction points **73** and **76** is diode **82** whose positive terminal is connected to junction point **73** and whose negative terminal is connected through resistor **84** to junction point **76**. Resistor **84** is also a relatively low resistor in this particular instance being about 100 ohms.

Returning to junction point **73**, a wire connection goes to primary winding **88** of pulse type transformer **89**. Pulse type transformer **89** has secondary winding **90** whose terminals are connected respectively to grounded terminal **92** and load (wire fence) terminal **93**. Shunted across secondary winding **90** is neon light **94** in series with ballast resistor **95**. Preferably, the arrangement is such that one terminal of the neon tube is grounded. Resistor **95** functions as a ballast for the neon bulb and has a suitably high value. As a rule, such resistors will have a value of the general order of about 1 megohm, the exact value being determined by the type of neon bulb, operating voltage output and the like.

As is well known, a pulse type transformer is adapted to receive a steep voltage pulse impressed upon the primary winding and to emit a sharp pulse from the secondary winding. As a rule, the output potential of secondary winding **90** will be in the order of several thousand volts. However, the time duration of such pulse is extremely short but at very low currents in the milleampere range.

The new fence charger may be adapted for battery operation by the conventional expedient of converting the battery direct current to interrupted current, stepping the interrupted voltage to a desired high value by a transformer and charging capacitor **36** to an appropriate voltage. As a rule, a transistorized blocking oscillator having a repetition rate of say about 200 or 300 per second may be used with the battery supplying the input and the output energizing a step-up transformer corresponding in function to transformer **10**. The remainder of the system may be generally similar to the system so far described. The values of components and potentials may differ due to optimizing battery life.

OPERATION OF THE SYSTEM

The operation of a system embodying the present invention is based upon the fact that normally a fence to be charged presents a very high resistance capacitive load when the fence is "unloaded." The average fence may have a capacitance of from about 0.015 micro farads to as much as 0.1 mf or even higher depending upon the length of the fence. This is on the assumption that the fence is dry, has no animal to "load" the fence and has no water, snow, weeds or the like to reduce the resistance of the fence system. When an animal is present and "loads"]the fence, a resistance of the order of several thousand ohms to as much as about 100,000 ohms may be seen from the output of the pulse transformer.

Assuming that the fence is "unloaded", the secondary of the pulse transformer will see a high ohmic resistance. In this connection, care must be exercised to be sure that the ballast resistor for the neon light across the output of the pulse transformer secondary winding is high, in the actual example given, this being almost one megohm. Under such conditions, capacitor **36** will charge substantially to its full potential within a few cycles (if 60 cycle operation is assumed). Thus the potential of junction point **54** will rise to an appropriate value such as, for example, 325 volts in the assumed example. Resistance network **53** will permit a small current to flow to junction point **52**.

If timing capacitor **50** is fully discharged, the potential of junction point **52** will rise from zero or ground (junction point **73** may be assumed to be ground) in about 2½ or 3 seconds and will, after breakdown of barrier device **78**, cause the potential of wire **77** to the gate electrode of SCR **75** to reach a value of about **30** or **35** depending upon the characteristics of potential barrier device **78**. For the voltages involved, the gate electrode potential will be adequate to trigger SCR **75** to conduction. Capacitor **36** will thereupon discharge a heavy current through SCR **75** to junction point **73** and thence through

primary winding **88** of the pulse transformer, to junction point **38** and wire **37** to the negative terminal of capacitor **36**. The cut-in potential of barrier device **78** will, in this instance, be about **30** or **35** and the cut-out potential of device **78** will be about 6 volts lower. While discharge current is going through SCR **75**, it should be noted that timing capacitor **50** will also discharge some current through current limiting resistor **80**, **78**, and SCR **75** to junction point **73** and thence to the remaining terminal of timing capacitor **50**.

The heavy discharge current through SCR **75** and through the primary winding of the pulse transformer will result in the sudden creation of a strong magnetic field for generating a high potential in pulse transformer secondary **90**. The high resistance seen by pulse secondary **90** will permit cooperation between the energy stored in the magnetic field of the pulse transformer and the energy stored of the electric field in capacitor **36**. The result will be a discharge through SCR **75** which has the characteristics of a resonant peak or wave for at least one-half cycle. The energy stored in the magnetic field of primary winding **88** when the field collapses tends to keep current flowing in the same direction (the polarity is now reversed) so that capacitor **36** will not only discharge completely but may even by partially charged with reversed polarity for a short time. At the same time, the self-induced high voltage generated in primary winding **88** of the pulse transformer will pass through rectifier **41** and through choke **44** and will tend to charge auxiliary capacitor **46** so that the terminal of this capacitor connected to choke terminal **45** will be positive.

The shock effects in the system, particularly the resistance network associated with SCR **61**, results in this latter device conducting and practically short circuiting timing capacitor **50**. The discharge of timing capacitor **50** results in the potential of junction point **52** going to zero with reference to junction point **73**. Thus at the end of about 3 seconds from the beginning of the initial charging of capacitor **36**, the situation is as follows — SCR **75** is non-conducting; capacitor **50** is discharged fully; auxiliary capacitor **46** may be charged as indicated; SCR **61** is non-conducting and capacitor **36** is completely discharged.

Rectifier **82** protects SCR against reverse voltage. Choke **44** will provide desirable control action when the pulse from transformer primer **88** results from the decay of the magnetic field (this tending to keep the current flowing). Auxiliary capacitor **46** will discharge through resistance element **68** of the potentiometer just slowly enough to stabilize the trigger action on SCR **61**.

Thus, a relaxation type of oscillator action involving capacitor **36** cooperates with an auxiliary relaxation type of oscillator only when the latter is triggered by the apparent existence of some resonance between capacitor **36** and primary winding **88** during discharge of SCR **75**. If the resistance seen by pulse transformer secondary **90** is low enough so that the reflected resistance into the primary circuit militates against resonance, then the following action occurs. Capacitor **50** cannot discharge very much through SCR **75** and the potential of junction point **52** will drop enough (about 6 volts in this instance) to cut off the gate electrode for SCR **75**. The discharge of capacitor **36** through SCR **75** is fast enough so that capacitor **36** is completely discharged. The discharge through SCR **75** is very short, such as about 300 micro seconds, during which time, timing capacitor **50** can discharge slightly. The time for re-charging timing capacitor **50** after its partial discharge is such that the potential of junction point **52** will rise to maximum value within about one second, thus making the repetition rate for the entire system 1 per second.

Insofar as barrier device **78** is concerned, the cut-in potential in the direction of conduction to the gate of **75** will be between about 30 and 35 volts and the cut-out potential for this same device will be about 6 volts lower, making it about 29 volts. Thus the potential of junction point **52** will vary between about 35 volts and about 29 volts with the charging period for timing capacitor **50** being about one second. Barrier device **78** in this particular system should preferably have desirable and definite cut-in and cut-out voltage values for dependable and controllable repetition rate when the fence is "loaded". Barrier device **70** associated with SCR **61** should have a desired voltage cut-in point in the direction of conduction from wiper **68***a* to the gate electrode of SCR **61**. The cut-out point is zero. With the system as shown, the lower that wiper **68**a is adjusted along resistor **68** away from junction point **63**, the greater is the feedback potential to the gate electrode of SCR **61** and the greater the stability of operation as between " loaded" and "unloaded" conditions.

With reference to barrier or trigger device **70**, for the system as set forth in the example given, a so-called silicon bilateral switch made by General Electric Company, Part No. 2N4991 has been used. It happens that this device has three electrodes and can control conduction in either direction. However, the requirements of the new charger system are such that conductivity in only one direction is necessary, the direction of positive current flow being toward the gate electrode of SCR **61**. This particular device on the market has the desired barrier potential characteristics to block the flow of current in the desired direction for voltages of from about 6 to about 9 volts. Current flow in the desired direction will continue until the voltage drops to practically zero, the particular cutoff voltage being unimportant in this particular application of the switch.

Substantially the same considerations apply to disc **78**, the desired direction of positive current flow in this instance being from junction point **52** to the gate of SCR **75**. No flow in the reverse direction is desired or necessary. With respect to diac **78**, a trigger or diac device No. S–032 made by Hunt Electric Company is available on the market. In the charger example given, diac **78** happens to cut-in or trigger at from about 28 to about 35 volts and will cut-off at about 6 volts below the trigger point. These values for diacs **78** and **70** are convenient for the particular example of the charger system involved here. Simple diodes having desired barrier potentials may be used or desired bias diode systems may be used.

In each instance, the diac is used as a diode conducting in only one direction and normally having a breakdown voltage as previously set forth. It is therefore understood that devices **70** and **78** respectively may be conveniently replaced by simple diodes having desired operating characteristics with regard to breakdown voltage in the direction of conduction and, of course, having satisfactory reverse potential characteristics.

With respect to capacitor **46**, the circuitry involving capacitor **46**, choke **45** and the resistor network is such that the inductive emf generated in the pulse transformer makes it necessary for capacitor **46** to withstand high potentials and in the particular example given, a 600 volt non-electrolytic capacitor of the non-polarized type is recommended.

In connection with the pulse transformer, as is well known, low inductance in the millihenry range is present. Thus, a pulse transformer having a primary inductance of the order of about 16 mh was used (the secondary was open) and an inductance of about **6** Henries in the secondary with the primary winding open. A pulse transformer of this general character is widely used in the fence charger art. It is understood, however, that variations may be made in the inductances of the pulse transformer and that variations may be made in the cut-in and cut-off values of the various solid state switches. In practice, the voltage characteristics of the SCR devices must be such that suitable control of the breakdown values of such devices must be exercised. In some instances, underwriter laboratories and insurance requirements may dictate certain values such as, for example, the repetition rate of a charger, the value of storage capacitor **36**, the output potential of the pulse transformer and the like.

Referring now to FIGS. **2** to **9** inclusive, these show oscillographic traces of voltage or current variations with respect to time of a fence charger embodying the present invention whose components substantially have the values previously given by way of example. The traces were taken on an oscil-

loscope having means for substantially simultaneously exhibiting two separate traces as hereinafter described.

FIG. 2 shows a fence charger operating with a 16 mile long fence or equivalent. In the top trace, the fence was loaded with a 100K resistor so that the charger was "loaded." The sawtooth top trace shows that the SCR 75 was conducting, in this instance, at intervals of a bit less than 1.5 seconds. The voltage trace taken across timing capacitor 50 shows that the potential of junction point 52 with reference to junction point 48 would range between 22 and about 28 volts. This indicated that SCR 61 was not breaking down and that timing capacitor 50 was discharging lightly during the time that SCR 75 was conducting.

The lower voltage trace in FIG. 2 indicates that the voltage across capacitor 50 would range from a minimum of substantially zero to a maximum of about 27 or 28 volts. Because timing capacitor 50 completely discharged, the sawtooth wave indicating a longer charging time resulted in an unloaded repetition rate of approximately once per four seconds. This unloaded repetition rate clearly indicates that SCR 61 was not only functioning to short timing capacitor 50 but shows that the free unloaded running rate is about one-third of the loaded repetition rate. The 16 mile fence load was connected to 220K ohms resistance for simulating an unloaded fence.

The left beginning of each voltage trace shows a practically vertical voltage drop resulting from the sudden discharge at SCR 75. The upwardly sloping voltage curve indicates that SCR 75 has cut-off and that the potential of junction point 52 is beginning to climp up again at a rate determined by the time constant of the system. The entire charger system is so designed that SCR 75 breaks down before the capacitor charging curve begins to assume the normal curved shape incident to a full charge in a capacitor. In short, the part of the voltage charging curve used here is the lower straight portion, this being common in many capacitor charging circuits.

Referring now to FIG. 3, the two curves show the charger operating with load equivalent to 16 miles of fence and having a loading resistor of substantially 100K ohms. In this particular instance, the 16 miles of fence is roughly equivalent in capacitance to a 0.25 mf and serve to load the charger. The top trace shows the voltage across primary winding 88 of the pulse transformer while the bottom trace shows the current passing through SCR 75 at breakdown. As the top trace shows, the voltage across primary winding 88 drops rapidly from an original voltage of about 280 volts when SCR 75 begins to break down to zero and drops below zero and then levels off about 30 or 40 volts during the time that capacitor 36 is re-charging. Up to the time that SCR 75 breaks down, the potential of junction point 73 is isolated so that there is little, if any, potential across primary winding 88. However, when SCR 75 breaks down, the various capacitors and resistors in a system together with the capacitance of the fence load and the inductance of the pulse transformer all cooperate to have storage capacitor 36 over-discharge and reverse charge to some extent. The heavy current indicated by the lower trace shows the characteristic pulse pattern resulting from the breakdown of SCR 75 and shows the current pulse applied to the pulse transformer winding. The charger load in this instance is heavy enough so that the charger is "loaded" and SCR 61 does not break down.

FIG. 4 shows the voltage curve across the primary winding of the pulse transformer. Again the beginning or left end of the trace shows the characteristic sudden drop of voltage when SCR 75 breaks down. In this particular instance, the bottom portion of the voltage drop shows the negative voltage pulse after which the voltage flattens out from a value about plus 40 to 0 and then drops below 0 and finally stabilizes at about 0. The curves in FIG. 4 are from a charger having a 16 mile fence load. The lower trace shows the fence charger both "loaded" and "unloaded" as marked.

The lower trace shows the potential across timing capacitor 50. With the charger loaded with 100K ohms, the potential across the timing capacitor 50 goes from about 28 or so volts down to about 22 volts and remains at that value for the balance of the operating period. The trace shows, however, when a 220K ohm load was used (the charger is now "unloaded"), a short instant of time after the discharge of SCR 75, SCR 61 triggers and the voltage across timing capacitor 50 rapidly drops to 0. Due to changes in the length and capacitance of a fence as well as the amount of resistance faced by the output pulse transformer, the time after SCR 75 discharges when auxiliary SCR 61 discharges may vary. This involves such considerations as the interaction between the pulse transformer and the capacitance of storage capacitor 36 and the resistor networks associated with both SCRs.

FIG. 5 illustrates the voltage conditions across the primary of the pulse transformer, this being generally similar to the top trace of FIG. 4. However, the bottom trace of FIG. 5 shows the potential across capacitor 46. This .4 mf capacitor 46 shows some lateral displacement of the potential curves along the time axis with respect to capacitor 46 when the charger as a whole is "unloaded" and "loaded" respectively. Resistance 220K ohms keeps the charger system "unloaded" whereas the 100K ohms is low enough so that the system is "loaded". In the lower traces of FIG. 5, the left or beginning of the trace shows the effect of the presence of choke 44. Thus a sharp initial pulse across capacitor 46 is due to the action of the choke. By contrast, note in FIG. 9, the substantial potential peak due to the absence of a choke. The choke is particularly desirable when a long fence such as 16 miles is being charged.

The lateral displacement of the potentials across the .4 microfarad capacitor shown in the lower trace in FIG. 5 is due to the differences between the loaded and unloaded fence charger operation.

Referring now to FIG. 6, this shows the operation of the charger system when the fence load was one mile. Such a load does not have very much capacitance (about 0.015 mf). Thus the primary voltage illustrated in the top trace is generally similar to the top traces in other figures with some displacement along the time axis. However, the two lower traces showing the "loaded" and "unloaded" conditions are generally similar to the curves shown in FIG. 4 with the exception that the breakdown of SCR 61 appears to occur much faster. It is thus evident that changes in the fence length as well as resistance will all have their effects in relative displacement along time axes.

Referring now to FIG. 7, this shows voltage traces across the trigger or barrier diac 70. Thus with 100,000K ohm (charger loaded) the voltage across capacitor 46 is too low and will not permit SCR 61 to operate. However, when capacitor 46 has sufficient voltage across is (this will occur when the charger is s"unloaded" with a sufficiently high resistance), the potential across barrier device 70 will be high enough to cause breakdown so that the potential of the gate electrode for SCR 61 rises to the breakdown value. SCR 61 will conduct and short-circuit capacitor 50. It is clear that the traces are in some respects discontinuous because of the action of the barrier characteristics. Thus, for example, the lowest trace in FIG. 7 is simply a straight horizontal line showing a voltage of something less than one volt. The left or beginning of this bottom trace probably should join up to the horizontal or initial portions of the traces at or somewhat below 0 volts. The next trace reflecting the action due to 100,000 ohms shows a rapid rise in potential but continues past the peak to drop off as capacitor 46 discharges across the potentiometer resistor. However, the two plots that show almost vertical rises from 0 to almost 8 volts are continuous due to the sudden breakdown of SCR 61. It is important that capacitor 46 discharge before a new sawtooth wave begins.

Referring now to FIG. 8, the top trace shows the primary voltage at initial breakdown of SCR 75 with the voltage going down to 0 and to a negative value. At times, the negative pulse at the beginning of the trace may also result in a short negative pulse somewhat later and before the next initiation of a working cycle. The lower trace shows the potential across capacitor 46. At the beginning, the voltage is 0 or substantially zero and

quickly rises to about 1 volt. This action occurs with choke **44** and particularly with a long fence. In this particular instance the fence load was 16 miles with the resistance having a value of about 100K ohms. This is equivalent to a "loaded" condition on the charger. FIG. **9**, however, is the same system with the same load except that choke **44** is removed. The large amount of capacitance present with a 16 mile fence causes a potential across capacitor **46** to jump to a substantially high value, 60 volts, after which the voltage gradually discharges. This is undesirable since there will be erratic operation with respect to the charger changing its repetition frequency between "loaded" and "unloaded" conditions.

Due to transient conditions inherent in the operation of the system under various conditions, some changes in voltage traces, time periods and the like are bound to occur. By adjustment of potentiometer wiper **68***a* and other components, satisfactory operation of a charger embodying the present invention may be obtained within satisfactory limits. As an example, the choke may be omitted if the charger will not be used on long fences. In addition, the characteristics of the pulse transformer in regard to inductance, and the characteristics of the various diodes and other solid state devices with regard to breakdown or trigger voltages and the characteristics of the various capacitors will all have some effect on the operation of the system. However, for the most part, precision as to the duration of a period between successive pulses is not necessary as a rule so that considerable tolerances will be permissible.

What is claimed is:

1. An electric fence charger for intermittently charging a fence to a shocking potential, said charger including a first storage capacitor, means for charging said first storage capacitor to a predetermined high potential within a fraction of a second, a first solid state device having positive, negative and gate electrodes, a wire connection from said negative electrode to a first junction point, a pulse step-up transformer having primary and secondary windings, a direct connection from one terminal of said primary winding to said first junction point, a direct wire connection from the other terminal of said primary winding to the other terminal of said first capacitor, a first resistor network connected between said positive electrode and gate electrode, said first resistor network including a direct current non-conducting barrier device having a predetermined breakdown potential, said first resistor network including a second junction point with said barrier device disposed between said second junction point and said gate electrode, a second (timing) capacitor connected between said two junction points, a second solid state device having positive, negative and gate electrodes, a direct wire connection from said second device negative electrode to said first junction point, a direct current connection between said second device positive electrode and said second junction point, a second resistor network including a rectifier device having a predetermined voltage breakdown value in the conducting direction between the gate and negative electrodes of said second device, a third auxiliary capacitor connected across a portion of said second resistor network, said third capacitor having one terminal connected to said first junction point and having the other terminal connected through a wire connection to the negative terminal of a rectifier, said rectifier having its positive terminal connected to the other terminal of said pulse transformer primary winding, said system having the portions thereof cooperating so that when the pulse transformer secondary winding faces a sufficiently high resistance, the discharge of said first solid state device causes said second solid state to discharge completely said second capacitor whereby recharging said second capacitor requires maximum recharge duration (and consequent minimum pulse repetition rate), said charger, when facing a lower resistance, operating to permit said first solid state device to discharge without discharge of said second solid state device, said second capacitor discharging only partially through said first device and thus increase the pulse and repetition rate.

2. The system according to claim **1** wherein said first capacitor and said timing capacitor each have values of over 10 microfarads, said first capacitor being of the non-polarized type, said third capacitor having a value of a lower order than either of said first or second capacitors.

3. The system according to claim **2** wherein a choke is connected between the negative terminal of said first named rectifier and the other terminal of said third capacitor, said choke having a value in the millihenry range for reducing the self-inductive pulse from the primary winding of the pulse transformer after shut-off of said first solid state device.

4. The system according to claim **1** wherein a second rectifier and current limiting resistor are connected across said first solid state device, the polarity of said second rectifier being reverse of said first device, said second rectifier having a sufficiently high breakdown value to protect said first device against reverse potential originating in said pulse transformer primary winding.

5. The system according to claim **1** wherein said resistance network associated with said second device comprises a current limiting resistor between said first junction point and the positive electrode of said second device, a second current limiting resistor connected between the gate and negative electrodes of said second device, a potentiometer resistor element connected across said third capacitor, said potentiometer resistor having a wiper associated therewith connected through said second trigger barrier device to the gate electrode of said second device, said second barrier trigger device having a predetermined breakdown potential in the direction of current flow from the wiper toward said gate electrode, said first barrier trigger device connected to said gate electrode of said first solid state device having predetermined cut-in and cut-out potentials in the direction of current flow from said first junction point to the gate of said first device.

6. The system according to claim **5** wherein a choke in the millehenry range is connected between the negative electrode of the first rectifier and the common terminal of said potentiometer resistance and terminal of said third capacitor.

7. The system according to claim **6** wherein the resistance element of said potentiometer has a sufficiently high value so that said third capacitor, when charged from the operation of the pulse transformer primary winding, will discharge slowly enough so that substantially no change in the potential across the same will occur during the sudden precipitant change in potential conditions in the system incident to the discharge of either of said devices but instead will discharge over the substantial portion of a sawtooth wave.

8. A fence charger system comprising a sawtooth wave generator including a primary winding of a pulse transformer, said generator also including a resistor for determining a repetition rate for sawtooth wave generation, a timing capacitor connected between two point in said generator, said two points being so disposed as to have potential differences therebetween available for charging said timing capacitor, the level of charge in said timing capacitor having an effect upon the repetition rate of said generator system, said pulse transformer having a secondary winding for connection to a fence and ground and means responsive to the loading on said secondary winding with regard to high resistance corresponding to a normally "unloaded" fence and lower resistance corresponding to a normally "loaded" fence for changing the charge level in said timing capacitor and thereby changing the difference in potential between said two points in said generator sufficiently to increase the repetition rate of said sawtooth generator when said pulse transformer secondary winding sees a "loaded" fence and to decrease substantially the pulse repetition rate when said secondary winding sees an "unloaded" fence, the pulse repetition rates being sufficiently different so that substantial changes in operating power for the charger occur.

* * * * *