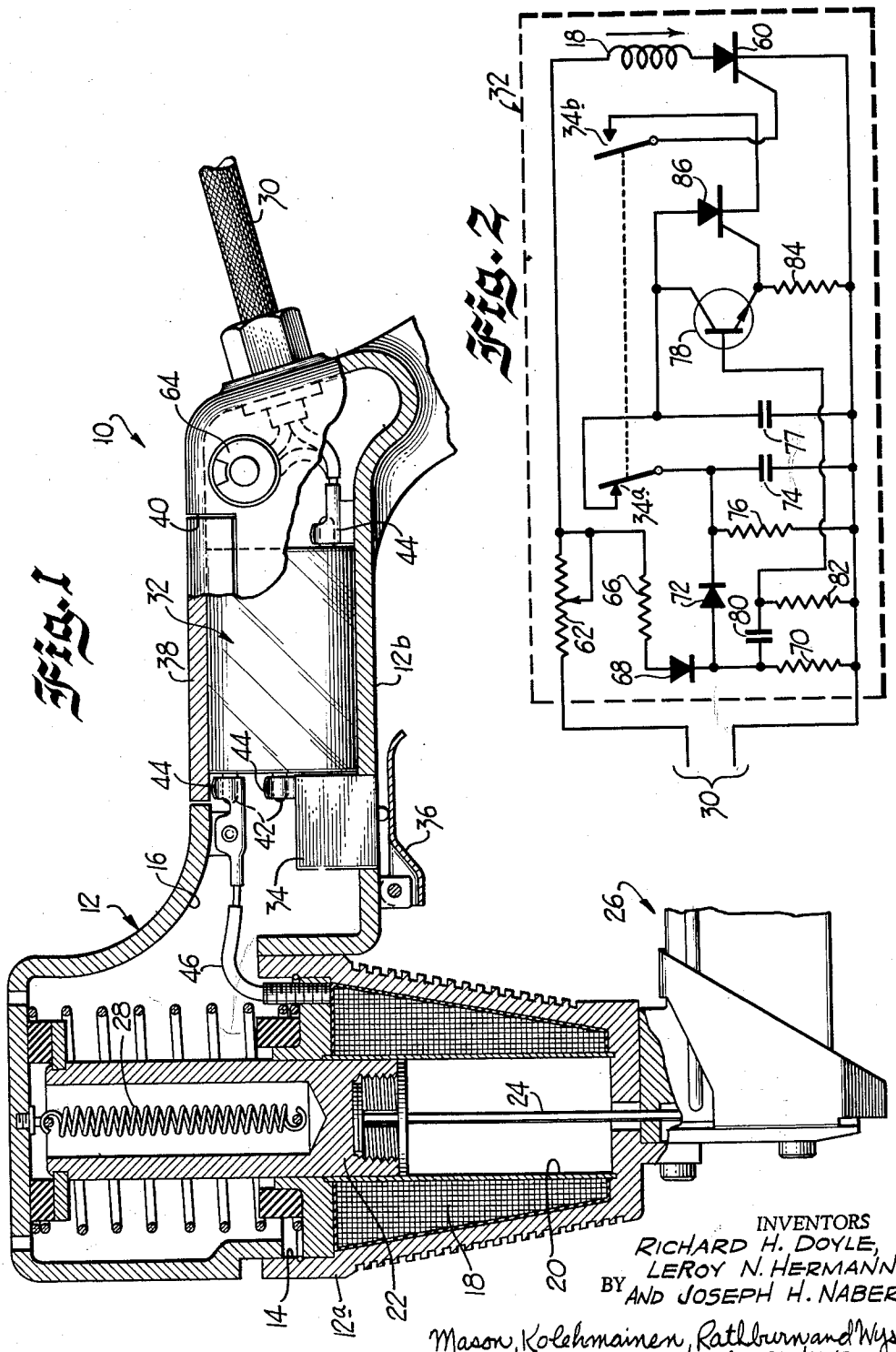
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ELECTROMAGNETICALLY OPERATED TOOL

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ELECTROMAGNETICALLY OPERATED TOOL

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This invention relates to a portable tool and, more particularly, to a self-contained tool in which all of the components for controlling the electrical operation of the tool are carried on the tool.

The need for portable tools capable of performing the many different types of material working operations has long been recognized, and many different approaches have been tried in an attempt to provide tools that are capable of easy manual manipulation while supplying the power or energy necessary to perform the desired operation. These approaches have been used in such varied devices as staplers, nailers, staking tools, riveters, punches, chisels, scarfing tools, stud drivers and hog ring tools. The primary difficulty is to be able to supply sufficient driving power without increasing the weight and size of the tool to the point at which it becomes so unwieldy and cumbersome that it cannot be easily handled by one hand of an operator.

One common expedient used in designing portable tools is to provide a device in which the work is performed in a series of power strokes so that the power required in any given one of the operations is greatly reduced. This approach is embodied in the use of rotating or reciprocating pneumatic and electric motors to apply increments of energy over an extended period of time. However, in addition to the obvious deficiency of the greater length of time required to complete the operation, some of the types of operations performed by the tools described above are such that they should be completed in a single power stroke. As an example, it is much more desirable to drive a staple or nail and to punch an opening in a single operation rather than to apply repeated blows to the crown or head of the staple, nail or punch element. In addition, the use of electrically operated tools over the extended periods of time required by repetitive power stroke operation presents the substantial problem of dissipating the heat due to the losses in the tool so as to keep the temperature of the tool low enough for manual use.

To overcome some of the deficiencies in this type of equipment, a number of single power stroke tools, both pneumatic and electric, have been devised. The pneumatically operated tools have been satisfactory in many applications because of the large amount of power that can be supplied to the point of impact with the work by using increased fluid pressure and larger piston diameters. These tools also do not encounter the heating problems of electrically operated tools. However, the necessity of providing a relatively high pressure source of compressed air or other pressurized fluid severely limits the range of use of pneumatic tools to those applications in which the expected use is large enough to economically justify the expense of providing compressing facilities. These compressing facilities also are somewhat costly to maintain.

An electrically operated tool of the single power stroke

type would have the advantage that electric power is almost universally available and can be used as an energy source at a nominal cost. One approach to providing an electrically operated tool having a single power stroke is to use a rotating electric motor to compress a spring that is subsequently released to drive the work engaging portion of the tool. However, the springs are subject to fatigue and the weight of the motor and linkage for stressing and releasing the spring often makes the tool unwieldy for manual operation. In other types of devices, the driving force for actuating the tool is derived from an electromagnetically induced field acting on a magnetic member forming a part of the drive mechanism. However, it has been difficult to generate sufficiently large magnetic fields with windings energized directly from the 110–120 volt lines commercially available without using energy storing devices, such as capacitors. The size and weight of these components as well as the related control components is generally such that they cannot be mounted directly on a portable tool and require a separate housing, such as the ones shown in the contemporaneously filed applications of Richard H. Doyle et al., Serial Nos. 161,653 and 161,706, which applications are assigned to the same assignee as the present application.

Accordingly, one object of the present invention is to provide a new and improved electrically operated portable tool.

Another object is to provide a portable tool including new and improved means for supplying electrical energy thereto.

A further object is to provide an electrically operated tool that is self-contained so as to be capable of easy, manual operation.

Another object is to provide a self-contained and electrically operated portable tool which does not require energy storing means and which is capable of delivering a large amount of output power.

Another object is to provide a portable tool of the single power stroke type including control means for supplying all the necessary operating energy during no more than a single cycle of an alternating current potential.

Another object is to provide a tool including a control circuit actuated by manually operable switch means for supplying operating energy to the tool for no more than a single cycle of an alternating current potential.

Another object is to provide a control or operating circuit for a tool in which a manually actuated switch selects a single cycle or less of alternating current energy for operating the tool.

In accordance with these and many other objects, one embodiment of the invention comprises an electrically operated stapler or tacker comprising a portable, lightweight housing having a chamber in which an operating winding is disposed. A work engaging element, such as a driver blade, is provided with a magnetic portion disposed adjacent the operating winding. The portable tool is connected to a source of commercially available alternating current potential by a flexible cable and includes a control circuit carried completely on or within the housing and connected between the cable and the winding. This control circuit includes a manually actuated switch means carried on the housing that is effective, when actuated, to select the first complete half cycle of the alternating current potential following the time at which the

switch is actuated for energizing the winding to operate the tacker or stapler.

The control circuit includes a controlled conduction device, such as a gated silicon rectifier, connected in series with the operating winding and an alternating current potential source. The gate or control electrode of the controlled conduction device is selectively connected to a source of gating current under the control of the manually actuated switch through a second controlled conduction means. This second controlled conduction means is placed in a conductive state to place the gated rectifier in a conductive condition at the beginning of and for only the first positive-going half cycle of the alternating current potential that occurs following the manual actuation of the switch means. Thus, the operating winding is energized from the power source for only a part of a cycle of the input alternating current potential and is provided with an operating current of relatively large amplitude to deliver a large amount of power to the workpiece. By directly energizing the operating winding from the alternating current potential source, the need for energy storing components, such as capacitors, is obviated with the result that all of the control components can be carried on the tool to provide a self-contained portable tool. Because of the extremely short duration that the operating winding is energized, the problem of excessive heating of the tool is obviated.

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawing, in which:

FIG. 1 is an elevational view in partial section of a portable tool embodying the present invention; and

FIG. 2 is a circuit diagram of the controlled energy supply circuit included in the tool.

Referring now more specifically to FIG. 1 of the drawing, therein is shown a portable and electrically operated stapler or nailer, indicated generally as 10, which embodies the present invention. The tacker 10 includes a non-magnetic housing 12 having a vertically extending forward head portion 12*a* defining a chamber 14 and a rearwardly extending hollow handle portion 12*b* defining a cavity or chamber 16. An operating winding 18 having a low resistance is disposed in the lower end of the chamber 14 and includes an axially extending opening 20 in which is received the lower end of a magnetic plunger or core 22. A fastener driving blade 24 is secured to the lower end of the magnetic plunger 22 and is adapted to engage and drive a fastener, such as a staple or nail, supplied by a magazine assembly indicated generally as 26. A tension spring 28 connected between the core 22 and the housing 12 resiliently returns the core 22 and the connected driver blade 24 to a normal position at the end of a cycle of operation.

To provide means for energizing or operating the tool 10, a flexible cable 30 is connected between a conventional source of 60 cycle alternating current potential and a control circuit, indicated generally as 32, that is carried on the tool 10 and disposed within the chamber 16 in the hollow handle 12*b*. The control circuit 32 is connected to the winding 18 and to a manually actuated switch 34 which is also disposed within the chamber 16 and which is actuated by a pivotally mounted trigger 36. When the switch means 34 is actuated, the control circuit 32 selects the first complete and properly polarized half cycle of the alternating current potential supplied over the cable 30 following the actuation of the switch means 34 and connects the winding 18 to the alternating current potential during this half cycle so that a relatively heavy current flows through the winding 18 for the duration of this half cycle. The duration of the current flow through the winding 18 will be extended beyond a half cycle in some applications because of the inductance of the winding 18. The energization of the winding 18 by this pulse of high energy and short duration produces a flux field that acts on the magnetic core 22 to drive the blade 24 downwardly to engage and set a fastener. After the termination of the half cycle and when the induced field collapses, the core 22 and the blade 24 are restored to their normal positions by the tension spring 28.

Although the physical construction of the electrically operated tacker or stapler 10 can be of any suitable design, the construction shown in FIG. 1 is similar to that of the electrically operated tacker shown and described in detail in the contemporaneously filed application of Richard H. Doyle et al. Serial No. 161,651, now Patent No. 3,141,171, which application is assigned to the same assignee as the present application. This construction, however, has been modified to permit the control circuit 32 to be mounted directly on the housing 12 of the tacker 10 so as to provide a completely self-contained tool 10 that is both portable and capable of supplying adequate power to perform a fastener driving operation. The control circuit 32 can be formed in any desired physical form, but preferably is formed on a suitable supporting means and then "potted" in one of the many well known compositions therefor. In order to facilitate repair of the tool 10, it is desirable to removably mount the control circuit 32 on the housing 12 or within the chamber 16 in the hollow handle 12*b*. Accordingly, the upper wall of the handle portion 12*b* is provided with a removable closure element or plate 38 that is normally secured in position by removable fasteners (not shown) to close an opening 40. When the plate 38 is removed, the control circuit 32 can be removed through the opening 40 and a replacement circuit inserted therein. This replacement of the control circuit 32 is facilitated by using detachable electrical connectors to interconnect the circuit 32 with the other components of the portable tool 10.

More specifically, the control circuit 32 is provided with a plurality of connectors or terminals 42 connected to the components in the circuit. The housing 12 for the tool 10 and the housing for the switch means 34 are provided with a plurality of electrical connectors 44 that are insulated from electric contact with the housing 12. The two terminals 42 at the right end (FIG. 1) of the control circuit 32 engage two connectors 44 connected to the cable 30 to provide means for energizing the circuit 32. The two connectors 44 on the switch 34 engage two terminals 42 at the left end of the circuit 32 to connect the switch means 34 with the control circuit 32, and the remaining two terminals 42 on the circuit 32 engage a pair of connectors 44 connected to a cable 46 to connect the control circuit 32 with the winding 18. By the provision of the detachable terminals 42 and connectors 44, the control circuit 32 can easily be replaced merely by removing the previous control circuit 32 and inserting an additional one of these circuits.

FIG. 2 of the drawing illustrates the details of one control circuit 32 that can be used to control the operation of the tool 10 or the energization of the winding 18. In general, the circuit 32 controls the conductivity of a controlled conduction device, such as a gated silicon rectifier 60, to connect the winding 18 in series with the alternating current supplied over the conductors of the cable 30 for only the first positive-going half cycle of the input voltage occurring following the manual actuation of the switch means 34. A rheostat 62 connected in series with one of the conductors of the cable 30 limits the current that can flow through the winding 18 and, thus, controls the energy supplied to the tool 10 during the half cycle in which the gated rectifier 60 is in a conduction condition. The rheostat 62 can be mounted on the handle portion 12*b* of the housing 12 (FIG. 1) and includes a manually actuated dial or knob 64 for adjusting the setting of the rheostat 62. This rheostat is connected in series between one of the electrical connectors 44 and one of the conductors of the cable 30.

In the normal condition of the control circuit 32, cur-

rent flows through a voltage dividing network including a resistance element **66**, a diode or rectifier **68**, and another resistance element **70** during the positive half cycles. The potential appearing across the resistor **70** is applied through another diode or rectifier **72** to charge a capacitor **74** shunted by a resistor **76**. This potential is also forwarded through the diode **72** and a pair of normally closed contacts **34***a* in the switch means **34** to charge a capacitor **77**. In this manner, the capacitors **74** and **77** are normally charged to a potential determined by the value of the resistance elements **66** and **70**. During the negative-going half cycles of the input alternating current potential, the charge on the capacitors **74** and **77** discharges slightly through the shunting resistor **76** and the collector-emitter circuit of a transistor **78** that is biased just above its cut-off point. However, whenever the charge on the capacitors **74** and **77** drops below the desired value, these capacitors are recharged through the diode **72** during the next following positive-going half cycle of the input voltage.

To provide means for controlling the periods of conductivity of the gated rectifier **60**, a differentiating network including a capacitor **80** and a resistance element **82** are connected across the resistance element **70**. The leading and trailing edges of the positive-going and basically square wave generated across the resistance element **70** during the positive-going cycles of input potential are differentiated to provide positive-going and negative-going pulses, respectively, which are coupled directly to the base electrode of the transistor **78**. The positive-going pulses corresponding to the leading edges of the square wave occurring at the beginning of each positive-going half cycle of the input alternating current signal increase conduction through the transistor **78**. This transistor operates as an emitter follower with current amplification so that each positive-going input pulse applied to its base provides a corresponding positive-going output pulse across an emitter resistor **84**. This positive-going output pulse tends to drive a gate current through the gate electrode of a controlled conduction device, such as a gated silicon rectifier **86**, the anode of which is connected to the capacitors **74** and **77**. However, the cathode of the rectifier **86** is connected to an open circuit at a pair of normally open contacts **34***b* included in the switch means **34**. Thus, the rectifier **86** normally cannot be placed in a conductive state. The control circuit **32** remains in this condition until the switch means **34** is operated.

When the tacker **10** is to be operated, the trigger **36** is actuated to operate the switching means **34**. The operation of the switching means **34** closes the normally open contacts **34***b* and opens the normally closed contacts **34***a*. The opening of the contacts **34***a* interrupts the charging path for the capacitor **77** and disconnects the collector electrode of the transistor **78** and the anode of the controlled rectifier **86** from all potential sources except that provided by the charged capacitor **77**. The closure of the contacts **34***b* connects the cathode of the controlled rectifier **86** to the control electrode of the gated rectifier **60**. However, the gated rectifier **86** is not placed in a conductive condition at this time unless the alternating current potential supplied by the cable **30** is at the beginning of a positive-going half cycle. This is true because an input signal is not provided at the base electrode of the transistor **78** at any other time.

When the beginning of the next positive-going half cycle of the alternating current potential is reached, the differentiating network including the capacitor **80** and the resistance element **82** supplies a positive-going pulse to the base of the transistor **78** so that this transistor is placed in a heavily conducting condition producing a positive-going potential drop across the emitter resistance element **84**. The drop across the resistance element **84** places the gate electrode of the controlled rectifier **86** at a positive potential relative to its cathode and places the gated rectifier **86** in a conductive condition so that the capacitor **77** now discharges through the conductive transistor **78** and the gated rectifier **86** into the gate or control electrode of the gated rectifier **60** through the closed contacts **34***b*. This places the gated rectifier **60** in a conductive condition so that the winding **18** is connected directly across the alternating current potential supplied by the cable **30** in series with the rheostat **62**. This energizes the winding **18** to actuate the stapler or tacker **10**.

At the end of the positive half cycle, the rectifier **60** lacks a proper potential across its cathode-anode circuit, and the rectifier **60** is restored to a nonconductive condition. If the switch means **34** remains in an operating condition at the beginning of the next positive-going half cycle of the applied alternating current potential, a positive-going pulse is again applied to the base of the transistor **78**. This positive-going pulse is not effective to initiate another period of conduction through the gated rectifier **60** because the charge on the capacitor **77** has been depleted and the components **78** and **86** lack collector and anode potential. When the switch means **34** is released to close the contacts **34***a* and to open the contacts **34***b*, any further conduction through the gated rectifier **86** is prevented by opening the circuit to its cathode at the contacts **34***b*, and the charging circuit for the capacitor **77** is established at the closed contacts **34***a* so that this capacitor is charged from the capacitor **74** and the alternating current potential supply. The control circuit **32** is conditioned for another cyclet of operation.

Accordingly, the provision of the control circuit **32** makes possible the portable tool **10** which is electrically operated and which is completely self-contained in requiring a connection to only a conventional source of alternating current potential. In view of the fact that the gated rectified **60** can be placed in a conductive condition for only one positive-going half cycle of the input signal following each manual actuation of the switch means **34**, excessive heating of the winding **18** and the tool **10** is avoided while providing adequate power to drive the blade **24**.

Although the control circuit **32** can be fabricated with components of many different values and types in accordance with the desired circuit application, one control circuit **32** using the following listed components supplied the winding **18** with an operating current of between 40 and 120 peak amperes persisting for a duration of around 8⅓ milliseconds.

Gated rectifier **60**	2N1770 or 2N1770A.
Rheostat **62**	0–2 ohms.
Resistor **66**	10K.
Diode **68**	Sarkes-Tarzian 2F4.
Resistor **70**	10K.
Diode **72**	Sarkes-Tarzian 2F4.
Capacitor **74**	100 μfd.
Resistor **76**	2.2K.
Capacitor **77**	.47 μfd.
Transistor **78**	2N1304 or 2N213.
Capacitor **80**	.01 μfd.
Resistor **82**	22K.
Resistor **84**	2.2K.
Gated rectifier **86**	2N1774.

Although the present invention has been described with reference to a single illustrative embodiment thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of this invention.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. In a portable tool, a housing having a chamber, a winding disposed in said chamber, work engaging means including a magnetic portion disposed adjacent said winding, a flexible cable connected to said housing and adapted to supply an alternating current potential to said tool, and control circuit elements carried solely on said hous-

ing and connected to said cable and said winding, said control circuit elements including both a manually actuated switch means operable at random times relative to the alternating current potential and means controlled by actuation of said switch means and responsive to the polarity and amplitude of the alternating current potential for rendering no more than one full cycle of said alternating current potential effective to produce a flow of current through said winding to operate said tool so that the tool is operated a single time independent of the length of the period during which the switch means is maintained in an operated condition.

2. The portable tool set forth in claim 1 in which said housing includes a hollow handle portion and including means mounting said control circuit elements in said hollow handle portion.

3. A single stroke portable tool comprising a nonmagnetic housing forming a chamber, winding means disposed in said chamber, work engaging means movably mounted on said housing and including a magnetic portion positioned adjacent said winding means, flexible cable means connected to said housing for supplying an alternating current potential, manually operable switching means carried on said housing, and control circuit elements carried on said housing and controlled by operation of said switching means for connecting the alternating current potential from said cable to said winding for only the first one half cycle of said potential following the actuation of said switching means so that said winding is energized only during this half cycle to actuate said work engaging means through a single power stroke regardless of the length of time that the switching means is held operated.

4. In a portable tool, a housing having a chamber, a winding disposed in said chamber, work engaging means including a magnetic portion disposed adjacent said winding, a flexible cable connected to said housing and adapted to supply an alternating current signal to said tool, a manually actuated switch means carried on said housing, a controlled conduction device carried on said housing and connected in series with said winding and said cable, said controlled conduction device having a control electrode, and circuit means energized by the alternating current signal and carried solely on said housing, said circuit means including means responsive to the amplitude and polarity of the alternating current signal and the operation of said switch means for supplying an operating signal to said control electrode to place said controlled conduction device in a conductive state for only a portion of the duration of a single cycle of the alternating current signal supplied to said tool by said cable, said circuit means preventing further conduction through the controlled conduction device until the switch means is released and reoperated.

5. In a portable tool, a housing having a chamber, a winding disposed in said chamber, work engaging means including a magnetic actuating means disposed adjacent said winding, a flexible cable connected to said housing and adapted to supply an alternating current signal to said tool, a first controlled conduction device carried on said housing and connected between said cable and said winding to control the energization of said winding, said controlled conduction device having a control electrode, a control circuit mounted on said cable and said housing and connected to said control electrode for selectively placing said first controlled conduction device in a conductive state, said control circuit including a second controlled conduction device requiring a unidirectional operating potential, means carried on said housing and energized by the alternating current signal from said cable for supplying a unidirectional potential to said second controlled conduction device, and manually operated switch means carried on said housing for controlling the operation of said control circuit.

6. A single stroke portable tool adapted to be energized by an alternating current potential source comprising a portable housing, winding means in the housing, work engaging means having a magnetic portion disposed adjacent the winding means, a flexible cable including two conductors adapted to be connected between the alternating current potential source and the tool, manually actuated switch means carried on the housing and operable at random times relative to the alternating current potential, a gated rectifier means carried on the housing and connecting the winding means in series with the two conductors of the cable, said gated rectifier means having a gate electrode, and control circuit means coupled to the gate electrode and connected to and controlled by actuation of the switch means for placing the gated rectifier in conduction to energize the winding means from the alternating current potential supplied by the cable for no longer than a single cycle of the potential occurring following the random operation of the switch means, said control circuit means including means for inhibiting reinitiation of conduction through the gated rectifier until the switch means has been released.

7. The tool set forth in claim 1 in which the housing includes a hollow handle portion and in which the control circuit means is disposed in the hollow handle portion.

8. An electric tool adapted to be energized by an alternating current potential source and controlled to provide a single power stroke comprising a portable housing having a chamber, winding means disposed in the chamber, work engaging means including a magnetic actuating means movably mounted adjacent the winding means, a flexible cable connected to the housing and including two conductors adapted to supply alternating current voltage to the tool from the potential source, manually operable switch means carried on the housing and operable at random times relative to the alternating current potential, control circuit means connected to the two conductors to be energized by the potential source and coupled to the unidirectional conducting means, and means connecting the switch means to the control circuit means, said control circuit means including means responsive to the time of actuation of the switch means and the amplitude of the alternating current potential for placing the unidirectional conducting means in conduction for no more than one cycle of the alternating current potential for each actuation of the operable switch means.

9. An electric tool adapted to be energized by an alternating current potential source and controlled to provide a single power stroke comprising a portable housing having a chamber, winding means disposed in the chamber, work engaging means including a magnetic actuating means movably mounted adjacent the winding means, a unidirectional conducting device including a control electrode, a flexible cable connected to the housing and adapted to supply alternating current voltage to the tool from the potential source, first circuit means in said housing connecting the unidirectional conducting device and the winding means in series with the potetial source over the flexible cable, control circuit means connected to the cable to be energized by the potential source and connected to the control electrode to supply a control signal to the control electrode capable of causing conduction through the unidirectional conducting device for no more than one cycle of the alternating current potential, a manually operable switch means carried on the housing and operable between operated and released conditions, and second circuit means connecting the switch means to the control circuit means and effective to control the control circuit means to deliver a control signal to the control electrode during a selected single cycle only of the alternating current potential supplied by the flexible cable and to prevent the delivery of another control signal to the control electrode until the manual switch means has

been operated to its released condition and then returned to its operated condition.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,179,866 April 20, 1965

Richard H. Doyle et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 64, strike out "cable and said"; same column 7, line 65, after "said" insert -- cable and said --.

Signed and sealed this 24th day of August 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

UNITED STATES PATENT OFFICE

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