Feb. 23, 1965 J. H. ROWE, JR 3,171,062

TOOL IMMOBILIZER CIRCUIT

Filed April 11, 1962

FIG. 2

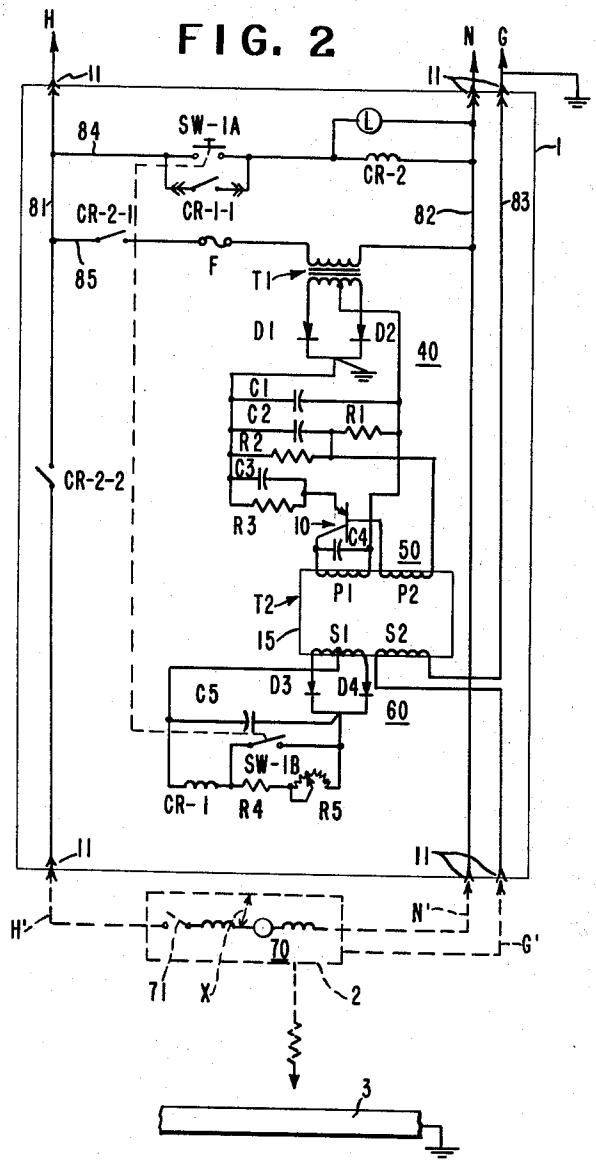
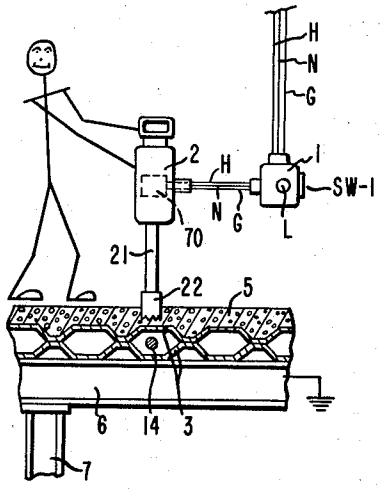


FIG. 1



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TOOL IMMOBILIZER CIRCUIT

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This invention generally relates to the field of safety devices for immobilizing power tools under certain predetermined unsafe work conditions. More specifically, this invention involves a novel improved electrical safety device for immobilizing an electrically powered or electrically controlled cutting, chipping, or drilling tool or the like, under conditions in which (*a*) the tool in use encounters an electrically grounded object such as an electrical conduit, a pipe, or a metallic supporting structure, (*b*) an internal short circuit or ground fault occurs in the tool, or (*c*) a failure of any component of the safety device occurs.

Especially valuable use of cutting, chipping or drilling tools having such safety devices has been in work on buildings and structures in which extensive use has been made of metal support structures employed as the under support for concrete floors. The support structures used usually have a corrugated cross section which contributes strength and stiffness and also define, by association with opposed similar structures, enclosed passageways which are utilized for housing electrical cables and other wiring and piping necessary for providing the usual service facilities required. With such support structures, forms for the casting of concrete floors are eliminated, several inches of concrete being cast directly over the top surface of the top support structure which provides all of the support necessary for the concrete. The support structures are usually supported at intervals by the usual steel building framework. In present practice the building framework and support structures are electrically grounded.

After construction it frequently is necessary to drill through the concrete carried by the support structure in order to make connections with the conduits enclosed in the passageways formed in the support structure. Heavy power drills are commonly employed for this purpose and because of the very high resistance of concrete to drill it is often impossible for the drill operator to determine when he has cut away all of the intervening concrete and is about to cut into the metallic support structure. Many times the drill head is cooled with a running stream of cooling water which bathes the area being worked. This use of cooling water creates a problem in that if the support structure is pierced by the tool and the passageways formed therein laid open, the cooling water enters the passageway short-circuiting or damaging the electrical cables therein. In addition other damage is done to the structure by leakage. However, the most serious problem arises when a passageway formed in the support structure is entered unknowingly by the operator's tool, it may cut through the insulation of electrical conductors housed in the passageway and result in fatal or severe shock to the tool operator.

Prior efforts have been made to solve these problems with certain tool immobilizing circuit arrangements such as those disclosed in U.S. Patent 2,747,154 to Abrams. However, such prior art arrangements have had serious shortcomings. For example, devices such as those disclosed in the abovementioned Abrams patent would not "fail-safe" or terminate tool operation upon the failure of components of the safety device itself. This meant that the tool operator could continue to operate the tool not knowing that the safety device had been disabled. Another difficulty of these prior art safety devices lies in the fact that their tool housing ground circuit develops sufficient resistance to current flow upon occurrence of a short circuit within the tool housing, or upon engagement of the tool with a high electrical potential object, that current is more likely to flow back to ground through the operator's body than through the ground circuit or line. In addition, the prior art devices applied a ground-sensing voltage to the tool housing of such a magnitude due to the high resistance of the housing ground circuit that it produced a continuous unpleasant tingling or shock sensation to the operator's hands while in use. This is of course undesirable.

It is an object of this invention to provide an improved safety device which operates, in an improved manner overcoming the prior art defects, to permit unhindered drilling, cutting, or chipping of material up to the point at which the surface of electrically grounded members are contacted, and then promptly shut off or immobilize the power tool with which the safety device is associated.

It is another object of the invention to provide a lightweight, simple yet reliable electrical safety device for power drilling and cutting tools which substantially eliminates the possibility of electrical shock injury to operating personnel from (*a*) contact of the tool with high voltage lines in grounded conduits, or (*b*) the occurrence of an internal short circuit or ground fault within the tool itself.

It is a further object to provide such a safety device which will "fail-safe" and shut off the power tool with which it is associated, upon the failure of one or more of the components of the safety device.

It is a further object of this invention to provide a power tool immobilizing safety device as described above and in addition provided with an adjustable sensitivity for handling varying ground path resistances in order to enable tool operation in varying mediums such as wet earth, concrete and the like without false operation of the safety device.

Other objects and advantages will appear upon consideration of the following specification and claims taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a schematic representation of a power tool combined with the safety device of this invention to illustrate the "in-use" relationships with the operator, building structure, and electrical conduit elements.

FIGURE 2 is a circuit diagram of the improved safety device of my invention showing general relationship with the power tool and a grounded object.

Referring to FIGURE 1, a power tool **2** is shown provided with a rotary shaft **21** and drill or cutting head **22** for cutting through floor material **5** supported on grounded support elements **3** which house a power conduit **14**. Support elements **3** are shown further supported by horizontal beams **6** and vertical elements **7** in a suitable manner. This illustrates a preferred use of the apparatus of this invention. The power tool **2** may be driven by an electrical drive means or by other power drive means controlled by an electrical control means, the electrical drive means and electrical control means being indicated by the reference numeral **70**. The safety device of this invention is shown contained in a housing **1** which is connected by conductors H, N, and G to a power source (not shown) and to the power tool **2**. It will be apparent from FIGURE 1 that the power tool operator will be in a very dangerous position upon the cutting head cutting into a power conduit or cable **14** or upon development of a short circuit or "ground fault" within the tool itself due to application of the full voltage of the power conductor H directly to the tool housing.

The preferred version of the power tool immobilizing device of my invention is shown in detail in FIGURE 2. Generally speaking, the safety device of this invention

comprises a rectifier **40** for converting the usual 60 cycle alternating current power, supplied by means of conduits H and N, into direct current. This direct current is supplied to a oscillator circuit **50** which generates a high frequency output which is supplied to the primary winding of transformer T2. The transformer T2 is provided with two secondary windings S1 and S2. The output of secondary winding S1 is rectified in rectifier **60** and supplied to a relay coil which holds closed a normally open switch in the main power line to a power tool **2**. The normal condition of secondary winding S2 is an open circuit condition with one terminal of this winding connected to ground via ground conduit G. The other terminal of winding S2 is connected to the housing or appropriate portion of the power tool **2**, such as the working head structure. When a circuit is closed through secondary winding S2 by the portion a working head of tool **2** contacting a grounded element or mass, or by a short circuit such as indicated at "X" between power line H and the tool housing, the action of current in winding S2 in transformer T2 reduces the current produced by winding S1 to the point where the relay coil in the circuit of the S1 winding cannot hold the normally open switch in the main power line closed. At this point the switch opens and the tool is immobilized or stopped by termination of power to its driving or control means.

Referring to the circuit of FIGURE 2 in more detail, the safety circuit is preferably contained in a casing or housing **1** which is provided with two sets of terminals or connection elements **11** for connecting the safety device with the power supply and electrical ground and for connecting power supply and electrical ground to the power tool **2**. Three main conductor elements **81**, **82**, and **83** are arranged within the housing for respectively connecting the high voltage line H from the power source (not shown) with the high voltage line H' to the power tool, for connecting the neutral line N from the source with the neutral line N' to the tool and for connecting the ground line G to the ground line G' to the power tool. In the preferred embodiment of this invention a conventional 60 cycle 120 volt power supply is utilized. A normally-open manually operated starting and reset switch SW–1A and a relay coil CR–2 are connected in series across conductors **81** and **82**. A normally open relay-operated switch CR–1–1 is connected in parallel across manually operated switch SW–1. A pilot lamp L is connected in parallel with relay coil CR–2.

The primary winding of transformed T1, normally open relay-operated switch CR–2–1, and fuse F are also connected in series across conductors **81** and **82**. Transformer T1 furnishes input power to the rectifier **40** which is conventionally comprised of diodes D1 and D2 and capacitor C1. The direct current output of rectifier **40** is furnished to a conventional suitable oscillator circuit **50** which comprises, in their embodiments, transistor **10** with a tuned collector circuit, transistor bias resistors R1 and R2, bypass capacitors C2 and C3, stabilizing resistor R3, tank circuit capacitor and primary windings of transformer T2. In the preferred embodiment the oscillator frequency is approximately 10 kilocycles. Primary winding P1 of which is in the tank circuit of the oscillator generates an alternating flux in the core of the transformer T2. This flux induces an alternating voltage in all of the windings wound on this core in well known manner. Secondary winding S2 has a low impedance at 60 cycles and a high thermal capacity. Winding S2 is connected in series with the conductor **83** in the tool ground circuit G', **83**, G between ground and the tool structure **2**. Secondary winding S1 of transformer T2 supplies alternating power to rectifier **60** which comprises diodes D3 and D4 and capacitor C5. The direct current output of rectifier **60** is supplied through variable resistor R5 and fixed resistor R4, to relay coil CR–1. A normally open switch SW–1B is connected in parallel across resistors R4 and R5. Switch SW–1B is actuated with manually operated switch SW–1A. Relay coil CR–1 when energized closes normally open switch CR–1–1. Relay coil CR–2 when energized closes normally open switches CR–2–1 and CR–2–2. Switch CR–2–2 is connected in series with the high voltage conductors H, **81**, and H' for control of power to the power tool drive means or drive control means. As will be readily understood, the power tool may be driven by an electrical motor or may be driven by other means which are controlled by an electrical control means which would be supplied by conductors H, **81**, and H', without changing the operation of the safety device of this invention. For example, a pneumatically driven power tool could be controlled by an electrically actuated normally closed main supply valve as is disclosed in the above-mentioned patent to Abrams.

In operation the tool **2** and safety device **1** are connected to each other and to a power source as shown in FIGURE 1. In order to energize the safety device and supply power to the power tool on-off switch **71** as shown in FIGURE 2, the push button switch SW–1A is manually momentarily closed. This action also momentarily closes switch SW–1B which is suitably linked to switch SW–1A. Closing switch SW–1A energizes pilot light L and relay coil CR–2 which closes switches CR–2–1 and CR–2–2. Switch CR–2–1 when closed energizes the direct current power supply **40** and oscillator **50** to apply the 10 kc. sensing voltage from secondary winding S2 of transformer T2 to the power tool structure through conductors **83** and G', and also the energize relay coil CR–1 through secondary winding S1 of transformer T2 and rectifier **60**. Relay coil CR–1 when energized closes normally open switch CR–1–1 against the urging of a resilient means such as a spring element (not shown) to establish the holding circuit which maintains relay CR–2 energized when the push button and switches SW–1A and SW–1B are released to open position. Upon opening of switch SW–1B relay coil CR–1 is maintained in the energized condition by means of the circuit path through resistors R4 and R5. As a result of closing switch CR–2–2 power is supplied to the tool **2** and upon actuation of switch **71** the tool will be operated. In operation, whenever any metallic part of the power tool, most especially the working head structure, makes contact with a grounded metal object or conductor, such as the support elements **3** shown in FIGURE 1, the high frequency sensing voltage applied to the tool causes a current to flow in secondary winding S2 in transformer T2. This current flow generates an alternating flux in the core of transformer T2 which opposes the flux generated by the oscillator-fed primary winding P1 which results in a reduction in the net flux and voltage developed across winding S1. This reduction in the voltage output of winding S1 reduces the current in relay coil CR–1 to the point where this relay can no longer hold switch CR–1–1 closed and this switch opens. Opening switch CR–1–1 deenergizes relay coil CR–2 and causes switches CR–2–1 and CR–2–2 to open removing power from the tool to shut it off and from the oscillator D.C. power supply.

In the event of a ground fault or internal short circuit in the tool structure, such as at "X" between the high voltage line and the tool structure (FIGURE 2), current will flow back through conductors G' and **82**, secondary coil S2 of transformer T2, and conductor G to ground. This will cause the tool to become immobilized in a manner similar to that occurring upon contact of the tool with a grounded conductive object or mass.

In order to recommence operations of the tool and safety device, the tool must be removed from contact with the grounded object or the short circuit removed, and switch SW–1A again manually momentarily closed.

Other desirable features of the disclosed arrangement involve (*a*) termination of the power supplied to the tool upon failure of any component of the safety device, (*b*)

maintenance of the high frequency sensing voltage at a value low enough to eliminate sensation of shock to the operator yet high enough to insure positive reliable operation of the device (the preferred frequency is about 10 kc. and the preferred voltage level is about 6.3 volts R.M.S. at 10 kc.), (*c*) functioning of the safety device to shut off the tool even when contact is made to conductors grounded through relatively high resistances (in the preferred embodiment of this invention the sensitivity of the device is adjustable over a range of about 20 ohms to 100 ohms plus maximum ground path resistance; this avoids false operation or shut down when using the tool in media such as wet earth and concrete with a very low resistance to ground) and (*d*) maintenance of a low voltage from tool to ground in the event of a tool short circuit or "ground fault" due to keeping the 60 cycle impedance of secondary winding S2 at very low or negligible values. (In the preferred embodiment a voltage drop of only 3 volts peak will exist across the coil when it is subjected to a 100 ampere R.M.S. 60 cycle short circuit current.)

The sensitivity of the safety device is controlled and varied as desired by adjustment of variable resistor R–5, it being understood that the maximum resistance of a known test resistor which when applied across lines G and G^1 causes positive operation of the circuit under adjustment and testing also represents the maximum ground path resistance under which definite operation of the device will occur.

The following values and characteristics are set forth for the various elements of the preferred circuit arrangement of FIGURE 2.

Power supply—120 v., 60 cycle A.C., 15 a. circuit.
Sensing voltage—10 kc., 6.3 v. R.M.S.
Pilot light—S–6 lamp.
Relay coil CR–2—110 v., 60 cycle A.C., 2 N.O. 15 a., 120 v. contacts.
Fuze—3 AG, ⅓ a., 250 v.
Transformer T1—Filament transformer 12.6 v. CT @ 2 a.
Diodes D1, D2—Stud type 50 VP1V, 3 a.
Capacitors C1, C2, C3—Electrolytic, 1000 mfd., 15 v.
Capacitor C–4—Metallized paper 2 mfd. 200 v.
Capacitor C–5—Metallized paper 1 mfd. 200 v.
Transistor 10—Tungsol 2N378.
Diodes D3, D4—Silicon, 200 VP1V, 300 ma.
Resistor R1—Carbon, 470 ohm, 1 watt, 10% TOL.
Resistor R2—Carbon, 100 ohm, 1 watt, 10% TOL.
Resistor R3—Carbon, 3 ohm, 5 watt, WW.
Resistor R4—39K ohm, 1 watt, 10% TOL.
Resistor R5—10K ohm, 2 watt, wire wound pot.
Transformer T2—Core type "H" material, General Ceramics.
Relay CR–1—Enclosed plug-in type—Sigma 42 RO 5000–G–51L.

It will be seen that a tool immobilizing circuit has been provided which is greatly improved in safety, reliability, effectiveness and flexibility of operation and application.

While one preferred embodiment of this invention has been disclosed in accordance with the patent statutes, it will be apparent to those skilled in the art that many modifications and changes may be made therein without departing from the spirit of the invention. All such modifications and changes are considered to fall within the scope of the following claims.

I claim:

1. An improved electrical safety device for immobilizing a power tool when an unsafe work condition is encountered, said device comprising an electrical circuit arrangement, said arrangement comprising, a first conductor adapted to be operatively connected to one output terminal of a low frequency alternating current power source and to be operatively connected to a control element of a power tool, a second conductor adapted to be operatively connected to the other output terminal of such a power source and to such a control element of a power tool, a third conductor adapted to be operatively connected to electrical ground and to a part of such a power tool structure, an electrical oscillator means operatively connected across said first and second conductors for generating a high frequency alternating current output, a transformer having a primary winding and a secondary winding, said oscillator operatively connected to said primary winding to apply the high frequency alternating current output thereto, said secondary winding comprising a first portion and a second portion, a normally open switch means operatively connected in said first conductor, a switch operating means operatively connected to said switch means, an electrical actuating unit for switch operating means, said unit electrically connected to said first portion of said transformer secondary winding for actuating said operating means to close said switch means upon energization of said first portion of said secondary winding, said second portion of said secondary winding operatively connected in series with said third conductor, said first and second portions of said transformer secondary winding constructed and arranged so that any contact of the part of a power tool structure connected to said third conductor, with an electrically grounded object causes an increase in current in said second portion of said secondary winding in a direction to cause a sufficient reduction in energization of said first portion of the secondary winding to render the actuating unit for the switch operating means inoperative to maintain said switch in its closed position, permitting said switch to open and operatively disconnect the control element of an associated power tool from a power source connected to said first and second conductors.

2. The improved safety device of claim 1 in which said second portion of said transformer secondary winding is constructed, arranged, and its characteristics selected to present a high electrical impedance to the high frequency alternating current developed in the transformer from said oscillator means, and to present an extremely low electrical impedance to low frequency alternating current developed by said power source.

3. The improved safety device of claim 2 in which a selectively variable current controlling impedance is connected in series with said first portion of said secondary winding and said electrical actuating unit for the switch operating means for varying the magnitude of current applied to the unit for holding the switch in the closed position and hence the sensitivity of the safety device.

4. An electrical safety device for use in combination with a low frequency alternating current transmission means and a power tool; said transmission means comprising a first power conduit, a second neutral conduit and a grounded conduit, and said power tool comprising a working head structure and an electrical control means; said safety device comprising an electrical circuit arrangement, said arrangement comprising a first conductor means provided with a one connection element for electrically connecting said first conductor to one of the first and second conduits and another connection element for simultaneously electrically connecting said first conductor to the control means of the power tool, a second conductor means provided with one connection element for electrically connecting said second conductor means to the other of said first and second conduits, and another connection element for simultaneously electrically connecting said second conductor means to the control means of the power tool, a third conductor means provided with one connection element for electrically connecting said third conductor means to said grounded conduit and another connection element for simultaneously electrically connecting said third conductor means to the working head structure of the power tool, an electrical oscillator means operatively connected

across said first and second conductor means for generating a high frequency alternating output, a transformer having a primary winding, and a first secondary winding and a second secondary winding, said oscillator means operatively connected to said primary winding to apply the high frequency alternating current output thereto, an electrical switch connected in series with said first conductor means, resilient means urging said switch into open position, a switch closing means operatively connected to said switch, an electrical actuating unit for said switch closing means, said unit electrically connected across said first secondary transformer winding for actuating said closing means upon creation of a given magnitude current in said first secondary winding, said second secondary winding connected in series with said third conductor means for applying a high frequency low sensing voltage to the power tool working head structure when connected to said third conductor means, said first and second secondary windings constructed and arranged and in cooperative association with each other so that each contact of the connected power tool working head structure with an electrically grounded

mass and each short circuit condition applying low frequency alternating current power to the tool working head causes an increase in current in said second secondary winding which current acts to reduce the current in said first secondary winding below said given magnitude and render the actuating unit for the switch closing means inoperative and permit the resilient means to open the switch disconnecting the power tool control means from the power transmission means.

5. The device of claim 4 in which the circuit arrangement further comprises a means for resetting said switch for continued application of power to the power tool control means after removal of the tool working head structure from contact with a grounded mass.

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