Aug. 20, 1968 L. PIEKARSKI 3,398,328

ELECTRICAL RELAY CIRCUITRY FOR MAGNETIZING SYSTEMS AND THE LIKE

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Fig. 2

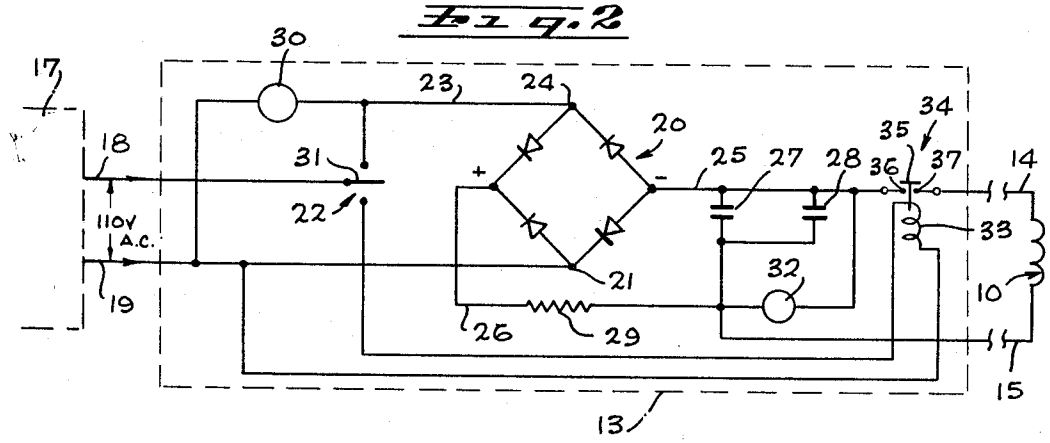


Fig. 3

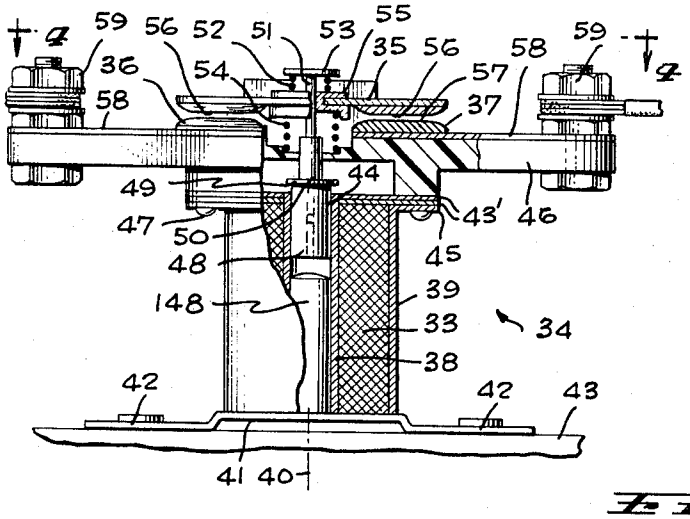


Fig. 5

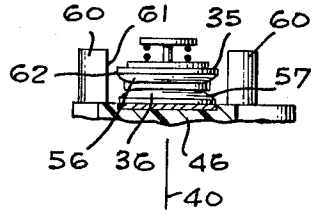


Fig. 4

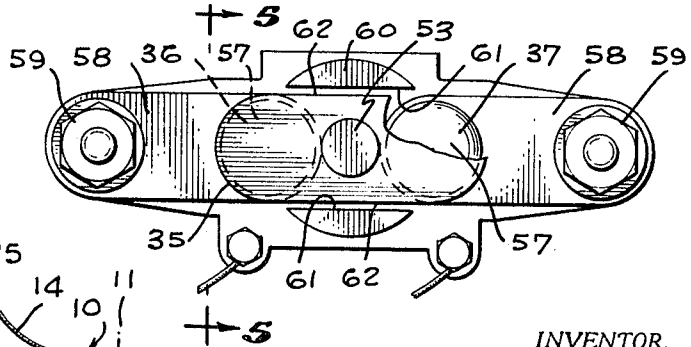
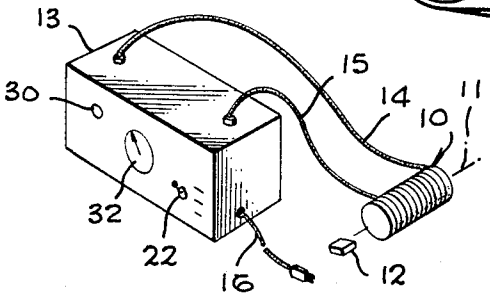


Fig. 1



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ELECTRICAL RELAY CIRCUITRY FOR MAGNETIZING SYSTEMS AND THE LIKE

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This invention relates to improved electrical apparatus for opening and closing an electrical circuit, with certain features of the apparatus being in some respects especially useful for momentarily closing a circuit to a unit which is responsive to or actuable by an electrical impulse of short duration. For instance, equipment embodying the invention is very useful for closing and then opening the circuit to a magnetizing coil, so that a rapid surge of current may pass through the coil for magnetizing elements placed therein. For simplicity of discussion, the invention will be described hereinafter primarily as applied to the energization of such magnetizing coils.

Though the magnetization of an element by subjection to the magnetic field within a coil does not require that the field be maintained for any extended period of time, and may be attained almost instantaneously by an electrical impulse of very short duration, the current flow during that short interval must in most instances be very heavy, in order to assure the development of a sufficiently intense magnetic field to attain the desired magnetizing action. This high amperage current flow has in the past proven very difficult to control because of the problems encountered in attempting to devise a switch or relay capable of instantaneously closing the coil energizing circuit without causing rapid pitting or burning of the switch or relay contacts by the heavy flow of current, and the resultant sparking between the contacts during closure. These contacts therefore have been capable of functioning for only a very short active life, and have been unreliable and unpredictable in operation at all times.

A major object of the present invention is to provide improved circuit for energizing and de-energizing a magnetizing coil or other electrically operated unit, with the circuit being especially constructed to positively avoid damage to the controlling contacts, even though the current passed through those contacts may be relatively high. Certain particular features of the invention relate to the construction and manner of energization of a relay which is utilized in the overall circuit of the invention for opening and closing the circuit to the coil or other electrically operated unit.

In accordance with the teachings of the invention, the coil of the circuit closing relay is energized by alternating current, desirably 60 cycle, 110 volt. A.C. The relay is so constructed, and the energizing potential and frequency are so selected, that the coil when energized is not effective to pull the movable contact or contacts of the relay to closed position as positively as is desired in most relay arrangements. Instead, the movable contact or contacts are purposely left free to vibrate through a very substantial range of movement relative to the stationary contacts while the relay is closed. More particularly, the movable contacts vibrate or oscillate at the frequency of the energizing current, that is, usually 60 cycles per second. This vibratory motion causes the movable contacts to continuously and repeatedly shift relative to and over the surface of the engaged stationary contacts while the relay is closed, to in this way actually mechanically polish the engaging surfaces of the contacts, in a manner continuously guarding against the development of any pits or other irregularities in the surfaces of the contacts. It is found that these vibratory relay contacts can

be closed and opened under heavy load conditions repeatedly and almost indefinitely without adversely affecting their current carrying capacity, and without pitting of or other damage to the contacts.

To attain the above discussed results, the relay may be of a construction essentially similar to that customarily employed for direct current relays, but with this direct current type of relay being energized by alternating current, as discussed above, and preferably of a voltage substantially higher than would be employed if the relay were under direct current operation. Structurally, the relay should have considerably less stationary iron or other stationary magnetic material than is present in most alternating current relays, so that the magnetic circuit provided for the flux is not of a great enough flux carrying capacity to smooth over the irregularities of the alternating current supply, and thus maintain the contacts in tightly closed non-vibratory condition.

The above and other features and objects of the invention will be better understood from the following detailed description of the typical embodiment illustrated in the accompanying drawing, in which:

FIG. 1 illustrates somewhat diagrammatically and in perspective a magnetizing device constructed in accordance with the invention;

FIG. 2 shows the electrical circuit of the Fig. 1 magnetizer;

FIG. 3 illustrates, partially in elevation and partially in section, a relay of the type preferably utilized in the FIG. 2 circuit;

FIG. 4 is a plan view of the FIG. 3 relay, taken on line 4—4 of FIG. 3; and

FIG. 5 is a fragmentary vertical section taken on line 5—5 of FIG. 4.

Referring first to FIG. 1, I have illustrated at **10** a magnetizing coil which is wound helically about an axis **11**, and is hollow to enable the insertion into the interior of the coil of an element **12** which is to be magnetized by electrical energization of the coil. The coil receives high amperage current from a control box **13** through two electrical leads **14** and **15**. Power is supplied to control box **13** through a cord **16** from any appropriate source of alternating current diagrammatically represented at **17** in FIG. 2, with the two conductors in cord **16** being designated **18** and **19** in FIG. 2. Preferably, as previously stated, the power source **17** is 110 volt, 60 cycle per second, alternating current.

The control box **13** contains a full wave rectifying circuit **20**, to the input side of which power source **17** is connected, by connection of lead **19** to the rectifier circuit at **21**, and connection of lead **18** to the rectifier circuit through a two-way manually operated control switch **22** and a line **23** leading to input terminal **24**. The resulting direct current leaves the rectifier circuit through two leads **25** and **26**, across which two capacitors **27** and **28** are connected in parallel, with a resistor **29** preferably being connected into lead **26** between the rectifier and the capacitors.

Capacitors **27** and **28** may typically have a value of 6,000 microfarad, 150 volt D.C., while the resistor **29** may typically have a rating of 8 ohms, 18 watts.

An indicator light **30** is shunted across the input side of rectifier circuit **20**, to indicate when the movable contact **31** of switch **22** is in its upper position for supplying alternating current to the rectifier circuit, and thus charging capacitors **27** and **28**. A voltmeter **32** is connected across the capacitors, to indicate the amount of the charge which has been attained on the capacitors, so that an operator can readily tell when the charge is sufficient to call for discharging the capacitors through the magnetizing coil **10**.

This discharging of the capacitors is controlled by

downward actuation of the movable contact **31** of switch **22**, to close through that switch a circuit leading from alternating current power source **17** to coil **33** of a control relay **34**. The movable contact **35** of relay **34** is actuable magnetically to closed position with respect to a pair of contacts **36** and **37** by energization of coil **33**, to thus close a discharge circuit from capacitors **27** and **28** to magnetizing coil **10** through leads **14** and **15**.

With reference now to FIGS. 3 to 5, which show a preferred construction for relay **34**, it is noted that coil **33** of this relay may consist of a large number of turns of wire wound in many layers about an inner tube **38** formed of non-magnetic material, such as an appropriate brass or the like. The coil may thus form an essentially annular structure, as illustrated in FIG. 3, with a cylindrical hollow housing or outer covering **39** being disposed about the periphery of the coil, and being concentric with coil **33** and tube **38**, all being centered about a main vertical axis **40** of the relay. Housing **39** may be rigidly brazed, welded, or otherwise secured to a transverse bottom wall **41** extending across the bottom of the coil and tube **38**, and having ears or tabs **42** by which the coil may be mounted to a supporting structure **43**. The upper end of housing **39** may be closed, about tube **38**, by one or a pair of essentially annular discs **43**, whose inner edges may engage tube **38** at **44**, and which discs **43'** may be secured rigidly to an upper flange **45** of housing **39** and a non-magnetic and non-electrically conductive top member **46** by screws **47**. Members **46** may be formed of an appropriate plastic material.

The armature **48** of the relay may be externally cylindrical and centered about axis **40**, and be a fairly close fit within the interior of tube **38**, so that the armature **48** is magnetically actuable downwardly by coil **33** from the full line position of FIG. 1 to the broken line position of that figure. This armature **48** is of course formed of an appropriate magnetic material, such as iron. The upper end of armature or plunger **48** may have an annular flange **49** engageable downwardly against the upper end of tube **38** to limit downward movement of the armature. Also, the armature may rigidly carry an upwardly projecting reduced diameter portion **50**, and a still smaller diameter portion **51**, which resiliently and shiftably carry the movable contact or cross head **35** which engages stationary contacts **36** and **37** of the relay. Movable contact **35** is normally held in the full line position of FIG. 3 relative to the plunger, by an upper spring **52** which is confined between movable contacts **35** and an upper enlargement **53** carried by the armature, with this spring **52** coacting with a second and lower spring **54** confined between the upper side of the plunger and movable contact **35**. These two springs are insulated from contact **35** by an annular non-conductive grommet structure **55**, mounted wtihin an aperture in contact **35**. The springs of course act together to yieldingly urge the armature and movable contact upwardly to the normally open full line position of FIG. 3.

Contact **35** is elongated in a left to right direction as viewed in FIG. 3, and has two contact surfaces **56** formed at its opposite ends, and facing downwardly for engagement with inverted contact surfaces **57** of the two stationary contacts **36** and **37**. The stationary contacts are connected by straps **58** to terminals **59** by which the stationary contacts are connected into the FIG. 2 circuit.

The resilient movement of contact **35** relative to stationary contacts **36** and **37** is limited by a pair of upstanding block portions or bosses **60** of the nonconductive member **46**. These two bosses project upwardly at opposite sides of contact **35**, as brought out in FIGS. 4 and 5, and have inner parallel vertical planar surfaces **61** which are spaced slightly outwardly from the opposite parallel side edges **62** of contact **35**, so that the contact **35** is free for some lateral movement, and is free for limited turning movement about vertical axis **40**, but both of these types of movement are definitely limited by engagement of edges **62** with boss surfaces **61**.

The various electrical and magnetic parameters of relay **34**, and the voltage and frequency of the alternating current which energizes coil **33** of this relay, are all so selected and predetermined as to attain an automatic polishing action between contact **35** and the engaged contacts **36** and **37**, whenever coil **33** is energized to pull armature **48** downwardly. More particularly, the energizing voltage and current are sufficient to pull armature **48** and its resiliently carried movable contact **35** downwardly from the full line position of FIG. 3 to the broken line position of that figure, whenever coil **33** is energized by the alternating current supplied to input lines **18** and **19**. However, the holding action of the coil with respect to armature **48** is purposely reduced to a minimum value which, though holding contact **35** substantially closed, will still allow that contact to vibrate relative to stationary contacts **36** and **37** through a very substantial and easily visible range of movement, preferably at least as much as about one sixty-fourth of an inch (also desirably through a distance at least about as great as 5% of the maximum dimension of each contact face, i.e. 5% of the maximum dimension of the actual contacting portion of faces **56** and **57**), so that faces **56** of the movable contacts repeatedly and continuously wipe across and vibrate relative faces **57** of the stationary contacts to effectively polish all of these contact faces and maintain them in optimum current transmitting condition. The vibratory motion thus attained can be observed to produce different types of movement of the movable contact **37**, so that the movable contact faces **56** and **57** move horizontally across the upper surfaces of contact faces **57**, and may in many instances follow a somewhat circular path in wiping across surfaces **57**, with different portions of contact **35** moving alternately into engagement with the two edges **61** of the motion limiting bosses, and with the springs **52** and **54** facilitating the vibratory motion because of their resilient mounting of movable contact **35** relative to the armature or plunger.

To describe briefly a cycle of operation of the circuit of FIG. 2, assume that switch **22** is initially in its intermediate open position, and that the element **12** of FIG. 1 is inserted into coil **10** to a position at which it is to be magnetized by the coil. An operator then moves contact **31** of the switch **22** upwardly to energize the rectifier circuit **20**, so that direct current is supplied to capacitors **27** and **28**, to charge them. When voltmeter **32** indicates that an appropriate charge has been attained on the capacitors, the movable contact of switch **22** is actuated downwardly to open the circuit to the rectifier arrangement, and close the circuit to coil **33** of the relay. The alternating current within coil **33** thus pulls armature **48** and the connected movable contact **35** downwardly to close the discharge circuit between stationary contacts **36** and **37**, so that the capacitors **27** and **28** suddenly discharge through the contacts of the relay to magnetizing coil **10**, to attain the desired magnetizing action. The discussed vibratory motion of contact **35** relative to stationary contacts **36** and **37** polishes all of these contacts in the manner discussed, and prevents development of pits or craters on the contact surfaces, so that the relay may be repeatedly opened and closed through many cycles, and almost indefinitely, without encountering the contact deterioration or damage which is a customary problem in magnetizers and other equipment of the discussed general type.

Obviously, many variations may be made in the structure of the relay and its relationship to the energizing alternating current while still attaining the discussed contact vibrating effect. No attempt will be made to set forth all of these different possible variations of the invention since persons versed in the electrical field will be able to devise apparatus embodying the invention from the above teachings. Some of the parameters which may be altered

to achieve and control vibration of movable contact 35 of the relay are the particular construction of coil 33, the amount of stationary magnetic material associated with the coil and typically constituting the parts 39, 41, 43 and 45, the size, cross section, and flux capacity of this stationary magnetic material as compared with the movable magnetic material of armature 48, the magnetic retentivity of the magnetic material, the strength of springs 52 and 54, and the voltage and frequency of the energizing alternating current. A characteristic which is especially important is the mentioned feature relating to the amount of stationary magnetic material associated with the coil. In this connection, it is noted that the coil is preferably free of the relatively large amount of stationary laminated iron or other magnetic material which is normally present in an alternating current coil, and which usually provides in an alternating current coil a substantially complete magnetic circuit entirely about the coil of very great flux carrying capacity. Desirably, no such laminations are present in the relay utilized in my invention, or if any laminations are present they have a flux capacity which is not great enough to prevent vibration of contact 35.

For best results, the stationary magnetic material is essentially non-retentive or "soft" magnetically (i.e. has a minimum magnetic retentivity), and for this purpose may typically be formed of soft iron or the like. Also, it is preferred that the stationary magnetic material, if any is present in the main magnetic actuating circuit of the relay, be suffciently limited in cross section to have a maximum flux capacity (along that circuit) which is not greater than the maximum flux capacity of the armature along the circuit, and preferably not greater than about 40% of that armature flux capacity. For purposes of this limitation, the magnetic circuit in FIG. 3 may extend vertically within the armature, then horizontally or radially through plates 43, then vertically through housing 39, horizontally through plate 41 and upwardly through a stationary core 148 if such is present (with all of the elements 43, 39, 41 and 148 typically being of magnetic material but preferably of fairly small flux capacity as indicated). As will be apparent the effective flux capacity of the stationary parts is of course determined by and equal to the capacity of that portion of the stationary material which is most poorly conductive magnetically and which therefore defines the minimum flux capacity point along the stationary flux path. Similarly the minimum flux capacity portion of the armature determines the effective overall capacity of that part.

I claim:

1. Apparatus comprising capacitor means, means for charging said capacitor means, a unit to be energized by discharge of said capacitor means, a discharge controlling relay having a coil and having contacts connected into a discharge circuit from said capacitor means to said unit, said contacts including a first contact and a second contact movable relative thereto into circuit closing engagement with the first contact by energization of said coil, and means for supplying alternating current of a predetermined voltage to said relay coil to close said contacts and thereby discharge said capacitor means to said unit, said relay being constructed to vibrate said second contact very substantially when energized by said predetermined voltage of alternating current and to an extent repeatedly and continually shifting said second contact relative to the other contact while the contacts are closed to thereby mechanically polish the contacts and prevent pitting thereof.

2. Apparatus as recited in claim 1, in which said unit is a magnetizing coil for magnetizing an element in the vicinity thereof upon discharge of said capacitor means.

3. Apparatus as recited in claim 1, in which said charging means include a rectifier circuit energizable by alternating current and operable to supply direct current to said capacitor means.

4. Apparatus as recited in claim 1, in which said charging means include a rectifier circuit energizable by alternating current and operable to supply direct current to said capacitor means, said means for supplying alternating current to said relay coil including switch means for successively connecting a common source of alternating current first to said rectifier circuit to charge the capacitor means, and then to said relay coil to discharge the capacitor means through said contacts.

5. Apparatus as recited in claim 1, in which said relay is constructed to vibrate said second contact through a distance as great as one sixty-fourth of an inch relative to the other contact while the contacts are closed.

6. Apparatus as recited in claim 1, in which said relay has an armature connected to said movable contact to actuate it and projecting into and movable axially within said coil.

7. Apparatus as recited in claim 1, in which said relay has an armature connected to said movable contact to actuate it and projecting into and movable axially within said coil, and means connecting said movable contact to said armature resiliently.

8. Apparatus as recited in claim 1, in which said relay has a movable armature formed of magnetic material for actuating said movable contact, and in which, if any stationary magnetic material is present in the magnetic circuit of the relay, said stationary material does not have a flux capacity along said circuit over about 40% of the flux capacity of said armature therealong.

9. Apparatus as recited in claim 1, in which said relay has a magnetic material armature connected to said movable contact to actuate it and projecting into and movable axially within said coil, said movable contact being a cross head disposed transversely of the axis of the coil at the outside thereof and engageable at opposite ends with two of said first contacts to close said discharge circuit, spring means connecting said cross head to said armature shiftably and resiliently and enabling some lateral movement of the cross head transversely of said axis, said relay having stationary magnetic material near the coil in sufficient quantity to hold the movable contact essentially closed when the coil is energized but not sufficient to prevent said vibration.

10. Apparatus as recited in claim 9, in which said unit is a magnetizing coil, said charging means including a rectifier circuit energizable by alternating current and operable to supply direct current to said capacitor means, said means for supplying alternating current to said relay coil including switch means for successively connecting a common source of alternating current first to said rectifier circuit to charge the capacitor means, and then to said relay coil to discharge the capacitor means through said contacts.

11. The combination comprising a relay including a coil to be energized by alternating current of a predetermined voltage, a first contact, and a second contact actuable relative to the first contact into circuit closing engagement with the first contact by energization of said coil, and means for supplying alternating current of said predetermined voltage to said coil, said relay being constructed to vibrate said second contact very substantially when energized by said predetermined voltage of alternating current and to an extent repeatedly and continually shifting said second contact relative to the other contact while the contacts are closed to thereby mechanically polish the contacts and prevent pitting thereof.

12. Apparatus as recited in claim 11, in which said relay is constructed to vibrate said second contact relative to the other contact while the contacts are closed through a distance as great as 5% of the maximum dimension of the contacting faces of said contacts.

13. Apparatus as recited in claim 11, in which said relay has an armature connected to said second contact to actuate it and projecting into and movable axially within said coil.

14. Apparatus as recited in claim 11, in which said

relay has a movable armature formed of magnetic material for actuating said second contact, and in which, if any stationary magnetic material is present in the magnetic circuit of the relay, said stationary material does not have a flux capacity along said circuit over about 40% of the flux capacity of said armature therealong.

15. Apparatus as recited in claim 11, in which said relay has a magnetic material armature connected to said second contact to actuate it and projecting into and movable axially within said coil, said second contact being a cross head disposed transversely of the axis of the coil at the outside thereof and engageable at opposite ends with two of said first contacts, spring means connecting said cross head to said armature shiftably and

resiliently and enabling some lateral movement of the cross head traversely of said axis, said relay having stationary magnetic material near the coil in sufficient quantity to hold the second contact essentially closed when the coil is energized but not sufficient to prevent said vibration.

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