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[54] **DEMAGNETIZER, SOLID STATE**
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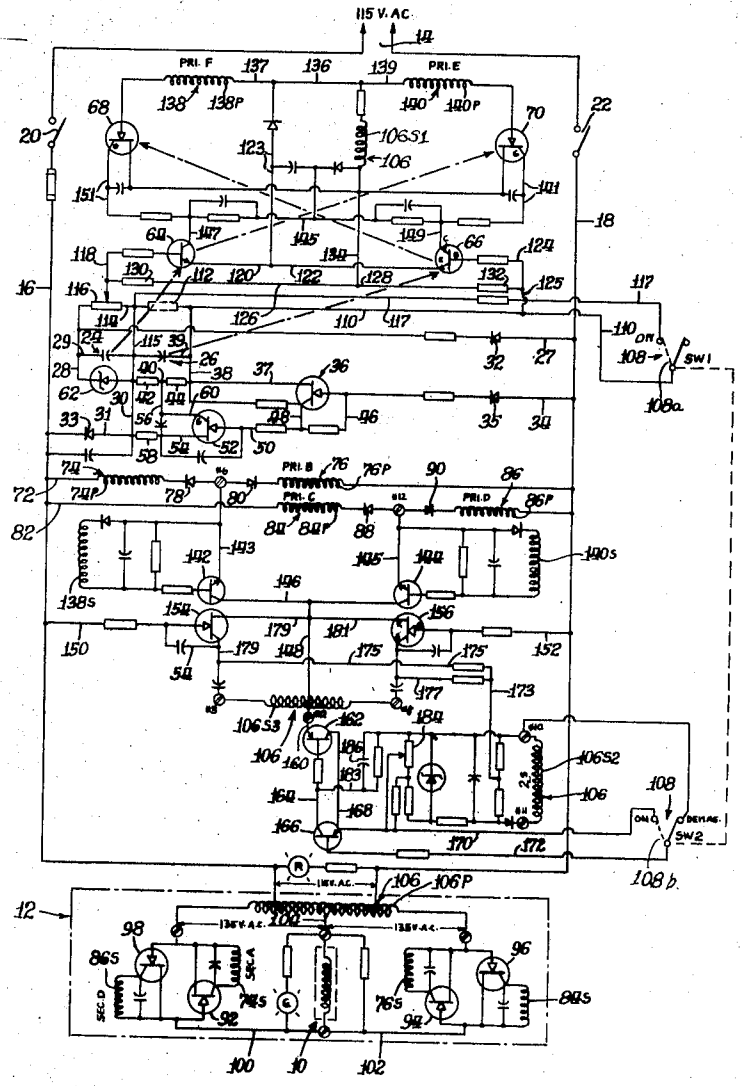
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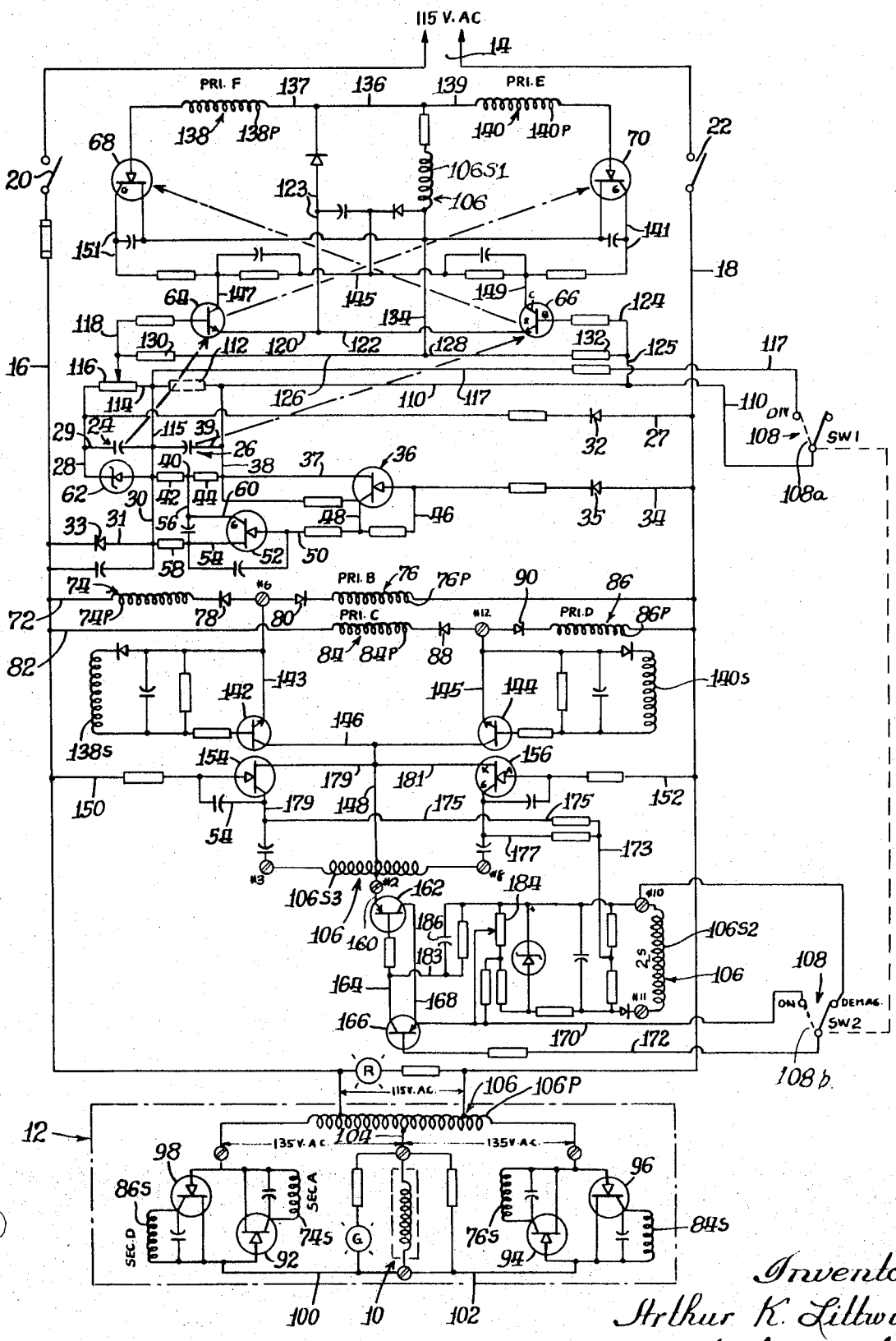
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ABSTRACT: A completely solid state demagnetizer including: a circuit including the object to be demagnetized and including a portion for applying DC to the object, and including portions operable for so applying the DC in successively opposite polarities; a first condenser of fixed capacity chargeable substantially instantaneously, and charged constantly by the power source; a second condenser progressively chargeable, of variable capacity, and having limits above and below that of the first condenser; the first condenser, when the second condenser is charged to a value less than itself, energizing the circuit portion operable for applying DC of a first polarity to the object; and the second condenser, when charged to a value greater than that of the first condenser; energizing the circuit portion operable for applying DC of the opposite polarity to the objects; an additional condenser means providing a decaying action for progressively and continuously reducing the value of the voltage applied to the object.





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DEMAGNETIZER, SOLID STATE

OBJECTS OF THE INVENTION

The present invention relates to demagnetizing of an object of the general character in which DC is applied to the object in successive steps of opposite polarity and in which the voltage in the successive steps is gradually reduced, whereby at the final step the voltage is at or near 0, and the object is accordingly substantially demagnetized.

Demagnetizing as just referred to is generally known, as represented for example in my prior U.S. Pat. No. 2,825,854, dated Mar. 4, 1958.

A broad object of the present invention is to provide a demagnetizing circuit and method of demagnetizing of the foregoing general nature, which is of completely solid state nature.

Another broad object is to provide a solid state demagnetizing circuit of the character referred to having a novel arrangement of condensers in mutually opposed relation one of which is of fixed capacity and the other of variable capacity, each of the condensers, when of a greater charged condition than the other, controlling the polarity of the DC applied to the object, and the two together operable for applying the DC in mutually opposed steps throughout a series for accomplishing the demagnetizing operation.

Another object is to provide a solid state circuit for demagnetizing of the character just immediately referred to which includes means for maintaining the voltage on the condenser means at a point close to that necessary for activating each condenser over the other, so that upon buildup of voltage for the particular condenser, only a minimum of such buildup is required for triggering that condenser and so that it overcomes the opposed condenser.

A still further object is to provide a circuit for demagnetizing of the foregoing character including novel means for reducing the DC applied to the object, so that when the DC is reversed under control of the reversing means referred to, i.e., the condensers reduce the magnetism of the object in the successive steps.

A still further object is to provide apparatus of the kind just immediately referred to and including means for shutting off the demagnetizing circuit when the voltage of the DC as applied to the object is substantially at 0, wherein that shutting off means is independent of the reversing means, whereby to effectively shut off the apparatus when the magnetism of the object to be demagnetized is substantially accomplished.

DESCRIPTION OF A PREFERRED EMBODIMENT

In the drawings:

The single figure is a diagram of a completely solid state arrangement for demagnetizing an object.

Referring in detail to the circuit, a magnetic chuck **10** is shown (bottom center), of a kind commonly used in a machine tool, such for example as in a grinder and utilized in the reciprocating table for holding the workpiece to be ground. Such a chuck is represented in FIG. **5** of my prior patent referred to above (see No. 16, and the workpiece No. 17 in that patent). The magnetic chuck itself does not form a part of the invention, and is well-known, as is the overall and general arrangement and method for demagnetizing the chuck and the workpiece thereon. In the circuit the portion at the bottom enclosed in dot-dash lines and indicated at **12** represents the reversing means utilized in the demagnetizing operation, and the other portion of the circuit the control means for controlling that reversing means.

The circuit represented in the drawing includes a suitable AC source **14** from which conductors **16, 18** lead, and in which are included switch means **20, 22** which may be ganged. Condensers **24, 26** include principal control elements for reversing the polarity of the DC applied to the chuck. The condenser **24** is connected between the main lines **18, 16** through conductors **27, 28, 29, 30** and **31**, the conductors **27** and **31** having rectifiers **32, 33** therein. The condenser **26** is

connected between the lines **18, 16** through conductor **34** having a rectifier **35** therein, and leading to the cathode of an SCR (silicon controlled rectifier) **36**. Leading from the plate are conductors **37, 38, 39**, the latter containing the condenser **26** and leading through conductors **30, 31** to the line **16**. Connected across the conductors **37, 30** is a conductor **40** containing series adjustable resistors **42, 44** which are connected across the condenser **26**.

Another conductor **46** leads from the conductor **34** to another conductor **48** connected with the gate of the SCR **36** holding the SCR in conducting condition. The conductor **46** also connects with another conductor **50** leading to the plate of an SCR **52**, and leading from the plate of the latter is another conductor **54** connected with an additional conductor **56** connected between the resistors **42, 44**. Another adjustable resistor **58** is interconnected between the conductors **54, 30**. The gate of the SCR **52** is connected with another conductor **60** which is connected with the conductor **56**. A zener diode **62** is connected across the condenser **24**.

Associated with the condensers **24, 26** are transistors **64, 66** respectively (upper), and associated with those transistors are SCR's **68, 70** respectively (top), and controlled in a manner referred to below. The rectifiers, transistors and SCR's may be referred to each and generically as valve means or gate means.

Connected between the main lines 16, 18 is a conductor **72** having series primaries **74P, 76P** of transformers **74, 76**, and the line has back-to-back rectifiers **78, 80** therebetween. Also connected between the main lines is another conductor **82** having series primaries **84P, 86P** of transformers **84, 86**, and including back-to-back rectifiers **88, 90** therebetween. The secondaries of these transformers re found at the bottom of the circuit, having the same reference numerals with the subscript S.

The secondaries just referred to are incorporated in the portion **12** at the bottom of the circuit, and are individually connected with the gates of SCR's as follows: **74S** with SCR **92**, **76S** with SCR **94**, **84S** with SCR **96**, and **86S** with SCR **98**. These SCR's are respectively arranged in back-to-back relation, i.e. the SCR's **92, 94** providing unidirectional current in one direction to the chuck **10**, and the SCR's **96, 98** providing unidirectional current in the other direction. The chuck is connected with a conductor **104** center-tap connected with a primary **106P** of a transformer **106**, the primary being connected across the main lines **16, 18**, and connected respectively the SCR systems, viz, **92, 98** at one end and **94, 96** at the other end, completing circuit through the chuck. This transformer **106** includes secondaries **106S1** (top), **106S2** (lower right), and **106S3** (lower center).

Upon energization of the primary **106P** (bottom) the chuck **10** is energized, and according to which of the secondaries directly connected with that primary are energized, the chuck is magnetized at one or the other direction: when the secondaries **74S, 76S** are energized, the chuck is magnetized in a first direction, or first polarity, and when the secondaries **84S, 86S** are energized, the chuck becomes energized or magnetized in the opposite or second direction, or second polarity. The back-to-back arrangement as to the secondaries **74S, 76S**, and the other secondaries **84S, 86S**, together with the arrangement of the primary **106P** in itself is known and the means for controlling the energization of those coils by the remaining portion of the circuit is of the essence of the invention.

Included in the circuit is switch means **108** (right, upper and lower), including two individual switches **108*a*** and **108*b***, preferably ganged together and movable between ON and DEMAG (demagnetizing) positions.

Leading from the first switch **108*a*** is a conductor **100** connected with the conductor **38** and leading to a variable resistor **112** and connected with another conductor **114** which includes an adjustable resistor **116**, and also connected with a conductor **115**. A return conductor **117** leads from the conductor **114** to the ON terminal of the switch **108*a***. Leading from the adjusting element of the resistor **116** is a conductor **118** connected with the base of the transistor **64** and leading

from the emitter of that transistor is another conductor **120** connected with a conductor **122** which leads to the emitter of the transistor **66**. Leading from the base of the transistor **66** are conductors **124**, **125** connected with the conductor **110**. Interconnecting the conductors **118**, **124** are additional conductors **126**, **128**, respectively, including resistors **130**, **132**, and connected with these conductors between the resistors is another conductor **134** which includes the secondary **106S1** and is connected with another conductor **136** leading in one direction to a conductor **137** which includes a primary **138P** and in the other direction to a conductor **139** including a primary **140P**. The conductor **137** leads to the anode of the SCR **68** while the other conductor **139** leads to the anode of the SCR **70**.

The transformer **138** includes a secondary **138S** (center, left) while the transformer **140** includes a secondary **140S** (center, right). The secondary **138S** leads to the base of a transistor **142** while the other secondary **140S** leads to the base of a transistor **144**. Leading from the emitter of the transistor **142** is a conductor **143** connected with the conductor **72** between the rectifiers **78**, **80**, and similarly a conductor **145** leads from the emitter of the transistor **144** and is connected with the conductor **82** between the rectifiers **88**, **90**. Leading from the collectors of the transistors **142**, **144**, is a conductor **146** connected with which is another conductor **148** center-tapped to the secondary **106S3**.

Connected across the main lines **16**, **18** are additional conductors **150**, **152** leading respectively to the anodes of SCR's **154**, **156**, and the cathodes thereof are interconnected by conductors **179**, **181** which also connect with the conductor **148**. The gates of the SCR's **154**, **156** are connected at opposite ends to the secondary **106S3**.

Leading center-tapped from the secondary **106S3** is a conductor **160** connected with the emitter of a transistor **162** and connected with the base of that transistor is another conductor **164** leading to the collector of another transistor **66**. The emitter of the transistor **166** is connected through a conductor **168** to the collector of the transistor **166** and to another conductor **170** leading to the ON terminal of the switch **108*b***. A conductor **172** leads from the base of the transistor **166** to the common terminal of the switch **108*b***. Leading from the DEMAG terminal of the switch **108*b*** is a conductor **174** connected with the secondary **106S2**.

In the use of a magnetic chuck it is utilized for holding a workpiece on which a work operation is performed, such as grinding, and for that purpose it must be fully magnetized. Although the principal purpose of the present invention is to demagnetize that chuck, and the workpiece thereon, it is necessary that the circuit also directly control all phases of control of the chuck, in order to perform the demagnetizing operation. Specifically, it may be desired to turn off the chuck to remove a piece for testing purposes and often that piece is again placed on the chuck and a further grinding operation is performed thereon. Thus the circuit is utilized for turning on and off the chuck as well as for demagnetizing it. The present circuit is interposed in the control circuit normally provided for energizing the chuck and operates to turn on and off that circuit. To put the circuit of the present invention into operation, in an initiating step, the switch means **20**, **22**, is of course closed which energizes all of the elements then directly connected with the main lines **16**, **18**, including the primary **106P**. Then depending on whether the grinding operation is to be performed, or a demagnetizing operation, the switch means **108** is thrown to corresponding position, and normally it is first thrown to ON position for energizing the chuck.

For convenience in describing the operation, reference is made first to the DEMAG, or demagnetizing position and to establish that position, after the main switch means **20**, **22** is closed, the switch means **108** is thrown to its full line position. A circuit is established from the main line **18** through the conductor **27**, rectifier **32**, conductors **28**, **29**, **30**, **31** to the line **16**. This charges the condenser **24** instantaneously. At the same time, a circuit is established through conductor **34**, SCR **36**, this SCR being turned on through the conductor **46**; the circuit continues through conductors **37**, **38**, **39**, the condenser **26**, and conductors **30**, **31**. The condenser **26** charges slowly from its lower value of e.g., 10 volts to its upper value of, e.g., 40 volts, while the capacity of the condenser **24** may be of 25 volts.

The condensers **24**, **26** are opposed, the negative sides thereof being connected with the conductor **30** and with an additional conductor **115** which connects with the conductor **114**. Upon the condenser **24** reaching its capacity charge, it controls the transistors **64**, **66** as follows: from the positive side, through conductors **29**, **28**, adjustable resistor **116**, conductor **118** applying a positive charge on the transistor **64** and turning it on; it continues through conductors **120**, **123**, **145**, **149**, the collector of the transistor **66** and from the base thereof, through conductors **124**, **125**, **110**, **39** to the condenser **26** and the negative of condenser **24**. The transistor **64** is thus turned on and the transistor **66** is turned off. A similar circuit is established through the condenser **26** and the transistor **66** when the condenser **26** becomes charged and takes over, as referred to below. When the transistor **64** is turned on, it turns on the SCR **70**, and similarly, when the transistor **66** is turned on, it turns on the SCR **68**.

Upon turning on the the SCR's **70**, **68**, the respective primaries **140P**, **138P** are energized, and in a first case, the energized primary **140P** energizes the secondary **140S** (center, right) and the latter completes a circuit through the transistor **144** and turns on the latter. The secondary **106S3** (center lower) is energized, which turns on the SCR's **154**, **156** in respective half cycles, and upon turning on of the transistor **144**, the primaries **84P**, **86P** are energized in respective half cycles, and they in turn energize the secondaries **84S**, **86S** (bottom) and establish a continuous circuit in those half cycles of a first polarity through the chuck **10** and the primary **106P** for energizing the chuck. This energization occurs and persists throughout the range of effectiveness of the condenser **24**, until the condenser **26** takes over.

Although the charge on the condenser **24** controls the transistor **64** as referred to, it remains constantly and fully charged by the main lines, and while the condenser **24** so controls the transistor **64**, the charge on the condenser **26** builds up and when it reaches its maximum charge, e.g., 40 volts, it predominates and reverses the circuit arrangement, turning on the transistor **66** and the SCR **68**, and turning off the transistor **64** and the SCR **70**, in a circuit similar to the circuit including the condenser **24** as referred to above. Energization of the primary **138P** pursuant to turning on of the transistor **66** and SCR **68**, energizes the secondary **138S** (center, left) which turns on the transistor **142** and completes a circuit for energizing the primaries **74P**, **76P** in respective half cycles. The latter primaries in turn energize the secondaries **74S**, **76S** (bottom) and complete a circuit through the chuck **10** and primary **106P** in corresponding half cycles, and in conjunction with the secondaries **84S**, **86S**, as described above, maintain a DC circuit through the chuck. The voltage thus established is of the second polarity or opposite that of the first step.

Upon decay of the voltage of the condenser **26**, as determined by the resistors **42**, **44**, **50** its minimum value which in the assumed example is 10 volts, it shuts off and the condenser **24** having remained charged, again predominates and establishes a controlling circuit through the transistor **64** and SCR **70**. This continues until the voltage in the condenser **26** again builds up to its maximum capacity.

The effectiveness of the condenser **24**, **26** on the reversals of polarity on the chuck are controlled by the transistors **162**, **166** which in turn are controlled by the switch **108** *b*. The secondary **106S2** normally remains energized, placing a charge on the condenser **186**, and when the switch **108*b*** is thrown to DEMAG position, it removes the voltage supply from the condenser **186** and the latter discharges, the negative bias controls the transistor **162** and therethrough, the transistor **166**, and when this charge is expended, the transistor **166** shuts off. During the one and off periods of the

condenser **186** and control thereby, the one or the other of the secondaries **140S**, **138S** is energized, and through the primaries **84P**, **86P**, or **74P**, **76P**, control the polarity the DC imposed on the chuck as described producing gradually decreasing periods of opposite polarity and the desired demagnetizing action.

As referred to above, the circuit is operative for turning on the circuit means for energizing the chuck, independently of the demagnetizing feature, and to produce that condition, the switch means **108** is thrown to its ON position as represented in dotted lines. In such position and through the switch **108***a* the condenser **26** is discharged, but the condenser **24** remains charged. The subcircuit including the secondary **106S2** and the transistors **162**, **166**, includes an adjustable resistor **184** for predetermining the charge on the condenser **186**, and the resulting decaying action is independent of the charge on either of the condensers **24**, **26**; when the action of the condenser **186** is terminated, the voltage of the chuck **10** is at 0, or substantially zero, and any further reversing action by the condensers **24**, **26** thereon, is of no effect.

Another feature of the invention is a means for accurately controlling the points of effectiveness of the transistors **64**, **66**. The resistors **130**, **132** are connected respectively with the bases of the transistors and constantly provide a voltage thereon which is slightly less than the voltage required for turning them on. Then upon the imposition of the voltage as provided by the condensers **24**, **26** on the respective transistors, the latter need be only a very small increment whereby only a very small additional voltage is required under the control of the condensers **24**, **26** to trigger the transistors. Accordingly the transistors are rendered more accurately responsive than would otherwise be provided for.

I claim:

1. Solid state demagnetizing means comprising a circuit adapted to be connected with an electrical source and with an object to be demagnetized, the circuit including means for applying DC to the object and for applying it in successive steps of opposite polarity,

a first condenser of fixed maximum capacity constantly chargeable and substantially instantaneously charged by the source,

a second condenser relatively slowly and progressively chargeable by the source, and adjustable through a range of maximum capacity extending above and below that of the first condenser,

and means responsive to and controlled by the first condenser operative, when the second condenser is charged to a value less than that of the first condenser, for effecting application of DC of a first polarity to the object,

means responsive to and controlled by the second condenser operative, when it is charged to a value greater than that of the first condenser, for effecting application of DC of the opposite polarity to the object,

and means for reducing the value of the voltage applied to the object during the reversals of polarity as controlled by the first and second condensers.

2. Demagnetizing means according to claim **1** and including a first and a second transistors related to the condensers, the condensers respectively controlling the transistors by rendering the corresponding transistor conducting and the other nonconducting, and each condenser being operative for so controlling the respective transistor upon its predominance over the other, and the transistors operative for controlling the application of DC of respective opposite polarities to the object.

3. Demagnetizing means according to claim **2** and including first and second SCR's related to and controlled by the first and second transistors, and transformer means controlled by the SCR's and themselves controlling the application of DC to the object.

4. A demagnetizing means according to claim **1** adapted for connection with an AC source and wherein each condenser is operative throughout a range including a plurality of AC cycles and the condensers retain their charges throughout a plurality of AC cycles, and the charges decay independently of the AC cycles.

5. Solid state demagnetizing means comprising a circuit adapted to be connected with an AC source and with an object to be demagnetized,

a first charging transformer and rectifier means for effecting a DC of a first polarity and imposing it on the object,

a second charging transformer and rectifier means for effecting DC of a second polarity and imposing on the object,

a first condenser of fixed maximum capacity constantly chargeable and substantially instantaneously charged by source, rectifier means interposed between the source and the first condenser,

a second condenser relatively slowly and progressively chargeable by the source, and adjustable through a range of maximum capacity extending above and below that of the first condenser, rectifiers means interposed between the source and the second condenser,

means responsive to and controlled by the first condenser operative, when the second condenser is charged to a value less than that of the first condenser, for energizing the first charging transformer and thereby magnetizing the object in the corresponding first polarity,

means responsive to and controlled by the second condenser operative, when it is charged to a value greater than that of the first condenser, for energizing the second charging transformer and thereby magnetizing the object in the corresponding opposite polarity,

valve means operatively interposed between the condensers and the charging transformers,

the first condenser during a predetermined value of charge thereon greater than that of the second condenser, being operable for holding the corresponding valve means in the respective conductive condition and the corresponding charging transformer in energized condition for imposing DC of a first polarity of the object,

the second condenser during a predetermined value of charge thereon greater than that of the first condenser, being operable for holding the corresponding valve means in the respective conductive condition and the corresponding charging transformer in energized condition for imposing DC of the opposite polarity on the object,

and means for reducing the value of the voltage imposed on the object throughout a predetermined range independently of the periods of energization of the condenser means and corresponding energization of the charging transformers.

6. Demagnetizing means according to claim **5** wherein the means for reducing the voltage includes additional condenser means chargeable from the AC source, and means for controlling the discharging effect of the additional condenser means and corresponding range of the control of the first mentioned condenser means throughout a predetermined range.

7. Demagnetizing means according to claim **6** wherein the means for controlling the discharge of the additional condenser means establishes a range of effectiveness thereof greater than the range of discharge of either of the first and second condensers and independently thereof.

8. Demagnetizing means according to claim **6** wherein the first and second condensers are constantly chargeable by the source, and the circuit includes means normally holding the charging transformers in deenergized condition, and manually controlled means for actuating the means for controlling the discharge of the additional condenser means and thereby energizing the charging transformers.

9. Demagnetizing means according to claim **8** wherein the period of discharge of the additional condenser means is greater than that of either the first or second condensers.

10. Demagnetizing means according to claim **9** and including transformer means for energizing the additional condenser means, this last transformer means being utilized also for controlling the charging transformers.

11. Solid state demagnetizing means including a circuit adapted for connection to an AC source and to an object to be demagnetized, comprising

a first condenser of fixed maximum capacity connected with the source, constantly chargeable and substantially instantaneously charged by the source, with rectifier means interposed between the source and the first condenser,

a second condenser relatively slowly and progressively chargeable, connected with the source and adjustable through a range of maximum capacity extending above and below that of the first condenser, with rectifier means interposed between the source and the second condenser,

a transistor associated with each condenser and controlled thereby,

an SCR related to each transistor and controlled thereby,

each condenser being operative to energizing its related transistor while deenergizing the opposite transistor and the transistors being correspondingly operative for energizing the corresponding SCR's when they themselves are energized,

transformer means for controlling the object including a main transformer energized directly by the source, and back-to-back transformers related to each of opposite polarities of DC and including associated back-to-back SCR's directly related to the back-to-back transformers,

a first pair of transformers having primaries in series connected with the source and having back-to-back rectifiers therebetween and including secondaries forming parts of the back-to-back transformers associated with the object,

a second pair of transformers having primaries in series connected with the source and having back-to-back rectifiers therebetween and including secondaries forming posts of the back-to-back transformers associated with the object, in the opposite polarity of the DC

conductors respectively center-tapping the first pair of transformer primaries and the second set of transformer primaries,

SCR's connected with the center tappings,

additional transformers having primaries controlled by the first mentioned SCR's and secondaries controlled by the last mentioned SCR's,

and means for controlling the application of DC to the object to be demagnetized including transformer means controlled by the last mentioned SCR's and including the second and third SCR's in a subcircuit, the transformers above mentioned being constantly energized under the control of the first and second condensers, throughout a range indeterminate in length,

control means for terminating the application of DC to the object to be demagnetized including an additional condenser operative when charged for energizing the last mentioned transformer and thereby energizing the transformer controlling the object to be demagnetized,

said additional condenser being constantly charged, and the circuit including means normally disconnecting the additional condenser from the last mentioned transformer,

and manually control means for connecting the additional condenser with the last mentioned transformer whereby that transformer is energized throughout the period of decay of the additional condenser and during that period the last mentioned transformer energizes the transformer directly controlling the object to be demagnetized and after the decay of the additional condenser it becomes deenergized and the circuit is opened to the object to be demagnetized,

the period of decay of the additional condenser being greater than at least the period of energization of each of the first and second condensers.

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