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MAGNETIZING AND DEMAGNETIZING APPARATUS

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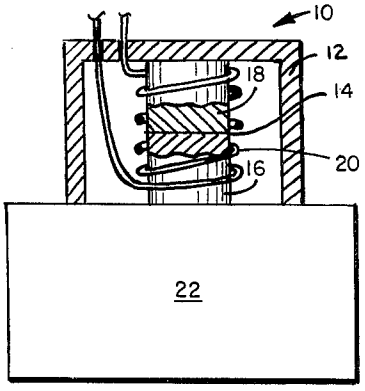


FIG. 1

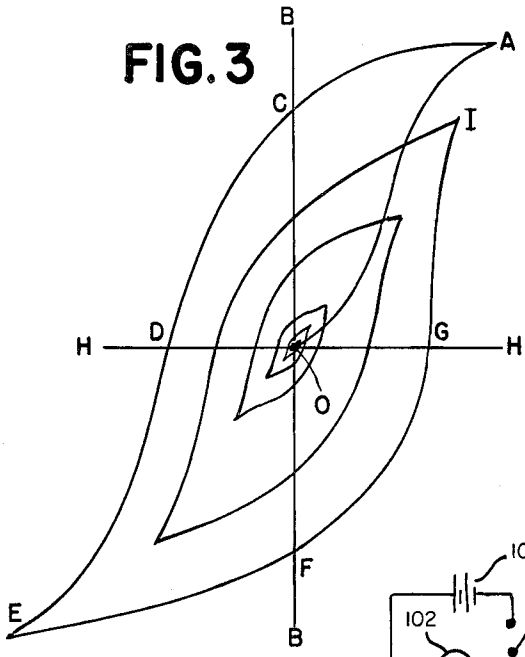


FIG. 3

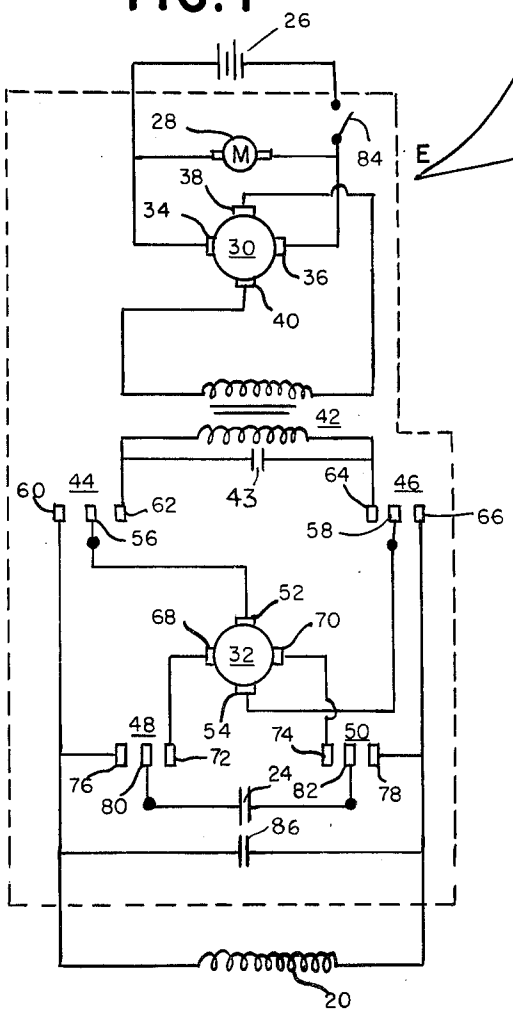


FIG. 2

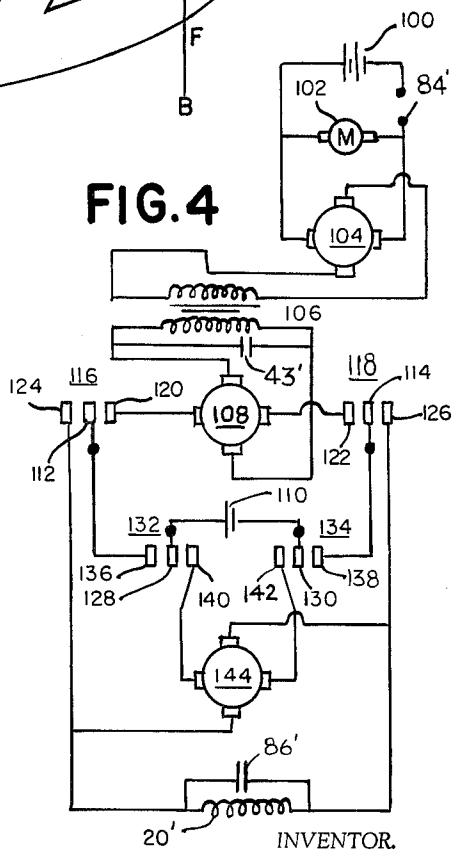


FIG. 4

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MAGNETIZING AND DEMAGNETIZING APPARATUS

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This invention relates to the magnetization and demagnetization of permanent magnet materials.

The teachings of this invention will perhaps find their widest application in the field of industrial lift magnets and, for convenience, will be discussed in that environment; however, since this invention has uses and applications beyond that of industrial lift magnets it is not intended that it be limited to that particular area.

Industrial lift magnets practically universally incorporate electro-magnetic structures wherein holding power is maintained by a constant flow of electrical current. Such structures have, for all practical purposes, been the only effective structures available and, hence, their use has continued even in view of several recognized shortcomings which are that such structures inherently present a potentially hazardous condition in that a power failure causes premature release of the load which may result in serious damage and/or injury unless auxiliary holding devices are utilized; they require a constant flow of current to maintain holding power and, in many applications, in large quantities which in a further cost increasing factor; and they are subject to the particularly vexatious problem of residual magnetism in the core and load requiring costly, time consuming manual removal of the adhering load or the incorporation of auxiliary means for removing the residual magnetism, another cost increasing factor.

Lift magnets incorporating a permanent magnet structure although they would require no constant flow of energy to maintain holding power and would not present the potential danger of dropping the load permaturely have heretofore been considered as unsuited due to the difficulty of releasing the load.

An object of this invention is to provide apparatus whereby permanent magnet material can be utilized in applications heretofore filled by electro-magnets.

Another object of this invention is to provide apparatus for selectively magnetizing and complete demagnetizing permanent magnet material.

Still another object of this invention is to provide for selective magnetization and complete demagnetization of permanent magnet material utilizing a minimum of electrical power.

A further object of this invention is to provide a lifting magnet which, in comparison to prior art electro-magnets, is safer, more economical in operation and is substantially free of residual magnetism upon demagnetization while retaining the desirable lifting properties of prior art electro-magnets.

For the accomplishment of these, and additional objects, I contemplate the provision of apparatus which when used in association with permanent magnet material is operative to alternately magnetize and demagnetize that material. The material is permanently magnetized and will hold a load indefinitely without further application of electrical current, the load being released only upon demagnetization of the material. More particularly, an electric charge is stored by suitable means and then discharged through a coil to magnetize the material which is inductively related with the coil. All power then can be removed from the apparatus until it is desired to demagnetize the material. The storing means, with a predetermined charge thereon, is isolated from any external source of electric power and is discharged through the coil in such a manner that its direction is alternated at a predetermined interval sufficient to vary the magnetic induction in the material from a maximum value through zero to a maximum value in an opposite direction. The storing means being the sole source of power, the alternating discharge will be successively decaying in value so that the successive alternating pulses will magnetize the material to lesser and lesser degrees until the magnetic induction in the material is virtually zero.

In another aspect of this invention, the material to be permanently magnetized incorporates both soft magnetic material and a portion of high energy magnetic material such an Alnico V which has a relatively high energy product to increase the holding properties of the magnet.

The novel features of my invention are set forth in the appended claims. The invention itself, together with additional objects and advantages thereof will be more clearly understood from a reading of the following description in connection with the accompanying drawings wherein two preferred embodiments thereof are disclosed and in which:

FIG. 1 is a semi-diagrammatical representation of a lifting magnet associated with a load;

FIG. 2 is an electric circuit diagram for a preferred embodiment of this invention;

FIG. 3 is a typical magnetization curve and series of hysterisis loops; and

FIG. 4 is an electric circuit diagram for an additional embodiment of this invention.

Although the lifting magnet about to be described in connection with this invention can technically be termed an electro-magnet, it should be understood that the use of the term electro-magnet herein is intended to be limited to electro-magnets as they are now commonly known in the art, i.e. comprising a magnetic core material having an electric coil associated therewith, the core becoming magnetized upon the passage of a current through the coil and retaining its magnetization only as long as current flows through the coil.

With particular reference to the drawings, in FIG. 1, a lifting magnet **10** comprises a core **12** including a central portion **14** having a lower portion **16** and an upper portion **18**. Core **12** can be made of any suitable permanent manget material, preferably portion **18** is a high energy magnetic material, such as Alnico V, and the remainder of the core is a soft magnetic material. Incorporating a portion of high energy magnetic material such as Alnico V in the core permits a sufficiently high degree of magnetization while maintaining a core of workable size.

An electric coil **20** is wound circumferentially on central portion **14** and is inductively associated with core **12** so that upon passage of electric current through the coil the core is magnetized or, as will also be described more completely hereinafter, is demagnetized. When magnetized, lifting magnet **10** will raise and carry load **22** as desired.

Turning now to FIG. 2, the apparatus for selectively

magnetizing and demagnetizing the core will be more completely described. A capacitor 24 is suitably connected in circuit with a source of electrical energy, for example batteries 26, so that a predetermined charge can be placed upon and stored in capacitor 24. More particularly, electrical energy from batteries 26 is supplied to a motor 28 which drives commutators 30 and 32. Through a suitable brush arrangement electric current from battery 26 is delivered to commutator 30 at two terminals 34 and 36 and is picked off at terminals 38 and 40 so that, in a manner well known in the art, direct current from batteries 26 is converted to an alternating current. The alternating current output of commutator 30 is passed through a transformer 42 where it is suitably transformed. Current from transformer 42 is conducted through suitable switching means 44 and 46 to commutator 32 and from commutator 32 through switching means 48 and 50 to capacitor 24. It will be understood that capacitor 24 can be one capacitor of suitable size or a bank of capacitors depending upon the capacitance value desired. Furthermore, for simplicity of illustration and description switching means 44, 46, 48 and 50 are shown as single pole double throw switches but could take any other suitable form such as a suitable relay arrangement or switches 44 and 46 and switches 48 and 50 could be combined in double pole double throw switches.

Terminals 52 and 54 of commutator 32 are electrically connected to movable contacts 56 and 58 of switches 44 and 46 respectively, contact 56 being movable between fixed contacts 60 and 62 and contact 58 being movable between fixed contacts 64 and 66. Terminals 68 and 70 of commutator 32 are connected to fixed contacts 72 and 74 of switches 48 and 50 respectively, switches 48 and 50 also including second stationary contacts 76 and 78 and contacts 80 and 82 movable between respective pairs of fixed contacts. Commutator 32 is operative to take alternating current from transformer 42 and convert it to direct current for charging capacitor 24.

In operation, the apparatus of FIG. 2 is initially energized by closing on-off switch 84. This establishes a circuit through motor 28 which drives commutators 30 and 32. To charge capacitor 24 movable contacts 56 and 58 are closed on contacts 62 and 64 and movable contacts 80 and 82 are closed on contacts 72 and 74. This establishes a circuit wherein current from source 26 flows through commutator 30, is converted to alternating current and then passed through transformer 42 and switches 44 and 46 to commutator 32. The alternating current is converted back to direct current at commutator 32 and then passed through switches 48 and 50 to capacitor 24 which takes on a charge sufficient to induce a desired amount of magnetism in magnet 10.

With a sufficient charge on capacitor 24 contacts 80 and 82 are moved into electrical engagement with stationary contacts 76 and 78, respectively, thereby connecting the capacitor directly to the coil 20. Discharge of capacitor 24 through coil 20 magnetizes core 12 which can then lift and hold load 22 indefinitely. Core 12 becomes permanently magnetized and, as no current is required to maintain holding power, switch 84 can be opened which represents a savings in operation cost and for all practical purposes completely eliminates the danger of premature release of the load.

To release load 22 the core is demagnetized. This is accomplished quickly and effectively by closing switch 84 and recharging capacitor 24 by moving contacts 56 and 58 into engagement with stationary contacts 62 and 64 and moving contacts 80 and 82 into engagement with stationary contacts 72 and 74. It will be appreciated that capacitor 24 could be recharged at any time as desired, e.g. immediately after magnetization of the core, however for obvious safety reasons it may be preferred to do so just prior to release. The charge imposed upon capacitor 24 is selected so as to be sufficiently large to completely demagnetize core 12 assuming the core to have been magnetized to the greatest degree possible. In a manner well known in the art, the charge required can be calculated, as for example using a magnetic curve and hysteresis loop diagram similar to that of FIG. 3 for the particular magnetic material used.

With the predetermined charge on capacitor 24 contacts 56 and 58 are moved into engagement with contacts 60 and 66, with contacts 80 and 82 remaining in engagement with contacts 72 and 74. This again isolates capacitor 24 and coil 20 from any exterior source of electrical energy and discharges capacitor 24 through commutator 32 to coil 20. As will be described more particularly hereinafter, commutator 32 is driven at a preselected speed to alternate direct current discharge of capacitor 24 through coil 20 at a predetermined interval. The capacitor and coil being isolated, the alternating impulses from the capacitor will be progressively decaying in strength so as to vary the magnetic induction in the core from a maximum value through zero to progressively lesser maximum values in an opposite direction.

With reference to FIG. 3, the magnetization curve OA illustrates initial magnetization of core 12. When the charge on capacitor 24 is completely dissipated, no magnetizing force is impressed upon the material and the amount of magnetic induction trails off from a maximum value A and the core retains a permanently impressed residual magnetic induction C. When the demagnetization cycle is initiated, the first impulse from capacitor 24 varies the magnetic induction of the core as illustrated by portion CDE of the hysteresis loop. More specifically, the impulse from capacitor 24 constitutes a magnetizing force of sufficient magnitude to vary the magnetic induction of the core from a maximum positive value (C) through zero (D) to a maximum negative value (E), with removal of the magnetizing force the magnetic induction trails off to F. The next impulse from capacitor 24 is in an opposite direction and varies the magnetization from F through zero (G) to a maximum value (I). The charge on capacitor 24 having decayed somewhat after the initial impulse, the available magnetizing force is only sufficient to produce a magnetic induction value of I which is less than the original magnetic induction value. As illustrated by the continuous series of progressively smaller hysteresis loops in FIG. 3, subsequent impulses will be progressively diminishing in strength so that the degree of magnetization of the core becomes progressively smaller gradually approaching zero at point O.

The successive impulses from the capacitor are alternated at a predetermined interval equal to what I refer to as the time constant for the particular core material used. This time constant is the time necessary to vary the magnetic induction of the core from maximum through zero to a maximum in an opposite direction, from point C through D to E. In the preferred embodiment of this invention, this interval of alternating impulses is provided by adjusting the speed of motor 28 such that commutator 32 will be driven at that speed necessary to provide proper alternation. With a lifting magnet constructed as described, core 12 with Alnico V portion 18, a commutator speed of 1½ revolutions per second has given satisfactory results. It will be appreciated that this speed will be dictated by the particular application and can be varied as desired without departing from the scope of my invention. In practice, demagnetization of the core occurs in a matter of seconds. Furthermore, in the case of a load held by a magnetized core, when the magnetic induction passes through zero in the first impulse from the capacitor (point D) the load can be released and dropped; if desired, and such practice is preferred, core 12 can be allowed to remain in contact with the load throughout the demagnetization process so as to virtually complete the removal of mag-

netic induction from both core and load and leave no effective residual magnetization in either.

This invention takes advantage of the natural tendency of the core to be magnetized and in effect successively magnetizes the core to progressively lesser degrees until the charge on the capacitor is dissipated at which point the core is effectively free of magnetic induction.

Capacitor **86** is connected across coil **20** to absorb the counter E.M.F. generated by the collapsing fields produced by alternating impulses from capacitor **24** during the demagnetization cycle so as to prevent possible arcing at the switch contacts. Also, it may be desirable to connect a buffer condenser **43** across the secondary of transformer **42** to reduce sparking at the brushes of commutator **30**.

The amount of electrical energy necessary to charge capacitor **24** is relatively small, for example source **26** can comprise either a six or twelve volt battery and the energy expended can be readily replaced in any well known manner, for example when source **26** is used in association with a charging generator the energy is replaced during a normal charging operation.

It will be appreciated that this invention is not to be limited to any particular electrical source. It is conceivable that the elements enclosed by the dotted lines in FIG. 2 could be embodied in a single packaged unit. This unit being adapted for connection to any magnetizing coil and to any suitable source of direct current, or with slight modifications in the internal structure, alternating current e.g. it could be plugged into a household outlet.

The arrangement shown in FIG. 2 will function satisfactorily for various size structures; however, for cores of materials having longer time constants it may be desirable to incorporate a third low speed commutator as shown in FIG. 4. The arrangement of FIG. 4 is essentially identical to that of FIG. 2 except for the inclusion of a thrid commutator and hence only the operation of this alternative arrangement will be described. Source **100** supplies electric energy for driving motor **102** which in turn drives commutators **104** and **108**. Commutator **104** transforms direct current from source **100** to alternating current which is passed through transformer **106** to commutator **108** where it is reconverted to direct current to charge capacitor **110**, movable contacts **112** and **114** of switches **116** and **18** are engaged with stationary contacts **120** and **122** and movable contacts **128** and **130** of switches **132** and **134** are engaged with stationary contacts **136** and **138**. Direct current from commutator **108** then charges capacitor **110**. To discharge capacitor **110** through coil **20'** and magnetize the core associated therewith (not shown), contacts **128** and **130** remain in engagement with contacts **136** and **138** and contacts **112** and **114** are moved into engagement with contacts **124** and **126**. This establishes a direct circuit through coil **20'**.

To demagnetize the core, capacitor **110** is again charged as described above and, when a predetermined charge has been imposed thereon, contacts **128** and **130** are moved into engagement with contacts **140** and **142**. This then connects the capacitor to a coil **20'** through commutator **144**. Commutator **144** is driven from a motor **102** through a suitable speed reducing gear drive (not shown) at a lower speed than that of the other two commutators, but at that speed necessary to alternate the discharge from the capacitor in intervals equal to the time constant of the magnetic core material. It will be noted that movement of contacts **128** and **130** into engagement with contacts **140** and **142** isolates the capacitor from all external sources of power and, to further insure isolation of the capacitor and the coil, switches **116–118** and **132–134** can be suitably synchronized to move contacts **112** and **114** to neutral when the capacitor is being discharged through the coil. In this manner, capacitor **110** is discharged through commutator **144** and, being isolated from any exterior source of electrical energy, the discharge will be a constantly decaying in nature so that the magnetic induction in the core is completely removed as was described above in connection with FIG. 2. In the arrangement of FIG. 4, commutator **108** functions purely as a rectifier and hence can be replaced by any suitable rectifying device. Condensers **43'** and **86'** are also included and function as discussed above in connection with FIG. 2.

It can then be seen that in accordance with this invention a particularly economical, efficient, safe and relatively compact device is provided whereby permanent magnet materials can be effectively magnetized and demagnetized at will, thereby opening the use of permanent magnet material into areas heretofore occupied only by electro-magnets, e.g. industrial lift magnets.

Although this invention has been discussed in connection with particular preferred embodiments and uses thereof, it should be understood that such description is intended for illustrative purposes only and should not be taken by way of limitation. Accordingly, it is intended in the appended claims to cover all modifications and embodiments of this invention as fall within the true spirit and scope thereof.

What I claim is:

1. In combination, a portion of permanently magnetizable material, electrically energized means for magnetizing said material, a source of electrical energy, means for storing said electrical energy, means for selectively connecting said energy storing means to said electrical source and said electrically energized means so that said energy storing means can be alternately charged by said source and discharged through said electrically energized means, and means selectively connectable between said energy storing means and said electrically energized means for alternating the discharge of said energy storing means through said electrically energized means to effect complete de-magnetization of said material.

2. The combination of claim **1** wherein said permanently magnetizable material includes a portion of high energy magnetic material.

3. The combination with a portion of permanently magnetizable material and an electric coil inductively associated with said material of, a source of electrical energy, means for storing electrical energy, means for selectively connecting said storage means to and disconnecting said storage means from said source, means for alternating the discharge of said storage means, and means operative when said electrical storage means is disconnected from said source to selectively connect said storage means for discharge of direct current through said coil or for discharge through said alternating means to said coil so that said material can be selectively magnetized or demagnetized.

4. In combination, a portion of permanently magnetizable material, an electric coil inductively associated with said material, a source of electrical energy, capacitor means for storing electrical energy, means for selectively connecting said capacitor means to and disconnecting said capacitor means from said source, means for alternating the direction of flow of the discharge of said capacitor means, and means operative when said capacitor means is disconnected from said source to selectively connect said capacitor means for discharge directly to said coil or for discharge through said alternating means to said coil so that said material can be selectively magnetized or demagnetized.

5. The combination of claim **4** wherein said permanently magnetizable material includes a portion of high energy magnetic material.

6. The combination with a portion of permanently magnetizable material and an electric coil inductively associated with said material of, a source of electrical energy, capacitor means for storing a predetermined electric charge sufficient to induce a predetermined degree of magnetization in said material or completely demagnetize said

material after it has been magnetized, means for disconnecting said capacitor means from said source, commutating means for alternating the flow of current, means for cycling said commutating means at a predetermined time interval, and means operative when said capacitor is disconnected from said source to selectively connect said capacitor means for discharge of direct current to said coil or for discharge through said commutating means to said coil so that said material can be selectively magnetized and demagnetized.

7. In combination, a portion of permanently magnetizable material, an electric coil inductively associated with said material, a source of direct current, first commutating means for converting said direct current to alternating current, an electric transformer connected to the output of said first commutating means, second commutating means for converting said alternating current to direct current, first control means operable between two positions and in a first position connecting the output of said transformer to said second commutating means and in a second position connecting said second commutating means directly to said coil and isolating said second commutating means from the output of said transformer, capacitor means for storing electrical energy, and second control means operable between two positions and in a first position connecting said capacitor means to said second commutating means and in a second position connecting said capacitor means directly to said coil so that said capacitor means can be connected to receive a charge through said second commutating means and selectively connected to discharge directly to said coil for inducing magnetization or through said second commutating means for effecting demagnetization.

8. The combination of claim 7 wherein said second commutating means is driven at a predetermined speed to alternate said discharge at a cycle equal in time to the interval required to vary the magnetic induction of said material from a maximum value of first polarity through zero to a maximum reduced value of opposite polarity.

9. The combination of claim 7 wherein said portion of permanently magnetizable material includes a portion of high energy magnetic material.

10. In combination with a portion of permanently magnetizable material, an electric coil inductively associated with said material, a source of electrical energy, capacitor means selectively connectable with said source for storing electrical energy, and means operative when said capacitor means is disconnected from said source to alternate the direction of flow of the discharge of said capacitor means at an interval equal in time to that required to vary the magnetic induction of said material from a maximum value of first polarity through zero to a reduced value of opposite polarity.

11. In combination with a portion of permanently magnetizable material, an electric coil inductively associated with said material, a source of electrical energy, capacitor means selectively connectable with said source for storing a predetermined electrical charge sufficient to completely demagnetize said material, means for disconnecting said capacitor means from said source, and means operative when said capacitor means is disconnected from said source to alternate the discharge of said capacitor means through said coil at an interval equal in time to that required to vary the magnetic induction of said material from a maximum value of first polarity through zero to a reduced maximum value of opposite polarity.

12. Apparatus for use in combination with a portion of permanently magnetizable material comprising capacitor means for storing electrical energy, commutating means for alternating the discharge of said capacitor at an interval equal in time to that required to vary the magnetic induction of said material from a maximum value of first polarity through zero to a maximum reduced value of opposite polarity, and means for selectively connecting said capacitor means for direct discharge of its electric charge bypassing said alternating means or for connecting said electrical storage means for discharge through said commutating means so that said apparatus can be connected with means for magnetizing or demagnetizing permanently magnetizable material and a charge on said energy storing means used selectively to magnetize said material by direct discharge to said magnetizing or demagnetizing means or to demagnetize magnetized material by discharge to said magnetizing or demagnetizing means through said commutating means.

13. Apparatus for use in combination with a portion of permanently magnetizable material comprising capacitor means for storing electrical energy, commutating means, means for driving said commutating means at a predetermined speed to cycle the discharge of said capacitor means at an interval equal in time to that required to vary the magnetic induction of said material from a maximum value of first polarity through zero to a maximum reduced value of opposite polarity, and means for selectively connecting said capacitor means for direct discharge of its electric charge bypassing said commutating means or for connecting said electrical storage means for discharge through said commutating means so that said apparatus can be connected with induction means for magnetizing or demagnetizing permanently magnetizable material and a charge on said energy storing means used selectively to magnetize said material by direct discharge to said induction means or to demagnetize magnetized material by discharge to said induction means through said commutating means.

14. Apparatus for use in combination with a portion of permanently magnetizable material comprising, first commutating means, a transformer connected to the output of said first commutating means, second commutating means, capacitor means, and control means operable to selectively establish a plurality of electrical circuits, one of said circuits connecting said capacitor means through said second commutating means to the output of said transformer, another of said circuits isolating said capacitor means from said transformer output while connecting said capacitor means for discharge through said second commutating means and still another circuit isolating said capacitor means from said transformer output while connecting said capacitor means for direct discharge bypassing said second commutating means, and means for driving said first and second commutating means.

15. The combination of claim 14 wherein said second commutating means is driven at a predetermined speed to cycle the discharge of said capacitor means at an interval equal in time to that required to vary the magnetic induction of said material from a maximum value of first polarity through zero to a maximum reduced value of opposite polarity.

16. Apparatus for use in combination with a portion of permanently magnetizable material comprising, first commutating means, a transformer connected to the output of said first commutating means, rectifying means connected to the output of said transformer, capacitor means, second commutating means, and control means operable to selectively establish a plurality of electrical circuits, one of said circuits connecting said capacitor means through said rectifying means to the output of said transformer, another of said circuits isolating said capacitor means from said transformer output while connecting said capacitor means for discharge through said second commutating means and still another circuit isolating said capacitor means from said transformer output while connecting said capacitor means for direct discharge bypassing said second commutating means, and means for driving said second commutating means at a slower speed than that of said first commutating means.

17. The combination of claim 16 wherein said second commutating means is driven at a predetermined speed to cycle the discharge of said capacitor means at an

interval equal in time to that required to vary the magnetic induction of said material from a maximum value of first polarity through zero to a maximum reduced value of opposite polarity.

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