

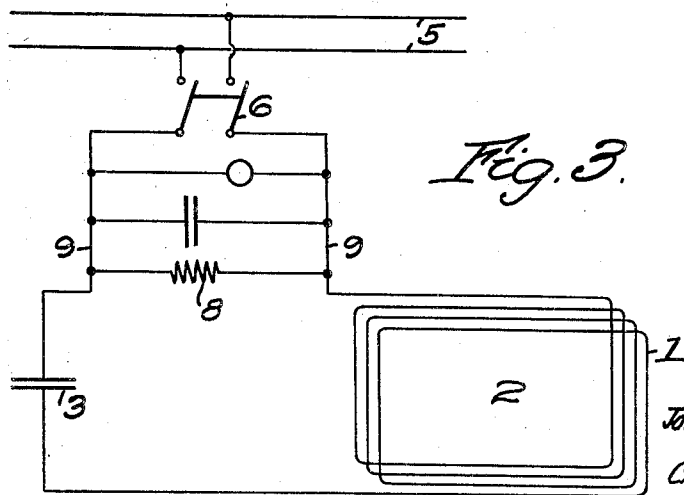
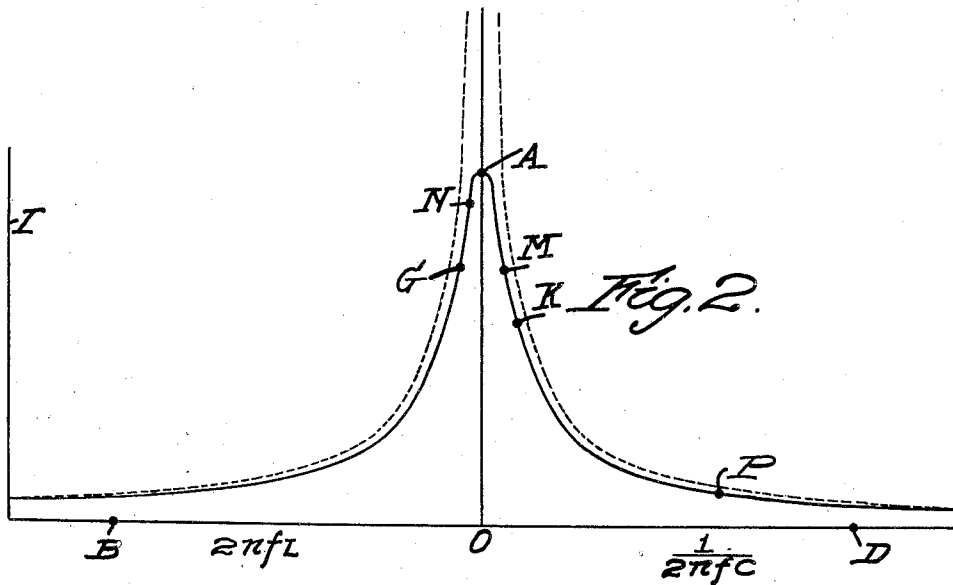
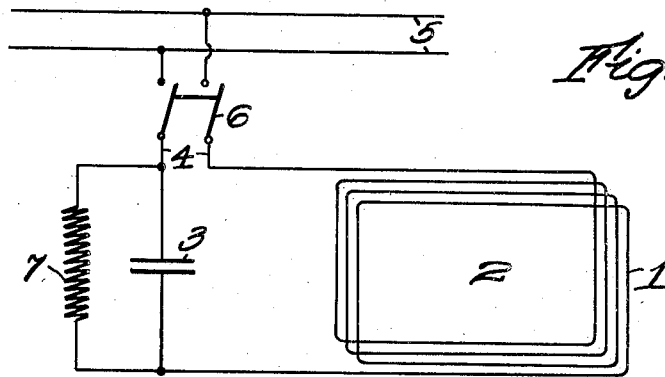
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ALTERNATING CURRENT DEMAGNETIZER

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ALTERNATING CURRENT DEMAGNETIZER

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This invention relates to apparatus for removing residual magnetism from steel materials, a process that finds its greatest application in industries where machine parts, during their manufacture, have been held by magnetic chucking. The process involves subjecting the material to the induction of an alternating flux, and then gradually reducing the induction to zero value during a period that must embrace an adequate number of reversals.

The type of field most often used for demagnetizing purposes is that provided by a simple solenoid of moderate length. Such a field has the advantage of a relatively uniform and extended flux gradient, permitting the easy withdrawal of a work piece that has been subjected to the highest induction in the coil aperture, and assuring, with an ordinary rate of motion, that a sufficient number of cycles intervene while traversing the gradient, especially when the coil is energized at ordinary commercial frequency, such as 60 cycles.

However, if an adequate field intensity is to be provided at such frequency, the counter E. M. F. due to self-inductance will place serious restrictions on the design of the winding. Since the inductance varies as the square of the number turns, the needed ampere turns can be obtained only by using relatively few turns and a correspondingly higher amperage. With increased scale of coil aperture the current requirement will quickly reach a prohibitive figure. Moreover, since the introduction of a sizeable work piece into the field involves a sharp rise in the reactance, the ampere turns will decline just when they are most needed. A certain excess of ampere turns must therefore be provided, and these, in turn, involve an undue current rise during idle intervals between operations.

It is the general object of the invention to overcome the above noted effects of inductance that, in the past, have greatly restricted both the effectiveness and the practical size of such devices, and, more particularly, it is an object to provide means whereby a powerful field may be obtained from a relatively small current drawn from the line. It is also an object to provide, in a simple manner, automatic control of the current so that, in a given device, the strength of the field will rise in general proportion to the size of the work piece being treated and by using a novel application of the principle of resonance the present invention contemplates a substantial reversal of the above described undesirable characteristics.

It is to be noted that the quality of resonance in an A. C. circuit depends on the relative values of capacity, inductance, resistance and frequency, and it may be procured by either parallel or series connections.

Other objects and advantages of the invention will appear hereinafter.

Reference is to be had to the accompanying drawing, in which—

Fig. 1 is a circuit diagram of one form of the invention;

Fig. 2 is a chart showing the current variations accomplished by the use of the invention; and

Fig. 3 is a circuit diagram of another form of the invention.

The present device belongs to a class in which an alternating field is produced by a winding directly energized from an A. C. source, such as, for instance, a power line at ordinary commercial frequency.

In Fig. 1 is illustrated a preferred simple arrangement that fulfills the desired object. This shows the coil 1, embracing an aperture 2, here shown as rectangular in outline, suited to receive the part to be demagnetized. In series connection with the coil is a capacitor 3. Conductor wires 4, provide for connection to an A. C. power line 5 by means of the switch 6. A discharge resistor 7 is connected in shunt with the capacitor.

This resistor, which is of high magnitude, does not form an essential part of the system, but serves to dissipate the capacitor charge after the device has been disconnected from the line, such charge being likely to involve a high voltage when the capacitor 3 and coil 1 are attuned for resonance.

In Fig. 2 is shown the relation of the factors conducive to resonance. The abscissa in the left half of this graph shows an inductive reactance $2\pi/L$ plotted in a left hand direction from zero value at the center. The corresponding current admittance I , at some constant voltage and frequency, is indicated by the ordinates, the dotted line showing the current value, at 90° lag, when the entire impedance in the circuit is represented by inductive reactance. However, with a given resistance also present in the circuit, the current, shown by the full line, will reach its finite, maximum value when the reactance is reduced to zero and at this point, A, it will be determined by Ohm's law, and in phase with the impressed voltage.

In the right hand side of the graph the lead-

ing current admitted by a condensive reactance

$$\frac{1}{2\pi fC}$$

plotted to the same scale, is similarly shown by the dotted line; the full line showing the current when there is also present the same resistance as in the first instance.

If in a circuit, having this same value of resistance, there is connected in series both an inductive and a condensing reactance, and the two reactances are of the same magnitude, then extreme voltage resonance will take place, forcing through the two reactances a current that will be limited only by the resistance and the current will be in phase with the impressed line voltage.

From this it follows that the coil in such a circuit may be designed with an entire disregard of the magnitude of its inductance, so long as this be balanced by a suitable measure of capacity. In other words, the required ampere turns may now be obtained through a large number of turns and a relatively small current, substantially as if the coil were designed for D. C. operation at a similar line voltage.

Referring again to Fig. 2, it will be seen that the maximum current value at A, occurs when the two reactances, such as O—B and O—D, are of equal magnitude. If now a workpiece be introduced into the coil the inductive reactance in the circuit will increase, and the current, now slightly lagging, will descend to some value at G, where the resonance is less pronounced.

This condition may, of course, be met by providing an excess of maximum field strength, now easily attained, but a better condition is obtained by attuning the circuit in the first place, not for full resonance, but for a condition where in a leading current, short of the maximum value, prevails when the device is idle. This will, of course, involve either the use of fewer turns or a smaller capacity.

Utilizing either or both of these conditions, the current will correspond to a point as K on the curve in the diagram of Fig. 2, i. e. a smaller leading current, under idle conditions. When, however, iron is introduced into the aperture of the induction coil 1, it will be evident that the inductive reactance is increased, and the current therefore tends to increase towards its maximum and into phase relation with the impressed voltage at a now attained point of resonance.

This effect is somewhat dependent on the general dimensions of the workpiece introduced into the coil aperture and the coil and the capacitor may be designed so as to approximate resonance under any average expected load. For example, the apparatus might be made so that the largest workpiece load possible to be inserted into the coil aperture will produce optimum conditions, i. e. resonance and maximum current A.

On the other hand, the apparatus may be designed so that under idle conditions, the leading current will be approximately at a point M, so that the average expected load will result in resonance, and an extreme load, to the full capacity of the apparatus, and not contemplated as usual, will cause a larger inductive reactance to take place as will send the current beyond its maximum A to a point N, where it lags very slightly and is somewhat less than the maximum.

In any event, it will be apparent that the field will automatically adjust itself to the magnitude of the load, throughout a considerable range,

with the added advantage that the wattage loss, I^2R , will be the lowest during periods when the device is idle.

In the above disclosure, it has been assumed that no other losses beyond that of resistance occur, in which case the stated result will obtain in practice. However, any additional losses in the system beyond that of the resistance will modify the conditions to some extent. Such additional losses may possibly involve secondary currents created in the material to be treated, and the effects of such losses would be to dampen resonance and prevent the current from exactly reaching maximum current at A. With the circuit shown in Fig. 1, wherein the discharge resistor 7 provides a by-pass for the condenser 3, another source of loss is present, since the current thru the resistor 7 may be said to bleed the system and thereby dampen the resonance. This effect may be detrimental unless the resistor 7 is of very high value, but in this case, the time interval for dissipating the capacitor charge will be greatly extended, as the high voltage across the condenser 3 tends to force a considerable current thru the resistor.

This condition may be met and overcome by placing a comparatively small resistor across the line behind the switch. By this means the high voltage in the circuit is quickly dissipated, the current is held in the circuit, and the resonance is not affected, since such a resistor does not increase the reactance in the demagnetizer, but merely draws a small current from the line.

A circuit arranged in accordance with the above is shown in Fig. 3, wherein the coil 1, aperture 2, capacitor 3, line 5, and switch 6 are the same as in the circuit of Fig. 1. However, the resistor 7 may be omitted, and a resistor 8, of smaller ohmic capacity is connected across the line 9 from the switch 6.

However, it sometimes happens that as the switch 6 is opened, there may be enough of a charge in the capacitor 3 to produce a spark from the terminals of the switch to corresponding line terminals, since the resistor 8 cannot disperse a large capacitor charge in a split second. In this event, the insertion of a capacitor, designed preferably for line voltage and in parallel with the switch resistor 8 (across the line) will serve to absorb instantaneously the major part of the charge from the capacitor 3, thereby greatly reducing the residual charge voltage due to the capacitor 3, and the switch 6 may then be opened without danger of sparking. In this case, the charge induced in the parallel capacitor at the moment of opening the switch is thereafter safely dissipated in its parallel resistor 8, and sparking is thereby avoided. Also, with the hook-up just above described, it is now possible to provide a lamp across the switch terminals to show the operation of current, with no danger of blowing out through high voltage from the capacitor 3. The capacitor across the line should be of similar capacity to the capacitor in series with the coil 1, but being of lower voltage design, naturally may be of much smaller dimension.

From the foregoing it will be evident that the present invention provides a means for greatly improving the characteristics of demagnetizers and greatly extends their range of effectiveness. The gain that can be made in this manner is very significant, and readily involves a ten fold increase in the effective use of the current consumed.

Also, since large and powerful fields may now

be obtained without difficulty, it becomes practical to treat steel objects, "en masse" instead of by handling singly, as formerly. Thus, where a device is designed for treatment of specific production, such as ball bearing races, files, etc., the idling current may be adjusted for a very low value, such as at a point P, involving a field too weak for the treatment of a single piece. Yet, when a sufficient batch of the product, handled in a container, is passed through the aperture, the field strength will momentarily increase to a far greater value and readily produce complete demagnetization of the entire batch.

While the invention has been illustrated in connection with an air cored, or coil type, demagnetizer, the underlying principle may equally well be applied to a demagnetizer of the cored type; that is, one in which the magnetic circuit over a considerable span of its path traverses a laminated iron core.

Resonance is, of course, not a sharply defined phenomenon. Indeed, were it dependent on an exact mathematical quantity, it would be difficult, if not impossible, of attainment. The term may be reasonably taken to cover a range wherein conditions are radically different from what would be obtained, were its quality not present. Where the term "resonance" has been used in the claims, it is assumed that its responsible agent has effected at least a several fold change in the normal current characteristics of the circuit.

Having thus described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what I claim is:

1. Apparatus for removing residual magnetism from materials, comprising an inductive winding for producing a magnetic field of alternating sign, said field being suited to be energized by an alternating current circuit of substantially constant frequency, an air space in said field adapted for magnetic traverse of the material to be treated, and a capacitor connected in said circuit, said inductive winding and said capacitor being attuned for mutual resonance under said constant frequency.

2. Apparatus for the removal from steel parts of residual magnetism, comprising an inductive winding adapted to produce a magnetic field of alternating sign when connected in an alternating current circuit having a substantially constant frequency, an air space in said field suited to receive the parts to be treated, and a condensive reactance connected in said circuit, the magnitude of said reactance being comparable with that of the inductive reactance in said winding under said constant frequency.

3. In a demagnetizing device adapted to be energized from an alternating current power line,

an inductive winding for producing a magnetic field of alternating sign, a space in said field adapted to receive material to be demagnetized, and means for producing in said winding the flow of a current in leading phase with respect to the line voltage.

4. Apparatus for the demagnetization of steel parts, comprising an alternating current circuit of substantially constant frequency, an inductive winding in said circuit, a capacity also in said circuit connected in series with said winding, the relative magnitudes of the capacity and inductance being such as to cause the current in said circuit to be in leading phase with respect to the voltage, and a space in the magnetic field of said inductive winding adapted to receive parts to be demagnetized.

5. In an A. C. demagnetizer, an inductance coil, a capacitor in circuit therewith, said capacitor having a reactance of sufficient magnitude to cause the current in the circuit to be of a predetermined quantity and of leading phase when the demagnetizer is idle, and the coil having an increased inductive reactance of a magnitude to produce resonance in the circuit when a piece to be demagnetized is applied thereto, whereby the current is increased to its maximum, said circuit being one having a substantially constant frequency.

6. In an A. C. demagnetizer, an inductance coil having a predetermined inductive reactance when idle, a capacitor in circuit therewith, said capacitor having a condensive reactance greater than the inductive reactance of said coil at a given constant frequency of the circuit, whereby a condition of resonance in the circuit is obtained upon increase of the inductive reactance of the coil due to application of a workpiece thereto with said frequency remaining constant.

7. In an A. C. demagnetizer, an induction coil and a capacitor in a circuit having an impressed constant frequency, the relative magnitudes of the reactances thereof being such as to produce resonance in the circuit upon application of a workpiece to be demagnetized to the coil.

8. In an A. C. demagnetizer, an induction coil and a capacitor in a circuit having an impressed constant frequency, said coil and capacitor having reactances of such relative magnitudes at said constant frequency as to produce resonance in the circuit upon the application of an average size workpiece load to the coil, and to approach resonance upon the application of any load to the coil.

9. In an A. C. demagnetizer, an induction coil having means in circuit therewith to prevent the current from dropping when a workpiece is applied to the coil, and the reluctance is thereby decreased.

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