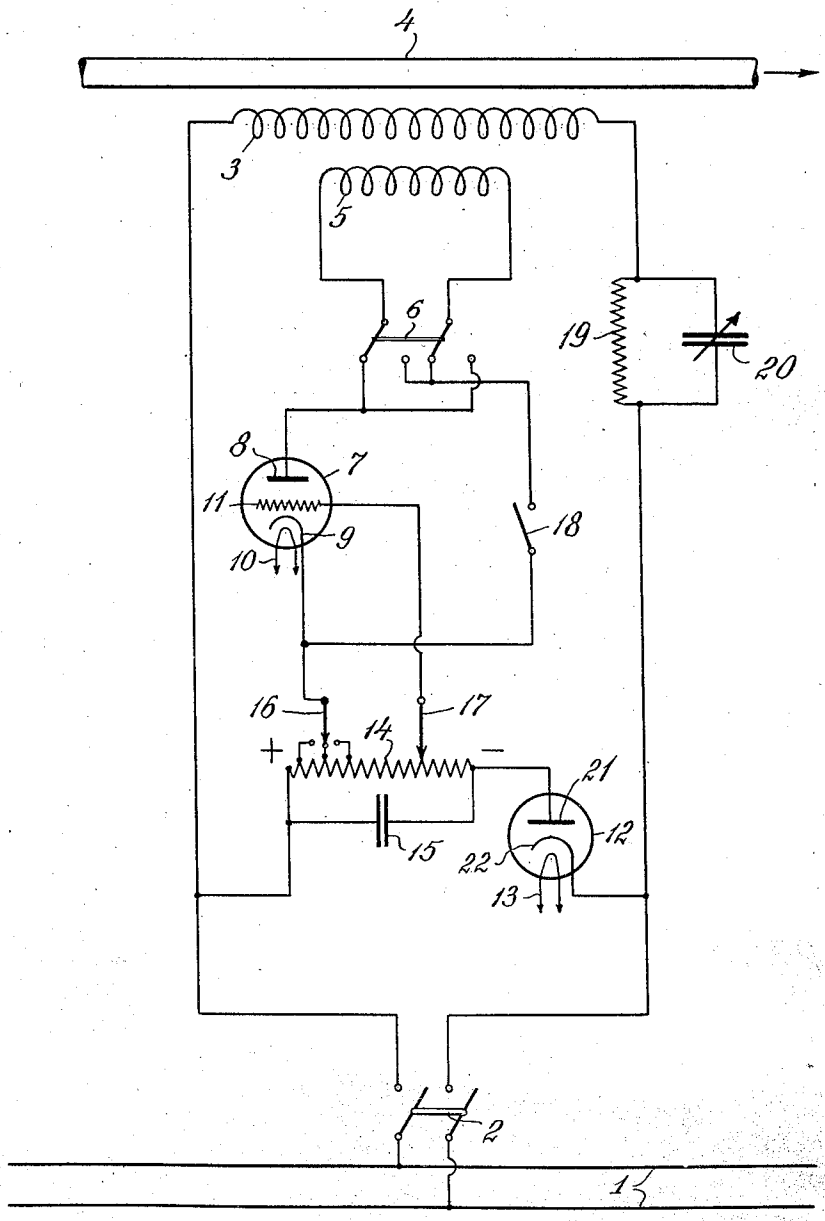
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DEMAGNETIZING APPARATUS

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DEMAGNETIZING APPARATUS

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This invention relates to the demagnetization of magnetic bodies and is directed especially to improvements in demagnetizing apparatus. The invention is an improvement, for example, on the systems and apparatus disclosed in my United States Letters Patent No. 2,207,392, granted July 9, 1940, and No. 2,355,940, granted August 15, 1944, this application being filed as a continuation-in-part of the application which matured into the last-named patent.

Products manufactured of magnetic materials such as iron and steel are susceptible to magnetization, and such magnetization in many cases interferes with their satisfactory use. While this is true of articles of any shape it is particularly true of elongated steel and iron products such as rods, bars and tubes.

The unavoidable or inadvertent magnetization of steel or similar products sometimes results as the natural consequence of normal manufacturing processes which mechanically affect or influence the arrangement of molecules in the body or product, or, again, as a consequence of the subjection of the product to one or more magnetic fields at a stage in the process when the material thereof is comparatively fluid and thus susceptible to the influence of magnetic fields. Such magnetic fields may, for example, comprise the normal magnetic field of the earth or artificial fields set up by electrical circuits or apparatus in the neighborhood, or a combination thereof.

Additionally, it has become quite common, especially in connection with the manufacture of steel products, to subject them to a testing operation to determine their physical or structural and metallurgical characteristics such, for example, as the existence of strains or flaws. In the course of such testing the steel products are sometimes passed through an electromagnetic field which is likely to leave a certain degree of residual magnetism in the products.

Whatever the source of the residual magnetism in steel or like products it is usually desirable that all traces of such residual magnetism be erased or removed before the material is shipped from the mill. Although such undesired residual magnetism may readily be removed in the manner described in my mentioned patents, those systems have certain inherent limitations which it is the purpose of the present invention to overcome.

This present invention makes possible a considerable enlargement of the range of both the alternating-current and the direct-current voltages available from a wide range of line voltages, without the use of additional booster, or step-up, transformers and without changing any of the coils in the demagnetizing system itself. Thus, the demagnetizing apparatus in accordance with this invention is useful without structural change at practically any location, and it also permits the demagnetization of bodies more heavily magnetized or of greater retentivity, as well as providing improved efficiency and more exact and rapid demagnetization of bodies having low residual magnetism. The invention thus provides apparatus at once more simple to operate, more universally useful, and more economical in use, than that heretofore known.

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The apparatus of the present invention is illustrated in the drawing, in which is shown an alternating current supply 1 of, say, 120 volts of commercial frequency, such as 60 cycles, which is connectible through a line switch 2 to the demagnetizing system shown above. This system includes an A. C. (alternating-current) energizing coil 3, the terminals of which are connected to the source of A. C. current which, for convenience, may be considered as the line switch 2. This coil should normally be of sufficient reactance to permit direct connection across the power line at the prescribed voltage. In the particular embodiment of the invention here described this coil may comprise approximately 300 turns wound on a diameter large enough to allow the body 4, which is to be demagnetized, to be placed within it or to be passed through it, depending upon the length of the body. Preferably connected in series with energizing coil 3 is a condenser 20 adjusted to a capacity value such as to resonate the energizing coil 3 at the applied line frequency—in the assumed case, 60 cycles. By thus tuning the energizing circuit, which includes coil 3, at least approximately to the frequency of the energizing current, a considerable gain in current, and hence in the strength of the energizing field, is simply and economically achieved. Shunted across condenser 20 is a "bleeder" resistor 19 of a resistance suitable to permit the safe discharge of condenser 20. The secondary, or neutralizing, coil 5 is disposed in inductive relation to coil 3 so as to be also in inductive relation to the body to be demagnetized. To this end, coil 5 should preferably be wound outside of coil 3 and positioned to be concentric with coil 3. In the particular embodiment referred to, secondary coil 5 may be of about 2,000 turns, and of much finer wire than that with which the primary coil 3 is wound. Coils 3 and 5 together

may preferably be constructed as a unitary coil assembly of the air-core type, of which coil 5 comprises not only the secondary of an alternating-current transformer (coil 3 being the primary), but in addition performs the function of a D. C. (direct-current) neutralizing coil, as will be explained below.

As shown in the drawing, a polarizing or reversing switch 6 is connected across the terminals of coil 5 so that the direct-current polarity of coil 5 may be selected as required. The two pairs of contacts of this reversing switch are connected, respectively, to the anode 8 and cathode 9 of a triode rectifier tube 7. This tube may be of type 2A3 or 6A3, for example. Serially connected in the lead between switch 6 and cathode 9 is a switch 18 the purpose of which will be described later.

A diode rectifier tube 12 is connected to the terminals of the A. C. current source 2 to furnish an adjustable control potential to the control grid of half-wave rectifier tube 7. To this end the cathode 22 of diode 12 is connected to one terminal of the A. C. voltage source 2 and the anode 21 of diode 12 is connected in series with a resistor 14 to the other terminal of source 2. The resistance value of resistor 14 may be about 2,000 ohms. A filter condenser 15, of say 25 microfarads, may be shunted across the terminals of resistor 14, as shown. In the embodiment illustrated, resistor 14 is used as a potentiometer and has two adjustments, one of which is a switch 16 selectively connectible to a plurality of taps on the resistor for coarse voltage adjustment, and an adjustable slider 17 on the resistor for fine voltage adjustment. The resistor 14 need not comprise a single element as shown in the drawing, but may conveniently comprise a rheostat type resistor provided with taps cooperating with a selector switch 16, and connected in series with a potentiometer type resistor having an adjustable slider 17. The filaments or cathode heaters 10 and 13, respectively, of the tubes should, as is well known in the art, be connected to suitable secondary windings of a filament-heating transformer, the primary of which should be connected to the current source 2.

The operation of this system is as follows: The closing of line switch 2 causes alternating current at the line frequency to flow through energizing coil 3. The value of this current is economically increased by reason of the resonance, or approach to resonance, produced by variable condenser 20 in combination with the inductance of coil 3. Thus, an A. C. energizing field of considerable strength is produced by coil 3. It is important that the strength of this field be sufficient to effect rapid demagnetization, but it is unimportant if the field is stronger than necessary. Coil 5, being electromagnetically coupled to coil 3 and preferably arranged to be symmetrically spaced in relation thereto, acts as a secondary with respect to coil 3 by reason of which an alternating potential will be developed across secondary coil 5. Due to the unilateral conducting property of rectifier 7 this alternating potential causes a unidirectional pulsating current to flow through the rectifier circuit traced from coil 5 to switch 6, anode 8 of tube 7, cathode 9 thereof, switch 18, switch 6, and back again to coil 5. This coil 5, being disposable in electromagnetic relation to the body 4, also functions as a neutralizing coil. The connection of resistor 14 in series with rectifier 12 across the power line creates uni-directional current flow through resistor 14, thereby establishing the indicated polarities at the respective terminals of the resistor. Filter condenser 15 tends to smooth out the pulsations so as to keep the potential difference of the mentioned terminals substantially constant.

Manipulation of the coarse adjustment 16 and the fine adjustment 17 of the potentiometer 14 permits the very accurate control of the negative bias potential applied to grid 11 with respect to the cathode 9 of tube 7, over a wide range. By this means, in combination with the selection of polarity achieved by reversing switch 6, there may be established a uni-directional current in coil 5 of such magnitude and direction as to create a uni-directional electromagnetic field exactly equal in intensity and opposite in sign to the resultant field created in the neighborhood of body 4 by all extraneous magnetic forces acting on that body. The A. C. field of coil 3 acting in conjunction with this D. C. field thus reduces the residual magnetism in the body to an extremely low value, or substantially to zero.

As above explained, coil 5 functions as a secondary of transformer 3, 5 supplying alternating-current potential to rectifier 7, and through this same coil 5 flows no appreciable alternating current, but only rectified current produced by rectifier 7. The alternating-current potential induced in coil 5, being impressed across the anode and cathode of rectifier 7, produces a flow of current in the circuit including coil 5 when the alternating potential renders the anode positive with respect to the cathode but not when it renders the anode negative with respect to the cathode. Thus the rectifier "passes" either one half or the other half of the cycles, depending upon the position of switch 6. The rectified current flowing in coil 5 actually comprises a succession of uni-directional current peaks occurring at the frequency of the current in power line 1. Although this rectified current is therefore not actually a continuous direct current the effect of it is to produce a polarized or uni-directional field about coil 5; and for the purpose of the present invention such a field is equivalent to one produced by a continuous direct current.

From the foregoing it will be evident that since the energy source for the rectifier circuit is coil 3 which is also the source of the alternating demagnetizing field, any change or variation in this demagnetizing field, or in the current of the circuit of coil 3, will automatically result in a corresponding change or variation in the unidirectional neutralizing field, so that the relative strength of the two fields remains the same even though variations occur in the circuit of coil 3 which causes variations in the demagnetizing field. For example, it frequently happens that, as the body under treatment moves simultaneously through the fields of coils 3 and 5, structural or metallurgical variations in the body react magnetically on coil 3 to produce changes in the magnitude of current in the coil and hence in the strength of its field, and if the rectifier circuit were coupled independently to an energy source the neutralizing field would remain constant while the demagnetizing field varied. This is a serious disadvantage in demagnetizing equipment for the present purpose, and is here obviated by deriving the energy for the rectifier circuit solely from the coil which generates the demagnetizing field (the electron energy from cathode 10 being disregarded). Similarly, when the voltage of the power line 1 fluctuates, relative strength of the alternating-current and direct-

current fields with respect to the body 4 will remain substantially constant, first, for the reason above described, and second, because the control potential applied to grid 11 of rectifier tube 7 is derived directly from rectifier 12 which in turn is energized by the same alternating current source. The relative strength of the A. C. and D. C. fields can, of course, always be adjusted by means of tap switch 16, in conjunction with finer adjustment 17.

The demagnetizing process can best be carried out in three stages. The first stage requires merely the placing of a magnetization meter near the body and observing the deflection of the meter to determine whether and to what degree the body under observation is magnetized. Meters suitable for this purpose and methods for using them are described in more detail in my mentioned patent. If the body is not magnetized, nothing further need be done to that particular body or portion thereof. However, if the magnetization meter indicates a deflection, the body is moved slowly through or past the coils 3 and 5, at say a speed of 100 feet per minute, with only the energizing coil 3 energized. This may be accomplished by setting the switch 18 in its open circuit position. The direction of deflection of the magnetization meter at this stage will furnish a guide as to the direction in which the reversing switch 6 should then be thrown. The third stage of operation comprises passing the body again through the apparatus with power supplied to both the energizing coil 3 and the neutralizing coil 5 by closing switch 18 and adjusting tap switch 16 and finer adjustment 17 until the magnetization meter reads zero. Under some circumstances, as for example when the body 4 is of fairly small size, the grid bias available through controls 16 and 17 may be sufficient to block entirely the output current from tube 7. In such event the switch 18 may remain closed during the entire operation, if desired. Should a neutralizing field of greater strength than that provided by a single triode rectifier tube of the types above mentioned be required, two or more such tubes may be connected in parallel, or a grid-controlled rectifier tube of greater output may be substituted. The power required to furnish the bias potential for the control of the output of tube 7 being negligible, diode 12 may be of any convenient type, that commonly designated as type 5Y3 having been found satisfactory. Furthermore, a copper-oxide or other type of rectifier can be substituted with equal success.

From the foregoing description of a preferred embodiment of the invention and of the operation thereof it will be evident that a precise control of the strength of the neutralizing field can be readily obtained over a large range of field strength, and that the apparatus of the invention may without any structural change whatever, be satisfactorily employed on power supply lines which differ considerably as to voltage or frequency or both. Furthermore, the apparatus is, without change, adapted to the successful demagnetization of bodies of a wide variety of types and shapes and of any dimensions, so long as the bodies, or required portions thereof, can be symmetrically disposed within the magnetic fields of coils 3 and 5. Rings, plates, billets and any other shapes and types of magnetizable bodies may thus be satisfactorily treated.

What is claimed is:

1. In apparatus for demagnetizing a magnetic body movable with respect to said apparatus, the combination which includes a demagnetizing coil connectible to a source of alternating current, said coil being disposable in inductive relation to said body, a neutralizing coil inductively related to said demagnetizing coil and disposable in inductive relation to said body, a rectifier tube having an anode, a control grid and a cathode, said coils being positioned to be in inductive relation simultaneously to the same portion of said body as said body moves with respect to said coils, a rectifier circuit for producing unidirectional neutralizing current in said neutralizing coil, said circuit including said neutralizing coil and a half-wave rectifier including the anode and cathode of said tube, said circuit being coupled to said source only by means of said inductive relation to said demagnetizing coil, whereby changes in the magnitude of alternating current in said demagnetizing coil resulting from variations in the magnetic effect of said body on said demagnetizing coil as said body passes through the field thereof automatically produce corresponding changes in said unidirectional current in said neutralizing coil, a second rectifier, a resistor connected in series with said second rectifier across said source, connections from the cathode and control grid of said half-wave rectifier tube to said resistor, whereby a bias potential derived from the second rectifier is impressed on said control grid, and means for adjusting said bias potential.

2. In apparatus for demagnetizing a magnetic body, the combination which includes a demagnetizing coil connectible to a source of alternating current, said coil being disposable in inductive relation to said body, a neutralizing coil inductively related to said demagnetizing coil and disposable in inductive relation to said body, said coils being positioned to be in inductive relation simultaneously to the same portion of said body, a rectifier tube having an anode, a control grid and a cathode, a rectifier circuit for producing unidirectional neutralizing current in said neutralizing coil, said circuit including said neutralizing coil and a half-wave rectifier including the anode and cathode of said tube, said circuit being coupled to said source only by means of said inductive relation to said demagnetizing coil, whereby changes in the magnitude of alternating current in said demagnetizing coil resulting from variations in the magnetic effect of said body on said demagnetizing coil when said body is in the field thereof automatically produce corresponding changes in said unidirectional current in said neutralizing coil, a diode rectifier, a resistor connected in series with said diode rectifier across said source, connections from the cathode and control grid of said half-wave rectifier tube to said resistor whereby a bias potential derived from said diode rectifier is impressed on said control grid, and variable contact means on said resistor included in at least one of said connections for adjusting said bias potential, whereby the strength of said demagnetizing field may be accurately adjusted over a wide range.

3. In apparatus for demagnetizing a magnetic body, the combination which includes a demagnetizing coil connectible to a source of alternating current, said coil being disposable in inductive relation to said body, a condenser connected in series with said coil, said condenser having a capacity such as at least approximately to resonate said coil with the frequency of said source,

a bleeder resistor connected in shunt to said condenser, a neutralizing coil inductively related to said demagnetizing coil and disposable in inductive relation to said body, said coils being positioned to be in inductive relation simultaneously to the same portion of said body, a rectifier tube having an anode, a control grid and a cathode, and a rectifier circuit for producing unidirectional neutralizing current in said neutralizing coil, said circuit including said neutralizing coil and a half-wave rectifier including the anode and cathode of said tube, said circuit being coupled to said source only by means of said inductive relation to said demagnetizing coil, whereby changes in the magnitude of alternating current in said demagnetizing coil resulting from variations in the magnetic effect of said body on said demagnetizing coil when said body is in the field thereof automatically produce corresponding changes in said unidirectional current in said neutralizing coil, a second rectifier, a resistor connected in series with said second rectifier across said source, connections from the cathode and control grid of said half-wave rectifier tube to said resistor, whereby a bias potential derived from the second rectifier is impressed on said control grid, and means for accurately adjusting said bias potential.

4. In apparatus for demagnetizing a magnetic body, the combination which includes a demagnetizing coil connectible to a source of alternating current, said coil being of the air-core type disposable in inductive relation to said body, a condenser connected in series with said coil, said condenser having a capacity such as at least approximately to resonate said coil with the frequency of said source, a bleeder resistor connected in shunt to said condenser, a neutralizing coil inductively related to said demagnetizing coil and being of the air-core type disposable in inductive relation to said body, said coils being positioned to be in inductive relation to the same portion of said body, a rectifier tube having an anode, a control grid and a cathode, a rectifier circuit for producing unidirectional neutralizing current in said neutralizing coil, said circuit comprising in series connection said neutralizing coil, a polarity-reversing switch, and a half-wave rectifier including the anode and cathode of said tube, said circuit being coupled to said source only by means of said inductive relation to said demagnetizing coil whereby changes in magnitude of the alternating current in said demagnetizing coil automatically produce corresponding changes in the magnitude of said unidirectional current in said neutralizing coil, a diode rectifier, a second resistor connected in series with said diode rectifier across said source, coarse resistance-adjusting means and fine resistance-adjusting means in contact with said second resistor, a filter condenser connected in parallel with said second resistor, and connections from said adjusting means to the control grid and cathode, respectively, of said half-wave rectifier tube for impressing on said control grid a closely adjustable biasing potential derived from said diode rectifier, whereby the polarity of said demagnetizing field may be selected and the strength of said demagnetizing field may be accurately adjusted over a wide range.

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