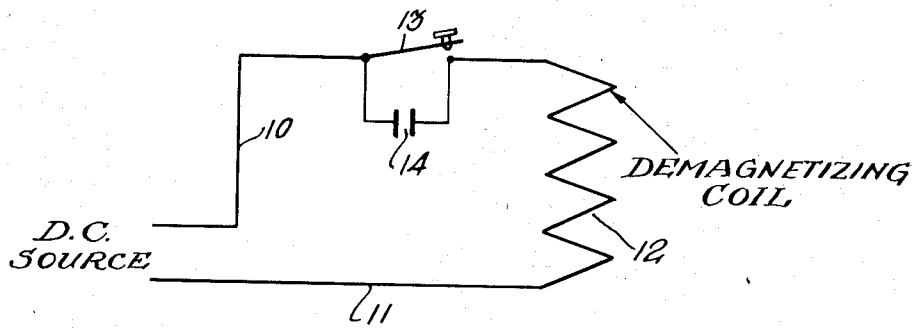
April 11, 1939. C. W. DAVIS 2,154,399

DEMAGNETIZATION

Filed March 11, 1935

Fig. 1.



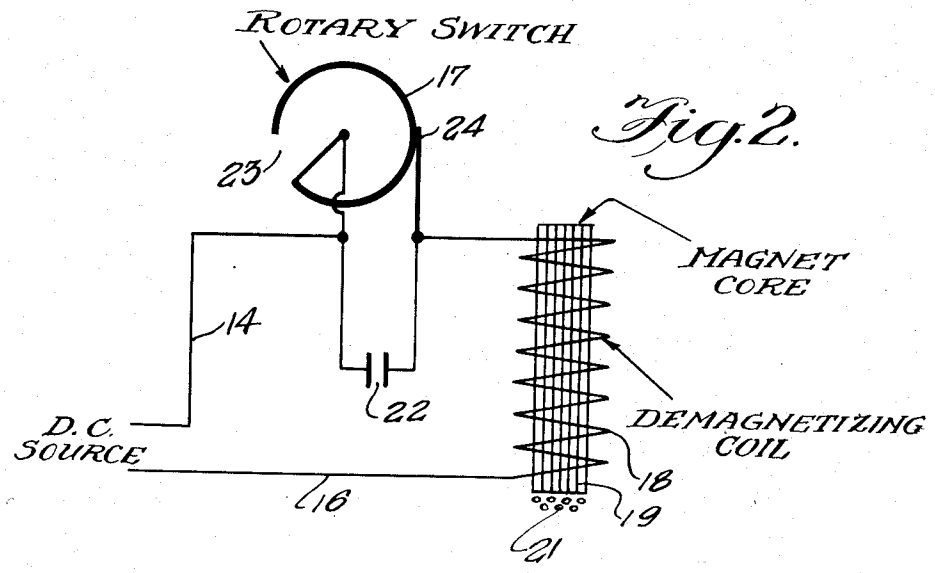


Fig. 2.

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DEMAGNETIZATION

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Application March 11, 1935, Serial No. 10,513

12 Claims. (Cl. 175—181)

This invention is concerned with a method and with means for accomplishing the demagnetization of ferro-magnetic materials and substances containing such materials in a novel and more expedient, as well as more efficient manner than was heretofore possible. The principle of my invention may be successfully applied in all such cases where demagnetization is desired or required, for example, for the removal of permanent magnetism from minerals in the process of magnetic separation of ores, or for the demagnetization of magnetic materials for testing purposes or in industrial processes requiring the demagnetization of materials preparatory to their use in electrical equipment and the like.

Demagnetization has been accomplished in the past by subjecting the magnetized material to successive fields of gradually diminishing strength and changed polarity. For example, if it is desired to demagnetize a rod-like magnetic body or the like, this may be accomplished according to orthodox methods by introducing the body into a solenoid the field of which is stronger than the field to which the body was previously subjected. The current is then decreased to zero and is subsequently reversed and increased again, applying, however, less field strength than previously. This procedure is repeated until a field force is finally applied which is practically zero. The body is then for practical purposes sufficiently demagnetized. Alternating current of low or moderate frequency may be applied in the case of demagnetizing relatively thin bodies, applying in this case fields of slowly diminishing strength. Eddy currents apparently prevent the penetration of the magnetic effect to the core of bodies of larger size (skin or umbrella effect) and slowly diminishing direct current must be used. The initial strength of the field is preferably chosen high, particularly in the case of materials with unknown magnetic characteristics and especially in the case of short and thick bodies because the demagnetizing effect will be most pronounced at the ends of such bodies. Special requirements may sometimes call for the use of a specially constructed apparatus for obtaining the proper current reversals and the uniform decrease of the field required for accomplishing the demagnetization, but ordinary, well-known equipment will in most cases suffice.

Summarizing the above, it may be said that demagnetization has been accomplished in the past by subjecting the ferro-magnetic material to a magnetic field of greater strength than the coercive force of the material to be demagnetized and then reversing and simultaneously lowering the field in successive steps or stages until it approaches zero. The reversal of the current flow and therefore of the polarity of the magnetic field may be accomplished by means of suitable switching means or by using alternating current of the usual moderate frequency, that is, about 25 to 60 cycles. The lowering of the field strength may be accomplished by removing the material gradually from the field or decreasing the current flow. It was believed and repeatedly stated in the past that slow reversals of the field are preferable and also that slow reduction of the field to zero produced the best results. This is indicated by the insistence of prior investigators with reference to the uniform application of gradually diminishing field strength in a series of gradual successive current reversals, as briefly outlined in the above notes referring to the customary procedures.

I believe that this general accepted premise is wrong or at least of only limited validity because I have found in the course of numerous experiments that I can make use of very rapid reversals of the field and comparatively rapid reduction of field strength and obtain excellent results. I believe that this wholly unexpected result is due to the fact that the speed of reversals which I employ is greater than that to which the poles of the magnetic substances can conform. In my method, the magnetic poles are not able to orient themselves in the least favorable position for demagnetization but are acted upon in a more favorable position and are thus demagnetized at a lower field strength.

The principal aim and object of my invention resides therefore in furnishing a new method and a new arrangement of apparatus for demagnetizing materials wherein the material is subjected to rapid reversals of current and rapid reduction of the field strength. This may be accomplished in numerous ways, for example, by subjecting the magnetic material to the action of high frequency oscillations, e. g., to the action of a damped oscillatory discharge in the field of a solenoid or the like.

In one embodiment of the invention the material to be demagnetized is placed in a solenoid which is operatively connected in a circuit in which damped high frequency electric oscillations are generated. The oscillations decrease in strength from an amperage necessary to produce a magnetic field strength in the solenoid

which is above the effective magnetic coercive force of the material, to zero in a small fraction of a second. It is difficult to determine the exact peak amperage of such damped oscillations and I am therefore unable to state just how much of the advantage gained by my invention is due to the fact that the effective coercive force of the substance is less in a field activated with high frequency oscillations than in a slowly reversing field and how much is due to a peak amperage generated in this manner being higher than could be generated in a circuit employing slow reversals of the same current source. However, it is not necessary to evaluate these factors for the purpose of practicing my invention.

I shall now describe the manner in which my invention may be carried out in practice.

In the drawing, Fig. 1 illustrates one form of circuit and associated apparatus with which my invention may be practiced, and Fig. 2 is a similar showing, modified with respect to the type of switch employed and the arrangement of the demagnetizing coil.

As shown in schematic form in Figure 1 of the drawing, an ordinary direct current source, for example a 110-volt dynamo, may be employed in one embodiment of my invention, with a suitable solenoid connected to the current source for receiving the material to be treated. A suitable switch, for example a rotary switch, arranged to make and break the circuit several times per second, may be used and operatively connected in the circuit, and a condenser may be shunted across the switch. In this arrangement an oscillatory discharge will be set up in the circuit and will flow through the solenoid every time the circuit is broken by the switch. The ohmic resistance of the circuit will damp the current flow to zero in a fraction of a second. The inductance and the capacity in the circuit are preferably adjusted and related to the operation of the switch in such a manner that arc formation is avoided upon breaking the circuit. The formation of a spark will not produce adverse effects. Otherwise the adjustment of the various elements with relation to each other is not particularly critical. The values of some of the elements in a practical arrangement, and the results obtained thereby are briefly noted below.

Favorable results were obtained in a circuit employing an ordinary current source including a 110-volt direct current generator and a solenoid connected thereto having 4000 turns of No. 22 D. C. C. wire wound on a core three inches long and one and three-eights inches in diameter. A 4MMF condenser was bridged across the interrupter switch used in this circuit for producing the oscillatory discharges. I have demagnetized with this arrangement cobalt steel of 250 oersteds coercive force and reduced hematite with 360 oersteds coercive force. It should be noted that the number of turns in the solenoid should be related to the coercivity of the material to be demagnetized, but the exact relation between these two factors must be determined by experiment for reasons explained previously. It is of no importance for the successful application of my invention whether the material is powdered or compact or whether it remains in the field or passes rapidly through it, provided, however, that it is subjected in its passage through the activated field to at least one complete oscillatory discharge. I have obtained excellent results by employing field reversals of the order of more than 500 reversals per second.

Another embodiment of my invention to be described below is particularly adapted for the purpose of carrying out the magnetic separation of ores or the like in a more efficient manner than was proposed in the past.

In the known art the entrainment of non-magnetic particles has been obtained by activating the separating magnet with interrupted direct current whereby the attracted mass started to fall away from the magnet but was reattracted before it left the field of the magnet. Substantially the same effect was obtained with low frequency alternating fields of various kinds arranged to produce a winnowing action to disperse the particles. However, none of these methods furnishes either a complete and satisfactory demagnetization of the magnetic particles or satisfactory and complete effect in avoiding entrainment of the non-magnetic particles.

These shortcomings are overcome by the above intimated embodiment of my invention wherein I make use of the demagnetizing effect of high frequency currents by superposing them on an interrupted direct current circuit provided for the activation of a magnetic separator. Satisfactory demagnetization is accomplished thereby and entrainment is reduced to practically zero.

The corresponding arrangement, as shown in schematic form in Figure 2 of the drawing, includes an interrupted direct current circuit in which a condenser of suitable capacity is shunted across the interrupter switch. When the current is interrupted the magnetic mass tends to fall away from the pole and is simultaneously subjected to an oscillatory field which demagnetizes it, causing the non-magnetic particles to be freed. When the current is again established, the magnetic particles are reattracted but the non-magnetic particles continue to fall away from the magnet.

I wish to mention in conclusion that damped oscillatory discharges may be produced in many known ways and most of the known methods may be used in practicing my invention. A familiar example is the mercury gap oscillator used with coreless induction furnaces. The field produced in such a furnace is suitable for praticing my invention. However, due to the superposition of several oscillations it is advisable to pass the material to be demagnetized rapidly through the activated field, for example, the solenoid of the furnace, rather than allowing it to remain in the solenoid and interrupting the current flow.

While references to the method contained hereinabove are clear and understandable in principle to those skilled in the art, reference may be had to the drawing for a further consideration of actual circuits and arrangements of parts which may be utilized.

Referring to Fig. 1, I show conductors 10 and 11 leading from a direct current source, such as from a direct current generator or commercial line carrying direct current. Where alternating current only is available, a suitable converter may also be used. The current is delivered to a demagnetizing coil 12, and the delivery thereof is controlled by a suitably operated switch 13. Any usual means, not shown, may be employed to control the periods at which this switch is operated. A condenser 14 is shunted across the switch terminals, this condenser being of the general type described hereinabove, suitably balanced, of course, with the circuit as a whole. In the form of the invention shown in Fig. 1, the material to

be magnetized may be passed through the demagnetizing coil.

In Fig. 2, conductors 14 and 16 lead to a similar source of direct current and, through rotary switch 17, deliver current to a demagnetizing coil 18. In this case, a core 19 is provided and the material to be demagnetized, indicated at 21, is adapted to pass near one of the poles of the electromagnet which comprises the coil 18 and the core 19. A condenser 22, of suitable type such as described, is shunted across the terminals of the rotary switch. In this figure, the gap 23 breaks the circuit as it passes contact 24, the remaining portion of the rotary switch functioning as a conductor to close the circuit. The rotary switch is operated at relatively high speed by suitable means not shown.

Where the method of my invention is employed in combination with magnetic separators, any of the usual direct current separators now on the market may be employed. As an example, the separator described in U. S. Patent No. 6,121 of February 20, 1849, and other patents issued from time to time utilizing the same general principles, may be cited. Since my invention is not concerned primarily with magnetic separation but rather with the demagnetization of magnetic materials, whether associated with a process involving magnetic separation or not, I deem it unnecessary to disclose any type of magnetic separator in detail, since those skilled in the art are fully conversant with the features of magnetic separators and many different types are commercially manufactured and offered to the trade.

I have described certain embodiments of my invention and also specific examples of how and where it may be successfully applied in order to teach others the use thereof. It is understood, however, that the invention is capable of changes and modifications over and above the embodiments and uses explained and such changes and modifications may be carried out within the limit and scope of the appended claims. I have defined in these claims what I consider new and desire to have protected by Letters Patent of the United States.

I claim:

1. The method of demagnetizing ferro-magnetic material which consists in subjecting said material to a magnetic field generated in a solenoid by a damped high frequency oscillatory discharge.

2. The method of demagnetizing ferro-magnetic material which consists in subjecting said material to a magnetic field generated in a solenoid by a series of damped high frequency oscillatory discharges.

3. The method of demagnetizing substances which consists in subjecting said substances to the action of a device activated by damped high frequency electric oscillations.

4. The method of demagnetizing substances which consists in subjecting said substances to a magnetic field, reversing said field successively more than 500 times per second, and gradually reducing said field to zero.

5. In a device for demagnetizing magnetic material, a source of direct current, electromagnetic means connected in circuit therewith for receiving said materials, and means for producing damped high frequency electric oscillations in said circuit.

6. In a device for demagnetizing magnetic material, a source of direct current, electromagnetic means connected in circuit therewith for treating said material, and means for producing damped high frequency electric oscillations in said circuit, said means including an interrupting device and a capacity cooperating therewith.

7. In a device for demagnetizing magnetic material, a source of current, electromagnetic means connected in circuit therewith for treating said materials, and means for producing damped high frequency electric oscillations in said circuit, said means including an interrupting device and a capacity cooperating therewith.

8. In a system for separating magnetic material from non-magnetic material, an electromagnetic device for treating said material, a source of current for activating said device, and means for producing in said device a damped high frequency oscillatory field.

9. In a method of effecting the magnetic separation of substances, the steps comprising subjecting said substances to the action of a magnetic field whereby magnetic material contained in said substances is alternately strongly attracted by a magnet and allowed to fall away therefrom and demagnetizing the magnetized material during the period of less attraction by the action of a damped high frequency oscillatory magnetic field.

10. The method of demagnetizing relatively finely divided ferro-magnetic material, which comprises subjecting said material to a magnetic field generated in a solenoid by a damped high frequency oscillatory discharge.

11. The method of demagnetizing relatively finely divided ferro-magnetic material which comprises subjecting said material to a magnetic field, reversing the field successively more than five hundred times per second, and gradually reducing the field to zero.

12. The method of demagnetizing relatively finely divided ferro-magnetic material which comprises generating a magnetic field in a solenoid, reversing said field successively more than five hundred times per second, and continuously passing said finally divided material into and out of said field.

CHARLES W. DAVIS.