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102,334 METHOD AND APPARATUS FOR DISSIPATING REMANENT FIELDS AND PRESERVING DIAMAGENETISM OF CERAMIC SUPERCONDUCTORS C. Arthur Youngdahl W-31-109-ENG-38

METHOD AND APPARATUS FOR DISSIPATING REMANENT FIELDS AND PRESERVING DIAMAGNETISM OF CERAMIC SUPERCONDUCTORS

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DISCLAIMER

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CONTRACTUAL ORIGIN OF THE INVENTION

The United States Government has rights in this invention pursuant to Contract No. W-31-109-ENG-38 between the United States Department of Energy and the University of Chicago.

BACKGROUND OF THE INVENTION

This invention is a continuation-in-part of U.S. patent application No. 728,477 filed July 11, 1991, relating to a method and apparatus for dissipating remanent magnetic fields while preserving the diamagnetism of ceramic superconductors. More particularly, this invention is directed to a method of dissipating remanent magnetic fields by using an AC current to significantly reduce or eliminate undesired effects.

Remanent magnetic fields can typically be found at or near the surface of ceramic superconductors after their exposure to conditions which produce electrical currents by Faraday induction in the superconductors. Remanent magnetic fields are measurable when a magnet is passed over a ceramic superconducting block. Such remanent fields are associated with persistent electrical currents in the material displaying the fields. Remanent magnetic fields exhibit effects that imply a resistance to alteration, or lateral motion of a magnet passed over ceramic superconductors and resistance to motion is increased with ceramic superconductors that display larger remanent field strengths. The strong diamagnetism exhibited by superconductors is distinct from the remanent fields, but the effects of the latter can act to reduce or enhance the diamagnetic effects.

In an application of ceramic superconductors for a magnetically levitated vehicle system, a vehicle contains permanent magnets and moves above a roadbed made of ceramic superconductor material. The induced remanent fields produce instability and a resistance to forward or backward motion of the vehicle requiring additional energy to be spent to overcome the effects of the remanent fields. This added expense to provide additional energy makes this mode of travel prohibitive for a large scale commercial operation. The present invention provides for a method and apparatus for dissipating remanent fields while preserving the desired diamagnetism of ceramic superconductors.

SUMMARY OF THE INVENTION

In the invention, a remanent field is dissipated while preserving the effects of diamagnetism by 1). providing a ceramic superconductor; 2). generating an AC current to the ceramic superconductor; and 3). gradually decreasing the AC current until the undesired remanent field is dissipated. The apparatus incorporates an electric generator connected to a switching device and a series of wound copper coils placed in contact with the ceramic superconductor. The generator sends a 60 Hz. electric current to the copper coils and over a desired period of time the switching device gradually reduces the current until the desired diamagnetism effect is achieved.

Therefore it is an object of the invention to provide a method to dissipate remanent magnetic fields while preserving the diamagnetism of ceramic superconductors.

It is an object of this invention to provide an apparatus to dissipate remanent magnetic fields.

It also an object of the invention to provide a method to overcome the resistance of remanent fields to the lateral motion of levitated magnetic vehicles.

Additional objects, advantages and novel features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

To achieve the foregoing and other objects and in accordance with the purpose of the present invention, as embodied and broadly described herein, the invention may comprise the steps of 1). providing a ceramic superconductor; 2). continuously or intermittently generating an AC current to the ceramic superconductor; and 3). gradually decreasing the AC current until the undesired remanent field is dissipated.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form part of the specification, illustrate an embodiment of the of the present invention and together with the description, serve to explain the principles of the invention. In the drawings:

Figure 1 shows the cross section of the initial laboratory configuration to create a remanent field;

Figure 2 shows the first experiment configuration of the equipment to create a remanent field and levitate a disk magnet;

Figure 3 shows the second experiment and the stabilized levitating disk magnet after the degaussing current was applied;

Figure 4 shows the stabilized levitating disk of figure 2 being measured by a Hall probe;

Figure 5 shows the third experiment configuration of a levitating train; and

Figure 6 shows an embodiment of the apparatus.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 1, a remanent field is produced by using a ceramic superconductor ring 1, a 5 gauss persistent current induced to flow circumferentially in the superconductor ring 1, and an insulating box 2. The remanent magnetic field is found at or near the surface of the ceramic superconductor 1 after exposure to conditions which produce electrical currents by Faraday induction in the superconductor 1. An electric coil 4 was used to remove the 5 gauss field by gradually decreasing the AC current until it is completely removed. A hall probe 3 was used to measure the strength of the remanent field. This technique was successful in the controlled reduction and dissipation of the remanent field.

Experiment I

In Figure 2 a coil of insulated copper wire 6 was wound circumferentially around a disk-shaped block of yttrium-barium-copper-oxide ceramic superconductor 7. The superconductor 7 was contained in an insulating box 9 filled with liquid nitrogen 5 along with a 3-kilogauss disk magnet 10. After the magnet 10 passes across the superconductor, the superconductor's temperature was lowered to 77K and the magnet 10 allowed to levitate at an observed oblique angle 8 above the superconductor 7. In Figure 3 a gradually increasing 60 Hz current was passed through the coil 6, producing an AC field strength of several gauss. The magnet 10 was then observed to be levitating in a stable flight and not constrained in its orientation by the remanent field. The lateral motion of the magnet 10 was also no longer appreciably inhibited by the remanent field. The levitation behavior of the magnet 10 continued to be unimpeded by the remanent field after the current was removed.

Experiment II

Referring to Figure 4 the procedure in Experiment I was repeated using a Hall probe 14 and a Bell model 615 Gaussmeter 15 to monitor the field at the center of the top surface of the superconducting disk 7. The remanent magnetic field is most measurable when a magnet is passed over the ceramic superconducting disk. The initial value of the remanent field was established and a 60 Hz current was sent through the wire coil 6 then gradually reduced to zero. The procedure was repeated and the current through the wire coil 6 was sequentially increased and removed in an intermittent fashion. The numerical results as presented in Table I showed that each value of current reduced the remanent field to a specific value that was independent of time. As was shown in the first experiment, the remanent field could be neutralized in one step by increasing the current to a maximum and then removing the current when the desired remanent field strength is reached.

Experiment III

In a final experiment, a series of 10-turn coils 18 were placed beneath the road bed 19 of a model train 20. The roadbed 19 was composed of a series of superconductor blocks 21 operated at 77K. A model train 20 equipped with small disk magnets 22 was levitated above the road bed and was moved by a series of electromagnets 23 located along the edges of the roadbed 19 and operated sequentially. The train operating without the degaussing technique produced instability in the levitation height and displayed a resistance to backward and forward motion. A 60 Hz. current was then sent through the coils 18 to reduce the remanent field to 1 Gauss. As a result, the propulsion power required to propel the train was significantly less in relation to what was required to operate the train prior to the degaussing, and the levitation height was observed to assume its most stable vertical orientation, when compared to its previous non degaussed levitation, without significant reduction in levitation height.

Figure 6 shows an embodiment of the apparatus 26 having a plurality of coiled copper wire spools 24 connected to cables leads 25. A manual control 27 is provided to allow for a manual increase or decrease in the ac current output. The apparatus 26 may also be computer controlled to regulate intermittent or continuous operation of the AC current output. A switch 28 may be used to select either manual or computer control of the apparatus 26.

The foregoing description of the preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and obviously many modifications and variations are possible in light of the above teaching.

ABSTRACT

A method for dissipating a remanent field, created when a magnetic field is brought into contact with a superconductor, while preserving the diamagnetism of a superconductor comprising the steps of 1) providing a ceramic superconductor; 2) continuously or intermittently generating an AC current to the ceramic superconductor; and 3) gradually decreasing the AC current until the undesired remanent field is dissipated.

Procedural Step No.	Coil Current Amps, 60 Hz	Remanent Field Strength, Gauss
0	0	11
1	2	—
2	0	7
3	3	—
4	0	5.5
5	4	—
6	0	4
7	5	—
8	0	3

NOTE: A YBCO superconductor block at 77K; the magnet disk at room temperature; and a 5-Amp coil current producing an AC field strength of 14 Gauss initially at the monitored location.

Table 1 INCREMENTAL DEGAUSSING OF A CERAMIC SUPERCONDUCTOR DISK

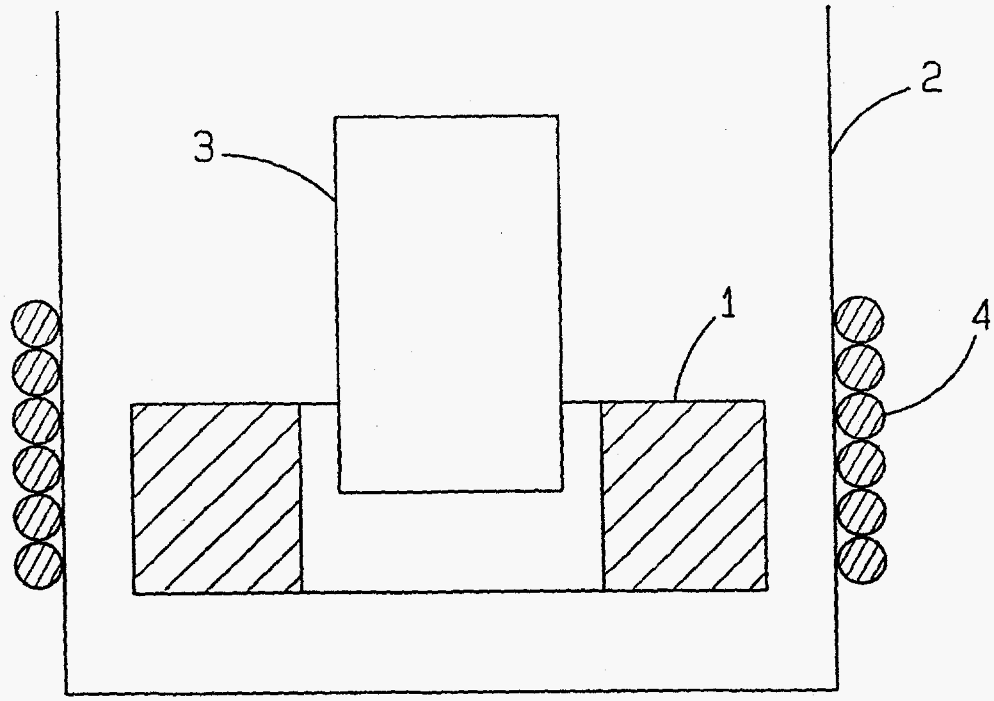

FIG. 1

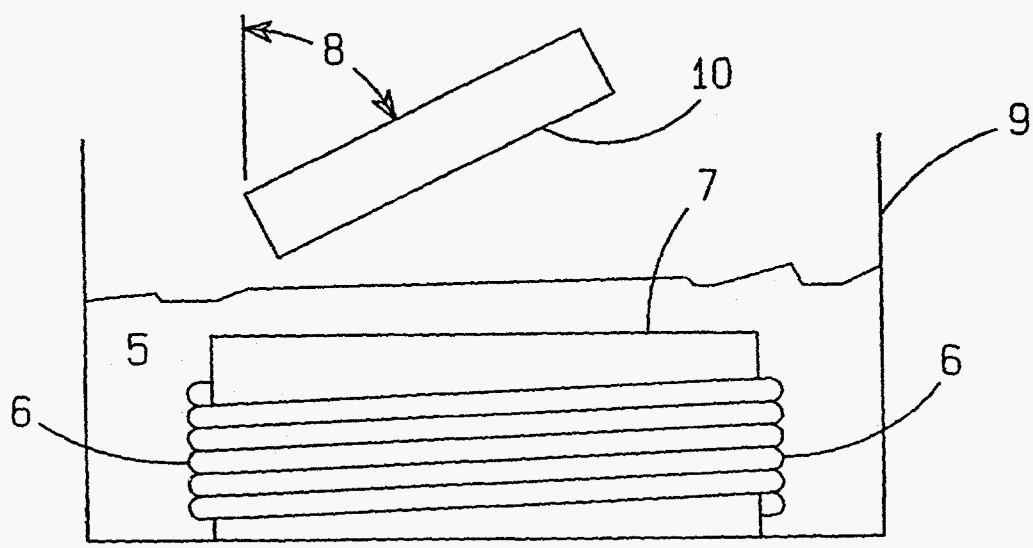

FIG. 2

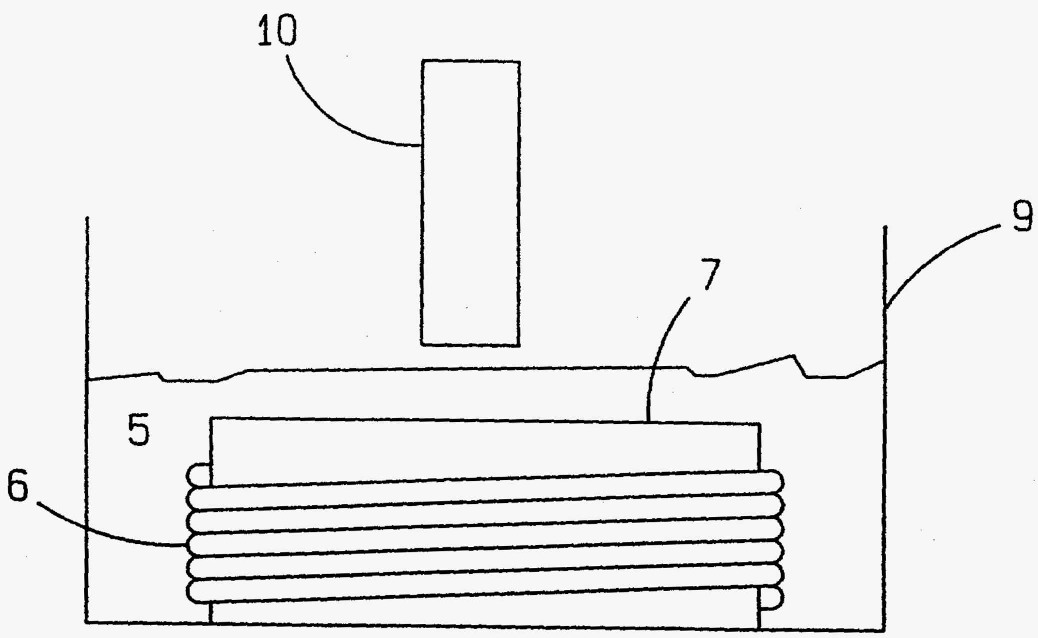

FIG. 3

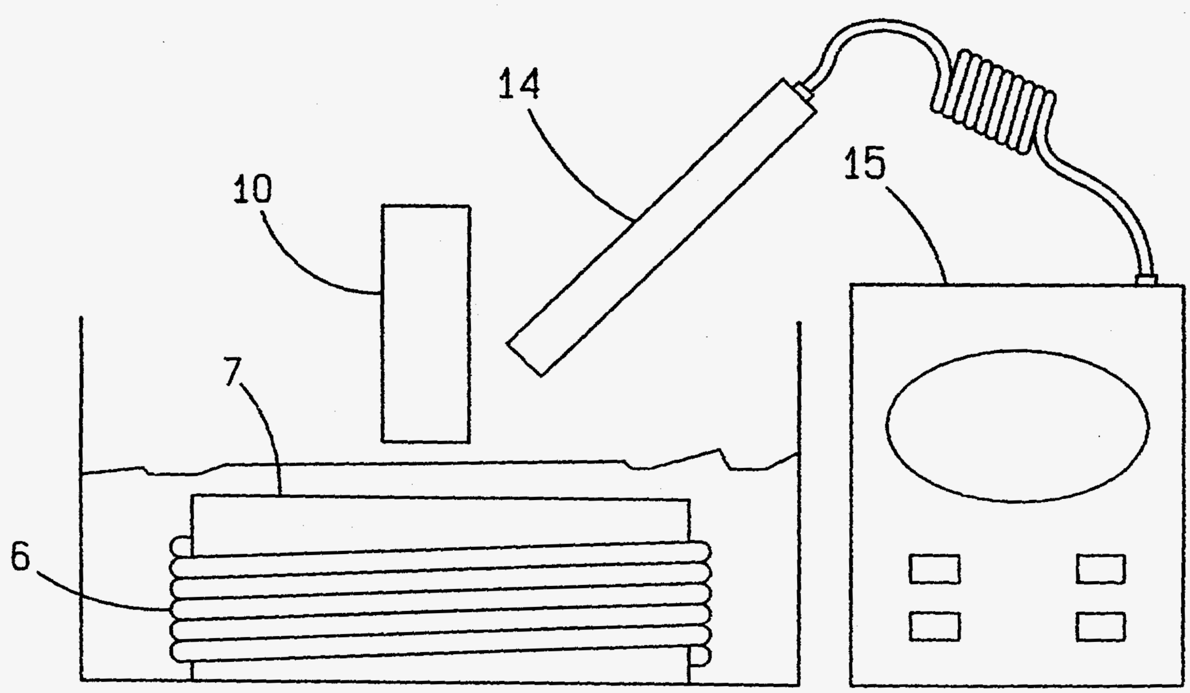

FIG. 4

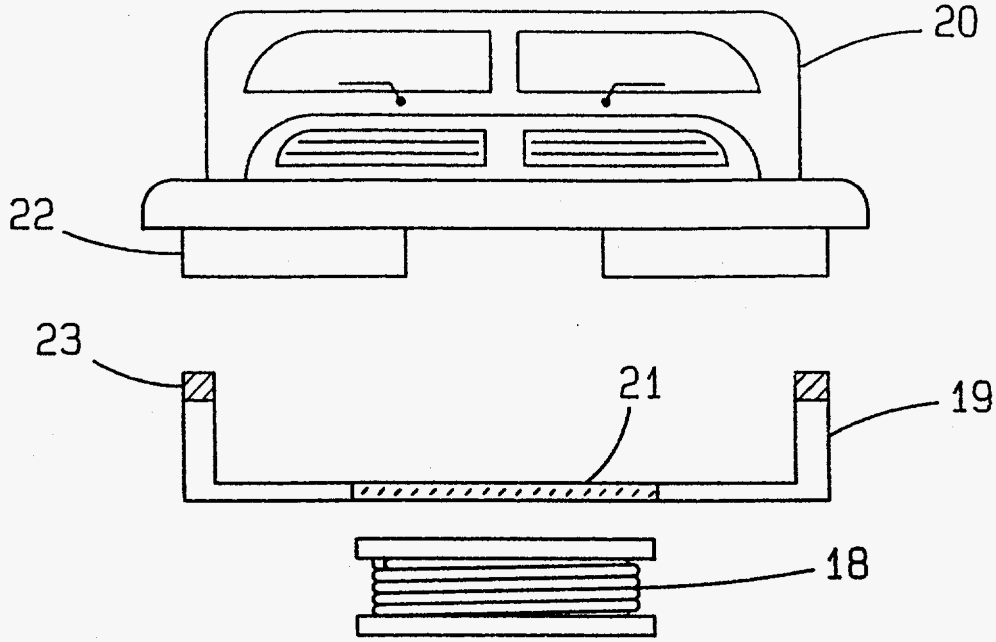

FIG. 5

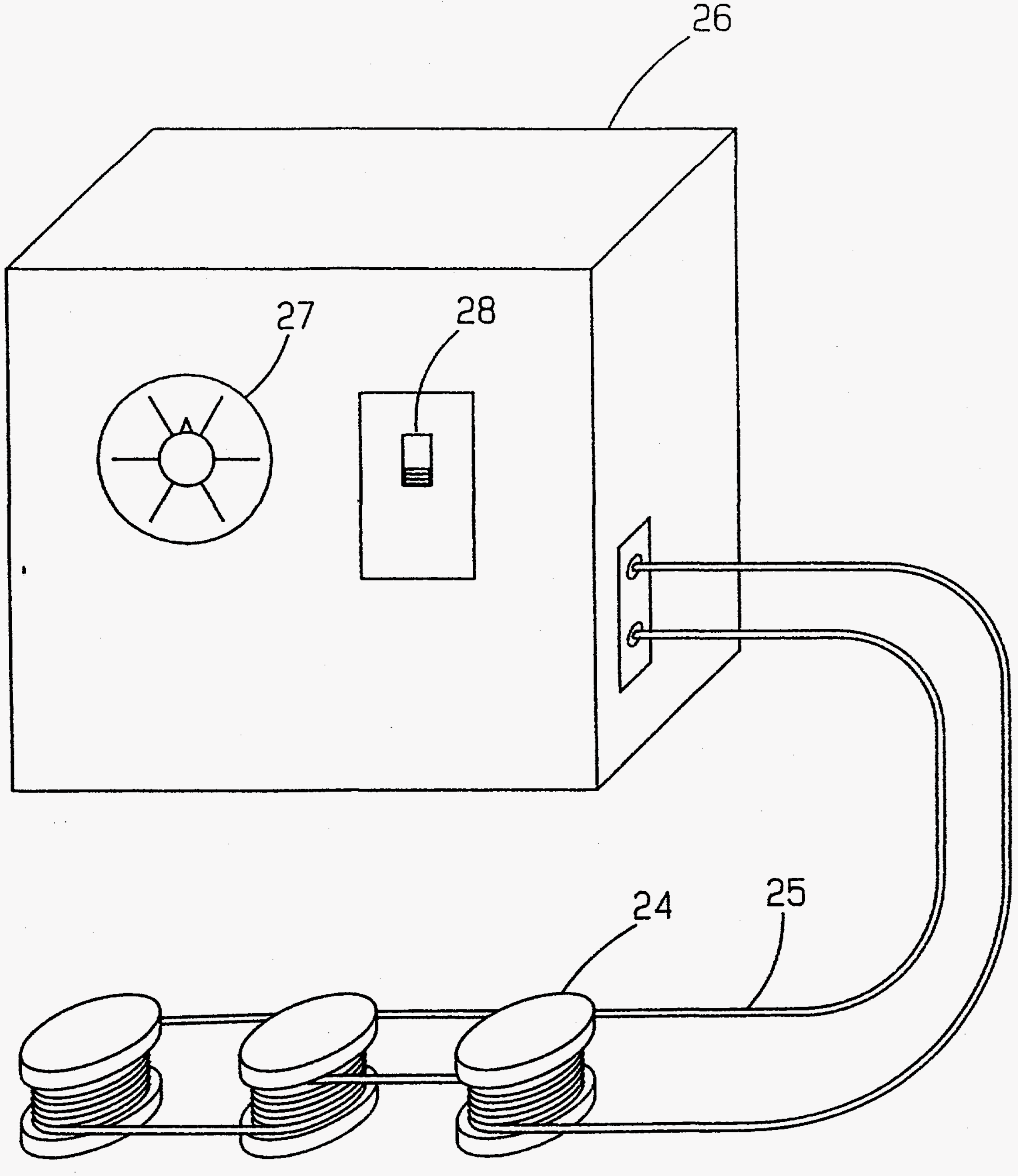

FIG. 6