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MAGNETICALLY LATCHED SWITCH OPERATOR

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FIG. 1

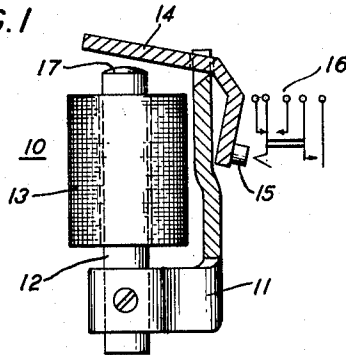
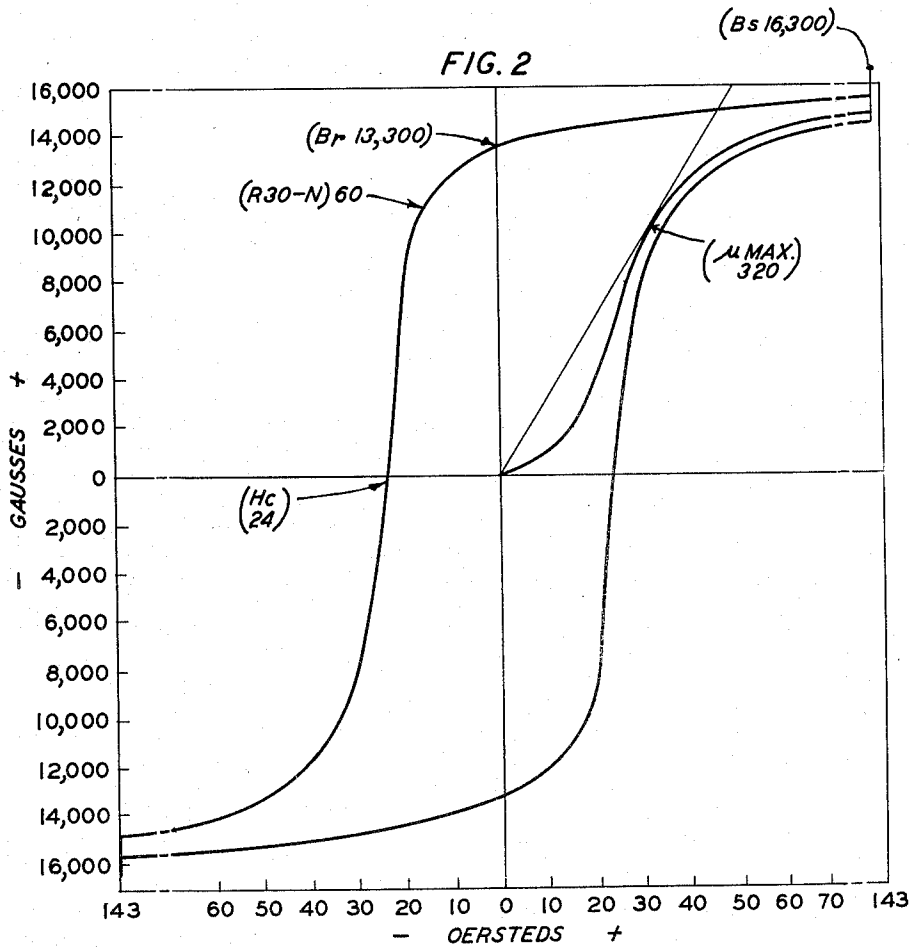


FIG. 2



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MAGNETICALLY LATCHED SWITCH OPERATOR
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2 Claims. (Cl. 317-165)

This invention relates to electromagnetically operated switches, relays, and similar devices, and more particularly to magnetically latched operating means for such devices.

It has been known for some time that the core of an electromagnetic switch operator could be made of a material having sufficient magnetic retentivity to latch or hold the switch after the coil of the electromagnet had been deenergized. One problem with such devices has arisen because of the difficulty in obtaining a core material having both high residual magnetic strength and low operating power requirements.

A material that is magnetically "hard," for example, high carbon permanent magnet material, has high retentivity but requires a relatively large force to magnetize it. On the other hand, a "soft" magnetic material, for example, annealed low carbon steel, is easy to magnetize but has very little ability to retain its magnetism.

An object of the present invention is to improve switch operating electromagnets by retaining good operating capability and, at the same time, increasing their magnetic latching ability.

A more specific object is to facilitate the operation of magnetically latchable electromagnetic switches by improving the magnetic properties of the core material.

A feature of this invention resides in an electromagnetic switch having high holding power at no current coupled with adequate force for a moderate expenditure of power during operation. More particularly, the noted feature involves an electromagnetic switch having a core with high magnetic retentivity and relatively high permeability.

An exemplary embodiment of this invention comprises a latching switch having a magnetic core, a coil for energizing the core, an armature to be attracted by the coil-energized core and held in attracted position by the residual magnetism of the core when the coil energization ceases. The core has a high magnetic retentivity and high permeability with a coercive force (H_c) of 23.5 oersteds and a residual flux density or induction (B_r) of 13,300 gauss for an applied magnetic force (H_{max}) of 143 oersteds, and a saturation induction (B_s) of 16,300 gauss, the maximum permeability (μ_{max}) being 320. Allowable deviations from the magnetic characteristics of this exemplary embodiment will be considered in the ensuing description of the invention.

Other and further objects and features of this invention will appear more fully and clearly from the following pertinent description and the appended drawings, in which:

FIG. 1 is an elevational view, partly in section, of a switch operator illustrative of a device incorporating this invention; and

FIG. 2 is a plot showing an initial magnetization curve and a hysteresis loop of a core material particularly suitable for the purposes of this invention.

As may be seen in FIG. 1, the switch operator 10 comprise a frame 11 to which is secured a core 12 and an operating coil 13. An armature 14 pivoted to the frame 11 includes a contact operating portion 15 for deflecting a multiplicity of contacts represented diagrammatically at 16. A portion of the frame 11 and of the armature 14 are shown in section to indicate that there is an extension of the armature and the cooperating portion of the frame for the operation of other contacts or groups of

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contacts; for example, the magnets for vertical row operation in a cross-bar switch as in Patent 2,021,329 to J. N. Reynolds, issued November 19, 1935.

The core 12 has a rounded end 17 facing the armature 14. This end may comprise a spherical surface having a suitable radius. With such an arrangement, the area of the armature-pole face contact will be substantially constant and yield a stronger concentration of flux and thereby a stronger latching force, notwithstanding slight tilting of the armature or longitudinal displacement of the core. For example, a 3.5 inch core of 0.375 inch diameter advantageously would have a spherical end surface of a radius between 7 and 9 inches.

As has been indicated, the ability of the switch operator of this invention to hold the armature in the absence of applied power and also to pick it up at moderate power lies in the novel magnetic characteristics of the core.

Applicant has discovered that a core having the magnetic characteristics previously noted for an exemplary embodiment may be made by a proper selection of high carbon steel and correct heat treatments of such steel. A suitable steel is 1.2% carbon tool steel which may typically contain 1.2% carbon, 0.3% manganese, 0.22% silicon, 0.10% vanadium, 0.025% sulfur and phosphorus, and the remainder iron. Such a steel heated at 1475° F. $\pm$ 25° F. for 30 minutes, quenched in water, and then reheated for 30 minutes at from 850° F. to 950° F., and cooled in air has particularly advantageous magnetic properties. It may be noted here that satisfactory magnetic properties may be obtained with properly heat treated steels having lower or higher carbon content, with or without other alloying elements which are known to promote the hardening process.

A desirable way to designate a suitable core steel is to use the hardness indications. Those of the Rockwell 30-N scale are quite suitable. Using this scale, investigations of steel and heat treatments to produce hardness in a range of about 35 to 80 were used to find a suitable material. It was found that if the hardness was within the range 54 to 64 on the noted 30-N scale, both the residual induction B_r and the coercive force H_c were particularly satisfactory. The results were outstandingly good with the material having a hardness designated as 60. Because the effectiveness of the heat treatment, particularly the quenching stage, is a function of the size of the bore piece, the hardness number was found to be a more satisfactory indication of the desired magnetic properties than the designation of a specific heat treatment. In other words, the heat treatment should, within the suitable range, be tailored to the size of the piece under treatment to result in a Rockwell 30-N hardness between 54 and 64.

A hysteresis curve of the magnetic characteristics of the noted 60 hardness material is shown in FIG. 2. The data for this plot was taken after the application of a maximum magnetizing force H_{max} of 143 oersteds, which gave a saturation induction B_s of 16,300 gauss. As may be seen, the residual induction B_r , when the magnetizing force is reduced to zero (H_0), is 13,300 gauss. Moreover, the reverse magnetization to produce zero induction is 23.5 oersteds, namely, the coercive force H_c . The maximum permeability (μ_{max}) is 320 for this material and treatment.

It may be noted that the same steel, heat treated to have a Rockwell hardness number of 35, has under like circumstances of test a B_r of about 10,000 gauss, an H_c of about 9 oersteds, and a μ_{max} of about 500. On the other hand, the same steel with a hardness number of 81 has a B_r of about 7,500 gauss, an H_c of about 44 oersteds, and a μ_{max} of 113.

By staying within the optimum hardness range of 54 to 64 on the noted Rockwell scale, it is possible to ob-

tain good cores by magnetizing at a force of over 70 oersteds. Such cores will have a coercive force H_c between 20 and 27 oersteds and a residual flux density B_r of 10,000 to 13,500 gauss.

What is claimed is:

1. A magnetically latching switch operator comprising a magnetic core of about 1% carbon steel, a coil for energizing the core, an armature associated with the core and for controlling contacts, said core having a Rockwell 30-N scale hardness of 54 to 64, and a high retentivity coupled with a high permeability, the coercive force of the core being from 20 to 27 oersteds and the residual flux density from 10,000 to 13,500 gauss based on an applied magnetizing force of at least 70 oersteds.

2. An electromagnetic operator for switch means comprising a core of magnetic material, a coil for energizing the core, and an armature associated with the core for actuation thereby, said core material comprising a relatively hard steel containing 1.2% carbon and heat treated to have a coercive force of 23.5 oersteds and a residual

induction of 13,300 gauss due to an applied magnetizing force of 143 oersteds resulting in a saturation induction of 16,300 gauss.

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