Oct. 3, 1933. F. R. JOHNSON 1,929,187

WATER AND AIR COOLED ELECTROMAGNET

Filed Sept. 24, 1930

Fig. 1

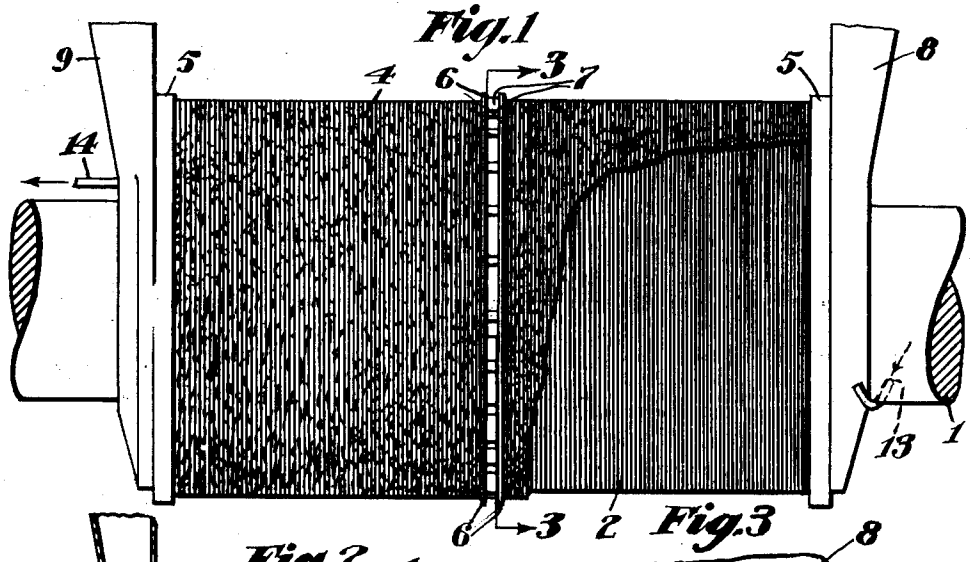


Fig. 2

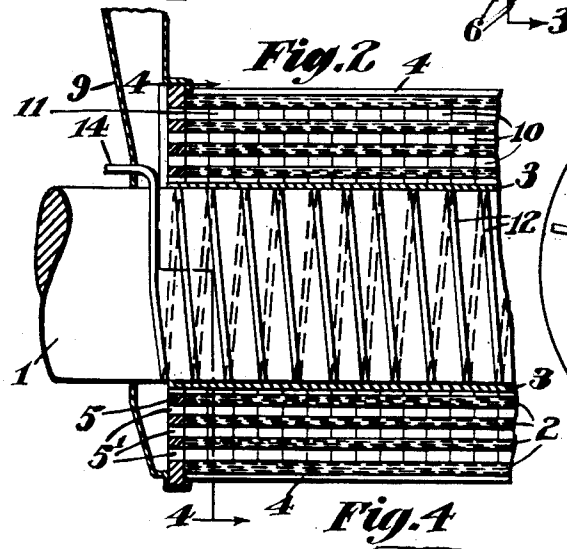


Fig. 3

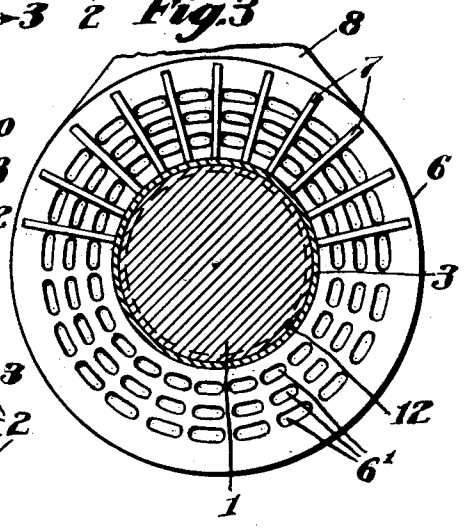
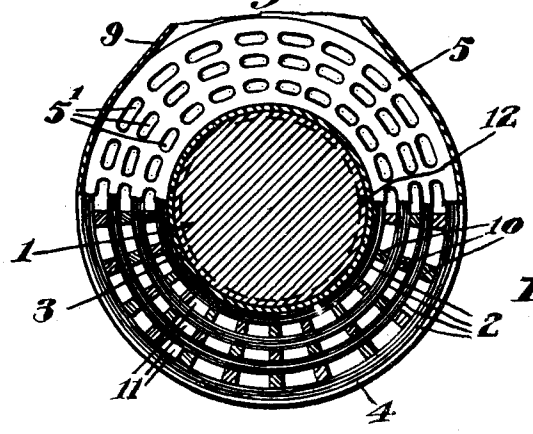


Fig. 4



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WATER AND AIR COOLED ELECTROMAGNET

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Application September 24, 1930
Serial No. 484,119

15 Claims. (Cl. 175—21)

This invention relates to electromagnets, and particularly to an electromagnet which is so constructed and arranged as to permit continuous operation thereof without danger of overheating or charring the insulation of the magnet winding and thus short circuiting the magnet.

In accordance with my general concept, the magnet is cooled by circulating both water and air between the core and the windings of the magnet, and to this end, the magnet is so constructed as to insure the most efficient circulation of the cooling water and air. In accomplishing this result, I utilize the spaces between the concentric turns or layers of the winding as circulating channels along which the cooling air may be forced from both ends of the core towards the center where it escapes.

In order to insure a more thorough distribution of the cooling air through the winding and particularly a distribution thereof radially of the winding, I provide the winding itself, and especially the layer or layers nearest the core with a special form of insulating material.

To this end, such insulation may take the form of spaced insulating blocks of porcelain, silicon carbide, or other appropriate material having the property of being a good conductor for the heat generated in this region. Moreover, the spaces between the blocks in the several layers define circulation channels for the cooling air whereby to permit the air to reach all layers of the winding.

In addition the core is directly cooled by the circulation of a cooling stream of water from end to end thereof, such stream being carried by a water tube wound helically about the core itself.

As illustrating the principles involved, I describe and show in the accompanying specification and drawing a form of electromagnet which I have found highly satisfactory under actual service conditions.

In such drawing:

Fig. 1 is an elevation, partly broken away, of an electromagnet equipped in accordance with my invention.

Fig. 2 is a partial longitudinal section, the concentric layers of winding 2 and the rope cover 4 of the magnet being shown however in elevation rather than in section for the sake of clearness of illustration.

Fig. 3 is a transverse section on approximately the line 3—3 of Fig. 1, and

Fig. 4 is a similar section approximately on the line 4—4 of Fig. 2.

I have indicated at 1 the core of an electromagnet of standard type, but equipped with the special features constituting the present invention. This core may be made of any suitable magnetizable material as iron and in practice I have found that special Swedish electrical iron of high purity, thoroughly annealed after machining, makes an especially satisfactory core.

As in any other electromagnet, the core 1 is provided with one or more layers or turns of winding. This may be simply copper wire 2 enclosed in any usual insulating sheathing.

The winding 2 is laid about the core 1 between an inside iron tube 3 and an outside cover 4 of rope or other suitable protective and insulating material. This covering 4 is confined between the end flanges 5 of brass or other non-magnetizable material of the core, and a pair of spaced central discs 6 of fibre or other suitable insulating material.

Mounted in the spaces between the discs 6 is a plurality of radially disposed spaced strips 7 of fibre or the like, which define exit openings for the cooling air which is circulated through the coil from each end thereof in the spaces between the superposed layers or turns of winding 2 and which exhausts at the centre of the magnet through the spaces between said fibre strips 7. The cooling air is forced through the magnet by any suitable blowers, the magnet being provided at each end with air inlets 8 and 9, and the end flanges 5 being provided with concentric rows of spaced perforations 5' to permit the cooling air from ducts 8 and 9 to pass therethrough and along the magnet towards its center where it exhausts through a like series of concentric rows of perforations 6' formed in the discs 6 and out to atmosphere between the radial strips 7 spacing said discs 6. The strips 7 are disposed in non-blocking relation to said perforations 6' so as not to interfere with the free exhaust of the air at the center of the magnet. In its circulation through the spaces between the layers of winding, the cooling air absorbs and carries off some of the heat generated by the magnet in operation.

The successive layers of winding are spaced from each other by concentric courses of spaced insulating blocks 10 of any suitable insulating material having the property of being a good conductor of heat, as for example, porcelain or silicon carbide, the spaces 11 between such blocks constituting air circulating openings through which air admitted at 8 and 9 into the spaces separating the superposed turns of winding may circulate radially of the magnet. The blocks 10 are relatively narrow strips. They are laid axially on

each layer of winding and are spaced circumferentially from each other about the winding itself. They extend from flanges 5 to discs 6, the spaces 11 between the concentric courses of blocks registering with the perforations 5' and 6' in the flanges 5 and discs 6 so that the cooling air admitted at the ends of the coil through said perforations 5' passes to the inside of the coil and longitudinally therealong between the layers of winding to the center of the coil where it exhausts to the atmosphere through perforations 6'.

Laid helically about the core 1 of the magnet in a continuous turn is a water circulating pipe 12 into which cold water may be admitted under pressure at one end as at 13 and discharged at its other end as at 14 after absorbing some of the heat generated by the magnet in operation.

The core 1 may, if desired, be continuously grooved to receive the copper or other tubing 12 for the cooling water thereby enabling such tubing to be wound flush with the surface of the core.

The magnet, therefore, is both water and air cooled, the water circulating between the core and the inside iron tube 3 keeping the core and first few layers of the winding 2 cool and the air assisting to keep the centre of the coil cool by reason of its circulation longitudinally through the spaces 11 separating the insulating blocks 10.

In practice, I have found that with my arrangement all parts of the coil are kept unusually cool, the rise in temperature being not more than a 25° rise as compared with the average temperature rise of 45°. This enables a constant flow of current to be maintained through the winding and hence no loss in time due to the necessity for shutting off the current in order to allow the magnet to cool, as has heretofore been necessary. It also enables the magnet to operate at greater efficiency than heretofore.

The circulation of water may be upon any well known siphon system or the water may be allowed to run freely without any attempt at re-circulation.

It will be noted that the special insulating blocks upon which the layers of winding are laid not only serve to conduct the heat from the winding to the iron tube of the spool 3 around which the wiring is laid, but also permit of the circulation of the cooling air longitudinally of the magnet, thus preventing the insulation of the wiring from becoming charred, with resultant liability of short circuiting the magnet or otherwise overheating the same.

While useful in any capacity where an electromagnet is commonly employed, my magnet is especially designed for use in a magnetic separator such as is described and illustrated in my several prior applications for patent.

Various modifications in assembly, materials and structure may all be resorted to within the spirit and scope of my invention as defined by the appended claims.

What I therefore claim and desire to secure by Letters Patent is:

1. In an electromagnet, a core, and a winding in the form of a plurality of spaced layers about said core, the spaces between said layers of winding constituting air circulation channels extending from end to end of the magnet, and means for introducing cooling air into such channels, and a water circulating tube disposed about the core of the magnet.

2. In an electromagnet, a core, and a winding in the form of a plurality of spaced layers about said core, the spaces between said layers of winding constituting air circulation channels extending from end to end of the magnet, and means at each end of the magnet for introducing cooling air into such channels, such air exhausting adjacent the centre of the magnet through a common exhaust opening, and a water circulating tube disposed about the core of the magnet.

3. In an electromagnet, a core having a helical groove therein from end to end, a water circulating tube in said groove substantially flush with the surface of said core, and a winding about said core.

4. In an electro-magnet, a core having perforated end flanges, a winding in the form of a plurality of spaced layers about said core, and layers of insulation between said layers of winding, each layer of insulation having therein a series of air circulating channels extending longitudinally of the magnet substantially from end to end thereof and registering at their outer ends with the perforations of said end flanges, and means at each end of the core for introducing cooling air through perforations of said flanges and into and through said channels for exhaust adjacent the center of the magnet.

5. An electro-magnet as claimed in claim 4 wherein the core adjacent its center is provided with a pair of spaced discs having perforations registering with the inner ends of said channels whereby the air from said channels may exhaust to atmosphere.

6. An electromagnet as claimed in claim 4 wherein the core adjacent its center is provided with a pair of spaced discs having perforations registering with the inner ends of said channels whereby the air from said channels may exhaust to atmosphere and the means which space the discs apart from each other consist of a series of radial strips disposed in a non-blocking relation to the perforations thereof.

7. In an electromagnet, a core, a winding in the form of a plurality of spaced layers about said core, and layers of insulation between said layers of winding, each insulation layer consisting of a plurality of blocks laid end-to-end on each winding layer and circumferentially spaced from each other to define a series of air circulating channels extending longitudinally of the magnet substantially from end to end thereof, means for introducing cooling air into said channels at the outer ends thereof, and means whereby the air from said channels may be exhausted adjacent the center of the magnet.

8. An electro-magnet as claimed in claim 7 wherein the core is provided at each end with flanges each having perforations therein registering with the outer ends of said channels and the cooling air introduced at the ends of the magnet passes through the perforations of said flanges and into and along said channels for exhaust therefrom adjacent the center of the magnet.

9. An electro-magnet as claimed in claim 7 wherein the core is provided adjacent its center with a pair of spaced discs each having perforations therein registering with the inner ends of said channels whereby the cooling air introduced at the ends of the magnet exhausts from said channels through the perforations of said discs to atmosphere.

10. In an electro-magnet, a core having end flanges, each flange provided with a plurality of concentric rows of spaced perforations, a core winding in the form of a plurality of spaced concentric layers about said core, and layers of

insulation between said winding layers, each insulation layer having a series of air circulating channels extending longitudinally of the magnet substantially from end to end thereof and registering with the perforations in the end flanges of the magnet, means for introducing cooling air through said perforations of the flanges and into the outer ends of said channels, means adjacent the center of the core constituting an exhaust common to all of said channels, said last named means consisting of a pair of spaced discs adjacent the center of the core, each disc having concentric rows of spaced perforations registering with the inner ends of said channels and a radial series of strips, spacing said pair of discs and disposed in non-blocking relation to said channels.

11. In an electro-magnet, a core having end flanges, each flange provided with a plurality of concentric rows of spaced perforations, a core winding in the form of a plurality of spaced concentric layers about said core, and layers of insulation between said winding layers, each insulation layer comprising a plurality of blocks laid end-to-end on each winding layer and circumferentially spaced from each other to define a series of air circulating channels extending longitudinally of the magnet substantially from end to end thereof and registering with the perforations in the end flanges of the magnet, means for introducing cooling air through said perforations of the flanges and into the outer ends of said channels, means adjacent the center of the core constituting an exhaust common to all of said channels, said last named means consisting of a pair of spaced discs adjacent the center of the core, each disc having concentric rows of spaced perforations registering with the inner ends of said channels, and a radial series of strips spacing said pairs of discs and disposed in non-blocking relation to said channels.

12. In an electro-magnet, a core, a plurality of spaced layers of winding about said core, the spaces between said layers of winding constituting air circulating channels extending from end to end of the magnet, means at each end of the magnet for introducing cooling air into such channels, and an exhaust for such cooling air consisting of a pair of spaced discs intermediate of the ends of the magnet and having concentric rows of perforations registering with the inner ends of such channels.

13. An electro-magnet as claimed in claim 12 wherein the means which space the pair of discs consists of a plurality of radial strips disposed in non-blocking relation to the perforations of said discs.

14. In an electro-magnet, a core, a core winding circumferentially wound about said core as a plurality of spaced concentric layers extending substantially from end to end of the magnet, a plurality of concentric layers of insulating material interposed between and spacing said layers of winding material from each other, said insulating layers extending substantially co-extensive with said winding layers, and each insulating layer having a plurality of circumferentially spaced longitudinal air circulating channels extending continuously from end-to-end thereof, and means whereby cooling air may be forced through said channels from end to end thereof.

15. An electro-magnet as claimed in claim 14 wherein each layer of insulating material consists of a plurality of circumferentially spaced rows of blocks laid in end-to-end abutment with each other and the spaces between said rows of blocks constitute the continuous longitudinally extending air circulating channels.

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