May 2, 1933. V. F. SHAW 1,906,820

MAGNETIC DETECTOR

Filed May 11, 1931

Fig. 1.

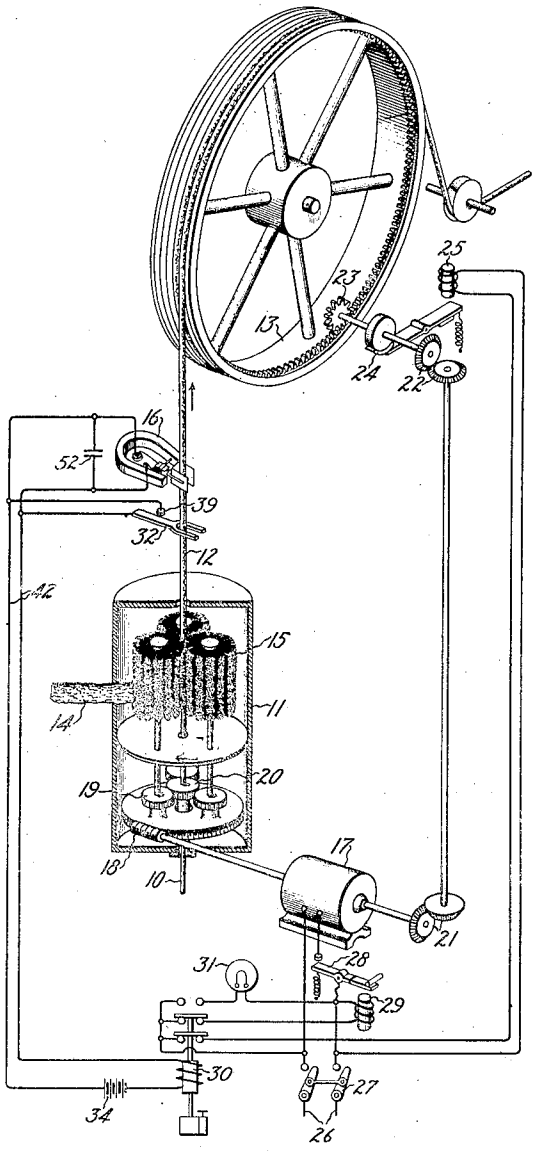


Fig. 2.

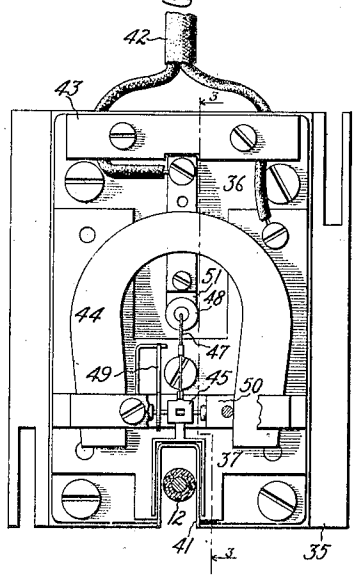
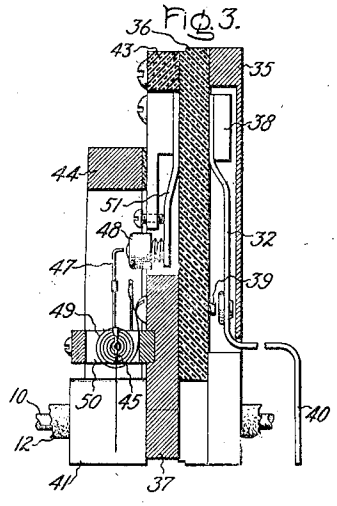


Fig. 3.



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UNITED STATES PATENT OFFICE

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MAGNETIC DETECTOR

Application filed May 11, 1931. Serial No. 536,465.

My invention relates primarily to apparatus for detecting the presence of small, invisible magnetic particles in the covering of insulated electric cables and the like during the continuous manufacture thereof, together with control means responsive to such detection for stopping the cable covering machinery in order that the magnetic particle may be removed.

In the manufacture of insulated electric cables it is important that the insulated covering be freed of any metallic particles before the cable is finished as otherwise the insulation of the cable is very apt to break down in service. In the manufacture of electric cables the covering of which includes a layer of asbestos a plurality of revolving wire brushes are employed in distributing and wrapping the asbestos about the cable as it passes a given point. The bristles of the brushes sometimes break off or work loose and become imbedded or partially imbedded in the asbestos layer of the cable. My invention detects such a condition as soon as it occurs and preferably stops the machinery in order that the condition may be corrected. Other features of the invention will appear as the description proceeds.

A detecting device for this purpose must be very sensitive but must not be influenced by the presence of the copper conductor on which the asbestos covering is wound. It must be positive in its action but not influenced by ordinary vibrations of the machine on which installed. The device hereinafter described has been found to meet these requirements.

The features of my invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. For a better understanding of my invention reference is made in the following description to the accompanying drawing showing in Fig. 1 a portion of an asbestos cable carding machine to which my invention has been applied; Fig. 2 shows a plan view of a preferred form of magnetic detector embodying my invention, and Fig. 3 is a sectional view of the detector taken on line 3—3 of Fig. 2.

In Fig. 1, I have represented certain parts of a machine for depositing a layer of asbestos on an electric cable in a continuous process. Such a machine is known as a carding machine. It may be one machine of a series through which the cable is passed in the insulating process. The cable 10 enters the carding chamber 11 at the bottom of its center, passes upward therethrough during which passage it receives a uniform layer of asbestos 12, passes out of the top, over a driving drum 13 and then to a reel or to other machines, not shown, for adding other insulating or protective layers. Asbestos in a loose form is fed to the carding machine as indicated at 14. The asbestos is received on a number of brushes 15 having fine steel bristles. These brushes are arranged concentrically about the cable 10 and revolve on their own axes parallel to the cable as well as bodily about the cable and in so doing deposit, wrap and card a uniform layer of asbestos about the cable as it passes upward between the brushes. Occasionally a steel bristle breaks off from a brush and is partially or wholly imbedded in the asbestos layer on the cable and the magnetic detector of my invention indicated at 16 is provided to detect such a condition as the asbestos covered cable passes this point and stops the machine in order that the steel bristle may be removed.

The carding machine 11 and drum 13 are represented as driven by an electric motor 17. A worm gear 18 on the motor shaft rotates the brush assembly of the carding machine. Gears 19 on the shafts of the brushes mesh with a central stationary gear 20 and cause the brushes to revolve on their own axes. The drum 13 is driven through gears indicated at 21, 22 and 23 from motor 17. In the driving connection to the drum there is an electric brake 24 which is released when its solenoid 25 is energized. The motor circuit contains an electromagnetic switch 28 which is closed when its solenoid 29 is energized. The supply to the motor 17 and the solenoids 25 and 29 is indicated at 26 and the parts mentioned are normally supplied when the line switch 27 is closed. The energizing circuits of the automatic motor switch solenoid

29 and the brake solenoid 25 are controlled by a relay 30 which is arranged to be energized by the magnetic detector 16 when a steel bristle or the like is present in the covering 12 as it passes the detector. In the deenergized position of relay 30 the circuits to 29 and 25 are closed and are opened when relay 30 is energized. Thus when relay 30 is energized the motor circuit is automatically opened and the brake is automatically applied. The energization of relay 30 also closes the circuit of a signalling lamp 31 and such other visible and audible signals as may be desired. Relay 30 may also be energized through a contact device 32 which is placed above the carding machine adjacent the covered cable 12. The purpose of this contact device is to detect the presence of undesirable bunching of the asbestos on the cable due to imperfect carding, etc. When a bulge or bunch of this character on cable 12 reaches contact device 32 the contact is closed and the machinery stopped in order that this condition may be corrected as well as to prevent damage to the magnetic detector. 34 indicates a separate source of direct current supply for relay 30 although this is not always essential.

The operation of the magnetic detector will be more fully understood after its details of construction have been explained and we will now refer to Figs. 2 and 3 for such explanation. The two detecting devices shown at 16 and 32 in Fig. 1 are combined in the same general structure in Figs. 2 and 3. These detectors are mounted on a suitable supporting structure consisting in general of a brass back plate 35, an intermediate plate of insulating material 36 and an upper brass plate 37 shaped and assembled as indicated.

The back plate 35 is slotted and recessed as shown to accommodate the contact lever 32 of the gauge or bunch indicator. One end of this lever is secured to the supporting structure at 38. It carries a contact which cooperates with a stationary contact 39 and its free end is bent downward and terminates in a fork 40 corresponding to the forked portion of the bunch detector which straddles the cable in Fig. 1. A U-shaped channel is cut through the central lower end of the supporting structure and embraces a trough 41 made of brass or other non-magnetic material through which the cable 12 to be tested is passed. The gauge fork 40 straddles the cable 12 as it is passed through this channel. The direction of movement of the cable is at right angles to and across the field and is to the left as viewed in Fig. 3 and if a bunch occurs on the cable or if for any reason the cable dimension becomes greater than can be freely passed through the trough the fork 40 will intercept it and the contact on 32 will be closed against contact 39.

These contacts thus close a circuit between the terminals of the cables 42 secured to the terminal support 43 as seen in Fig. 2.

The magnetic detector is mounted on the other or top side of the supporting structure and comprises a magnet 44 preferably a permanent magnet of horseshoe shape and a movable armature member 45 mounted on jeweled bearings on an axis extending between the poles of the magnet. One end of the armature member is of magnetic material and is preferably forked and loosely surrounds the cable channel 41. The trough 41 serves as a guard for the delicate magnetic vane. The forked magnetic vane thus extends in the leakage field of flux between the poles of the permanent magnet to a point closely adjacent the cable trough and is normally held in a substantially horizontal position, as viewed in Fig. 1, in the central region, or region of maximum flux density, of this field by the field itself. The vane is preferably equally distant from both pole pieces so as to avoid any side pull. The fingers of this vane are preferably thin, flat strips of magnetic material, the width of the strips being preferably about $\frac{1}{32}$ of an inch and the thin dimension only sufficient to make them stiff enough to keep their shape. The wide dimension is parallel to the leakage flux path. The other end of the armature member is provided with a bent over end 47 forming a contact which, when the armature is turned a limited amount on its pivots in a clockwise direction, as viewed in Fig. 3, dips into a mercury cup 48. When contact is thus made, another circuit is closed between the terminals of the cable 42. The movable contact of the armature is connected through a spiral conductor spring 49 to the non-magnetic metal supporting structure 50 for the bearings and is thus grounded to plate 37 to which one of the cable terminals is connected. The mercury cup is supported on an adjustable contact arm 51 insulated from plate 37 and connected to the other cable terminal. When a circuit is closed through the mercury cup contact 47 and spiral 49, a direct current from the source 34 (Fig. 1) flows therethrough and the current flowing through the spiral sets up a field of its own which reacts with the field of the permanent magnet, produces an armature torque, and causes the armature to be turned in one direction or the other depending upon the direction of current flow. Thus when such a contact is made the action just explained may be used to intermittently open the contact or to hold it closed, as desired.

The detecting action of this device is as follows: When a small piece of magnetic material such as a portion of a steel bristle is carried through the cable trough in the asbestos covering of the cable being tested it disturbs the position of the average flux crossing this space between the pole tips

of the permanent magnet. The average flux tends to pass through the path of least resistance which is now determined at any instant by the position of the moving magnetic particle and the forked armature being freely movable in the general direction of movement of the cable takes a corresponding position. The forked end of armature 45 thus first moves to the right (Fig. 3) as the magnetic particle enters the field from the right and then follows the magnetic particle to the left and in this movement it closes the mercury contact device at the opposite end of the armature. If the resulting current flow through the armature member is in one direction the contact device will remain closed until opened by hand or until the circuit is broken at some other point. If the current is in the opposite direction the contact will kick open again immediately and will then be closed again and this will be repeated until the magnetic particle has been removed or passed beyond the influence of the field.

When this apparatus is used on a machine such as is shown in Fig. 1, the operation is approximately as follows: The machine is started by closing line switch 27. The cable 12 generally travels from 5 to 20 feet per minute depending upon the size of cable being covered, the thickness of the coat, etc. Asbestos is fed to the carding machine and it is carded on the cable as indicated. Relay 30 is deenergized until one or both of the undesirable conditions previously referred to occurs. Should a portion of steel be broken from a brush and become embedded in the cable covering, it will operate the magnetic detector as above described and energize relay 30. Motor switch 28 opens and the brake at 24 is applied. For a cable moving about 7 feet per minute the cable will be stopped in about two inches of travel under usual conditions. I will assume that the direction of current through the detector is such as to cause its contact device to kick open. Relay 30 is thus intermittently energized and in such a case is designed to operate quickly to open the circuits to solenoids 29 and 25 but is provided with a dashpot or its equivalent so that it moves more slowly in the opposite direction. Consequently the circuits opened by its initial operation will remain open. However, the contacts in the circuit of signalling device 31 are so positioned as to be alternately closed and opened by the intermittent energization of this relay so that a flickering or intermittent signal is given. The operator then opens switch 27, examines the cable 12 just above the detector and finds and removes the metal particle. The detector armature and relay 30 will then move to the normal position and the machinery may again be started by closing line switch 27. If it is a bunched condition on the cable that causes the trouble the machine will be stopped as before in order that it may be remedied. A condenser 52 may be connected across the contacts of the detector to reduce sparking when it is arranged to have the contacts kick open as soon as closed. The trough 41 will preferably be positioned midway between the pole pieces of the magnet and so that the cable passes through its center. The forked insulation gauge 40 will preferably be positioned a sufficient distance below the detector structure that a bunched condition will cause stopping of the machine before the bunched portion reaches the main detector structure and causes damage.

It will be evident that the magnetic detector may be used as a portable device by moving it along a cable to be tested and watching for any movement of its armature. Its details of construction, size and shape may be varied to suit different conditions, sizes and shapes of cables, etc. It will detect any small magnetic particle not only in the covering of insulated cables generally but in any other non-magnetic object or material passed through its forked armature. It may also be used to locate positions of non-uniformity in magnetic materials such, for example, as a concealed defect in a steel cable. Where the device is employed to control the operation of a machinery in a continuous manufacturing process as herein described the control apparatus will of course be varied to suit requirements. The particular control scheme represented is for the purpose of illustration only. Such other modifications as fall fairly within the true spirit and scope of the invention are intended to be included within the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A device for detecting the presence of small magnetic particles in non-magnetic bodies comprising means for producing a magnetic field, a magnetic vane mounted so as to be movable across such field and normally held in a predetermined position therein by such field, and provisions for moving a body to be tested through said field in the general direction in which the vane is movable therein.

2. A device for detecting the presence of concealed magnetic particles in non-magnetic materials comprising a magnet provided with spaced poles of opposite magnetic polarity between which a magnetic field is produced, and a magnetic vane movably mounted in said field so as to swing across the field but normally held in a predetermined position therein by the field itself, the disposition of the vane being such as to allow room for material to be tested to be inserted into said field and moved therein in the general direction in which the vane is movable.

3. A magnetic detecting device comprising

a magnet having spaced poles of opposite polarity, between which a magnetic field is produced, a magnetic vane in said field, said vane being mounted so as to be movable across said field and to be symmetrically magnetically located with respect to both pole pieces in all positions and to be attracted to substantially that position where it intercepts the greatest amount of flux of said field, the spacing of said pole pieces and the disposition of said vane being such as to leave a space for an article to be tested to be moved across said field in close proximity to said magnetic vane, and a non-magnetic guard separating the vane and testing space in said field.

4. A magnetic detector comprising a permanent magnet of horseshoe shape, a non-magnetic testing trough centrally located in and perpendicular to the magnetic field produced between the pole pieces of said magnet, an armature member pivoted on an axis extending between said pole pieces and having a forked magnetic extension embracing the testing trough, said armature being free to move so that the forked vane seeks a position of least reluctance in said field.

5. A magnetic detector comprising a magnet provided with spaced apart pole pieces for producing a unidirectional flux therebetween whereby material to be tested for magnetic properties may be moved through said field at right angles thereto, an armature member pivoted for rotation on an axis extending between the pole pieces of said magnet, said armature having a magnetic vane extending into the region of maximum flux density between the pole pieces of said magnet and normally held there by said field, a contact carried by said armature which is connected to a stationary support by a conductor spiralled about the axis of rotation of said armature and threaded by a portion of the flux of said magnet, a stationary contact with which the armature contact cooperates to form a switch, and a direct current circuit including said spiralled conductor and switch controlled by the movement of said armature.

6. A magnetic detector comprising a magnet for producing a testing field, said magnet having pole pieces spaced apart so that material to be tested for magnetic properties may be passed at right angles through the field crossing between such pole pieces, an armature member having a magnetic vane extending into the region of the maximum intensity of such field, said armature being pivoted on an axis permitting limited movement of the vane across said field, the rotative position of the armature being determined by said field and changing with a shift of the field in the direction in which the vane is movable, a contact on said armature, a stationary contact with which the armature contact cooperates, a conductor spiralled about the axis of rotation of the armature and connected between the armature contact and a stationary support, a direct current circuit closed through said contacts and spiral conductor in one position of the armature, said spiral conductor being threaded by a portion of the flux from said magnet in such a direction with respect to the direction of current flow therethrough that armature torque is produced which opens the contacts, said contacts being open when the field is undisturbed and closed in response to a magnetic disturbance which it is desired to detect.

7. A device for testing materials for magnetic properties and dimensions comprising a magnet having spaced pole pieces for producing a magnetic field between them, a non-magnetic trough extending at right angles through the field between said pole pieces, an armature member pivoted for rotation on an axis extending between said pole pieces and having a forked magnetic vane extending towards and embracing said trough in the magnetic field, the magnetic attraction between the field and vane determining the rotative position of said armature, a signalling circuit controlled by the rotative position of said armature, and a gauge adjacent the inlet end of the trough for gauging a dimension of any material moved through said trough, said gauge being movable in response to its gauging action to also control said signalling circuit.

In witness whereof I have hereunto set my hand.

VIRGIL F. SHAW.