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F. B. DOANE

2,312,083

ELECTROMAGNETIC CONNECTOR

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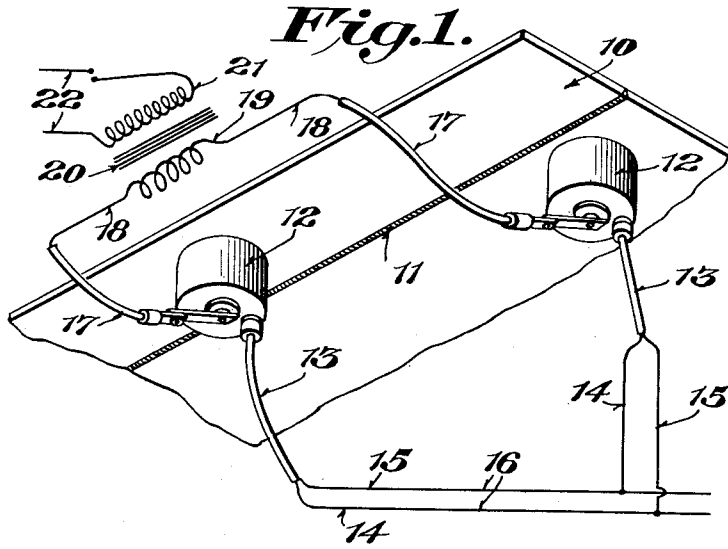


Fig. 2.

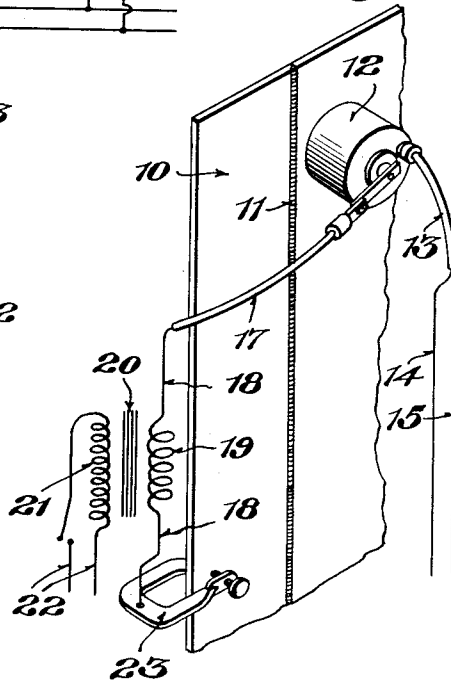


Fig. 3.

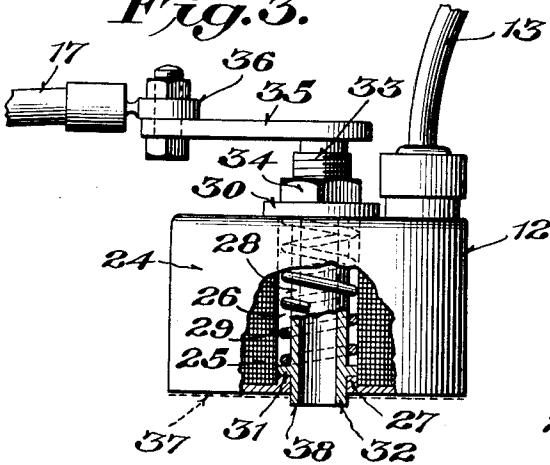
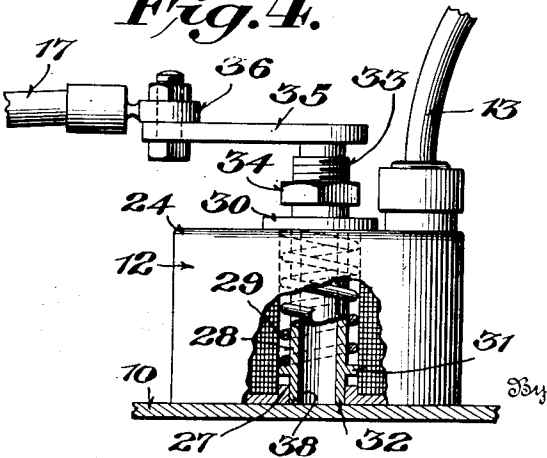


Fig. 4.



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ELECTROMAGNETIC CONNECTOR

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2 Claims. (Cl. 173—324)

This application is a continuation in part of my application Serial No. 224,676, filed August 13, 1938, and entitled "Method of and system for magnetic inspection."

This invention relates to terminal means for and the method of establishing a magnetic field in a magnetizable metallic object included in an electric circuit for current flow through the object along a selected path or longitudinally extending current flow zone, and so that the magnetic field about the terminals of the current path in the object may be of a desired character.

With systems and methods heretofore known, it has been extremely difficult to subject certain structures to a magnetic inspection, especially where it was desired to pass the magnetizing current directly through the piece to be inspected. Frequently, heavy current is used for this purpose and consequently the conductors and terminals are sometimes of material weight, and a firm pressure is necessary at the contact point where current enters and leaves the test piece. In overhead work, systems and methods heretofore known were exceptionally difficult and frequently dangerous to use and practice. For example, if an operator were inspecting a tank car at the top of the inside or the bottom of the outside, he would have to press upwardly with considerable force on a hand operated contactor embodied in an old system, and frequently carry the weight of the conducting cable also. If the surface of the work article is somewhat tortuous, wobbling or let-up in pressure may result in powerful arcing, injuring the test piece or work article and subjecting the operator to the danger of falling sparks or molten bits of metal. In addition, following the old systems and methods, only one of the operator's hands would be free at a time, in the few instances where it was not necessary to continuously use both hands, and it was substantially impossible for a single operator to conduct a complete magnetic inspection.

With the foregoing in mind, it is an important object of the present invention to provide means for magnetic inspection which eliminates the aforesaid defects and objections.

It is also an object of this invention to provide a means for magnetic inspection which enables a single operator to conduct a complete magnetic inspection on a test piece of relatively great size.

Another object of the invention is the provision of a means for magnetic inspection which

is operable in a manner to leave both hands of the operator free during the application of the paramagnetic particles to the test pieces.

A further object of the invention is the provision of a means for magnetic inspection, which means embodies apparatus of the character which is substantially entirely self-supporting during the magnetizing of the test piece.

While some of the more salient features, characteristics, and advances of the present invention have been above pointed out, others will become apparent from the following disclosures, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a fragmentary isometric view illustrating a method of using a pair of similar magnetizable terminal structures or leeches, embodying principles of the present invention;

Figure 2 is a fragmentary isometric view illustrating a method of using the magnetic contactor or leech embodying principles of this invention, where only one such contactor is used at a time;

Figure 3 is a fragmentary elevational view, with parts broken away and parts in section, of one of the magnetic contactors and the conductor connections thereto; and

Figure 4 is a fragmentary elevational view, with parts broken away and parts in section, illustrating the contactor of Figure 3 as applied to a metallic surface.

As shown on the drawing:

The magnetizable terminal or magnetic contactor structure described hereinafter is known in industry as a magnetic leech, and it may be made in any size or shape thought feasible or desirable. The round shape illustrated in the drawing has been selected merely for the purpose of ease in presenting a proper disclosure.

Also, for the purpose of clarity in presentation alone, the magnetic contactor or leech is illustrated in connection with the testing of welds, but the magnetic contactor is not limited in use to weld inspection, but may be used to inspect substantially any portion of a magnetizable metallic structure and is also found desirable for use in inspecting metallic parts by the so-called dunking method, wherein the part to be inspected is lowered into a bath of ferromagnetic particles held in suspension while current is being passed directly through the part. The use of the present invention eliminates the necessity of applying manual or mechanical pressure to the contacts while the dunking operation is in progress.

In Figures 1 and 2, separate methods of using an illustrated embodiment of the present invention are illustrated, the method in Figure 1 being shown in connection with the magnetic inspection of an overhead metallic structure, while the method in Figure 2 is shown in connection with the magnetic inspection of a vertically disposed metallic structure.

In Figure 1, a work piece or article 10 to be inspected is shown in the form of a relatively heavy sheet metal structure with two adjacent edges being joined by a V-weld 11. The structure is disposed overhead so that the operator must work beneath it, and it is proposed to magnetically inspect the weld 11. To this end, a pair of self-adhering magnetic contactors, each generally indicated by numeral 12, are used, and in this instance each contactor 12 is in the form of an electro-magnet contactor. The specific structure of a contactor 12 will be later described herein.

Each contactor 12 is provided with a cable 13 containing a pair of conductors 14 and 15 which may be connected to a current supply line 16 leading from a suitable source of electrical energy. As seen in Figure 1, the conductors 14 and 15 are included in the electro-magnetic circuit of each contactor so that when the circuit is energized, the contactor will magnetically adhere to the work piece 10. The connections are such that the contactors 12—12 may be separately energized and de-energized.

Each of the contactors 12 also has attached thereto a cable 17 containing a conductor 18, and by these conductors 18 the two contactors 12—12 are connected together through the secondary 19 of a transformer 20, the primary 21 of which is associated with a supply line 22 leading from a suitable source of electrical energy. While it may not be necessary in all cases to use separate supply lines, such as lines 12 and 22, in many cases it will be found preferable, because frequently a considerably higher amperage is used through the work-piece than is necessary for the energization of the electro-magnet to hold the contactors in position on the work piece. The conductors 18 are connected to suitable contacts held in position against the work piece by contactors 12—12, so that the circuit is completed through the secondary 19, each of the conductors 18 and the work piece itself.

In inspecting the weld 11, the operator need only close the electro-magnetic circuit through one of the contactors 12 by any suitable form of conveniently located switch, and place this contactor and the work piece 10 on one side of the weld. At whatever distance may be deemed feasible, the other contactor may be likewise placed on the work piece but on the other side of the weld 11. Then the transformer circuit may be closed and magnetizing current will pass directly through the work piece from one contactor 12 to the other. Thus, the work piece is magnetized to an extent sufficient to retain finely divided particles of paramagnetic material, and these particles may be dusted over the weld. The pattern formed by these particles will denote at once any defects in the weld. In similar manner, any portion of the work piece may be tested, either by passing the current entirely through the work piece or through sections of it at a time.

It will be noted that with this method, only one operator is necessary, and both hands of the operator are free to apply the paramagnetic particles. Further, the contact with the work

piece in each instance will be positive, without wobble, and in the event any arcing should result, sparks emanating therefrom would be prevented from falling by the body of the contactor.

After that section of the weld between the contactors 12—12 has been inspected, it is a simple expedient for the operator to leave one of the contactors in position on the work piece, after opening the transformer circuit, remove the other contactor, and advance it to a position beyond the remaining contactor still positioned on the opposite side of the weld, and thus proceed with the inspection of the next adjoining section of the weld.

As stated above, each contactor may be made in any suitable size or shape, and regardless of the tortuous character of the surface of the work piece, a positive contact with the work piece for the magnetizing circuit is readily effected in each instance.

In the event there is a way of readily attaching a conductor directly to the work piece, it is not necessary to use two magnetic contactors during an inspection. In Figure 2, I have shown the work piece 10 having a weld 11 therein, similar to the one previously described, with the exception that it is disposed in vertical position. A contactor 12 may be affixed to a suitable location on the work piece as above described, and the conductor 18 leading from the opposite side of the transformer secondary 19 may be attached to the work piece in any suitable manner, such as by a C-clamp 23, and the magnetizing circuit is satisfactorily completed through the work piece.

In similar manner, by way of example, a work piece having an open and a closed end might be satisfactorily inspected throughout the interior by attaching one of the conductors 18 to a bolt hole or any other suitable portion of the structure adjacent one end, and utilizing a magnetic contactor 12 in the interior of the structure, exploring sections of the structure of any size deemed feasible.

An important feature of this method of exploration for faults or defects not visible to the eye is apparent from the showing in Figure 1.

The body of each contactor 12 is metallic and functions as the electro-magnetic part. When the inside coil is energized, obviously there will be a magnetic field set up in the work piece as a result of the magnetic character of the contactor, in addition to the magnetic field set up by the magnetizing current passing through the work piece. In testing a weld, for example, it is desirable that the current transverse the weld but also run substantially longitudinally of the weld, and it is preferable to position the contact points close to the weld but on opposite sides thereof and spaced apart lengthwise of the weld. Thus, with two types of magnetic fields being induced in the work piece, the resulting field will in some instances give a component across the defect in almost every direction, and in many cases the necessity of magnetizing the work piece in two separate directions successively, in order to insure the location of all defects, will be eliminated, and only one operation is necessary.

In Figures 3 and 4, I have illustrated one embodiment of the magnetic contactor 12. In Figure 3, the contactor is shown removed from the work piece, while in Figure 4, it is shown applied thereto in operative position.

The contactor includes a metallic body part 24 containing a suitable coil 25 forming a part of

the circuit including the conductors 14 and 15 contained in the cable 13, and which, when energized, renders the body part magnetic. The coil is arranged to define a central aperture 26, and the lower end of the aperture is outlined by an upstanding flange 27 integral with the body part. In this instance, a tubular contact member 28 is positioned in the opening 26, and this contact member may be made of any suitable conductive material, such as copper. The contactor is urged outwardly by a suitable spring 29 or equivalent means. The spring is disposed between a collar 30 fixed to the top of the body part 24 and an annular shoulder 31 integral with the contact 28 adjacent the front or work-engaging end 38 thereof. The annular shoulder, of course, by abutting the flange 27, limits the outward movement of the contact, so that normally the contact would project slightly beyond the body part, as indicated at 32.

The upper end of the contact member 28 extends through the top of the body 24 and also the aperture in the collar 30, and this upper end is threaded, as indicated at 33, to accommodate a nut 34, the adjustment of which will lessen the amount of protrusion of the contact, if so desired. To the upper end of the contact, a terminal 35 is connected, which in turn is connected, as indicated at 36, to the conductor 18 carried in the cable 17.

It is convenient, for the moment, to think of the work piece 10 as a steel plate lying horizontally and with the front end 38 of the contact 28 seated on the plate. With the contact seated on the plate, it will be apparent that if the coil 25 is now energized the body 24 will become magnetized, and that due to the magnetic flux in the air gap between the body 24 and the plate 10, the body 24 will be pulled towards the plate, and against the action of the spring 29 to shorten the air gap. The air gap may thus be decreased to substantially zero, and the body 24 will be in as intimate contact with the surface of the plate as grease, paint, or the like on the surface of the plate will permit. If the plate is now thought of as in the positions shown in Figures 1 and 2, the magnetized body 24 will be securely held to the work piece 10, and the contact 28 is forced against the plate by the combined action of the magnetic field and the thrust of the spring 29.

The work-engaging front end 38 of the contact 28 is obviously now within the magnetic field established by the energized coil 25 in the magnetic circuit embracing the body 24 and that portion of the plate 10 immediately adjacent the body 24.

It will now be apparent that the contact 28 is one terminal of a current conducting circuit of which a similar contact on another device 12 is the other terminal when the circuit arrangement of Figure 1 is employed, or is one terminal of the circuit when a clamp is the other terminal when the circuit arrangement of Figure 2 is employed, and that current flowing through this one terminal is in the path of the magnetic field set up by the energized coil 25. There is a resultant field due to a circular field normally about the inner end of the contact member 28 and to the field normally in the magnetic circuit of the coil 25, and the effect of a transverse field from a magnet or the like upon the circular field of an arc in discouraging arcing is well understood in the electrical art.

When it is desired to separate the magnetic contactor 12 from the work piece 10 it will often

be quite enough to de-energize the coil 25, for the spring 29 is effective to push the body 34 away from the work piece. However, it is often advisable to adopt the well-known expedient of placing a thin sheet of copper or other non-magnetic material between the body 24 and the surface of the work to facilitate removal of the body 24 when there is the possibility of considerable magnetism remaining in the work piece after the coil is de-energized. Because the spring 29, acting on the contact 28, tends to push the body 24 away from the work this interposed non-magnetic material may be a thin piece of material on the work-engaging face of the body 24, as indicated by the dotted lines 37 in Figure 3.

Because the spring 29 is strong enough to hold the work engaging face of the body 24 rearwardly of the front face 38 of the contact element 28, the face 38 may be slid along the surface of the plate 10 by the operator to wipe the opposed current carrying surfaces, and to facilitate movement of the contact about the plate so long as the coil 25 is not energized.

In view of the above description of the structure and method of use of magnetic contactors embodying this invention, it is apparent that this invention greatly simplifies and increases the flexibility of the aforesaid so-called dunking method of magnetic inspection. It will be noted that this invention provides an improved method of inspecting metallic parts by the dunking process.

In addition to establishing electrical contact with the test piece, the contactor will support the test piece, one or more contactors being used as above described. For example, assuming that the test piece 10 in Figure 4 is to be subjected to dunking in a bath of ferromagnetic particles held in suspension, it is apparent that the test piece may readily be carried by the contactor or contactors alone, immersed and removed from the bath by movement of the contactor. In this manner, the use of air clamps, hydraulic clamps, mechanically operated clamps, or similar apparatus, is eliminated.

In other cases during conduction of a test, it may be desirable to merely suspend the test piece from a contactor or contactors and test it by any of the methods described above.

While in Figure 1 the contactors 12 are shown as the poles of a circuit for current flow along an elongated path, it is obvious that they may be used to connect the secondary of the transformer 20 under conditions approximating those for a short-circuit test by placing the contactors adjacent each other, or in opposed relation to each other on opposite sides of the plate. The contactors may, of course, be placed together in opposed relation to connect the poles of the secondary of the transformer for the short-circuit test.

While a steel plate, or the like, interposed between the connectors offers the advantage of a relatively large heat-radiating surface, means for readily connecting a pair of connectors in offset relation to each, and for connecting cables in parallel, it is obvious that lengths of cable may be readily connected in series by means of pairs of opposed and magnetized connectors 12. A number of cables may be connected in parallel to a copper plate which is backed by a steel plate to complete the magnetic circuit of the magnetizable body of the connector. In every case the circular field about the contact point is

within the field of the magnetizable connector body.

Thus, while the device 12 is peculiarly adapted to the severe service conditions incident to the magnetic inspection of welds in steel bodies, it also lends itself to use in the steel making and working industry as a holding magnet and as a magnetic connector for connecting heavy cables in series or in parallel.

It also lends itself, under certain test conditions often met with in industry, as a ready means of grounding a circuit to the grounded adjacent pipes or steel columns. The contact face 38 may be scraped along the column to provide a clean contact surface, and after a clean surface is provided the contactor will be firmly pressed against the column when the coil 25 is energized.

When the contactor 12 is placed relative to a plate or column to fall away from it by gravity, the heavy current circuit may be readily broken by simply opening the circuit of the coil 25, for the spring 29 would kick the contactor away from the column, so that it may readily fall clear of the column.

I claim as my invention:

1. In an apparatus for applying electrical current to a metallic work piece, comprising two body portions juxtaposed along a given line across which it is desired to flow electrical energy and which apparatus includes a terminal for connection to one body portion on one side of said line and a terminal for connection to the other body portion on the other side of said line, one of said terminals comprising an elongated contact member having a front face to be applied to one of said body portions for current flow therethrough, a magnetizable element surrounding said contact member and having a central

bore in which said member is reciprocable, spring means cooperable with said contact member and said element to normally maintain said element in longitudinally spaced relation rearwardly of the front face of said contact member and in spaced opposed relation to said body portion when the contact member is applied to said body portion, and means independent of said contact member including a solenoid for circuit connection to a source of current to magnetize said element and move it forwardly to decrease the air gap between the body portion and said element to hold the contact to said body portion, said spring being in the solenoid.

2. In an apparatus for applying electrical current to a metallic work piece comprising two body portions juxtaposed along a given line across which it is desired to flow electrical energy and which apparatus includes a terminal for connection to one body portion on one side of said line and a terminal for connection to the other body portion on the other side of said line, one of said terminals comprising a contact member to establish circuit connection with said work piece, a magnetizable member surrounding said contact member and extending laterally therebeyond in every direction, resilient means arranged to project said contact member so that an end thereof extends longitudinally beyond the adjacent end face of said magnetizable member, a coil associated with said magnetizable member to magnetize it and cause it to move toward said work piece against the action of said resilient means, said coil having a bore in which said contact member is reciprocable, and circuit means independent of said contact member to energize said coil.

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