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INDICATIONAL SYSTEM FOR ELECTROMAGNETS

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Fig. 1.

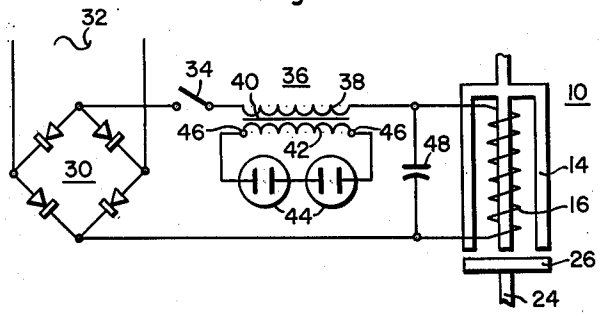


Fig. 2.

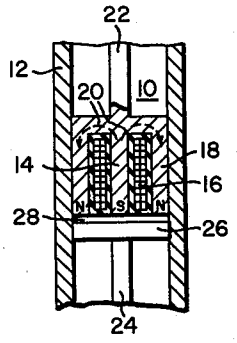
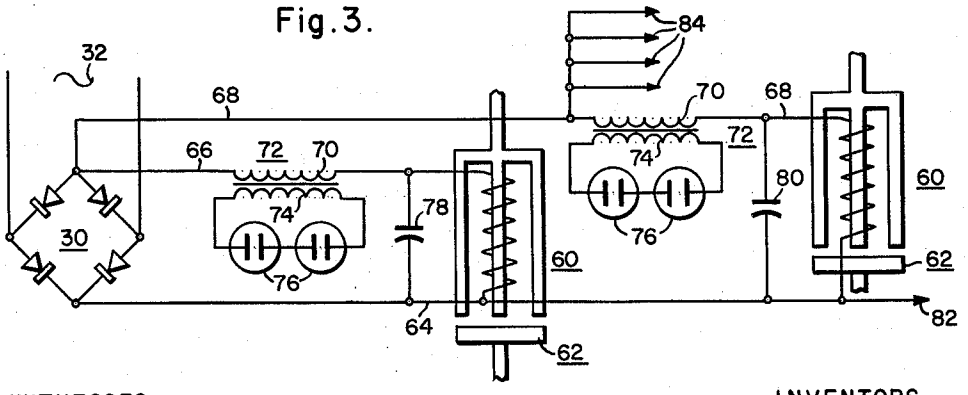


Fig. 3.



WITNESSES

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INDICATIONAL SYSTEM FOR ELECTROMAGNETS

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The present invention relates to an electrical circuit adapted for indicating a relatively small change in Q or quality of an eletcromagnet and, more particularly, to a circuit of the character described for indicating when a lifting or coupling electromagnet is in engagement with an external magnetic object.

The invention is adaped, in an exemplary form thereof, for indicating when a lifting electromagnet has picked up or engaged a magnetic object to be lifted particularly in those applications wherein the magnet and the object are inserted into a narrow passage or other location of limited visual access. For example, the indicational system of the invention can be employed for use with a lifting magnet for fishing out or removing tools or the like or other magnetic items from a vessel having limited access thereto or having relatively narrow passages formed within the vessel, as in certain known types of reactional containers. The invention can also be utilized in removing drilling bits or other tools from a well bore when employing a lifting electromagnet for this purpose.

In other applications, a linear driving mechanism is employed for inserting a controlling member through a closely fitting passage into a vessel for controlling a reaction being carried on within the vessel. The controlling member, for example, normally is coupled to a driving shaft, moved by the linear mechanism, by means of an electromagnet. The driving shaft and the controlling member sometimes are disengaged for one reason or another and it is necessary to move the linear shaft into the passage in an attempt to re-engage the controlling member. Inasmuch as this must be done relatively slowly and with care in order to avoid damaging the control member or the driving shaft, it is essential to provide some means of remotely indicating when the electromagnet associated with the driving shaft has become magnetically engaged with the control member.

When employing a lifiting or coupling electromagnet in rather confined passages such as the vessel passage or well bore indicated previously, it is necessary to provide the electromagnet with many turns of wire in order to attain the necessary lifting power. The lifting power is, of course, obtained by direct current in the winding. However, the Q or quality of such an electromagnet for alternating current signals is relatively low and, as is well known, cannot be readily used for detuning or otherwise changing the resonant condition of a simple L-C circuit consisting of the electromagnetic coil and a condenser coupled in series therewith. The resonant condition, of course, depends upon Q, L, C and R in accordance with the following formulae

$$2\pi fL=\frac{1}{2\pi fL}$$

and

$$Q=\frac{2\pi fL}{R}$$

where Q is the quality or ability of the electromagnet to tune a resonant circuit, L is the inductance of the electromagnet, C is the capacitance of the tuning capacitor, f is the frequency of the alternating current used, and R is the ohmic resistance of the electromagnet.

When employing electromagnets having a relatively high Q, the engagement of an object to be lifted with the magnets can cause sufficient detuning of a known type of resonant circuit associated with the electromagnet to give an external indication of this engagement. However, in relatively small compact electromagnets having large resistances, the Q is necessarily rather low since the lifting power is dependent upon having a large number of turns of the electromagnetic coil. It will be seen, then, that in the electromagnet of the character described, where a large number of turns, usually of relatively fine wire to conserve space, are employed, the ohmic resistance is relatively high and hence, the quality (Q) is low. Another reason that the quality of the lifting magnet is low is that in many applications, the lifting magnet is operated from a rectified alternating current having a direct current component needed for the lifting power and a ripple or alternating current component having a normal frequency of 60 or 120 cycles which is represented by f in the above-mentioned formulae. Although it would be possible to superimpose on the direct current a higher frequency source in order to increase Q, this obviously requires additional and expensive equipment.

It is an object of the invention, therefore to provide a novel indicational system adapted for use with a low Q electromagnet.

Another object of the invention is to provide an indicating circuit of the character described which is capable of being actuated by a relatively small change in Q of the electromagnet.

A further object of the invention is the provision of an indicating system capable of denoting when a lifting or coupling electromagnet is engaged with an external object.

Another object of the invention is the provision of a reasonable circuit whose resonant condition is capable of being detuned or otherwise changed by a relatively small change in Q of an electromagnet.

A further object of the invention is the provision of a reasonable circuit which is operable from a relatively low frequency source and whose resonant condition is capable of being detuned or otherwise changed by a relatively small change in Q of an associated electromagnet.

During the forthcoming description of an exemplary form of the invention, other objects, features and advantages of the invention will be enumerated and described in detail. The description is to be read in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a schematic circuit arrangement of one form of indicating system adapted for use with a lifting electromagnet;

FIG. 2 is a partial, longitudinally sectioned view of an illustrative application of the lifting magnet; and

FIG. 3 is a schematic circuit arrangement of another form of indicating and electromagnet operating circuit contemplated by the invention.

Referring now, more particularly, to the drawings, the exemplary form of the invention as shown therein is adapted for use with an electromagnet **10** and particularly with an electromagnet having a relatively low Q as described previously. In an illustrative application, as better shown in FIG. 2, the electromagnet **10** is adapted for insertion into a well bore or into a vessel passage or tubular channel member **12**, such as described previously. In this arrangement, the electromagnet **10** includes a core **14** and a winding or coil mounted upon the core and enclosed within an inverted cup-shaped member **18**. The core **14** and the cup-shaped member **18** preferably are fabricated from magnetic materials, such as silicon steel or low carbon steel and serve respectively to form opposite magnetic poles at the lower or lifting end of the electromagnet **10** as illustrated in FIG. 2 of the drawings. Thus, the cup-

shaped member 18 serves partially to complete the magnetic circuit about the coil 16 as denoted by arrows 20.

The cup-shaped member 18 is attached to the core 14 and to a linear driving shaft 22 as by welding or threading (not shown) and thus is insertable within the channel member 12 by manipulation of the driving shaft 22. When thus inserted, the electromagnet 10 is arranged for coupling with an appropriate tool or controlling member (not shown) inserted within the channel member 12, the operating extension of which is denoted by the reference character 24. In this arrangement, the operating extension 24 is provided with a transversely disposed magnetic disc 26 arranged for engagement with the lower end portions of the core 14 and the cup-shaped member 18. When so engaged, the disc 26 bridges the gap 28 separating the north and south poles associated with the lower ends of the core 14 and the cup-shaped member 18 respectively and thus completes the magnetic circuit of the electromagnet 10.

The coil 16 of the electromagnet 10 is energized in this arrangement by a full-wave rectified alternating current and for this purpose is coupled to the output of a rectifier bridge denoted by the reference numeral 30. The input of the bridge 30 is coupled to a suitable source 32 of alternating potential, for example, a conventional alternating-current line having a frequency of 60 cycles and a potential of about 115 volts. With this arrangement, a fluctuating or ripple direct current is applied to the electromagnet 10 and has a frequency of 120 cycles per second. A switch 34 is connected in series with the electromagnet 10 to control the energization thereof. A transformer denoted by the reference numeral 36 also is coupled to the output connections of the rectifier bridge 30 and to the electromagnet 10 such that its primary winding 38 is in electrical series with the energizing winding 16 of the electromagnet. The transformer 36 is a standard radio power transformer including in addition to the primary winding 38, a core 40 and a secondary winding 42. A pair of neon indicating lamps 44 are connected in series across the output terminals 46 of the secondary winding 42.

A condenser 48 is coupled in parallel with the electromagnet 10 but in series with the primary winding 38 of the transformer 36 and with the output of the rectifier bridge 30. When the magnetic disc 26 is removed from the electromagnet 10, the value of the condenser 48 is selected so that a series resonant circuit is established through the primary winding 38 and the condenser 48 at the frequency of the rectified output of the bridge 30, that is to say, at a frequency in this example, of 120 cycles per second. Under these resonant conditions, the voltage drop through the primary winding 38 is sufficient to induce an appreciable voltage in the secondary winding 42 and thus the output of this winding is sufficient to energize the neon indicating lamps 44.

When, however, the disc 26 is engaged with the electromagnet 10 and the operating extension 24 is thereby coupled to the driving shaft 22, the resonant circuit comprising the transformer primary winding 38 and the condenser 48 is detuned and the secondary output is insufficient to energize the indicating lamps 44. After removing the disc 26, the indicating lamps 44 again glow brightly and thus extinguishment of the lamps 44 indicates the precise instant at which the disc 26 is engaged with the electromagnet 10. According to the present understanding of the invention, this action occurs because the effect of the condenser 48 upon the aforementioned resonant circuit is changed radically with only a very slight change in Q or quality of the electromagnet 10. As explained previously, the slight change in Q of the electromagnet results from engagement of the disc 26 with the electromagnet. Use of the rectifier bridge arrangement 30, supplies both an alternating voltage component for operation of the resonant circuit and also a direct voltage component for optimum use of the electromagnet 10.

Referring now to FIG. 3 of the drawings, the exemplary form of the invention illustrated therein is adapted for use with a plurality of electromagnets 60 and for yielding separate and independent indications of engagement between the electromagnets 60, respectively, with magnetic coupling members 62. In furtherance of this purpose, the electromagnets 60 are each connected to a common conductor 64 which, in turn, is connected to one of the output terminals of the rectifier bridge 30 or other source of fluctuating potential, as described previously in connection with FIG. 1 of the drawings. The other terminals of the electromagnets 60 are joined to parallel conductors 66 and 68, respectively which, in turn, are connected to the remaining output terminal of the rectifier bridge 30. A primary winding 70 of a transformer 72 is coupled in each of the parallel conductors 66 and 68 so as to be disposed in parallel relation to the rectifier bridge 30 but in series relation to each electromagnet 60, respectively. The secondary winding 74 of each transformer 72 is connected in series to a pair of indicating lamps 76 in the manner described previously in connection with the neon lamps 44 of FIG. 1.

A pair of condensers 78 and 80 are connected across the input terminals of the electromagnets 60 and thus are disposed in parallel, respectively, to the electromagnets 60 and in series, respectively, with the transformers 70. Additional electromagnets 60 and associated resonant indicating circuits including the transformer 70 and the condenser 78 or 80 can be coupled to the rectifier bridge 30 by coupling these components in a similar manner to the common conductor 64 as denoted by lead 82 and respectively to additional parallel conductors denoted generally by the reference character 84.

The transformer 70 and the condenser 78 or 80 of each indicating circuit are tuned in this example to the resonant condition when the coupling members 62 are displaced from the electromagnets 60, respectively. Thus, the indicating lamps 76 associated with each of the electromagnets 60 and coupling members 62, respectively, will glow thereby giving an indication when each coupling member 62 is disengaged from its electromagnet 60. Obviously, however, the resonant circuit associated with each electromagnet 60 can be tuned to resonance when each coupling member 62 is in engagement with its electromagnet and thereby to energize the lamp when the coupling member is engaged.

It will be seen from FIG. 3 that a single source of fluctuating potential as represented by the rectifier bridge 30 and the source of potential 32 can be employed to operate a plurality of electromagnets 60 and to furnish indications of their operation. It has been found, moreover, that the detuning effect of each electromagnet 60 upon its associated condenser 78 or 80 is not transmitted in the circuit of FIG. 3 to the condenser or condensers associated respectively with the balance of the electromagnets 60. Thus, an indication of the operation of each electromagnet 60 is obtained independently although all of the electromagnets 60 and their associated indicating circuits are energized from a common source of potential. This is found to be the fact although more than two electromagnets 60 and associated indicating circuits are energized in this fashion.

From the foregoing, it will be apparent, then, that a reliable indicating system has been disclosed herein which is adapted particularly for use with one or more low Q lifting or coupling electromagnets. This is accomplished by a minimum of circuit components and without employment of a high frequency current component for the electromagnet.

Obviously, then, the descriptive materials employed herein are utilized for exemplifying the invention and are not to be interpreted as illustrative thereof. Accordingly, numerous modifications and embodiments of the invention will occur to those skilled in the art without departing from the spirit and scope of the invention.

Accordingly, what is claimed as new is:

1. An operating and indicating system for an electromagnet adapted for engagement with an external magnetic member, said system comprising a resonable circuit including inductance means and capacitance means coupled in electrical series with said inductance means, said electromagnet being coupled in electrical parallel with said capacitance means, said electromagnet changing the resonant condition of said resonable circuit upon engagement with said magnetic member, electrical indicating means inductively coupled to said inductance means, means for applying an alternating potential to said resonable circuit and for applying a direct potential to said electromagnet.

2. An operating and indicating system for an electromagnet adapted for engagement with an external magnetic member, said system comprising a resonable circuit including a transformer and capacitance means coupled in electrical series with the primary winding of said transformer, said electromagnet being coupled in electrical parallel with said capacitance means, said electromagnet changing the resonant condition of said resonable circuit upon engagement with said magnetic member, electrical indicating means coupled to the secondary winding of said transformer, and means for applying a fluctuating potential to said circuit and to said electromagnet.

3. An operating and indicating system for an electromagnet adapted for engagement with an external magnetic member, said system comprising a resonable circuit including a transformer and capacitance means coupled in electrical series with the primary winding of said transformer, said electromagnet being coupled in electrical parallel with said capacitance means, said electromagnet changing the resonant condition of said resonable circuit upon engagement with said magnetic member, electrical indicating means coupled to the secondary winding of said transformer, a rectifier bridge, circuit means for coupling said resonable circuit and said electromagnet to the output of said bridge, and additional circuit means for coupling the input of said bridge to a source of alternating potential.

4. An operating and indicating system having a plurality of electromagnets adapted for engagement with external magnetic members, respectively, said system comprising a like plurality of transformers having their primary windings coupled in electrical series with said electromagnets, respectively, capacitance means coupled in electrical series with each of said primary windings, said electromagnets being connected in electrical parallel with said capacitance means, respectively, each of said electromagnets changing the resonant condition of its associated resonable circuit upon engagement with its associated magnetic member, electrical indicating means connected, respectively, to the secondary winding of each transformer, and circuit means for connecting said resonable circuits and said electromagnets in a parallel relation with a common source of fluctuating potential.

5. An indicating and operating system for an electromagnet adapted for engagement with an external magnetic member, said system comprising a resonable circuit including capacitance means, said electromagnet being connected electrically to said resonable circuit, means for applying a fluctuating direct potential to said circuit and to said electromagnet so as to provide for lifting power derived substantially from direct flux, said electromagnet changing the resonant condition of said circuit upon engagement with said magnetic member, and means coupled with said circuit for indicating any change in its resonant condition.

6. An indicating and operating system for an electromagnet adapted for engagement with an external magnetic member, said system comprising a resonable circuit including capacitance means, said electromagnet being connected in electrical parallel with said capacitance means, a rectifier bridge, circuit means for coupling said circuit and said electromagnet to the output of said bridge so as to provide for lifting power derived substantially from direct flux, additional circuit means for coupling the input of said bridge to a source of alternating potential, said electromagnet changing the resonant condition of said circuit upon engagement with said magnetic member, and means coupled with said circuit for indicating any change in its resonant condition.

7. An operating and indicating system having a plurality of electromagnets each adapted for engagement with external magnetic members, respectively, said system comprising a like plurality of parallel connected resonable circuits each including capacitance means, said electromagnets being connected electrically to said resonable circuits, respectively, electrical indicating means coupled to said resonable circuits, respectively, means for applying a fluctuating direct potential to each of said resonable circuits so as to provide for direct flux lifting power, each of said electromagnets changing the resonant condition of its associated resonable circuit upon engagement with its associated magnetic member, and means coupled with each of said resonable circuits for respectively indicating any change in the resonant condition of said resonable circuits.

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