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54 **Circuit for the impulse-rate feeding of armoured electromagnets and electromagnets fed by such circuit.**

57 According to the invention an armoured electromagnet is obtained, including a preferably cylinder-shaped metal structure made of solid iron, within which there is a coil fed by a pulsating current with variable intensity, said current being at a maximum at start-off and at a minimum during the holding period, and being generated by an electronic circuit fed by alternate current by means of a normally closed electronic switch (40) with a delayed opening, and placed parallel to a capacitor (31), said bridge being fed at a reduced voltage when the electronic switch opens.

The invention is particularly efficient when applied to electromagnets with medium and small fields of force and traction. In the electromagnet according to the invention the ratio reached between the closing current and the current with the electromagnet in open position can even acquire a value of 1 to 30.

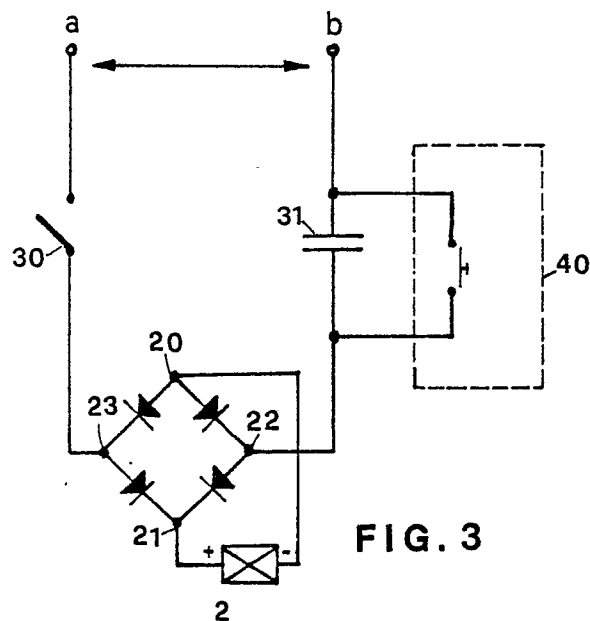


FIG. 3

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CIRCUIT FOR THE IMPULSE-RATE FEEDING OF ARMoured ELECTROMAGNETS AND ELECTROMAGNETS FED BY SUCH CIRCUIT

The invention concerns the realization of a circuit for the impulse-rate feeding of armoured electromagnets and of electromagnets fed by such circuit. The invention is particularly efficient when applied to electromagnets having small and medium traction fields of force.

It will be pointed out here that electromagnets are electromechanical devices which are used as driving units in different fields of application, such as automations, armour-plated doors, actuators, etc.

The currently known constructions are electromagnets having a cylindrical mobile core which are usually fed with direct current, or electromagnets fed with alternate current, but they are built with a frame and with a lamellar pack. In both of the just-mentioned constructions, the electromagnet coil is fed at a fixed voltage.

The distinctive and characteristic elements of each magnet are the maximum traction force which the electromagnet can exert in relation to the stroke of its mobile core and the maximum number of driving movements that can be performed within a predetermined period of time.

It will be pointed out that in the following description, the expression "electromagnet in closed position" will indicate the condition wherein the mobile core is drawn at the end of its stroke and the aircore is zero, while the expression "electromagnet in open position" will indicate the condition wherein the electromagnet is being fed and the mobile core must perform its stroke.

It is known that the current circulating within the coil of the electromagnet causes a heat dissipation, which besides wasting energy, also determines the limits in the performance of the electromagnet itself.

It will also be pointed out that, while the current required to move the core during the traction phase and to exert a certain force is significant, the current necessary to keep the magnet in its closed position is considerably reduced.

For instance, in the case of electromagnets, which are fed with alternate current, the current required when the electromagnet is in its closed position is 10 - 15 times lower than the current necessary to move the core during the traction phase. In fact, when the electromagnet is fed with alternate current, the current is higher when the electromagnet is in its open position, than when the electromagnet is in its closed position, since the inductance value is low when the electromagnet is open and high when the electromagnet is closed.

Therefore, it can be said that, in the case of

electromagnets which are fed with alternate current, a current drop will occur when the mobile core closes, due to the reactance change in the electromagnet circuit.

Even if there is self-limitation of the current in the closed position, the electromagnet which is fed with alternate current presents some serious construction limitations, due to the fact that the magnetic circuit must be built with laminated iron, in order to reduce the induced currents and, as a consequence, losses in the magnetic circuit; some riveting is also required to mechanically secure the lamellae, so that the construction is very expensive. During the operation of the electromagnet vibrations may easily occur and, in order to avoid the occurrence of said vibrations, it becomes necessary to insert into the magnetic circuits some adequate short-circuit windings.

All told, the alternate-current electromagnet presents considerable constructive as well as operative problems.

In the electromagnets of the cylindrical type which are fed with direct current, there are no vibrations since there are no voltage variations during the feeding process, but the main limit of the direct-current electromagnets consists in the fact that the current passing through the winding is practically constant during the entire operation, that is both during the opening and the closing of the electromagnet.

Since during the closing process the required current is high, and since said current remains unchanged during the entire closing time of the electromagnet, it can be clearly understood that the direct current electromagnets are suited to work in not-all-too hard cycles.

The purpose of the invention is that of obtaining a simply constructed electromagnet with reduced dimensions and high-level operations both concerning the traction capacity and the number of cycles which it can withstand.

Another purpose is that of obtaining an electromagnet fed by an alternate-current source, wherein the coil is passed through by high current in the opening phase, so that said electromagnet may develop a considerable traction force and that, at the same time, the current may be reduced to the minimum necessary to maintain the closed position, in order to avoid energy waste and damaging high temperatures which limit its functional performance. That is, the proposed construction should guarantee a high ratio between the traction current and the closing current.

Yet another purpose is that of making an elec-

tromagnet available, the construction of which is to be considerably simplified both from the mechanical and the electrical point of view, in comparison with electromagnets giving equal performances.

All above-mentioned purposes are reached by an armoured electromagnet which, in accordance with the patent claims, includes a metal, preferably cylindrical, structure, consisting of a cylindrical container, inside which there is an axial opening wherein the mobile core, which is also cylindrical, slides and wherein said coil is characterized in that it is fed by an impulse-rating current with variable intensity supplied by an electronic circuit, fed with alternate current.

According to the invention the terminals of the coil of the electromagnet are connected with the nodes of a diode bridge which is fed through a normally closed electronic switch, connected parallel to a capacitor.

When the feeding circuit is run through by alternate current, the electronic switch which is normally closed, represents a short circuit and the bridge is, therefore, fed by all the alternate current. Because of this a rectified and pulsating current will operate in the electromagnet coil; this will be the maximum current and, therefore, the maximum possible traction force of the electromagnet will develop. Since the normally closed electronic switch has a delayed opening, when said switch is run through by current, it will open after a certain programmable period of time and at the terminals of the diode bridge a reduced voltage will operate due to the voltage drop which will operate in the capacitor placed in parallel to the feeding source of the bridge. The voltage which is reduced at the terminals of the rectifying bridge will cause the coil to be fed at a reduced current. The current drop is also promoted by some special construction expedients concerning the cylindrical geometry of the electromagnet, the choice of a type of iron having a special magnetic permeability and the reduction of the air cores of the yoke between the core and the bottom of the external cylindrical housing.

It is obvious that if the opening of the electronic switch has been programmed for a period of time sufficient to allow the closing of the mobile core of the electromagnet, immediately after the closing a minimum current will operate which will be sufficient to keep the electromagnet in the closed position. Since the closing time will amount to a few hundredths of a second, it can easily be understood that the maximum current running through the coil will circulate for a very short period of time, so that the coil can withstand high currents without suffering any damage.

Tests performed on a prototype have led to the conclusion that the ratio between the current with the electromagnet in the closed position and the

current with the electromagnet in the open position in the construction according to the invention easily reaches the value of 1:30.

Thus the advantage of the invention becomes obvious, since, as had previously been pointed out, the ratios between the closing current and the opening current in the known direct current devices reach a value of 1:1 and the alternate-current ones reach a maximum value of 1:10-15.

It will be pointed out that the dimensioning of the electromagnet will be dictated by the opening current necessary to develop in the coil a magnetic force exceeding the re-calling force applied to the mobile core. As far as the current keeping the closed position is concerned, it is reduced because of the zero air-core.

In the substance, while it is necessary to bring into play high currents to close the electromagnet, only reduced currents are necessary to keep it in its closed position and that is why the advantage offered by the device according to the invention becomes even more significant, since the ratio between the closing current and the opening current is in the range of 1:30. As a consequence of the drastic reduction of current when the magnet is in its closed position, it follows that the holding position of the mobile core can be kept for an indefinite period of time, without any negative consequence for the device.

It will also be pointed out that the combination of the above-mentioned electromagnet characteristics, together with the mechanical characteristics concerning the compactness and the construction simplicity of the electromagnet, make the electromagnet according to the invention particularly advantageous when it is used in the robotic field and, in general, in the field of motion-mechanisms, where high performances and minimum dimensions are required.

Other advantages and characteristics will be better understood from the description of a preferred form of execution of the invention, which is given by way of explanation only, but is not meant to limit the scope of the invention and is illustrated in the enclosed tables of drawing, wherein:

- Fig. 1 represents a view of the electromagnet according to the invention;
- Fig. 2 is a cross-section of the electromagnet of Fig. 1;
- Fig. 3 shows the plan of the feeding circuit of the electromagnet according to the invention.

With reference to the above-mentioned Figures, it can be observed that the electromagnet consists of a cylinder-shaped housing made by cutting a normal tube available on the market, into which a coil 2 is inserted. Said coil 2 is anchored on the ring-shaped projection 3 of lid 4 closing one

end of the housing. Another lid 5 closes the bottom part of the electromagnet. The mobile core 6 is a solid metal cylinder which is inserted into the central opening of coil 2 and, as can be observed in Fig. 2, it can slide within the space comprised between the bottom of lid 4 and the C-shaped stroke-stop, indicated with 8, which is connected with housing 1.

Over the electromagnet, on top of lid 4, there is a box 9 containing the electromagnet circuit which feeds coil 2.

As can be observed in Fig. 3, coil 2 of the electromagnet is fed at the terminals 20 and 21 of the diode-bridge.

At the terminals A and B of the circuit feeding the diode-bridge an alternate current is applied and when the closing of the manual switch 30 is achieved, since the electronic switch 40 is normally closed, all the tension present between the terminals A and B will set on the terminals 22 and 23 of the diode-bridge.

Because of the effect of the diode bridge, coil 2 is run through by a rectified pulsating current which is approximately equal to the voltage applied to the terminal 22 and 23 of the diode bridge, divided by the resistance of coil 2 of the electromagnet. After the mobile core 6 has closed on bottom 3 of lid 4, the electronic switch 40 will open, and its opening causes a voltage drop at the terminals of capacitor 31.

Thus the purpose of feeding the electromagnet according to the invention at different current rating is fulfilled with the previously described advantages.

The electronic switch 40 which is normally closed and has a delayed opening, will not be further described, since it is a device known to people who are knowledgeable in this field.

It will then be understood that, by adjusting the delayed opening for the period of time sufficient for the mobile core 6 to run the closing stroke of the electromagnet, it is possible to limit the circulation of the maximum current within the coil to the strictly necessary period of time, while during the entire period in which the electromagnet remains in its closed position, the current is reduced to a minimum, which allows to limit to a minimum the effects of the circuit heating, caused by current circulation and with the consequence of reducing to a minimum the dimensions of the circuit.

Here it is also necessary to point out the simplicity of construction of the electromagnet according to the invention which, because it is fed with a rectified current, can be made from a tube or, in any case, of a compact iron material, without any need for magnetic lamellar constructions in order to avoid spurious currents due to the circulation of alternate currents.

In reality the housing of electromagnet 1 is a tube which can readily be found on the market; it is cut at its ends and closed with two simple, easily manufactured caps. Moreover, the electronic circuit shown in Fig. 3, adequately miniaturized, is placed in box 9 on top of the electromagnet, so that a compact construction with minimum overall dimensions is obtained.

It can be understood that the proposed construction not only offers electrical and mechanical operational advantages, but it is also manufactured at considerably lower costs in comparison with the costs of electromagnets offering equivalent performances, manufactured with the technique known up to now.

Claims

1) An armoured electromagnet including a preferably cylinder-shaped metal structure made of solid iron, within which there is a coil (2) fed by electric current and presenting an axial opening wherein a mobile core - also in a cylinder shape - slides, characterized in that the coil (2) of said electromagnet is fed by a pulsating current with variable intensity, the current being at a maximum at start-off and at a minimum during the holding period, said current being generated by an electronic circuit, fed by alternate current.

2) An electromagnet according to Claim 1, characterized in that the coil (2) of said electromagnet is connected with a diode bridge which is fed with all the outside alternate current by means of a normally closed electronic switch (40) having a delayed opening and being positioned parallel to a capacitor (31), said bridge being fed at a reduced rating when the electronic switch opens.

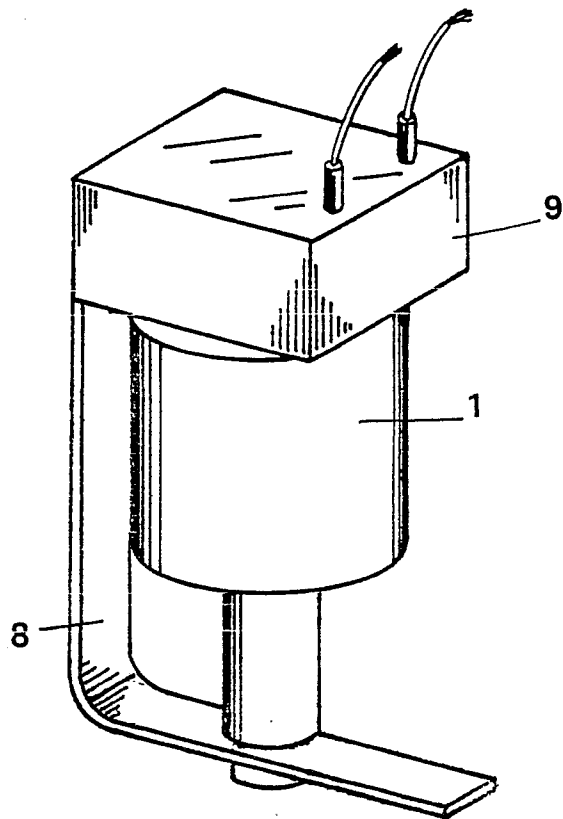


FIG. 1

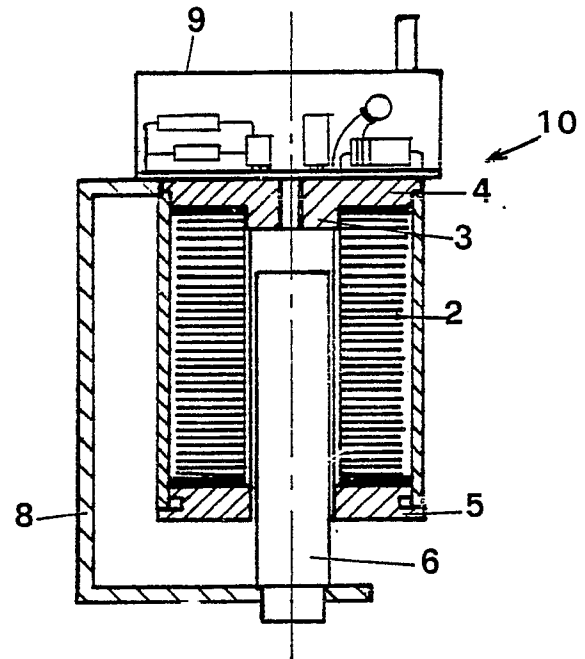


FIG. 2

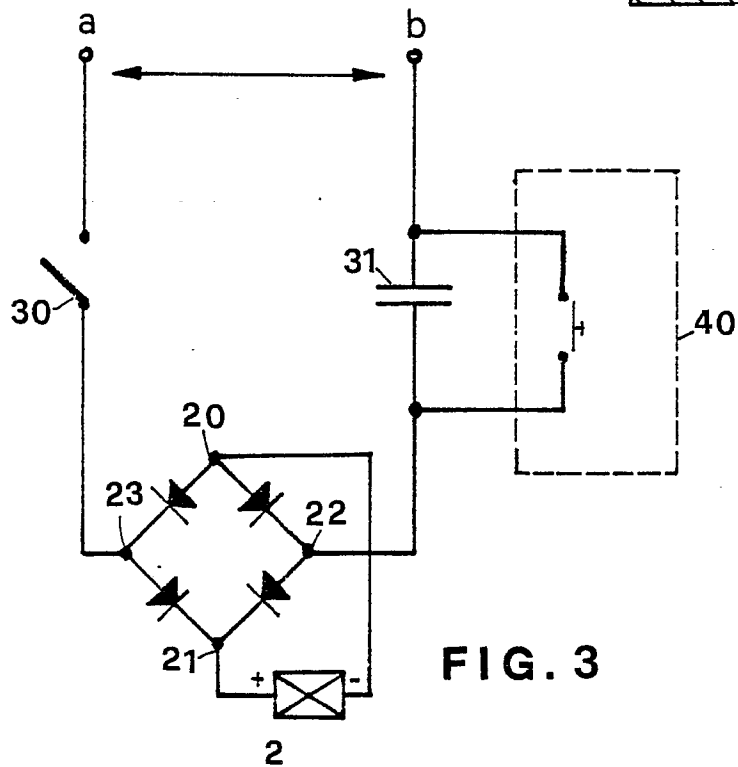


FIG. 3



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
X	PATENT ABSTRACTS OF JAPAN, vol. 6, no. 170 (E-128)[1048], 3rd September 1982; & JP-A-57 88 707 (MITSUBISHI DENKI K.K.) 02-06-1982 * Abstract * ----	1,2	H 01 F 7/18
A	DE-A-2 545 878 (PHILIPS PATENTVERWALTUNG GmbH) ----		
A	EP-A-0 177 215 (VENT-AXIA Ltd) ----		
A	GB-A-1 476 102 (LA TELEMECANIQUE ELECTRIQUE) -----		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 12-12-1988	Examiner VANHULLE R.
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