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3,391,307

CAPACITOR FED ELECTROMAGNETIC WINDING ARRANGEMENT

Filed Jan. 13, 1967

FIG. 1

PRIOR ART

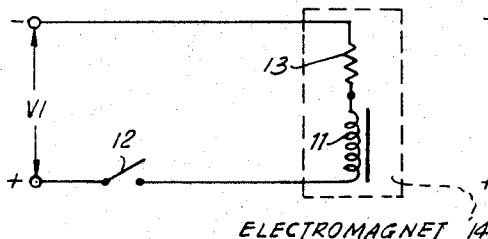


FIG. 2

PRIOR ART

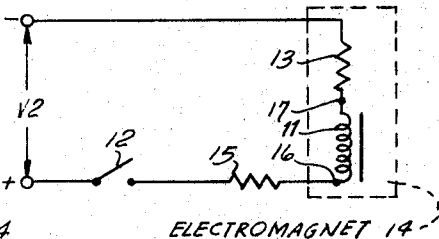


FIG. 3

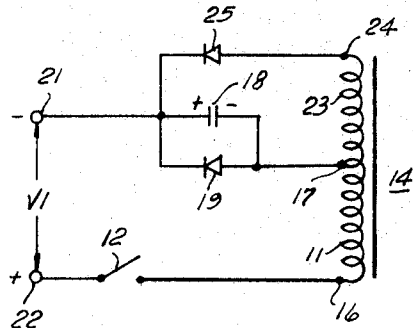


FIG. 4

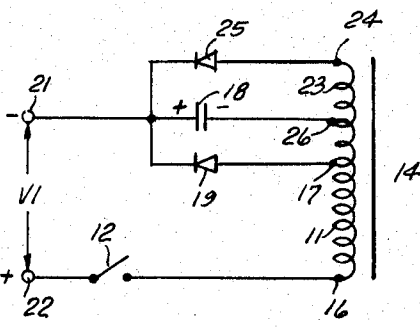


FIG. 5

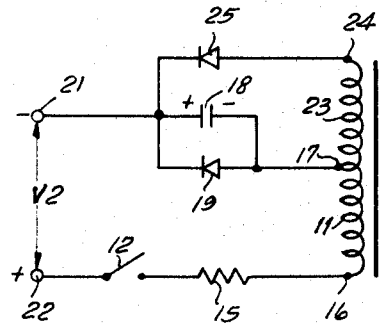
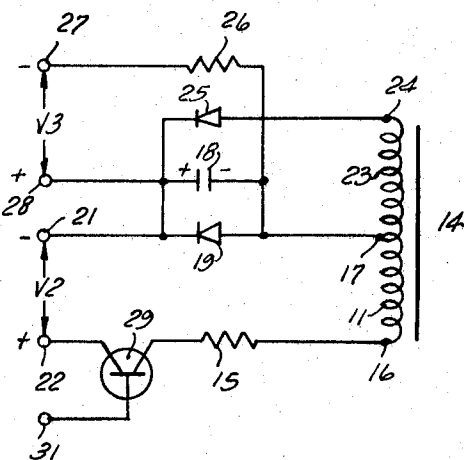


FIG. 6



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CAPACITOR FED ELECTROMAGNETIC WINDING ARRANGEMENT

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Continuation-in-part of application Ser. No. 468,700, July 1, 1965. This application Jan. 13, 1967, Ser. No. 617,747

Claims priority, application Germany, July 1, 1964, M 61,577

7 Claims. (Cl. 317-151)

ABSTRACT OF THE DISCLOSURE

The voltage energizing an electromagnetic winding is increased by the discharge of a condenser, which is charged by an auxiliary winding when the circuit of the electromagnetic winding is interrupted by a switch.

Cross-reference to a related application

The present application is a continuation-in-part application of my copending application Ser. No. 468,700, entitled, "Circuit Arrangement for Rapid Energization of an Electromagnetic Winding," filed July 1, 1965, now abandoned.

Background of the invention

The present invention relates to an excitation circuit for an electromagnetic winding of the type used for carrying out the selection of needles in a knitting machine.

A circular knitting machine utilizing electromagnetic windings for the needle selection is disclosed in the U.S. Patent No. 3,170,312.

The Swiss Patent 396,284, and the German Auslegeschrift 1,223,984 disclose electromagnetic needle selector devices. In the latter construction, resilient wires cooperate with the needles, and are shifted between selecting and nonselecting positions by an electromagnetic selector. An electromagnetic selector performing this function requires a very high current, and must have an operation frequency of several hundred Hz. since a circular knitting machine with 1680 needles rotating at 18 revolutions per minute, requires a needle selection within a time period of less than 1 millisecond.

The German Auslegeschrift 1,073,587 discloses an arrangement in which an electromagnet having a low holding current, is excited by the discharge of a condenser which is shunted by a diode in blocking direction and connected with the working winding of the electromagnet in series with the same, with the operating switch, and the source of voltage so that the voltage of the source is increased by the voltage of the condenser whereby upon connection of the working windings of the electromagnet, the working winding its first supplied with the total voltage, and after the discharge of the condenser with the voltage of the voltage source through the diode. In this circuit, the maximum number of operations is less than 10 Hz., so that the circuit cannot be used for selecting operations in a high speed knitting machine.

Summary of the invention

It is one object of the invention to provide a circuit arrangement for the rapid energization of an electromagnetic winding which is simple, but effective, efficient and reliable in operation.

It is another object of the invention to provide a circuit for the energization of an electromagnetic winding which is operable at very high frequency and requires a minimum energization current.

With these objects in view, the present invention relates to a circuit arrangement for the rapid energization of an

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electromagnetic winding having a high self-induction, such as, for example, an electromagnetic selector for a knitting machine. The circuit arrangement of the invention is particularly adapted to rapidly energize the electromagnetic selectors of a circular knitting machine in accordance with a program on a program carrier, such as a punched tape.

One embodiment of the invention comprises an electromagnetic winding, a condenser connected to a terminal of the winding; a source of electric energy connected with the winding through the condenser; switch means connecting the source with the electromagnetic winding in such a manner that upon closing of the switch means, the condenser discharges through the electromagnetic winding; shunt means, preferably a diode, across the condenser; and charging means, preferably an auxiliary winding located in the field of the electromagnetic main winding, for charging the condenser when the switch means is opened.

Due to the fact that the voltage of the source is increased by the discharge of the condenser, the current of the electromagnetic winding is reduced as compared with a circuit in which the electromagnetic winding is excited only by the source. Consequently, in accordance with the invention, for the same number of ampere windings and for the same excitation speed, the electromagnetic main winding can have a greater number of turns or windings.

Assuming a sufficiently high frequency of required operations, the rectifier or transformer of the source of voltage need not be larger, heavier and more expensive than in known needle selector arrangements whose electromagnets are not operated in accordance with the circuit of the present invention. Furthermore, the transistors of the electronic control circuit of the selector arrangement of the knitting machine, can be smaller, less expensive, and provided with smaller cooling surfaces as compared with the prior art constructions, so that in the same space, a far greater number of transistors can be arranged, which compensates the expense of the additional diodes and condensers required in the circuit of the present invention.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

Brief description of the drawing

FIG. 1 is a circuit diagram of an embodiment of a prior art arrangement for energizing an electromagnetic winding;

FIG. 2 is a circuit diagram of an embodiment of a prior art arrangement for rapid energization of an electromagnetic winding;

FIG. 3 is a circuit diagram of an embodiment of the arrangement of the present invention for the rapid energization of an electromagnetic winding;

FIG. 4 is a modification of the embodiment of FIG. 3; FIG. 5 is another modification of the embodiment of FIG. 3; and

FIG. 6 is still another modification of the embodiment of FIG. 3.

The same components are identified by the same reference numerals in the drawing.

Description of the preferred embodiments

A circular knitting machine utilizing electromagnetic windings of the type improved by the circuit arrangement of the present invention is disclosed in United States Patent No. 3,170,312. In the knitting machine disclosed by said patent, a plurality of electromagnetic selectors

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are utilized to perform mechanical functions. There are a plurality of pattern wheels, each wheel being rotated by a corresponding one of the electromagnetic selectors. Any desired pattern is produced by the machine in accordance with the rotation of the pattern wheels under the control of the corresponding electromagnetic selectors. Each pattern wheel supports a plurality of knitting needles.

The electromagnetic selectors may be positioned in any suitable relationship to the pattern wheels or to the needles supported by the needle cylinder, and an electromagnetic selector may be positioned at each knitting position. This would enable each knitting needle to be independently controlled and would enable the needles to remain in their rest positions, if desired. The selection and operation of the knitting needles must be accomplished with exceptional rapidity, especially during the actual knitting operation of the machine, during which the knitting needles are moved.

In a circular knitting machine of, for example, 30 inch diameter, having 1,680 knitting needles and operating at 18 revolutions per minute, the time available for selection of the needles by the electromagnetic selectors is 1.8 milliseconds, regardless of the positioning of the electromagnetic selectors around the pattern wheels, at each knitting needle or in other arrangements.

The circuit arrangement of the present invention is especially adapted to operate or move the knitting needles of the machine in a desired pattern by rapid energization of the electromagnetic selectors or windings. The circuit arrangement of the present invention provides rapid energization of an electromagnetic winding and a plurality of circuit arrangements of the present invention provide rapid energization of a corresponding plurality of electromagnetic windings, thereby providing a rapid control operation at knitting stations which follow each other rapidly in succession. The successive needle control operations may follow each other in fractions of a second under the control of the circuit arrangement of the present invention. The energized electromagnetic windings usually perform their functions when they are energized and are usually at rest or inoperative when they are unenergized.

An electromagnetic winding of the type of the electromagnetic selector is highly self-inductive. The time required for the current to rise in the winding of an electromagnet is determined by the time constant t . The time constant t equals the self-inductance L of the winding divided by the resistance R of the winding.

FIG. 1 is a circuit diagram of a prior art arrangement for energizing an electromagnetic winding. In FIG. 1, an energization voltage V_1 is applied to an electromagnetic winding 11 through a switch 12. The resistance presented by the winding 11 is illustrated separately from said winding as a resistor 13. The winding 11 is the energizing winding of an electromagnet indicated generally as 14. The time constant t for the current rise in the electromagnetic winding 11 equals the self-inductance L_{11} of the winding divided by the resistance R_{11} of the winding.

FIG. 2 is a circuit diagram of a prior art arrangement for the rapid energization of an electromagnetic winding. In FIG. 2, a resistor 15 is connected between the switch 12 and one end terminal 16 of the electromagnetic winding 11. The resistance of the winding 11 is illustrated as a separate resistor 13 connected to the other end terminal 17 of said winding. An energization voltage V_2 is applied to the winding 11 through the switch 12 and the resistor 15 connected in series with said switch. The energization voltage V_2 is of greater magnitude than the energization voltage V_1 .

Since the energization voltage V_2 is of greater magnitude than the energization voltage V_1 , the same energizing current flows through the electromagnetic winding 11, despite the connection of the resistor 15 to said

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winding, as flows through said winding in the circuit of FIG. 1. The time constant t for the current rise in the electromagnetic winding 11 in the circuit of FIG. 2 equals the self-inductance L_{11} of the winding divided by the sum of the resistance R_{11} of the winding and the resistance R_{15} of the resistor 15. The time constant t is thus varied inversely as the resistance of the resistor 15. Although the circuit of FIG. 2 provides rapid energization of the winding 11 due to the resistance of the resistor 15, which reduces the time constant t , it also produces a high loss in said resistor.

FIG. 3 is a circuit diagram of an embodiment of the present invention. The circuit arrangement of FIG. 3 provides rapid energization of the electromagnetic winding 11 without producing a high loss. The energy required for rapid energization of the electromagnetic winding 11 is provided by a condenser 18 shunted by a diode 19 connected in blocking relation to the negative polarity terminal of the energization voltage V_1 . The energization voltage V_1 may be provided by any suitable source of electrical energy and is applied to terminals 21 and 22, the terminal 21 being indicated as the negative polarity terminal and the terminal 22 being indicated as the positive polarity terminal.

The diode-shunted condenser 18 is connected between the energization voltage terminal 21 and the end terminal 17 of the electromagnetic winding 11. Since the energization voltage V_1 , the switch 12, the electromagnetic winding 11 and the diode-shunted condenser 18 are connected in series circuit arrangement, the energization voltage is increased by the voltage of said condenser. When the switch 12 is closed, the condenser 18 discharges and supplies the energization current to the winding 11. After discharge of the condenser 18, the energization voltage V_1 supplies the energization voltage of the winding 11 via the diode 19.

An auxiliary winding 23 extends coaxially from the winding 11 and is connected to the end terminal 17 of said winding 11 so that said auxiliary winding 23 has end terminals 17 and 24. The auxiliary winding 23 is connected in series with a second diode 25 and the series connection of said auxiliary winding and said second diode is shunted across the condenser 18. The second diode 25 is connected in blocking relation to the negative polarity terminal 21 of the energization voltage V_1 , as is the first diode 19. Thus, each of the first and second diodes 19 and 25 is connected with its cathode connected to the terminal 21 of the input voltage and with its anode connected to an end terminal of the auxiliary winding 23, the anode of the first diode 19 being connected to the common terminal 17 of the winding 11 and the auxiliary winding 23 and the anode of the second diode 25 being connected to the end terminal 24 of the auxiliary winding 23.

When the switch 12 is opened, the magnetic field, produced by the winding 11 during the period that said switch was closed, collapses and induces a voltage surge in the auxiliary winding 23. The voltage surge induced in the auxiliary winding 23 charges the condenser 18 through the second diode 25. The condenser 18 is then recharged and ready for operation in the aforescribed manner the next time the switch 12 is closed.

The circuits illustrated in FIGS. 3 and 4 assure that an electromagnetic selector will operate at the required excitation speed and frequency and with the required power.

However, the circuit also obtains an additional advantageous result, namely the reduction of the current required for the excitation of the electromagnetic winding 11.

Due to the fact that the voltage exciting the electromagnetic winding 11 is increased over the voltage V_1 of the voltage source 21, 22 by the discharge of condenser 18, a smaller current in the electromagnetic winding 11 will produce the same power as when the electromagnetic

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winding 11 were energized by the voltage source 21, 22 without the condenser. Consequently, for the same number of ampere windings, the number of turns of the electromagnetic winding 11 can be increased to be a multiple x , wherein the factor x is related to the amount of the reduction of the current in the winding 11 due to the voltage added by the discharging condenser to the voltage V1.

FIG. 4 is a modification of the embodiment of FIG. 3. In the modification of FIG. 4, the condenser 18 is connected between the input voltage terminal 21 and a tap 26 on the auxiliary winding 23. The first diode 19 is connected to the common end terminals 17 of the winding 11 and the auxiliary winding 23 and the series connection of said first diode and the portion of the auxiliary winding 23 between the tap 26 and the end terminal 17 is shunted across the condenser 18. The second diode 25 is connected to the end terminal 24 of the auxiliary winding 23 and the series connection of said second diode and the portion of the auxiliary winding between the end terminal 24 and the tap 26 is shunted across the condenser 18.

In the modification of FIG. 4, the discharge current of the condenser flows through the portion of the auxiliary winding 23 between the tap 26 and the end terminal 17, as well as through the electromagnetic winding 11 until the condenser has discharged and energizing voltage is supplied to said winding 11 by the energization voltage V2 through the first diode 19. The charging of the condenser 18 by the auxiliary winding 23 through the second diode 25 is the same as in the embodiment of FIG. 3.

FIG. 5 is another modification of the embodiment of FIG. 3. The circuit of FIG. 5 is the same as the circuit of the embodiment of FIG. 3, except for the connection of the resistor 15 in series between the switch 12 and the end terminal 16 of the electromagnetic winding 11. The resistor 15, as utilized in the known circuit of FIG. 2, makes the rapid energization of the winding 11 by the circuit arrangement of the present invention even more rapid when utilized in the circuit of FIG. 3, as shown in FIG. 5. In the modification of FIG. 5, an energization voltage V2 of increased magnitude is utilized instead of the energization voltage V1 and is applied to the input terminals 21 and 22. The resistor 15 and the increased magnitude energization voltage V2 function, as in the known circuit of FIG. 2, to decrease the rise time of the current in the same manner as in said known circuit.

FIG. 6 is still another modification of the embodiment of FIG. 3. In the modification of FIG. 6, the condenser 18 is shunted by the first diode 19 between the input terminal 21 and the common end terminals 17 of the winding 11 and the auxiliary winding 23, as in FIG. 5. The second diode 25 is connected in series with the auxiliary winding 23 and the series connection is shunted across the condenser 18, as in FIG. 5. A distinction of FIG. 6 over FIG. 5 is that the condenser 18 is charged by an auxiliary source of electrical energy V3 applied to said condenser via a high resistance resistor 26 connected in series with said condenser and applied to input terminal 27 and 28. The auxiliary energy source V3 charges the condenser 18 prior to the operation of the circuit to energize the electromagnetic winding 11.

Another distinction of the modification of FIG. 6 over the modification of FIG. 5 is the utilization of a transistor 29 as a switch instead of the switch 12. The transistor 29 functions as a switch under the control of a control signal supplied to the base of said transistor via an input terminal 31. The auxiliary energy source V3 also functions to prevent the discharge of the condenser 18 through the transistor 29 and to prevent discharge of said condenser through faulty insulation.

The circuit arrangement of the present invention may be utilized to rapidly energize pulse-driven stepping motors having limited step frequency and overcomes the mechanical inertia of the rotor of such motor as well

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as any electrical inertia in any windings of such motor.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of energization arrangements for electromagnetic windings differing from the types described above.

While the invention has been illustrated and described as embodied in an electromagnetic winding having an excitation circuit including a condenser charged upon interruption of the circuit, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. A circuit arrangement for rapid energization of an electromagnetic main winding having two end terminals, comprising a condenser connected to an end terminal of said electromagnetic main winding; a source of electrical energy having one polarity terminal connected to said end terminal of said electromagnetic main winding through said condenser and another polarity terminal; a switch connected between the other polarity terminal of said source of electrical energy and the other end terminal of said electromagnetic main winding, said switch being connected in series circuit arrangement with said condenser and said source of electrical energy for closing said circuit arrangement to permit the discharge of said condenser through said electromagnetic main winding when said switch is closed whereby the voltage energizing said main winding is greater than the voltage of said source, and the current in said main winding is reduced; a first diode connected in blocking direction across said condenser for energizing said electromagnetic main winding from said source of electrical energy when said switch is closed; and charging means for charging said condenser when said switch is opened, said charging means comprising an auxiliary winding connected in series with said electromagnetic main winding, a second diode connected in blocking direction in series with said auxiliary winding and means connecting the series connection of said auxiliary winding and said second diode across said condenser, said electromagnetic main winding producing an energy surge when said switch is opened and inducing said energy surge in said auxiliary winding.

2. A circuit arrangement as claimed in claim 1 wherein for a predetermined excitation speed and required number of ampere windings, said electromagnetic main winding has a number of turns which is a multiple x of the number of turns required by the voltage of said source; and wherein x is related to the amount of the reduction of the current in said main winding due to the voltage added by the discharging condenser to the voltage of said source.

3. A circuit arrangement as claimed in claim 1, wherein said auxiliary winding and said electromagnetic main windings are substantially coaxially positioned and have a common end terminal.

4. A circuit arrangement as claimed in claim 1, wherein said charging means comprises an auxiliary source of electrical energy connected across said condenser, said auxiliary source of electrical energy applying electrical energy to said condenser when said switch is opened.

5. A circuit arrangement as claimed in claim 1, further comprising a resistor connected between said switch

and the other end terminal of said electromagnetic main winding.

6. A circuit arrangement as claimed in claim 1 wherein said auxiliary winding has a tap; and wherein said condenser is connected to said tap of said auxiliary winding.

7. A circuit arrangement as claimed in claim 6 wherein for a predetermined excitation speed and required number of ampere windings, said electromagnetic main winding has a number of turns which is a multiple x of the number of turns required by the voltage of said source; and wherein x is related to the amount of the reduction of the current in said main winding due to the voltage added by the discharging condenser to the voltage of said source.

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