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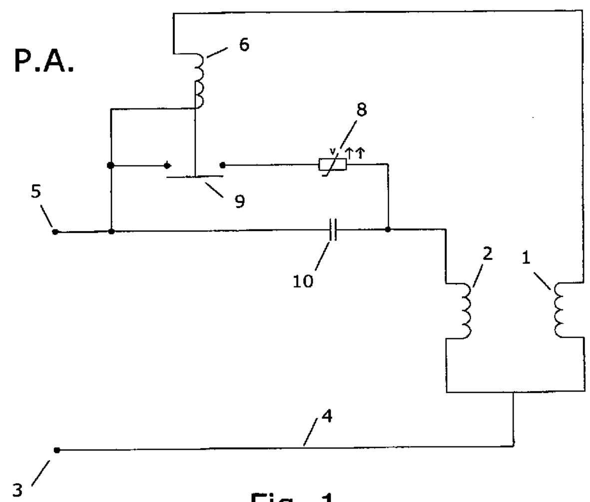

Fig. 1

(57) Abstract: The invention provides an AC single phase induction motor with a main winding and an auxiliary winding. The motor comprises a switch arranged to short circuit a run capacitor. To provide variable run capacitance, the motor further comprises an additional run capacitor inserted serially with respect to the other run capacitor, and the switch short circuits one of the capacitors.

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AN AC SINGLE PHASE INDUCTION MOTOR, A DEVICE FOR OPERATING A SINGLE PHASE INDUCTION MOTOR, AND A COMPRESSOR WITH SUCH A MOTOR OR DEVICE

INTRODUCTION

The invention relates to an AC single phase induction motor comprising a main winding and an auxiliary winding. In particular, the invention relates to an induction motor with a first connection structure for connecting the main winding between a supply phase and ground of a power supply, and a second connection structure for connecting the auxiliary winding between the supply phase and ground of the power supply.

BACKGROUND OF THE INVENTION

Single phase induction motors with a relay for activating or deactivating a run capacitor during operation.

A single phase motor is a rotating machine that has both main and auxiliary windings and a squirrel-cage rotor. The most common types of single phase motors are the split-phase, capacitor-start, capacitor-run, and capacitor-start capacitor-run. Supplying of both main and auxiliary windings enables the single phase machine to be driven as a two-phase machine.

Often, the motors are connected to a power supply via a relay which activates or deactivates the run capacitor in operation.

In a known motor, the above mentioned second connection structure comprises first and second paths extending in parallel between the supply phase and the auxiliary winding. The first of these two paths comprises a run capacitor and the second path may comprise a variable resistance, e.g. a PTC. A relay function disables electrical conductance in the second path unless the current in the main winding is above a certain limit, and the second path therefore only conducts when the motor draws a relatively high current.

DESCRIPTION OF THE INVENTION

It is an object of embodiments of the invention to provide an improved motor and device for operating a motor.

Accordingly, the invention, in a first aspect, provides an AC single phase induction motor comprising a main winding, an auxiliary winding, a first connection structure for connecting the main winding between a supply phase and ground of a power supply, and a second connection structure for connecting the auxiliary winding between the supply phase and ground of the power supply, the second connection structure comprising first and second paths extending in parallel between the supply phase and the auxiliary winding, where the first path comprises a run capacitor and the second path comprises a resistance, the motor further comprising a switch arranged to enable conduction in the second path in a closed configuration and to disable conduction in the second path in an open configuration, the switch being movable between the open and closed configurations depending on a current in the first connection structure, characterised in that the second connection structure further comprises an additional run capacitor in serial with the run capacitor in the second path and a bridge connecting the paths between first and second connecting points, the first connecting point being between the switch and the resistance and the second connecting point being between the run capacitor and the additional run capacitor.

Due to the additional run capacitor and corresponding bridge, the auxiliary winding is powered through a set of two serially connected run capacitors when the switch is in the open configuration.

According to well established capacitor theory, two serially connected capacitors provide a capacitance which is lower than the capacitance of at least one of the capacitors. If e.g. each run capacitor has a capacitance of 4 μF, then the comparable capacitance of the two serially connected capacitors become 2μF. Accordingly, the motor can very its run capacitance depending on the current drawn by the main winding which current activates and deactivates the relay.

Resultatet er en lastafhængig virkningsgrad En høj last resulterer i en høj condensatorværdi og dermed en tilpasset høj virkningsgrad og en lav last resulterer i en lav condensatorværdi som dermed er optimal for lav-last-situationen og derved igen giver en høj virkningsgrad.

Når lasten er høj forøges motorens drejningsmoment samtidig, dette er fordelagtigt netop når lasten er høj. Denne funktion er allerede patenteret men i en version hvor man parallelkobler condensatorer hvilket medfører et behov for en anden relæopbygning.

"a first connection structure" herein refers to a structure of conductors for connecting the main winding between a supply phase and ground of a power supply,

"a second connection structure" herein refers to a structure of conductors for connecting the auxiliary winding between a supply phase and ground of a power supply. The structure may share conductors with the first connection structure whereby some electrically conductive elements both form part of the first and the second connection structures.

"first and second paths" herein refers to conductive paths forming part of the second connection structure. In particular the second path may also form part of the first connection structure. The first and second paths are mentioned to extend in parallel between the supply phase and the auxiliary winding. I.e. the auxiliary winding can be powered via one or both of the first and second paths depending on the configuration of the switch. The motor may in addition comprise further paths.

"run capacitor" herein refers to any kind of capacitor suitable for running the motor.

"start capacitor" herein refers to any kind of capacitor suitable for starting the motor.

"a resistance" herein refers to a component providing an ohmic resistance. The resistance according to the invention may in particular be a variable resistance.

"a variable resistance", herein refers to a resistance which can vary, e.g. depending on the current running trough the resistance, a temperature of the resistance or a resistance which is changed based on duration of a time period. A PTC is an example of a variable resistance since the resistance increases by increasing temperature, but other resistances may also be chosen.

"a switch" herein refers to any kind of structure providing at least two configurations where conduction in the second path is enabled in one of the configurations and disabled in the other configuration. The switch may be a traditional switch or it may form part of a relay, e.g. a transistor based relay. Accordingly, the mentioning of "the switch being movable" may embrace larger movement of a switching elements relative to contact points, or it may embrace microscopic switching, e.g. in a CPU etc.

"a bridge" herein refers to a conductive connection between the first and second paths. If the resistance in the second path is high, the motor can be powered through run capacitor when the switch is closed and though the additional run capacitor in series with the run capacitor when the switch is open.

In accordance with the invention, the first connection structure may form a coil which can generate a magnetic field based on conduction of a current in the first connection structure, the coil being arranged relative to the switch such that the configuration can be changed by use of the magnetic field such that the configuration of the switch depends on the current in the first connection structure.

By including the coil in the second path, a further advantage is achieved since the additional run capacitor may thereby be discharged via the coil if the switch is moved from the open to the closed configuration at a moment where the additional run capacitor is charged. In this regards, the switch may preferably be located in the second path between the coil and the bridge so that the switch does not influence anything but the current between the coil and the auxiliary winding.

For discharging the additional run capacitor in a controlled manner, the motor may further comprise an additional resistance located in the second path between the supply phase and the switch. In this case, the aforementioned coil need not necessarily to be included in the second path since the discharged power from the additional capacitor is absorbed by the additional resistance. As an alternative to the coil or to the additional resistance, the second path may include any kind of suitable power consumer for discharging the additional capacitor when the switch moves to the closed configuration, e.g. a coil or a traditional resistor.

The motor may further comprise an additional switch arranged to enable conduction in the second path in a closed configuration and to disable conduction in the second path in an open configuration, the additional switch being movable between the open and closed configurations depending on a current in the first connection structure, and the additional switch being located in the second path between the bridge and the resistance. In this case, the additional switch may, in its open configuration prevent a current though the resistance while conduction is enabled in the first part of the second path from the supply phase through the bridge to the first path.

The first connection structure may form an additional coil which can generate a magnetic field based on conduction of a current in the first connection structure, the additional coil being arranged relative to the additional switch such that the configuration of the additional switch can be changed by use of the magnetic field generated by the additional coil.

Again to ensure power consumption for discharging the additional capacitor, the second path may include also the additional coil.

In addition to the two run capacitors, the motor may also comprise a start capacitor arranged in the second path between one of the switches and the auxiliary winding. The start capacitor provides increased torque during startup. During startup, i.e. before the PTC temperature has increased, conduction though the PTC and start capacitor increases the starting torque and the PTC switches off the current when its temperature increases so that the increased starting torque terminates.

In a second aspect, the invention provides a device for operating an AC single phase induction motor which has a main winding and an auxiliary winding. The device according to the second aspect comprises a first connection structure for connecting the main winding between a supply phase and ground of a power supply, and a second connection structure for connecting the auxiliary winding between the supply phase and ground of the power supply, the second connection structure comprising first and second paths extending in parallel between the supply phase and the auxiliary winding, where the first path comprises a run capacitor and the second path comprises a resistance, the device further comprising a switch arranged to enable conduction in the second path in a closed configuration and to disable conduction in the second path in an open configuration, the switch being movable between the open and closed configurations depending on a current in the first connection structure, characterised in that the second connection structure further comprises an additional run capacitor in serial with the run capacitor in the second path and a bridge (12) connecting the paths between first and second connecting points, the first connecting point being between the switch and the resistance and the second connecting point being between the run capacitor and the additional run capacitor.

The device may further comprise any of the features described relative to the first aspect of the invention.

In a refrigeration system, it is typical that the loading of the compressor changes depending on e.g. metrological conditions or depending on the amount of items being arranged in or removed from the refrigeration system. The loading therefore changes in an unforeseeable manner. In a third aspect, the invention provides a compressor comprising a motor or a device as described above. This compressor could in particularly be used in a refrigeration system.

Due to the ability of the device and motor to automatically change capacitance depending on the loading of the motor, the refrigeration system which includes such a device or motor becomes capable of automatically adapting to the present loading situation.

DETAILED DESCRIPTION

Further scope of applicability of the present invention will become apparent from the following detailed description and specific examples. However, it should be understood that the detailed description and specific examples, while indicating embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

Fig. 1 illustrates a motor diagram of a prior art motor;

Fig. 2 illustrates a motor diagram of a motor according to the invention; and

Figs. 3-8 illustrate various alternative embodiments of a motor according to the invention;

As illustrated in Fig. 1, a traditional electrical motor comprises a main winding 1 and an auxiliary winding 2. Both windings are connected to the zero terminal 3 of an AC power supply via the wire 4.

The main winding 1 is connected to the supply phase 5 of the power supply via the coil 6.

The auxiliary winding 2 is connected to the supply phase 5 via first and second parallel paths. The first path comprises a PTC 8 in series with a switch 9. The switch 9 is operated by the coil 6 so that it closes when a sufficiently high current is conducted in the coil 6. The second path comprises a run capacitor 10 connected between the supply phase 5 and the auxiliary winding 2.

In a start-up situation where the main winding 1 draws a high electrical current, the magnetic field generated in the coil 6 becomes sufficiently strong to close the switch 9 and the PTC 8 may therefore, depending on its temperature, provide power to the auxiliary winding 2 which thereby supports the main winding 1 in the startup mode.

Fig. 2 illustrates schematically, a motor according to the invention. In the following, the "*coil connector*" 7 will be referred to generally as an arbitrary place of connection at a location between the main winding 1 and the coil 6, i.e. the coil 6 is between the supply phase 5 and the coil connector 7.

The auxiliary winding 2 is connected to the supply phase 5 via first and second parallel paths. The first path, which extends between the coil connector 7 and the auxiliary winding 2, comprises a PTC 8 in series with a switch 9.

A first additional run capacitor 11 is inserted in the second path so that the auxiliary winding 2 becomes connected to the supply phase 5 via two run capacitors in series.

A bridge 12 extends between a location in the first path between the switch 9 and the PTC 8 and a location in the second path between the run capacitor 10 and the first additional run capacitor 11. The bridge 12 thereby couples the first and second path to each other.

In operation, the motor is turned on, and the main winding draws a relatively high current. The high current closes the switch 9 and the first additional run capacitor 11 is short-circuited via the bridge 12, the closed switch 9 and the coil 6. In this state, the PTC is cold and the resistance therein is therefore relatively low, e.g. between 5 and 25 ohm, and the auxiliary winding is therefore driven by power via the PTC.

In an example where both the run capacitor 10 and the first additional run capacitor 11 has a capacitance of 4 μF, the auxiliary winding is thereby powered through the PTC 8 and through a single 4 μF capacitor in parallel with the PTC 8.

When the motor is started and the current is reduced to a level where the coil 6 can no longer hold the switch 9 in the closed configuration, the opening of the switch activates the first additional run capacitor 11 and the auxiliary winding 2 is now powered through two serially connected 4 μF capacitors, i.e. the resulting capacitance becomes 2 μF according to well established capacitor theory.

Via the bridge 12, the PTC 8 is still connected in parallel with one of the capacitors. In a normal run mode situation, the PTC will, however, be relatively hot and therefore provide a high resistance, e.g. several kilo ohm, and the auxiliary winding 2 is therefore in principle only powered via the two serially connected capacitors 10, 11.

Fig. 3 illustrates an embodiment comparable to that illustrated in Fig. 2 but including an additional resistance structure 13, e.g. providing a capacitive, resistive or inductive resistance, or combinations thereof so that the additional run capacitor 11 is discharged in a controlled manner by use of this resistance structure.

The PTC 8 illustrated in Figs. 2 and 3 may preferably be an E-PTC in order to save energy in the run mode. In a traditional PTC, the heating of the PTC causes an unwanted energy loss whereas the use of an E-PTC in this case will prevent the heat loss since it disconnects until the current is switched off.

Fig. 4 illustrates an embodiment corresponding to the embodiment illustrated in Fig. 2 with an additional switch 14 operated by an additional coil 15. The switch 14 is inserted in the first path so that the PTC 8 is disconnected when the motor is not any longer in the startup mode - i.e. when the current through the main winding is not any longer sufficient to hold the switch 14 in the closed configuration. Switch 14, in other words, only relates to the startup mode and disconnects after the run mode is entered. In this case, the startup corresponds exactly to that of the embodiment illustrated in Fig. 2, but when startup mode is ended and the motor is operated in the run mode by nominal speed, the auxiliary winding 2 is powered only through the two serially connected capacitors. Again, if the capacitors each have a capacitance of 4 μF, the resulting capacitance in the run mode becomes 2 μF. The switch 9 and corresponding coil 6 is intended to operate back and fourth between the two states while the motor is operated in run mode. Each time the motor, while operated in run mode, is loaded heavily and the main winding 1 therefore draws a current which is high, however, not as high as in the startup mode, the switch 9 is closed and the additional run capacitor 11 is bypassed.

In the embodiment in Fig. 4, the motor further comprises a heat sensitive protector switch 16 inserted in the wire 4 to the zero terminal 3.

Fig. 5 illustrates an embodiment corresponding to that of Fig. 3, but including a start capacitor 17 inserted in series with the PTC 8. The start capacitor increases the start up torque.

Fig. 6 illustrates an embodiment corresponding to that of Fig. 3, but in this case, the additional switch 14 and additional coil 15 used in the embodiment of Fig. 3 to switch out the PTC 8 in the run mode is replaced by a double switch structure 18, 19 operated by a single coil 6.

In the startup mode, the high current closes both switches and bypasses the additional run capacitor 11 and activates the PTC 8 and which in the run mode deactivates the PTC 8 and activates the additional run capacitor 11. Additionally, the second path now extends between the coil connector 7 and the auxiliary winding 2, i.e. the run capacitor 10 and the additional run capacitor 11 are now connected serially between the coil connector 7 and the auxiliary winding 2. When the switch 19 closes, the additional run capacitor 11 discharges in a controlled manner through the resistance 20 to prevent damage by too fast discharging.

Fig. 7 illustrates an embodiment corresponding to that of Fig. 6, but herein the second path now extends between the supply phase 5 and the auxiliary winding 2, i.e. the run capacitor 10 and the additional run capacitor 11 are now connected serially between the supply phase 5 and the auxiliary winding 2. When the switch 19 closes, the additional run capacitor 11 discharges in a controlled manner through the coil 6 and damage of the contact points of the switch 19 by too fast discharging is thereby prevented.

Fig. 8 illustrates a motor where the run capacitor 10 is arranged in parallel with a path comprising the coil 6, the switch 9 and a second additional run capacitor 25 between the supply phase 5 and the auxiliary winding 2. In this case, the resulting capacitance of the parallel coupling of the run capacitor 10 and the second additional run capacitor corresponds to the sum of the two capacitors 10, 25 when the switch is closed, i.e. when the main winding 1 draws sufficient power to close the switch 9.

CLAIMS

1. An AC single phase induction motor comprising a main winding (1), an auxiliary winding (2), a first connection structure for connecting the main winding () between a supply phase (5) and ground of a power supply, and a second connection structure for connecting the auxiliary winding (2) between the supply phase (5) and ground (3) of the power supply, the second connection structure comprising first and second paths extending in parallel between the supply phase and the auxiliary winding (2), where the first path comprises a run capacitor (10) and the second path comprises a resistance (8), the motor further comprising a switch (9) arranged to enable conduction in the second path in a closed configuration of the switch (9) and to disable conduction in the second path in an open configuration of the switch (9), the switch (9) being movable between the open and closed configurations depending on a current in the first connection structure, characterised in that the second connection structure further comprises an additional run capacitor (11) in serial connection with the run capacitor (10) in the second path and a bridge (12) connecting the paths between first and second connecting points, the first connecting point being between the switch (9) and the resistance (8) and the second connecting point being between the run capacitor (10) and the additional run capacitor (11).

2. A motor according to claim 1, wherein the first connection structure forms a coil (6) which can generate a magnetic field based on conduction of a current in the first connection structure, the coil being arranged relative to the switch (9) such that the configuration of the switch can be changed by use of the magnetic field.

3. A motor according to claim 2, wherein the second path includes the coil (6).

4. A motor according to claim 3, wherein the switch (9) is located in the second path between the coil (6) and the bridge (12).

5. A motor according to any of the preceding claims, further comprising an additional resistance (13) located in the second path between the supply phase (5) and the switch (9).

6. A motor according to any of the preceding claims, the motor further comprising an additional switch (14) arranged to enable conduction in the second path in a closed configuration of the switch and to disable conduction in the second path in an open configuration of the switch, the additional switch being movable between the open and closed configurations depending on a current in the first connection structure, and the additional switch (14) being located in the second path between the bridge (12) and the resistance (8).

7. A motor according to claim 6, wherein the first connection structure forms an additional coil (15) which can generate a magnetic field based on conduction of a current in the first connection structure, the additional coil (15) being arranged relative to the additional switch (14) such that the configuration of the additional switch can be changed by use of the magnetic field generated by the additional coil (15).

8. A motor according to claim 7, wherein the second path includes the additional coil (15).

9. A motor according to any of the preceding claims, further comprising a start capacitor (17) arranged in the second path between one of the switches (9, 14) and the auxiliary winding (2).

10. A device for operating an AC single phase induction motor which has a main winding (1) and an auxiliary winding (2), the device comprising a first connection structure for connecting the main winding between a supply phase (5) and ground (3) of a power supply, and a second connection structure for connecting the auxiliary winding (2) between the supply phase (5) and ground (3) of the power supply, the second connection structure comprising first and second paths extending in parallel between the supply

phase (5) and the auxiliary winding (2), where the first path comprises a run capacitor (10) and the second path comprises a resistance (8), the device further comprising a switch (9) arranged to enable conduction in the second path in a closed configuration and to disable conduction in the second path in an open configuration, the switch (9) being movable between the open and closed configurations depending on a current in the first connection structure, characterised in that the second connection structure further comprises an additional run capacitor (11) in serial connection with the run capacitor (10) in the second path and a bridge (12) connecting the paths between first and second connecting points, the first connecting point being between the switch (9) and the resistance (8) and the second connecting point being between the run capacitor (10) and the additional run capacitor (11).

11. A compressor comprising a motor according to claims 1-9 or a device according to claim 10.

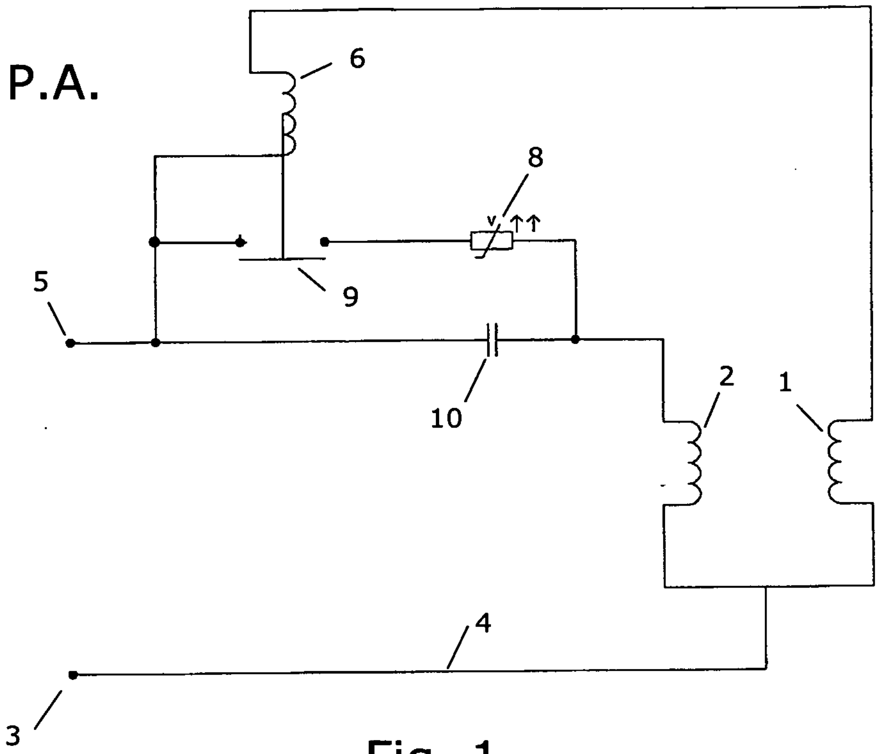

Fig. 1

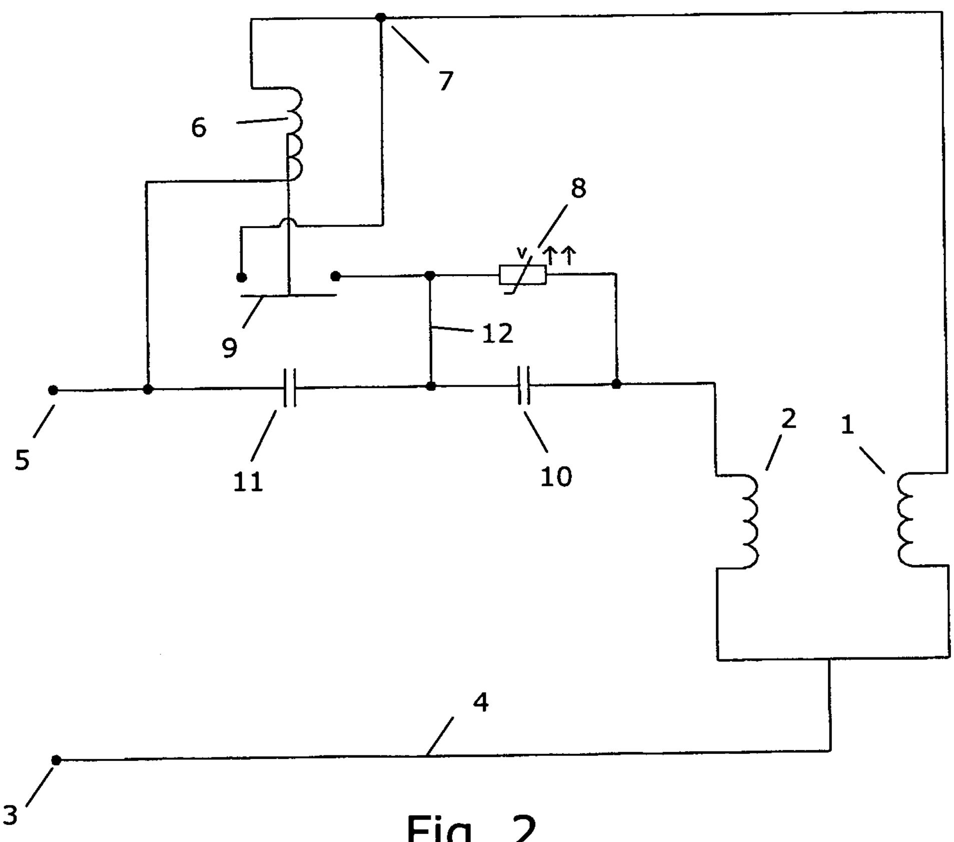

Fig. 2

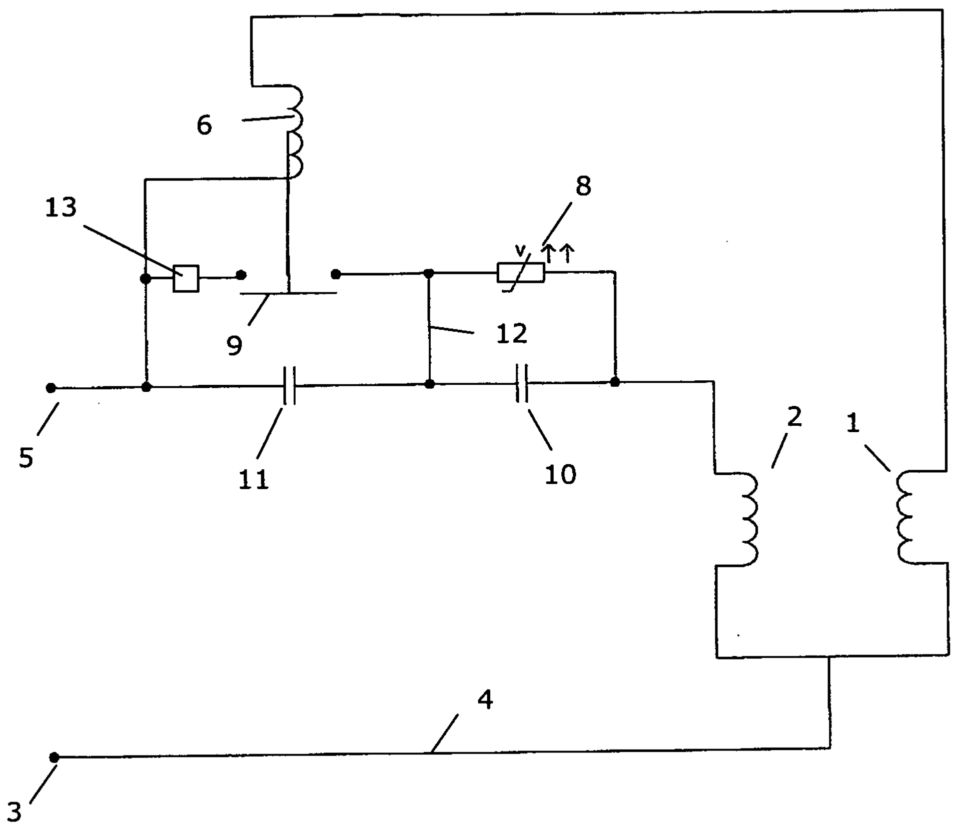

Fig. 3

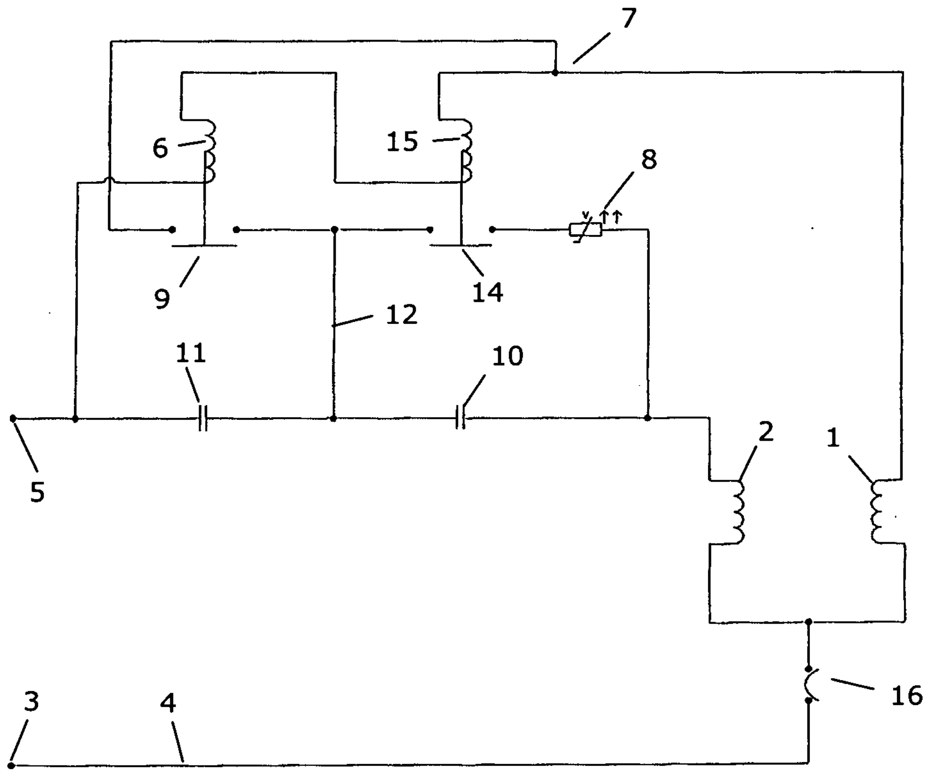

Fig. 4

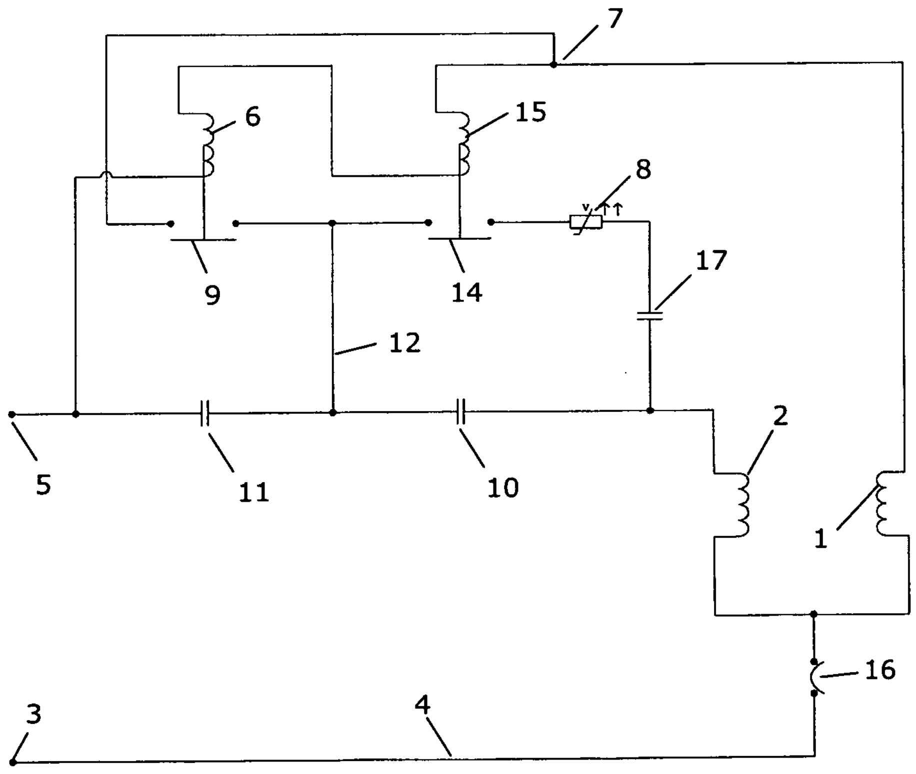

Fig. 5

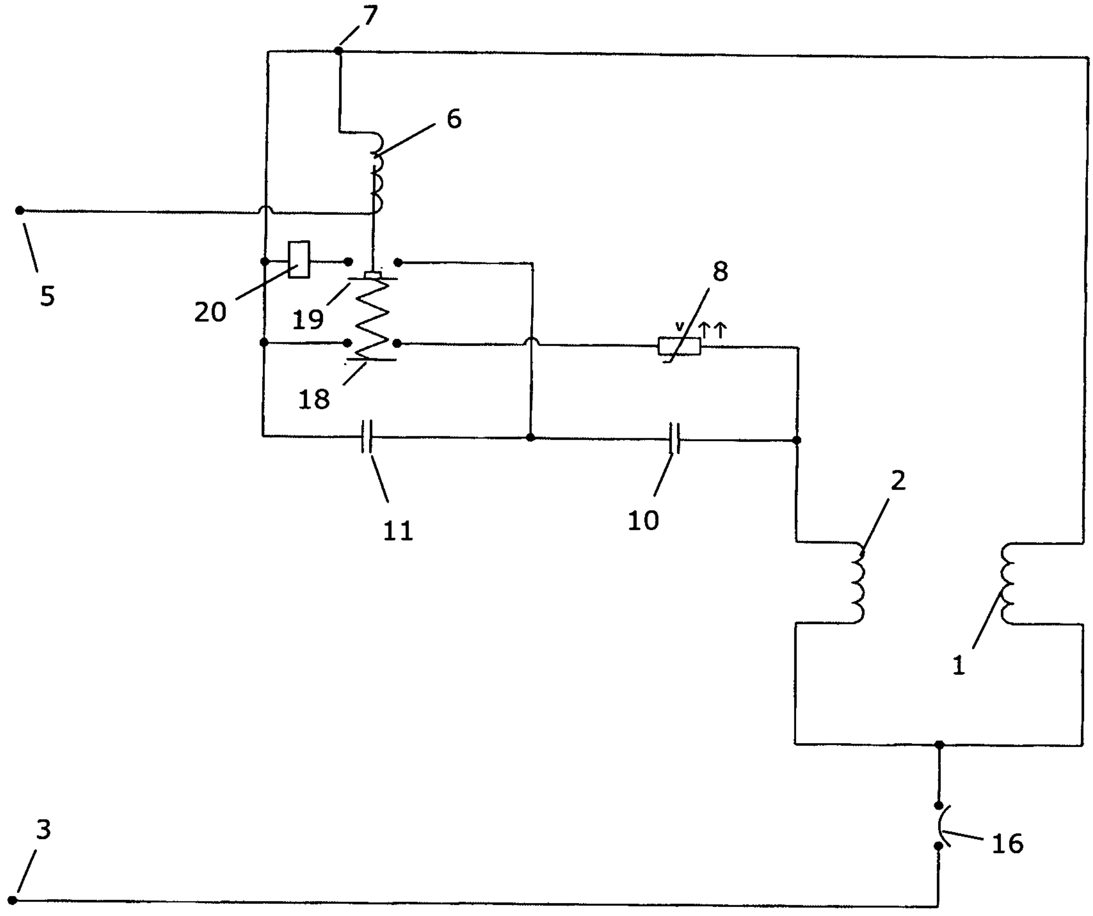

Fig. 6

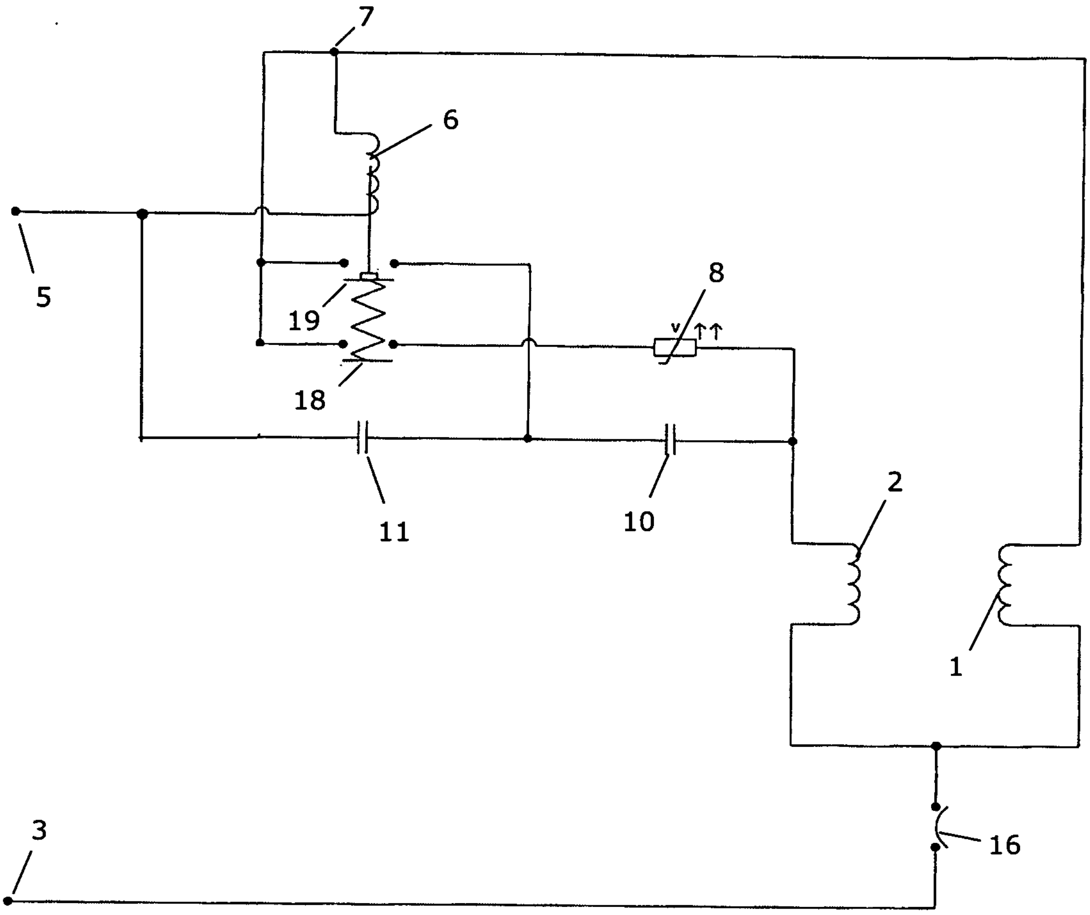

Fig. 7

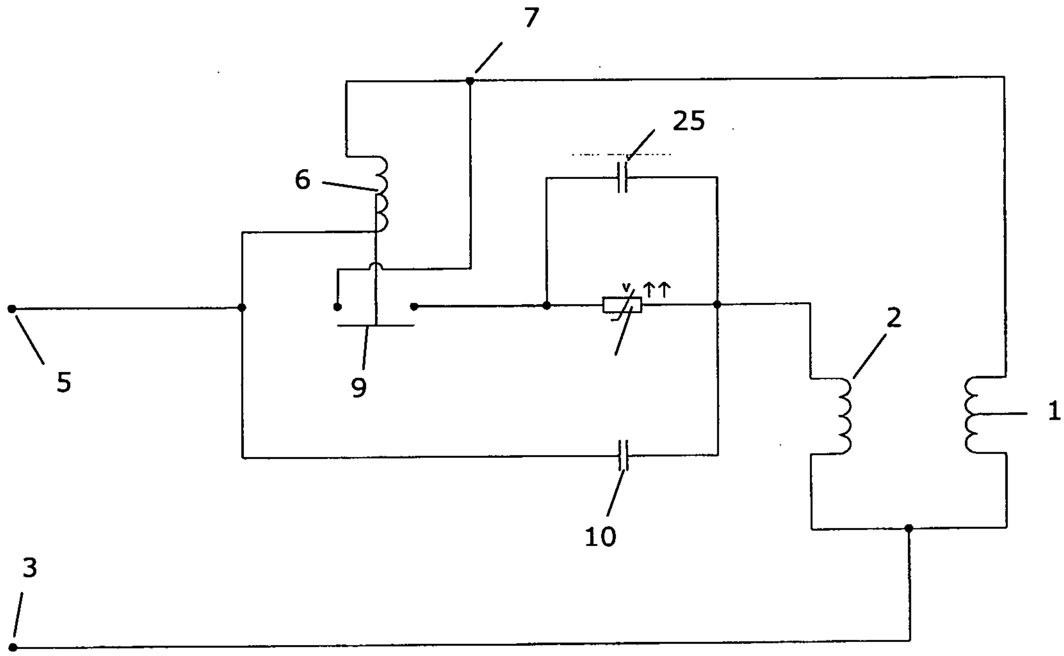

Fig. 8