No. 735,190. PATENTED AUG. 4, 1903.

A. P. ZANI.

CONTROLLING INDUCTION MOTORS.

APPLICATION FILED AUG. 11, 1899.

NO MODEL.

Fig. 1.

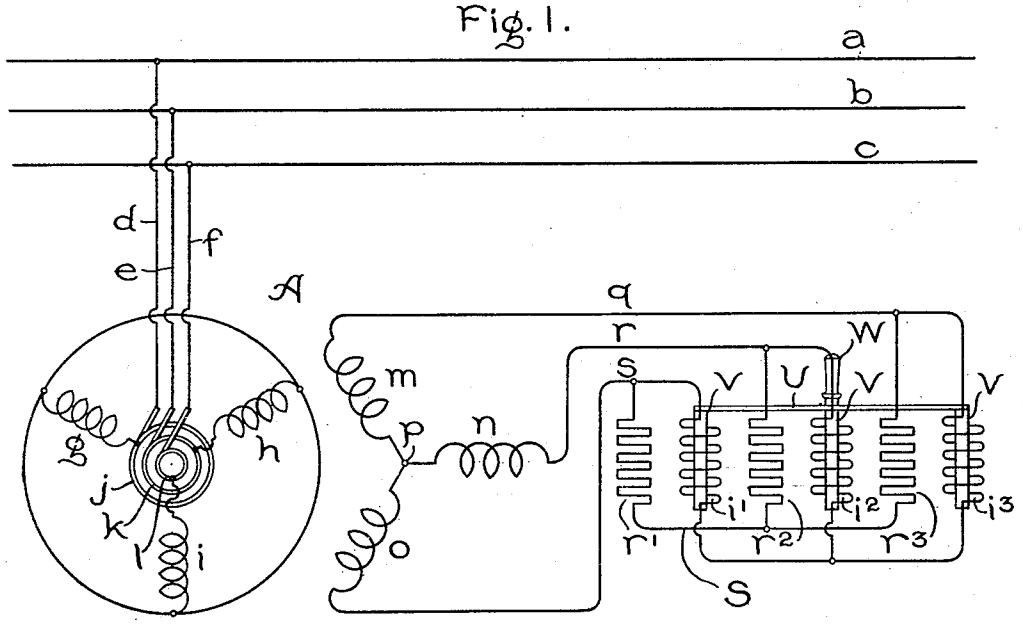


Fig. 2.

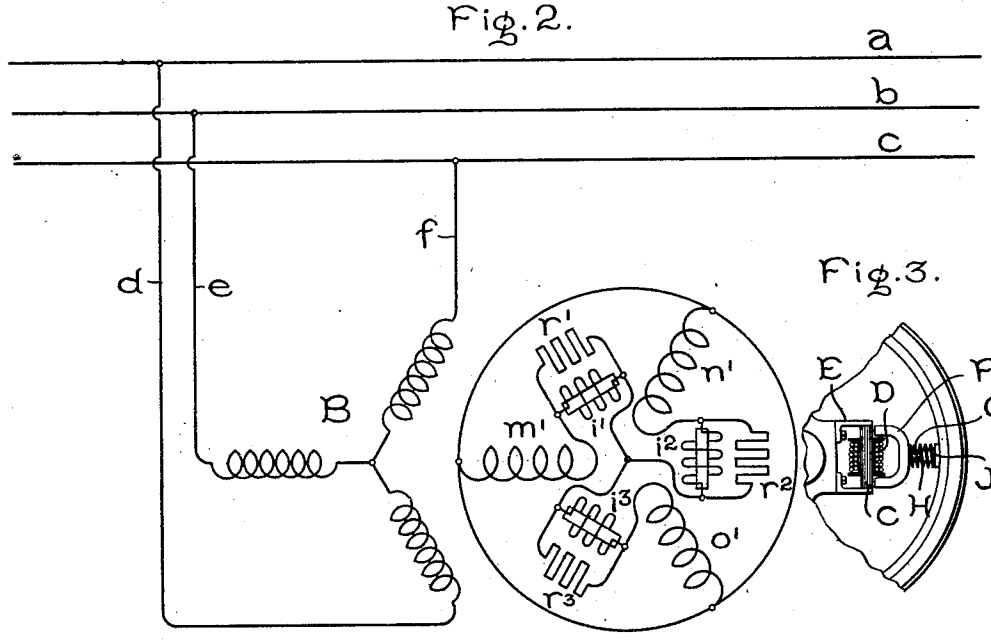


Fig. 3.

Witnesses.

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No. 735,190. Patented August 4, 1903.

UNITED STATES PATENT OFFICE.

ARNALDO P. ZANI, OF BERLIN, GERMANY, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

CONTROLLING INDUCTION-MOTORS.

SPECIFICATION forming part of Letters Patent No. 735,190, dated August 4, 1903.

Application filed August 11, 1899. Serial No. 726,910. (No model.)

To all whom it may concern:

Be it known that I, ARNALDO P. ZANI, a subject of the King of Italy, residing at Berlin, Germany, have invented certain new and useful Improvements in Controlling Induction-Motors, of which the following is a specification.

In starting induction-motors a non-inductive resistance is commonly inserted in circuit with the windings on the induced member of the motor in order to increase the starting torque and at the same time reduce the amount of current supplied to the motor. The resistance has the effect of bringing the currents in the induced member of the motor more nearly into phase with the electromotive forces induced therein and at the same time by reducing the amount of secondary current causes a more than correspondingly large reduction in the primary current. This reduction in the primary current is largely due to the fact that a reduced secondary current reduces the leakage flux between the inducing and induced members of the motor, and consequently reduces the amount of lagging or idle current called for by the self-induction produced by this leakage flux. A further description of the function of the starting resistance is unnecessary, since its operation is well understood by engineers.

In practice the non-inductive resistance may be operatively connected to the windings of the induced member in a number of different ways. Thus, for example, if the rotor be the induced member the resistance may be carried by the spider of the rotor or may otherwise be mounted within the same, or, if desired, the resistance may be located externally to the motor and connected to the windings of the induced member through collector-rings on the rotor-shaft. If the resistance is mounted within the rotor, it may be cut in or out by means of centrifugally-actuated switches carried by the rotor or by means of switches mounted on the rotor and connected by suitable mechanical devices with a switch-handle fulcrumed to some portion of the stator in a manner well known in the art. In cases where the resistance is externally located the same may be varied in value by any well-known means. In any case, however, these constructions are seldom absolutely sparkless in operation and are open to all the other objectionable features inherent in sliding contacts. In most cases the sparking produced at the contacts is not of sufficient importance to become seriously objectionable, while in some cases it is, on the contrary, so dangerous as to be prohibitive—as, for instance, where the motors or other devices are to be used in an atmosphere of an explosive nature, such as exists in flouring-mills, oil-refineries, or the like. I have therefore devised a means for starting induction-motors which possesses the advantages of the well-known rheostatic form of control, though acting on a different principle, without its corresponding disadvantages.

According to my invention the currents in the induced member of the induction-motor are caused to flow through a circuit so organized that at starting it has the effect of a circuit containing a high ohmic resistance and at full speed the effect of a circuit containing a low ohmic resistance.

In the particular embodiment of my invention which I have illustrated in the drawings of this application the circuit through which the currents in the induced member of the motor are caused to flow is provided with alternative paths, one of high ohmic resistance and little, if any, self-induction and the other of low resistance with a comparatively high self-induction. At starting when the frequency of the currents in the induced member is high the reactance in the path of high induction is so large as to practically prevent any considerable current from flowing in this path, thus causing nearly all of the currents generated in the induced member to pass through the high-resistance path. The result obtained is nearly the same as though the high-resistance path were the only one presented to the induced currents of the induced member, and the circuit as a whole has the effect of a circuit containing a high ohmic resistance. As the speed of the machine rises, however, the frequency of the currents in the induced member becomes less and less, thus correspondingly decreasing the reactance due to self-induction, and so causing a greater portion of the induced current

to pass through the self-inductive path and less through the path of high resistance. When the motor approaches full speed, the frequency of the current in the induced member becomes so low that the counter electromotive force of self-induction in the inductive path is greatly reduced. Then nearly all of the current will flow through this path, which is of low resistance, and only a small amount through the other path of high resistance, and the circuit as a whole will have the effect of a circuit containing a low ohmic resistance. This operation preserves the proper phase relation between current and electromotive force at all speeds without any mechanical adjustment whatsoever, though, if desired, I may still further vary the amount of reactance due to the inductive path above mentioned not by depending alone upon a decrease in the frequency of currents flowing in said path, but by also varying the coefficient of self-induction to the inductive device in any desired manner—as, for instance, by varying the reluctance of its magnetic circuit.

My invention will be better understood and its details more clearly apprehended by reference to the following description, taken in connection with the accompanying drawings, while its scope will be clearly and particularly pointed out in the appended claims.

Figure 1 represents my invention as applied to an induction-motor in which the induced member is stationary. Fig. 2 shows my invention in connection with a motor having a revolving induced member. Fig. 3 illustrates a detail.

In Fig. 1, $a\ b\ c$ represent three-phase supply-mains, which are connected, through leads $d\ e\ f$, with the windings $g\ h\ i$ of the inducing member of an induction-motor A. The inducing member is here shown as a rotor, and the connections between the leads $d\ e\ f$ and the rotor-windings are therefore made by means of collector-rings $j\ k\ l$ and suitable brushes operating in connection therewith, as is well understood. The stationary induced member is provided with windings $m\ n\ o$, with one end of each winding connected to a common point p, while the free ends of the windings are connected through leads q, r, and s with a set of resistances and inductances in shunt to each other. To be more explicit, the resistances referred to are indicated at $r'\ r^2\ r^3$, one end of each resistance being connected to a common point in any suitable manner—as, for instance, by means of the conductor S. The free ends of the resistances are connected, respectively, with the leads $s\ r\ q$. In an exactly similar manner three inductance devices $i'\ i^2\ i^3$ are provided, with one end of the circuit of each device connected, respectively, to the leads $s\ r\ q$ and the other ends connected together electrically, as shown. The inductance devices may consist of solenoids with cores of magnetic material, which may be moved in or out of the solenoids in order to vary the reluctance of the magnetic circuits of the same, and thus vary the coefficient of self-induction. As indicated in the diagram, the cores V are mounted on the cross-bar U, to which a handle W or other operating device is suitably connected, so as to simultaneously move the cores in and out of the solenoids.

Fig. 2 shows a slightly-different embodiment of my invention, such as becomes necessary when the rotor of the induction-motor is used as the induced member. In this case $a\ b\ c$ indicate, as before, the three-phase supply-mains, while $d\ e\ f$ denote the leads through which connections are made between the supply-mains and the windings of the inducing member B of the induction-motor. The induced member is here shown diagrammatically, with the resistances $r'\ r^2\ r^3$ in circuit, respectively, with the windings $m'\ n'\ o'$. Inductance devices $i'\ i^2\ i^3$ are placed in shunt to the resistances, thus forming with the same divided circuits, which are traversed by the currents set up in the induced windings. As heretofore explained, the proportion in which the currents divide between the inductive and the non-inductive paths depends upon the amount of reactance set up in the inductive path. At starting the reactance is high, owing to the high frequency of the currents flowing in the induced winding, while at or near normal speed the frequency becomes so small as to make the reactance almost negligible, in which case but little current flows through the path of high resistance, the greater portion of it having been diverted to the low-resistance alternative path, the reactance of which is very low when the motor approaches normal speed.

When it is desired to still further decrease the reactance of the inductance devices $i'\ i^2\ i^3$ by opening their magnetic circuits as the motor approaches normal speed, I make use of a centrifugally-actuated device. (Illustrated in Fig. 3.) The inductance device such as shown in this figure consists of a core C, of magnetic material, having placed thereon a suitable winding or solenoid D. The core C is supported by brackets E, of non-magnetic material, and its magnetic circuit is completed by means of a yoke F, the ends of which are arranged in proximity to the ends of the core C. The yoke F is arranged in any suitable manner so as to be movable radially by the action of centrifugal force away from the core C, while a spring G or other suitable means is employed for urging the yoke toward the core C. As here shown, the yoke F is provided with a shank H, arranged to slide in a suitable bearing J, carried by the rotor. When the motor approaches normal speed, the yoke F is moved away from the core C by the action of centrifugal force, and the air-gaps thus introduced into the magnetic circuit of the inductance devices are such as to make the self-induction negligible.

While I have illustrated my invention in

connection with a three-phrase induction-motor, it will of course be understood that its useful features are in no sense limited to use in connection with this particular type of motor, but are equally applicable to other types of induction-motors, whether single or multiphase. It will also be understood that my invention may be used in other connections than with induction-motors where it is desired to vary the effective resistance of a circuit. Furthermore, while I have shown means both manually and automatically operated for varying the coefficient of self-induction of the magnetic devices I wish it understood that while the use of such means or of others for accomplishing the same purpose are beneficial they are in no sense essential to the operation of invention, since, if desired, I may dispense with the use of the same and depend solely upon the variation in frequency of the currents in the induced circuits for varying the reactance of the magnetic devices.

I do not claim in this specification the novel method disclosed herein, since this said method constitutes the subject-matter of a divisional application, Serial No. 105,310, filed April 30, 1902.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In combination, an alternating-current source, a circuit connected thereto comprising two paths, one containing self-induction and the other resistance, and means for varying the frequency of the currents flowing in said circuit.

2. In combination with the induced winding of an induction-motor, a circuit therefor so organized that at starting it will have the effect of a circuit containing a high ohmic resistance, and at full speed the effect of a circuit containing a low ohmic resistance.

3. In combination with the induced winding of an induction-motor, a low-resistance circuit therefor so organized that at low speeds when the frequency of the currents flowing in the induced winding is high it will have the effect of a circuit containing a high ohmic resistance.

4. In combination with the induced winding of an induction-motor, a circuit therefor comprising two branches, one of high self-induction and the other of high resistance.

5. In combination with the induced winding of an induction-motor, a low-resistance circuit therefor comprising a plurality of branches, one of which contains self-induction, and means controlled by the speed of the motor for varying the self-induction of said branch.

6. In an induction-motor the combination with the induced member, of a resistance in circuit with a winding on said induced member and a device or circuit possessing reactance, in shunt to said resistance.

7. In an induction-motor the combination with the induced member, of a resistance in circuit with a winding on said induced member and a device or circuit possessing inductance, in shunt to said resistance.

8. In an induction-motor the combination with the induced member, of a resistance in circuit with a winding on said induced member, a device or circuit possessing inductance, in shunt to said resistance, and means for changing the coefficient of self-induction of said device or circuit.

9. In an alternating-current motor, the combination of a revolving member having an induced winding, a resistance in circuit with said winding, a device possessing reactance in shunt to said resistance, and means controlled by the rotation of said member for varying the value of said reactance.

10. In an alternating-current motor the combination of a revolving member having an induced winding, a resistance in circuit with said winding, a device possessing inductance in shunt to said resistance, and means controlled by the rotation of said member for varying the value of said inductance.

11. The combination with a winding on the induced member of an alternating-current motor, of a resistance in circuit therewith and a device having a variable coefficient of self-induction in shunt to said resistance.

12. In combination with an alternating-current induction-motor, having its induced member provided with a winding, a circuit for said winding comprising two branches, one of high self-induction and the other of high resistance, and means controlled by the speed of the motor for varying said self-induction.

In witness whereof I have hereunto set my hand this 27th day of July, 1899.

ARNALDO P. ZANI.

Witnesses:
WOLDEMAR HAUPT,
HENRY HASPER.