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INDUCTION MOTOR.

APPLICATION FILED FEB. 15, 1913.

1,216,397.

Patented Feb. 20, 1917.

2 SHEETS—SHEET 1.

Fig. 1.

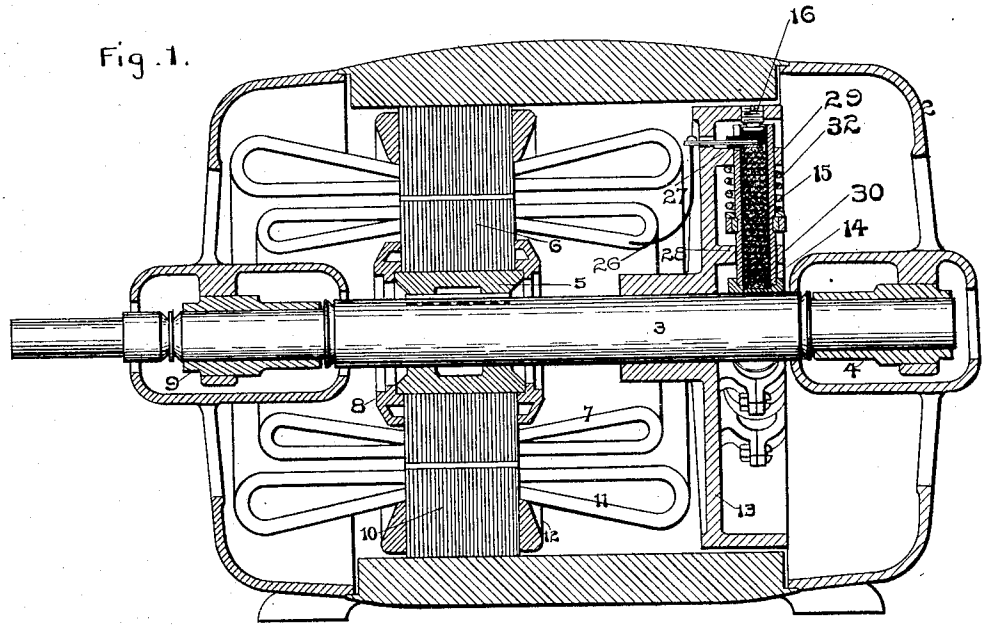


Fig. 2.

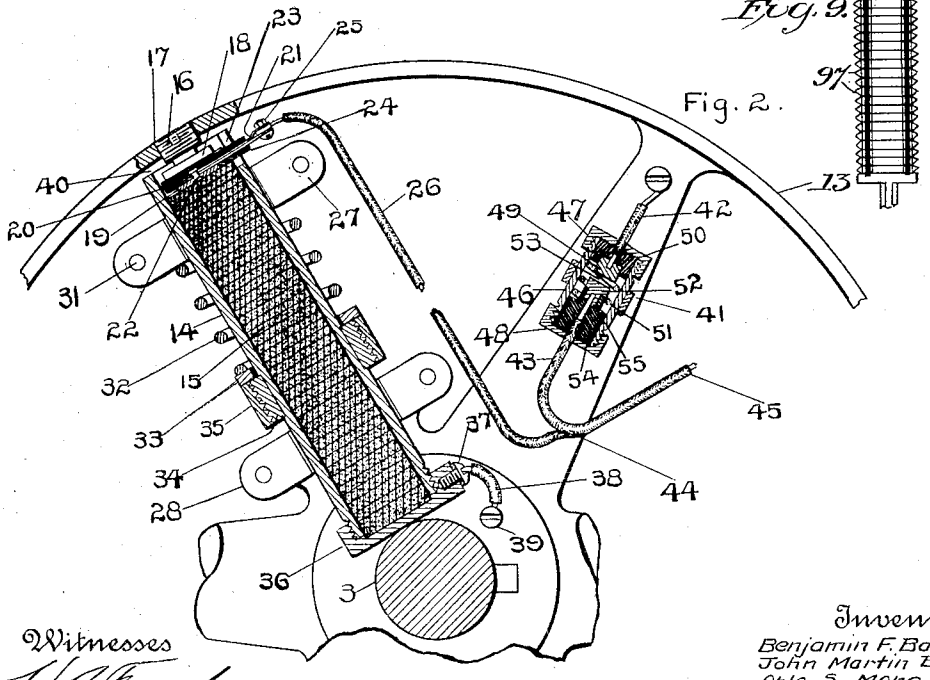


Fig. 2.

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2 SHEETS—SHEET 2.

Fig. 3.

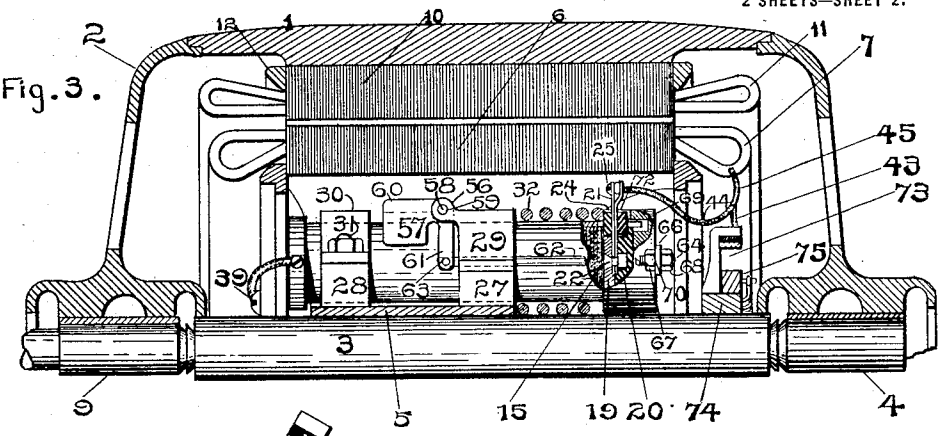


Fig. 4.

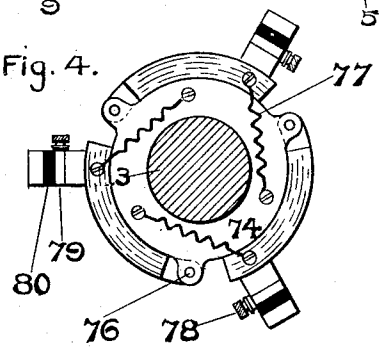


Fig. 5.

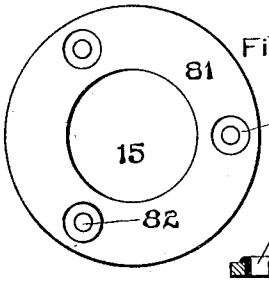


Fig. 6.

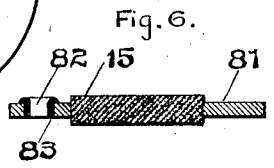
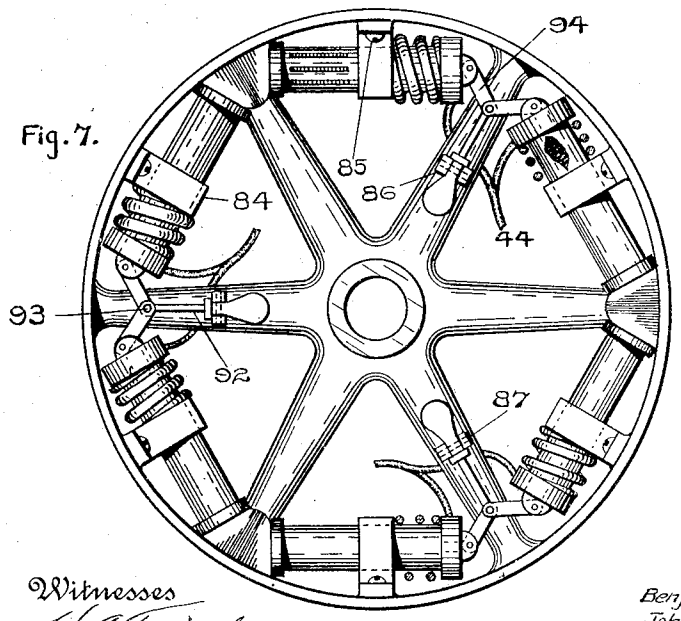


Fig. 7.



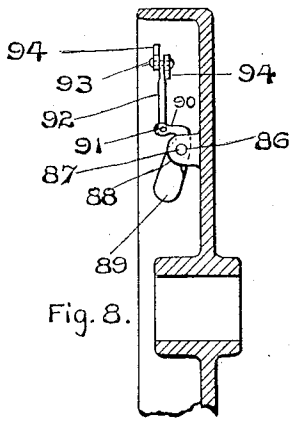


Fig. 8.

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INDUCTION-MOTOR.

1,216,397. Specification of Letters Patent. Patented Feb. 20, 1917.

Application filed February 15, 1913. Serial No. 748,582.

To all whom it may concern:

Be it known that we, BENJAMIN F. BAILEY, of the city of Ann Arbor, in the county of Washtenaw, State of Michigan, and JOHN MARTIN BARR, ORLO S. MORE, and L. GUY LONG, of the city of Indianapolis, in the county of Marion, in the State of Indiana, have invented certain new and useful Improvements in Induction-Motors, of which the following is a full, clear, and exact description, such as will enable those skilled in the art to make and use the same, reference being had to the annexed drawings, which are hereby made a part of our specification.

Our invention relates to alternating current induction motors, operating either by single-phase, two-phase, three-phase or polyphase currents and it is our object to provide a motor having its internal controlling mechanism dependent in its action solely upon the speed of the motor and not upon the will of the operator, and thereby preventing the motor being injured by his carelessness or incompetency, or in other words, what is known as a fool-proof motor.

Figure 1 is a longitudinal sectional view of our motor.

Fig. 2 shows a sectional view of the spider, the resistance holding mechanism and a centrifugal switch supported thereon.

Fig. 3 is a sectional view of another arrangement of our motor showing a centrifugally operated resistance mechanism and a centrifugal switch placed within the rotor laminæ.

Fig. 4 is a diagram of the centrifugal switch shown in Fig. 3.

Fig. 5 shows a form of disk having a center composed in whole or in part of resistance material and having a band of metal surrounding it and with spaces in the metallic rim to allow supporting rods to be placed.

Fig. 6 shows a cross section of the disk shown in Fig. 5.

Fig. 7 shows a number of resistance holders arranged within the rotor member with means for automatically compressing the resistance pieces therein.

Fig. 8 is a section of the centrifugal mechanism shown in Fig. 7.

Fig. 9 shows disks with beveled edges borne on insulated rods of a holder.

In the drawings, 1 represents the motor frame; 2 the end plates; 3 the shaft; 4 the back end bearings; 5 a spider mounted on the shaft; 6 the rotor core; 7 the rotor coils, which are embedded in the rotor laminæ; 8 the clamping heads, holding the rotor laminæ in position; 9 the pulley end bearings; 10 represents the stator laminæ, in which the stator coils, indicated by 11, are embedded, the stator clamping heads are shown at 12; 13 represents the spider mounted upon the shaft between the rotor and the back end bearings.

For the purpose of maintaining constant speed and avoiding shocks, etc., we provide a rim on the spider, which is thus made to serve the purposes of a fly wheel. Any number of arms may be used upon the spider but we prefer to use three arms except where we desire to place a centrifugal switch on alternate arms between, in which case we prefer to use six arms.

The spider is so constructed as to support upon its arms within its rim one or more resistance holders, represented by 14. While, for the purpose of securing better mechanical balance, we prefer to use three resistance holders on our motor, yet, one, two, or a larger number may be used. Where two or more are used they may be connected in series or multiple, as desired. There may be used as many resistance holders as there are phases in, or conductors upon, the rotor. Where it is not desired to have a rim on the spider, it may be omitted. These resistance holders may be made of pipe, tubing or other suitable non-conducting and heat resisting material. By reason of the fact that resistance holders made of earthen compositions, or non-metallic materials, cannot stand the strain to which they are subjected in all instances, we prefer to use a metallic holder such as iron and insulate the interior walls, sides or parts thereof.

While in the drawings we show resistance holders having their walls or sides entirely closed, yet under certain circumstances we find it desirable to have slots, or elongated spaces therein to facilitate the radiation of heat. Such slots are shown at

in Fig. 7. Instead of using an insulated lining within a metallic tube, there may be used rods or wires of insulating or insulated material, upon which the resistance pieces may be moved. Such an arrangement is shown in Fig. 9. Where the resistance holder is made of metal we use a heat resisting, non-conducting insulation made of a composition of silica, aluminum silicate, water glass or an enamel or porcelain or other insulating materials of this character. Many such compositions have been used for years for insulating purposes.

The resistance pieces 15, conform to the shape of the resistance holder and are made of a resistance material having a negative thermal co-efficient as, for example, carbon or compositions of carbon or magnetite. We preferably use thin disks with flat, smooth surfaces between $\frac{1}{16}$ and $\frac{1}{32}$ of an inch in thickness. The size of these pieces is determined largely by the amount of resistance desired and the length of the resistance tube that may be used. When using resistance holders having spaces therein for ventilation, we prefer to use resistance pieces or disks having their edges or sides beveled to facilitate the radiation of heat.

We have shown in Figs. 5 and 6 a form of disk having a metallic rim, such as copper. 16 is an adjustment screw plug, which is set in a threaded hole 17, in the rim of the resistance holder spider; 18 is a bearing plate, which may be moved by the screw plug 16, to increase or diminish the pressure of the contactor, 19, upon the resistance pieces. The contactor 19, is of a suitable conducting material, such as copper, and is separated from said bearing plate by the contact insulator, 20, to which it is attached. This contact insulator may be made of any suitable insulating material, as, for example, wood asbestos. In an electrical connection with the contactor and properly attached thereto is a conduction bar, 21. We show the contactor attached to the conduction bar by means of a screw, 22. It is obvious that the conduction bar and contactor may be made of one piece of metal instead of two. The conduction bar is likewise of a suitable conducting material. It passes through the slot, 23, in the resistance holder 14, and is separated from electrical contact with the sides of the said slot by the insulation, 24. Any good, non-conducting material may be used for this purpose, but as here shown, we prefer to use mica. The binding screw, 25, serves to attach the lead, 26, to the conduction bar, 21. Upon the resistance holder spider are two brackets represented respectively by 27 and 28. These brackets have seats to receive the resistance holder and yet allow it to move readily to and fro within the brackets. The resistance-holder retainers, indicated respectively by 29 and 30, extend about the resistance holder 14, and are attached to the brackets in any suitable manner. Like the brackets, there is sufficient space between them and the resistance holder to allow such holder to move freely therein.

We show the resistance-holder retainers attached to the brackets by means of the bolts, 31. 32 represents a restraining spring, loose borne upon the resistance holder, resting at one end upon the tube retainer 29, and bracket 27, and at the other end upon the washer, 33. This washer may be of any suitable material, as, for example, steel. 34 is a threaded collar attached to the resistance holder and 35 is a spring-adjusting-nut threaded on said collar so as to increase or diminish the tension of the spring. 36 is a cap or cover on the resistance holder, and may be made of any suitable material. We prefer to use, however, for this purpose, a cap of brass, or similar conducting material. The binding post, 37, serves to attach the other lead, 38, to this cap. The lead, 38 is grounded by connecting it to the spider of the motor at 39. 40 indicates the space between the resistance holder and the inner periphery of the rim of the resistance holder spider. 41 shows a centrifugal switch, which may be mounted upon the spider beside or back of a resistance holder or an extra arm may be provided for the spider to support same.

A lead, indicated by 42, connects this centrifugal switch to the spider, upon which it is grounded. 43 shows the switch lead; 44 the resistance lead and 45 the rotor lead to which both the switch lead and the resistance lead are connected. 46 is a tube having an upper cap, indicated at 47, and a lower cap, indicated at 48. These caps are shown threaded on the tube but any other means of attachment may be used. The stationary contact, 49, is separated from said tube by insulation, shown at 50. The helical spring, 51, under an initial tension separates the movable contact 52, from the stationary contact, 49, and the space left between the same, when the resistance holder is in circuit with the rotor coil, is indicated by 53. 54 indicates a movable weight, which, when the motor has attained running speed, is moved outwardly against the opposing tension of the spring, 51, whereby contacts 49 and 52 are pressed against each other, the rotor coil is short circuited and current ceases to flow through the resistance pieces.

Whenever the speed of the motor drops below the normal running speed, because of overload, or for any other reason, the spring presses back the movable weight, thus putting the resistance pieces in circuit with the rotor coil again. 55 shows insulation, which separates the movable contact from the switch tube. We may use an upper cap of

brass, which is in electrical contact with the arm of the spider and against which the movable contact, 52, is pressed by the movable weight, 54, thereby obviating the use of the lead, 42, stationary contact, 49, and insulation, 50.

We show in Fig. 3 another arrangement of our motor and use the same numerals to designate parts equivalent to the parts shown in Figs. 1 and 2. 5 represents a spider mounted upon the shaft, 3; 27 is a bracket upon the spider having a seat to receive the resistance holder; 28 is also a bracket with a similar seat on the spider. 29 shows a cap-piece having the projecting lug, indicated at 56, for bracket 27, and 30 indicates a cap-piece for bracket 28. These cap-pieces embrace and fixedly retain the resistance holder in position and are attached to the brackets in any suitable manner. We here show bolts 31, which we use for this purpose. 57 is a member intermediately mounted by the pivot, 58, borne in the aperture, 59, in lug 56. 60 is the weight end of this member and 61 the lever arm thereof. Member 57 may be of any suitable shape but for economizing the limited space within the rotor, we prefer to have its shape conform to the exterior of the resistance holder, upon which the weight end rests when the motor is idle. A lever arm extends on each side of the resistance tube and are there attached to the pull rods, 62, by the pivot, 63. The pull rods pass through holes in the cap-piece, 29, and their ends, indicated at 64, we prefer to make threaded. Upon these ends is placed the saddle piece, 66.

This saddle piece is held thereon by the adjusting nut, 70, and the lock nut, 68. Upon the resistance holder we place a restraining spring, indicated by 32. 34 is a threaded collar attached to the resistance holder and 35 is a spring adjusting nut see Fig. 2. A washer of steel or other suitable metal, shown at 71, is placed on the resistance holder. The restraining spring, 32, bears on the washer at one end and on the cap, 69, at the other end.

We show in Fig. 3 by a broken section the contacting elements and the resistance pieces with the holder. The slot, 72, in the cap and resistance holder admits the conduction bar, 21, protected by the insulation, 24. The contactor, 19, is attached to the conduction bar by the screw, 22. The contact insulator is shown at 20. The resistance disks are indicated at 15. The binding screw, 25, connects the resistance lead to the conductor bar. The lead is grounded by connecting it to the spider at 39. At the point where the rotor lead, 45, connects with the resistance lead, 44, there is connected the switch lead, 43. This is connected to the centrifugal switch, 73, a section of which is here shown. The spider mounted on the shaft, 3, is indicated at 74. 75 is the contacting arm; 76 a pivot on which the centrifugal weight is borne and 77 is a spring opposing the movement of the centrifugal weight.

Fig. 4 is an end view of this centrifugal switch, in which the binding post is indicated by 78, and the switch-contact, of suitable conducting metal, by 79, and 80 shows insulation interposed between the switch contact and the contacting arm.

Fig. 5 shows a resistance disk, 15, having a metallic rim about it, which rim is indicated by 81. Two or more apertures, represented by 82, are placed within said rim. Insulated bushings, 83, are shown within said aperture. These disks with such insulated bushings may be mounted in a holder of metallic guide rods or, where desired, the insulated bushings may be omitted and insulation instead placed upon such guide rods. These disks with metallic rims may be used in holders having insulated walls entirely closed, in which case the apertures and bushings are omitted. The metallic rims are, of course, of less thickness than the resistance centers thereof, as is shown in Fig. 6.

In Fig. 7 a number of resistance holders are disposed about the inner periphery of the rotor spider or rotor laminæ. These holders are of the type shown in Fig. 3. A supporting strap, 84, attaches them in position by means of the screw, 85. A shoulder on the spider serves to support the holders. This shoulder may be an independent piece suitably attached to the spider, but we prefer to make it a part of the spider. 44 shows resistance leads extending from the compression caps. The other end of the resistance holders are grounded on the spider. 86 represents lugs upon the spider, through the apertures in which extends the pivot, 87, upon which is borne the piece 88. The weight end is indicated by 89 and the lever end by 90. Through a hole in the lever end is placed the pivot, 91, to which is attached the toggle push rod, 92. The toggle push rod is connected in turn by pivoted connections 93 to the toggle lever 94.

In Fig. 9 is shown a resistance holder with insulated rods 96 upon which are disks with beveled edges 97. These disks have holes in them like those shown in Fig. 5. The rods 96 are slipped through holes in the disks and so held in proper position.

In the three-phase motor, which for convenience we have selected to illustrate our invention, the tubes are shown 120 degrees apart for the purpose of maintaining perfect mechanical balance. Three rotor leads are connected respectively to the three resistance holders and the other three leads are grounded on the rotor. The three resistances are thus connected so as to form a

three-phase Y. Within each holder we place the resistance pieces. As we have, in the drawings, shown these resistance pieces as thin, flat disks, we will refer to such resistance pieces as disks in illustrating the operation of our motor. These disks when free from compression offer a material amount of resistance to a current passing through them but when compressed their condition resembles the molecular condition of a single rod of carbon or magnetite, in which state their electrical resistance is very greatly reduced.

When the motor is started the pile of disks in each holder is in a loose condition and the current flowing through the holder encounters a high resistance but as the speed of the motor is increased the centrifugal force likewise increases and at a certain predetermined speed the centrifugal force overcomes the initial tension of the spring 32 whereby the resistance holder itself acts as a centrifugal weight to compress the pile of disks, as shown in Figs. 1 and 2. The weight of the disks likewise aids to a slight extent in effecting this compression. We prefer to use the helical spring to resist the outward thrust of the holder because in most cases where our invention is used, the holder would be pressed outwardly by centrifugal force while the motor was running at too low a speed and thereby the resistance would be cut out too soon. For this reason we prefer in most instances to use a spring arranged to hold an initial compression equal to the centrifugal force generated by the tube at the predetermined number of revolutions at which the holder will move outwardly. At the top of the holder is shown the screw plug 16. The object of this screw is to permit the pressure or tension upon the pile of disks to be varied and thereby obtain the desired initial resistance. When more than one of these tubes are used upon a motor the initial pressure on the disks may be adjusted by turning this screw plug so that the value of the currents in the various tubes will be the same and so that the motor will take the proper starting current. As the motor increases in speed the holders are moved outwardly by centrifugal force and the disks thereby compressed. The actual outward thrust of the holders is very slight, being only about one thirty-second of an inch for a holder six inches long. The resistance of these disks may be varied from almost infinity to zero, according to the internal and contact resistance of the resistance material itself by a change from zero pressure to some two hundred pounds per square inch. The practical range of resistance and variation is about two hundred to one. This is obtained without using pressures so high as to endanger the disks on the one hand or so low as to lead to imperfect contacts at the other extreme. The relation of the weight of the holders and the tension of the springs may be made such that the current is held at practically constant value until the motor has reached practically its full speed. The current being constant during acceleration the torque is also constant. This is the most favorable condition for the average load. With the ordinary type of resistance units, if the motor should be so overloaded, or if the voltage were so low that not enough current passed to start the load, the motor will be seriously injured, since, as the resistances heat up on account of the large current passing, the resistance would increase and the current would decrease. In a motor employing our invention, however, exactly the opposite takes place. The disks are confined between the bottom of the holder and the cap at the top and as they heat they are pressed more firmly together on account of the resulting expansion. The resistance decreases as the temperature increases. This action is quite marked and the resulting increase of current will be sufficient to start the motor under any normal conditions. Owing to the fact that the resistance holders are located as shown, they act directly as fans producing a fan action, which, owing to their rapid rotation through the air, dissipates any heat which may be absorbed during the starting period. It has been found that the holders after a normal heat run will very rarely show a rise in temperature of over ten or fifteen degrees.

We have found that the resistance in the holders when the motor is running at full speed is so small that it is not necessary to short-circuit the holders. Where, however, it is desired to cut out all this resistance it may be done by the use of a centrifugal switch, such as shown in Figs. 2, 3 and 4. The switches shown in these figures are used to short-circuit the resistance holders whenever the motor has attained a certain predetermined running speed and whenever the motor drops below this speed the centrifugal switch-arms break from the stationary contacts, thus breaking the short-circuit and again putting the resistance pieces in circuit with the rotor coils. The resistance pieces in our motor may be cut out simultaneously or those in one holder may be cut out and then the next and so on, in any manner, and in any phase and at any time interval, as may be desired. In the arrangement of our motor, as shown in Fig. 3, as the weight arm is moved outwardly under the influence of centrifugal force, the lever arm and the pull rods draw the saddle piece and compression cap toward the resistance pieces and the resistance pieces are subjected to an increasing compression until the desired

maximum compression is attained. This maximum compression may be effected at the instant the motor attains the normal running speed, or prior, or subsequent thereto, as may be desired. The centrifugal switch cuts the pieces out of circuit in the same manner as does the switch shown in Fig. 2. In Figs. 7 and 8 is shown a means of compressing the resistance pieces in a number of holders at the same time. The action is similar to that shown in Fig. 3. The weight arms are thrown outwardly under the influence of centrifugal force when the motor has attained a predetermined speed and the lever arm presses outwardly the toggle push rod and in turn the toggle levers, which move the compression caps against the resistance pieces. A centrifugal switch may be used here to short-circuit the rotor coils and cut the resistances out of circuit, as is shown in Figs. 2 and 3.

While in our motor we have used only resistance materials having a negative thermal co-efficient, yet, for certain purposes, materials having a positive thermal coefficient may be used in their stead. While we prefer to use a spring to oppose the compression of the resistance pieces, we do not limit ourselves to the use of such an element, since it may be desirable under certain circumstances to allow the resistance holder to begin to compress the disks as soon as current flows through the holders. The initial pressure upon the disks may be regulated by adjusting the cap or the spring adjusting nut or the screw plug either singly or together.

What we claim as our invention is:

1. In an induction motor, the combination of a rotor, a resistance in circuit with the motor for automatically regulating the supply of current thereto, the said resistance being supported by the rotor and consisting of a body of material made up of separate units in contact with each other, the electric resistance of which varies with the degree of pressure applied to said body of material, an insulating support for holding the said resistance, adjustable means for initially compressing the material of the resistance to a desired degree, means for causing further compression thereof through the action of centrifugal force due to the rotation of the rotor, and means for preventing the operation of centrifugal force to cause said compression until a predetermined degree of speed has been attained by the rotor.

2. In an induction motor, the combination of a rotor, a resistance in circuit with the motor for automatically regulating the supply of current thereto, the resistance consisting of superposed pieces of material, an insulating holder or support for the said resistance carried by the rotor, an insulated contactor in circuit with the line that supplies the motor bearing upon one end of the said resistance, the other end of the resistance being in electric contact with the said holder, the said contactor and holder being movable relative to each other whereby the resistance may be subject to varying degrees of compression, means for moving one of these parts through the action of centrifugal force due to the rotation of the rotor, to automatically compress the resistance material when the motor is in operation, and means for positively moving the other part to cause a predetermined initial degree of compression of the resistance.

3. In an induction motor, the combination of a rotor, a resistance in circuit with the motor for automatically regulating the supply of current thereto, the said resistance consisting of a body of material made up of separate units in contact with each other, the electric resistance of which varies with the degree of pressure applied to said body of material, an insulating support for holding the said resistance, carried by the rotor, means for causing a compression of the resistance through the action of centrifugal force due to the rotation of the rotor, and a spring opposing the operation of the said means, and preventing them becoming effective until a predetermined speed of the rotor has been attained.

4. In an induction motor, the combination of a rotor, a resistance in circuit with the motor for automatically regulating the supply of current thereto, the said resistance consisting of a body of material made up of separate units in contact with each other, the electric resistance of which varies with the degree of pressure applied to the said body of material, an insulating holder in which the said resistance is placed, carried by the rotor and free to move outward under the action of centrifugal force generated by the rotation of the rotor, thereby causing compression of the resistance it contains, a spring bearing upon the said holder opposing the outward movement thereof until a predetermined speed of the rotor has been attained, and means for adjusting the tension of the spring.

5. In an induction motor, the combination of a rotor, a resistance in circuit with the motor for automatically regulating the supply of current thereto, the said resistance consisting of a pile of separate disks, an insulating holder in which the said disks are placed carried by the rotor, the holder being movable outward under the action of centrifugal force generated by the rotation of the rotor, whereby the resistance is compressed, a spring surrounding the holder and opposing the outward movement thereof, and an adjusting nut by which the tension of the spring may be varied at will.

6. In an induction motor, the combination

of a rotor, carrying a spider with a peripheral rim, and with radially disposed bearings, a resistance in circuit with the motor for automatically regulating the supply of current thereto, the resistance consisting of a body of material made up of separate units in contact with each other, the electric resistance of which varies with the degree of pressure applied to the said body of material, an insulating support for the said resistance mounted in the bearings of the said spider and free to move therein under the action of centrifugal force generated by the rotation of the rotor, the outer end of the said holder being open, an insulated contactor in circuit with the line that supplies the motor, bearing upon the outer end of the said body of resistance material, an adjusting screw mounted in the rim of the spider arranged to force the said contactor into engagement with the resistance material and thus cause an initial compression of the latter, and a spring acting on the holder for the resistance material opposing the outward movement thereof and arranged to yield and permit further compression of the resistance only after the rotor has attained a predetermined speed of rotation.

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