May 1, 1945. J. M. NAUL 2,374,883

VARIABLE REACTANCE CONTROLLER

Filed April 2, 1942

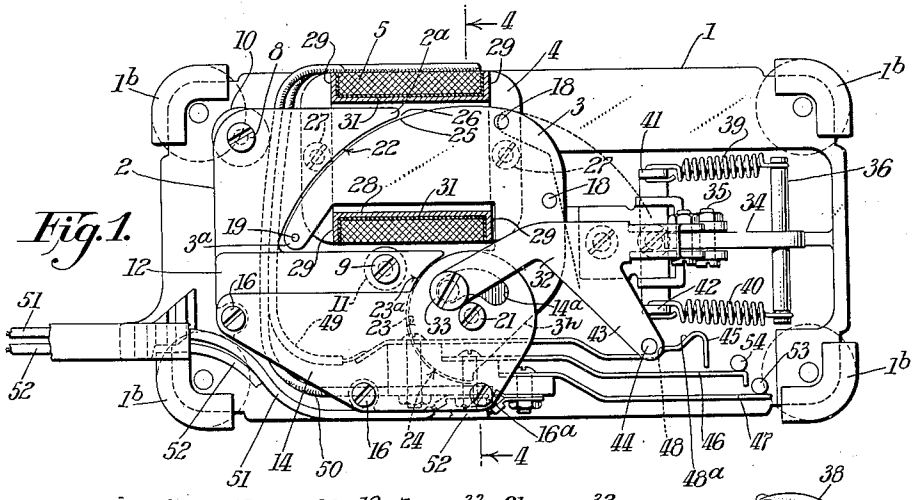


Fig. 1.

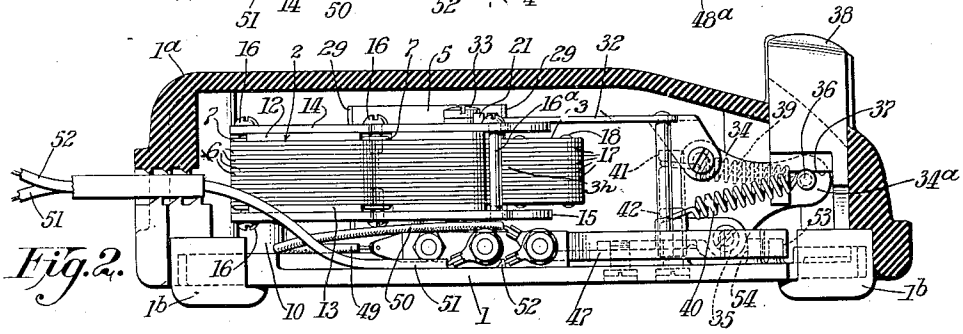


Fig. 2.

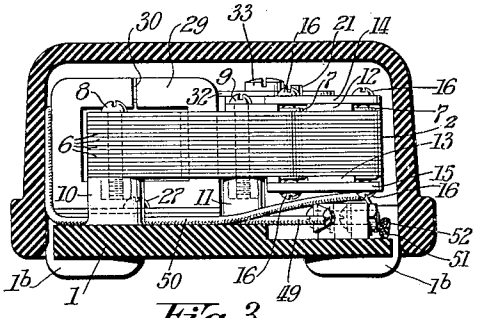


Fig. 3.

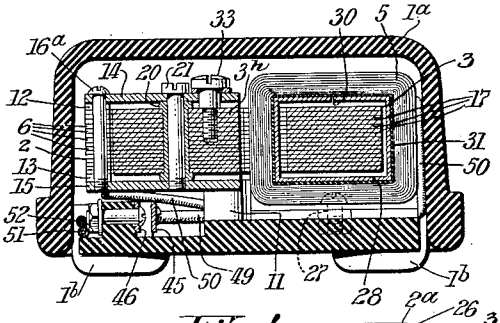


Fig. 4.

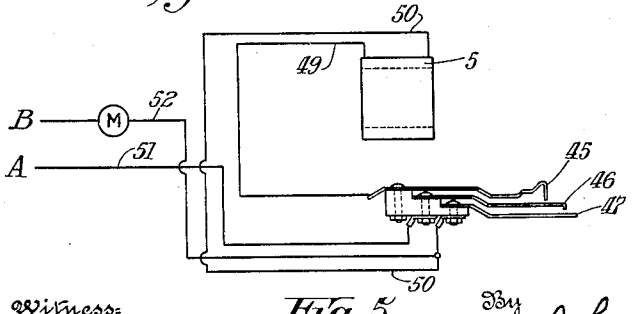


Fig. 5.

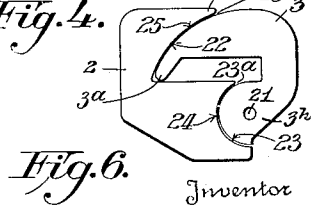


Fig. 6.

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VARIABLE REACTANCE CONTROLLER

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Application April 2, 1942, Serial No. 437,323

1 Claim. (Cl. 171—242)

This invention relates to a circuit controller for alternating current electric motors, particularly small motors used in driving light machinery such as sewing machines which are frequently started and stopped, and are required to run at variable speeds in use.

More particularly, the invention relates to a variable reactance type of controller in which the value of reactance is varied by adjustment of the reluctance of a magnetic circuit.

It is an object of this invention to provide an improved reactance device, which is variable over a wide range for controlling an alternating current sewing machine motor and capable of varying the speed of the motor, between zero and maximum speeds, smoothly and without any perceptible jumps or jerks.

Another object of the invention is to provide a variable reactance speed-controller for sewing machine motors which is capable of being operated by a foot pedal and which will not be objectionably sensitive to movements of the pedal in the slow speed positions thereof.

Rheostatic controllers of the carbon compression type have been used for many years for controlling the speed of sewing motors. Such a controller is shown and described in the U. S. patent to G. O. Wilms, No. 1,777,988, dated October 7, 1930. In such controllers it is difficult to make the resistance variation uniform over the entire resistance range. It is an inherent characteristic of compression-type rheostats to have a large change in resistance per unit compression displacement in the high resistance range and a low change in resistance per unit compression displacement in the low resistance range. This is particularly undesirable for controlling sewing motors because fine speed control cannot be obtained in the low speed range where it is most desirable. Single and compound actuator springs have been employed to correct this condition, but they are not entirely satisfactory.

It is a further object of this invention, therefore, to provide an improved controller for controlling the speed of an alternating-current motor, in which the variation in reactance with displacement of a pedal member may be readily made to follow substantially any predetermined characteristic by the simple expedient of properly shaping the face contours of stationary and movable magnetic cores at a variable air gap.

Still another object of the invention is to provide an improved motor controller which is rugged and compact in construction; and efficient and quiet in operation.

A further object of the invention is to provide an improved adjustable variable reactance in which a pivoted movable magnetic core member cooperates with a stationary magnetic core member to provide a magnetic circuit which threads a reactance coil and has an air gap which may be varied in area and length by movement of the pivoted core member.

With the above and other objects in view, as will hereinafter appear, the invention comprises the combinations and arrangements of parts hereinafter set forth and illustrated in the accompanying drawing of certain specific embodiments of the invention, from which the several features of the invention and the advantages attained thereby will be readily understood by those skilled in the art.

In the accompanying drawing, Fig. 1 is a top plan view of a controller embodying the invention and having the cover removed.

Fig. 2 is a side elevational view of the controller of Fig. 1 with the cover shown in section.

Fig. 3 is a left-end elevational view of the controller of Fig. 1 with the cover and base shown in section.

Fig. 4 is a vertical sectional view taken on the line 4—4 of Fig. 1.

Fig. 5 is a schematic diagram showing the electrical connections between the circuit elements of the controller when connected for controlling motor speed.

Fig. 6 is a diagrammatic view showing the relative position of the magnetic cores in closed gap condition.

Referring more particularly to the drawing, Fig. 2 shows a casing comprising a generally rectangular base member 1 and a removable cover member 1a, preferably made of molded insulating material, said base member 1 having supporting feet 1b and providing a platform with recesses and bosses on which are seated the various component parts of the controller. This casing is similar to that shown and described in the U. S. patent to Langille, No. 2,068,920, dated January 26, 1937. Secured to the base member 1 is a stationary magnetic core member 2 which carries a pivoted movable core member 3, and a stationary coil-form 4 to which is applied the reactance coil winding 5. The stationary magnetic core 2 comprises a series of generally L-shaped stacked lamination 6, fastened together by means of hollow rivets 7 and secured by screws 8 and 9 to

respective bosses 10 and 11 formed on the base member 1. Spacer plates 12 and 13 are positioned, one on the top and one on the bottom of the core 2, as shown best in Fig. 2. Non-magnetic hinge plates 14 and 15 are positioned in face-to-face relation with said respective spacer plates 12 and 13 and are secured to the stationary core member 2 by means of screws 16 threaded into the hollow rivets 7.

The movable magnetic core 3 is formed from stacked laminations 17, secured together by means of rivets 18, 19 and a hollow non-magnetic tube 20 which extends through the stack and is spun over on the ends as is seen best in Fig. 4. The tube 20 serves as a bearing for the core 3 and pivots on the stationary headed pin 21 which extends through a fitted aperture in the upper hinge plate 14 and is threaded into the lower hinge plate 15. A headed bolt 16a extends through an aperture in the upper hinge plate 14, passes outside of the laminations 6 and is threaded into the lower hinge plate 15.

The stationary core member 2 has concave arcuate face portions 22 and 23 which provide complemental pockets for receiving portions of the movable core as will be described. The movable core member 3 is formed with a hub 3h having a convex arcuate portion 24 which fits within and in spaced relation to the corresponding arcuate portion 23 on the stationary core member 2 to form therewith an air gap 23a which is fixed in length but may be variable in area. A convex arcuate face portion 25 of the movable core member 3 is spaced from but normally lies closely adjacent and in face-to-face relation to the face portion 22 of the stationary core member 2 and forms therewith a variable air gap 26, the dimensions of which are continuously adjustable by rotation of said movable core member 3 about the stationary pin 21. The arrangement of the magnetic circuit in the close gap condition is seen best in Fig. 6.

The hollow coil-form 4, preferably made of brass or some suitable non-magnetic material and secured to the base 1 by screws 27, comprises a hollow mandrel portion 28 which embraces portions of both stationary and movable cores at the air gap 26, and end flange portions 29 joined to said mandrel portion at each end thereof to provide therewith a rigid self-supporting form on which the winding 5 is applied. The mandrel portion 28 and end flange portions 29 are provided with a longitudinal air gap 30 which cuts completely through the coil form longitudinally of its axis so that no closed electrical conducting paths linking the magnetic circuit will be provided in which currents may be induced and losses thereby incurred. The usual insulation 31 is provided between the coil-form 4 and the winding 5.

The fixed reactance coil winding 5 is positioned so that, as the movable core is rotated clockwise, Fig. 1, the air gap area is decreased and the length may be increased substantially along the winding axis within the confines of the ends of the winding. The pivoted movable core may be entirely withdrawn from within the winding, leaving substantially no magnetic core material within said winding, as is shown clearly in dotted lines in Fig. 1.

It is well known that the reactance of a current-carrying winding linking a magnetic circuit may be varied by changing the reluctance of the magnetic circuit. This reluctance may be most conveniently changed, as in the present invention, by mechanically varying the dimensions of a variable air gap in said magnetic circuit. That is to say, the reactance of winding 5 varies in direct proportion as the effective area and as the effective length of the air gap 26 varies. Thus, for example, if the length and area of the air gap are made to vary coincidentally and linearly with the angular displacement of the movable core 3, then the reactance of the winding 5 will vary theoretically as the square of the angular displacement. It will be understood, therefore, that, by properly shaping the face portion 22 and 25 of stationary and movable cores respectively and by arranging said surfaces properly relative to the pivotal axis of the pin 21 so that the predetermined proper amounts of length and area change components may be combined, the reactance may be made to vary with the displacement of the movable core according to substantially any desired characteristic. It has been found, however, that the variation in magnetic pull between the movable and stationary cores is less for unit change in air gap area than for unit change in air gap length. Thus, in those cases where the magnetic pull produces a varying torque about the axis of rotation which pull must be overcome by pressure on the pedal, it is more desirable to employ area change. With this in mind, I have provided an air gap with face portions which are cylindrical and which have a common axis coincident with the fixed axis of rotation so that the magnetic forces between the stationary and movable cores, which forces are pulsating at twice the frequency of the alternating current, are all directed radially through said fixed axis whereby to prevent the production of pulsating torques which would not only react against the effort of the operator to move the controlled pedal but would also effect vibration with attendant undesirable noise. Accordingly, in the specific case illustrated, it is noted that the cylindrical face portions 22 and 25 are concentric with the pivotal axis so that initial clockwise movement of the pivoted core effects only a uniform decrease in the air gap area accompanied by a uniform decrease in reactance.

That portion of the rotatable core 3 which extends within the reactance winding 5 has a variable cross-sectional area. After the core 3 has completed the initial portion of its rotation, during which the area of the air gap between the coaxial cylindrical surfaces change linearly from a maximum to zero, the air gap formed between the small rounded horn-like portions 2a and 3a of the respective core members 2 and 3 begins to increase in length thus producing a further reduction in the reactance, throughout the remainder of the core rotation. By making the effective area of the horn-like portions small any vibrating torques due to the alternating flux between the stationary and movable cores are minimized.

It is important that the reactance be brought to its minimum value at the end of the core movement to provide maximum motor speed at this point and this is provided by applying a short-circuit around the reactance coil winding as will be described. Although the reactance winding may be placed at any convenient point on the magnetic circuit, by placing it to embrace the air gap portion of the magnetic circuit the leakage flux linking the winding is a minimum and the reactance at open-gap condition is lower than for any other winding position. This ar-

rangement is of particular advantage in this case, where the reactance of the winding is dropped suddenly to zero by applying a short-circuit around it, to reduce the magnitude of the sudden change and thus smooth out the reactance variation.

A pull-strap 32, pivotally and eccentrically connected at one end to the hub portion 3[b] by a headed screw 33 threaded into said hub portion and passed through the slotted portion 14[a] of hinge plate 14, is pivotally connected at the other end to a lever 34 fulcrumed at 35 on the base 1 and carries a cross bar 36 which is engaged by the lower faces 37 of a vertically slidable pedal slide 38 mounted in the cover member 1[a]. The shank portion of the screw 33 rests against the left-hand edge of the slotted portion 14[a] to form a stop for the movable core in its closed position as shown in Fig. 1. Recovery springs 39 and 40 connected to the ends of the cross bar 36 are anchored respectively to the horns 41 and 42 which rise from the base 1. The pull-strap 32 is formed with a side-arm extension 43 which carries at its extremity a pin 44 the purpose of which will be presently described.

A spring contact assembly comprising three current-conducting spring fingers 45, 46 and 47 suitably mounted and positioned on the base 1 provides connecting means whereby (1) initial movement of the pedal slide 38 closes a circuit through the reactance winding 5 and (2) extreme movement of said pedal slide applies a short-circuit around the reactance winding.

It will be seen by reference to Fig. 5 that spring finger 45 is electrically connected to one end of the winding 5 by the lead 49, the other end of said winding being connected through lead 50 to spring finger 47. Lead 51 connects spring finger 46 to one side A of an alternating-current supply source, while the other side B of said source is connected to a motor M and thence by means of lead 52 to the common junction of spring finger 47 and lead 50. It is clear that, in the initial position of the parts as shown in Fig. 5, no current can flow through the motor circuit until finger 45 makes contact with finger 46 when the reactance winding 5 is placed in series with the motor and the source of alternating-current. This is a position of maximum reactance and the motor starts and runs slowly. After a predetermined movement of the controller pedal slide, during which the reactance is being reduced and the motor speed accelerated, the fingers 45 and 46, already in contact, make contact with the finger 47 which places a short-circuit around the reactance winding through leads 49 and 50. The motor is thus placed directly across the source A, B, of alternating-current, and runs at its maximum speed. How this sequential switching is mechanically effected will now be described.

The upper spring finger 45 is bent to form an inclined cam portion 48 which cooperates with the pin 44, when the pedal slide is depressed, to force the free end of spring finger 45 into contact with spring finger 46. This initial contact is completed after very slight movement of the pedal slide. Continued downward displacement of the pedal slide maintains the spring finger 45 in contact with the spring finger 46 and, after a predetermined movement of the core 3, the pin 44 encounters the inclined cam portion 48[a] and forces the free end of finger 46 into contact with finger 47 and the forward end 34[a] of the lever 34 contacts the base member 1 which serves as a stop to limit this extreme position. In this position, all three spring fingers are in contact and the rotatable core 3 is withdrawn from within the hollow coil-form 4. When the foot-pressure is removed from the pedal slide 38, recovery springs 39 and 40 retract the pull-strap 32 to rotate core 3 into the hollow coil-form 4 and the spring fingers are taken out of contact sequentially in inverse chronological order to that in which they were placed in contact. Stop pins 53 and 54, preferably formed integrally with the base, provide a definite limit to the travel of spring fingers 47 and 46 respectively and thus effect a sharp, clean break in the contacts with resultant reduced arcing and maintenance.

From the foregoing it will be perceived that I have provided an improved circuit controller which combines a stationary and a movable magnetic core to form a magnetic ring having a variable air gap, including a reactance winding positioned to embrace the magnetic ring at the air gap and means for adjustably rotating said movable core whereby to vary the dimensions of said air gap and thereby the reactance of said winding.

It will be obvious to those skilled in the art that the invention may, without departure from its essential attributes, be embodied in various specific forms other than those shown and described, which latter are to be considered in all respects as illustrative of the invention and not restrictive, reference being had to the appended claim rather than to the foregoing description to indicate the scope of the invention.

Having thus set forth the nature of the invention, what I claim herein is:

A controller of the variable reactance type, comprising a stationary magnetic core and a pivoted magnetic core, said cores together forming a normally closed magnetic circuit, said stationary core having end portions affording two concave arcuate faces of different radii, the portion of said stationary core having the face with the greater radius terminating in a horn projecting in one direction, said pivoted magnetic core having two convex arcuate faces of different radii complemental to the concave faces of said stationary magnetic core and normally nested therein, with air gaps therebetween, said convex and concave faces being substantially coaxial with said pivoted core, the portion of said pivoted core having the face with the greater radius terminating in a horn projecting in a direction opposite to the horn of said stationary core, an electrical reactance coil linked with said cores, and manually actuatable means connected with said pivoted core for turning it about its pivot and relative to the stationary core over a range sufficient to widely separate said horns orbitally of the path of movement of the pivoted horn.

JAMES M. NAUL.