Feb. 22, 1955 R. L. JAESCHKE 2,702,872

CONTROLLED MOTOR-DRIVE UNIT

Filed Feb. 9, 1953 2 Sheets-Sheet 1

FIG. 1.

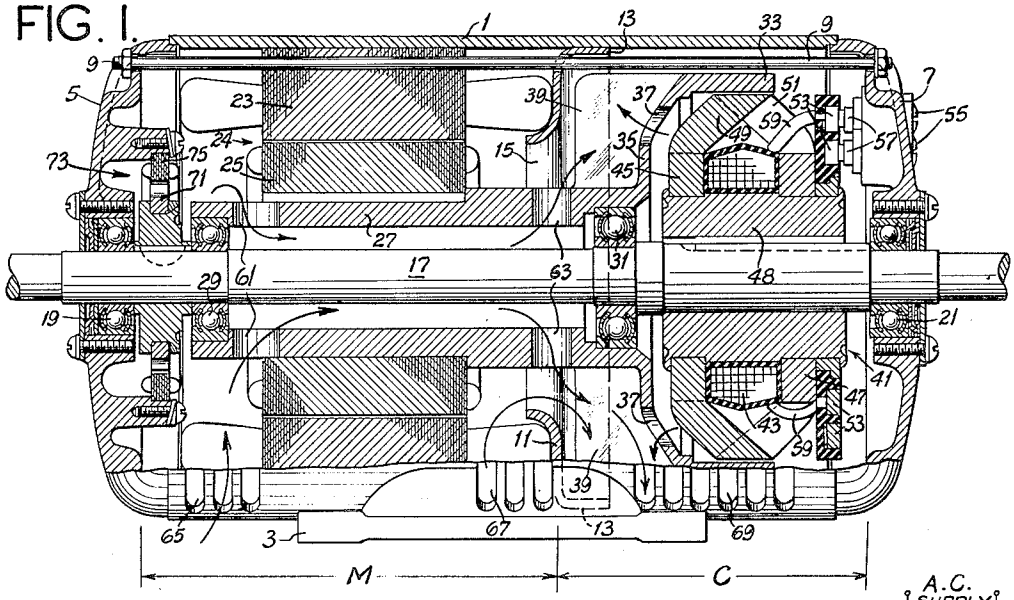
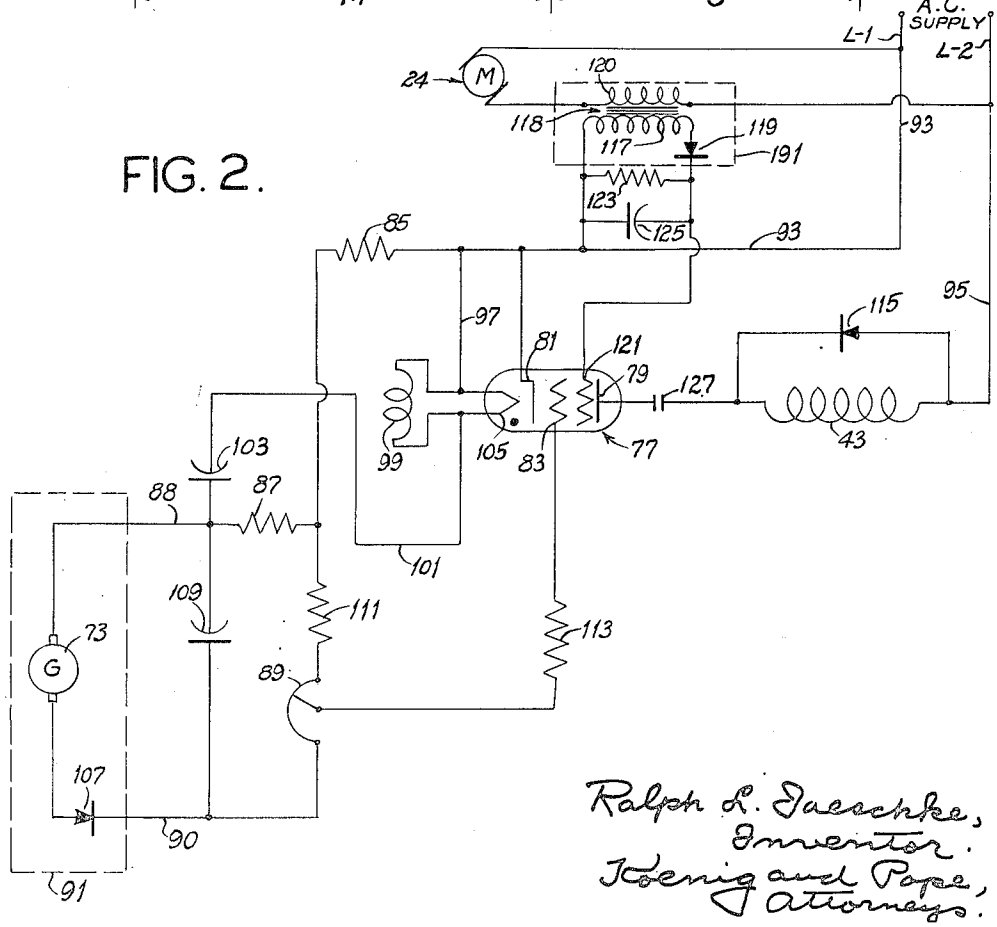


FIG. 2.



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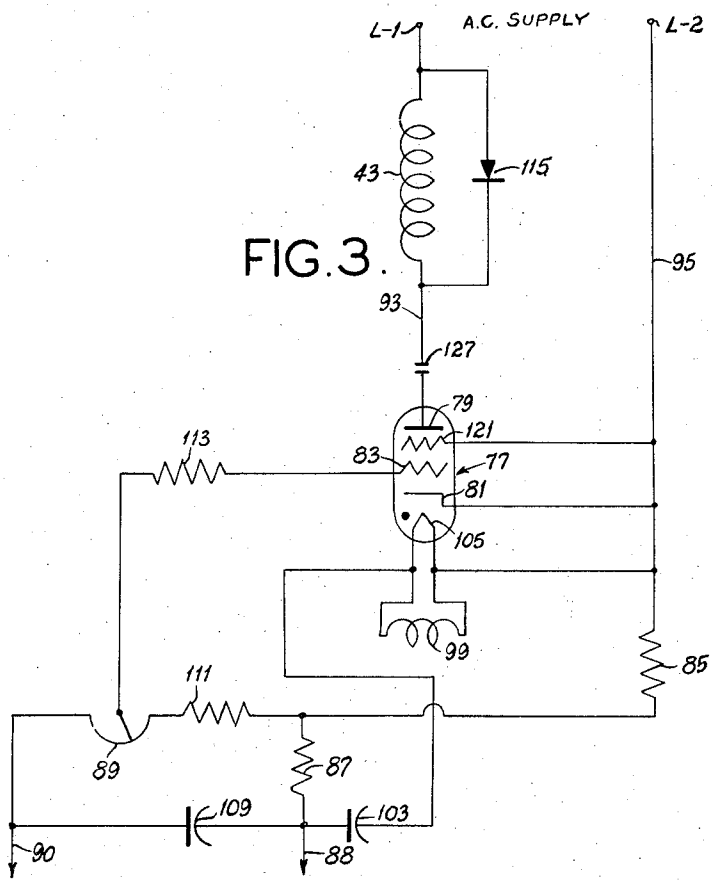


FIG. 3.

FIG. 4.

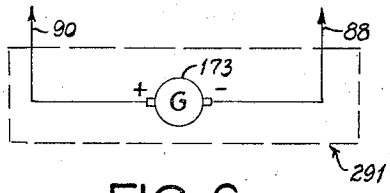


FIG. 6.

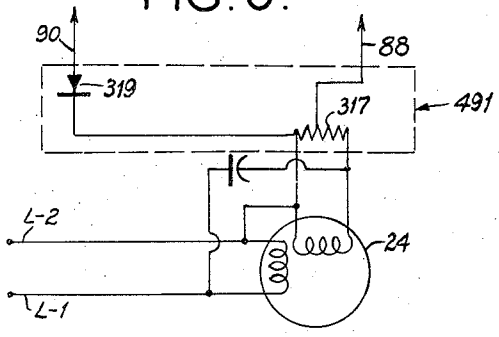
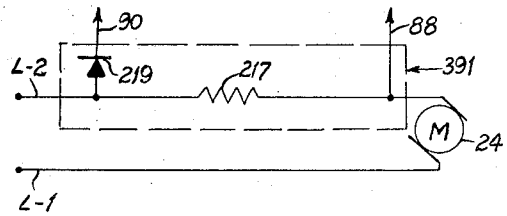


FIG. 5.



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2,702,872

CONTROLLED MOTOR-DRIVE UNIT

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Application February 9, 1953, Serial No. 335,920

14 Claims. (Cl. 310—94)

This invention relates to controlled motor-drive units, and with regard to certain more specific features, to such a unit incorporating an adjustably controlled magnetic coupling, being an improvement upon the electrical control apparatus shown in Anthony Winther U. S. Reissue Patent 22,432, dated February 1, 1944.

Among the several objects of the invention may be noted the provision of a low-cost electrically controlled motor-drive unit particularly applicable (though not limited to) fractional horsepower ratings such as from approximately ¼ to 1½ H. P.; the provision of a unit of the class described which, due to an improved cooling arrangement for its motor and coupling components, is more compact in size and reliable in performance with a lower temperature rise than heretofore; and the provision of a unit of the class described incorporating a simple but accurate and dependable electronic control. Other objects and features will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the constructions hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawings, in which several of various possible embodiments of the invention are illustrated,

Fig. 1 is an axial section through physical apparatus embodying the invention;

Fig. 2 is a circuit diagram of an electronic control for the apparatus of Fig. 1;

Fig. 3 is a circuit diagram of an alternate electronic control adapted for connection to certain torque-control or speed-control elements of Figs. 4 to 6;

Fig. 4 is a circuit diagram of a speed-control element;

Fig. 5 is a circuit diagram of a torque-control element; and,

Fig. 6 is a circuit diagram of an additional embodiment of a torque-control element.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring now more particularly to Fig. 1, there is shown a motor-coupling unit consisting of a sleeve **1** mounted upon a base **3**. Attached to the sleeve **1** are end bell enclosures **5** and **7**, held in place by draw bolts, one of which is indicated at numeral **9**. The internal cylindric chamber formed by the parts **1**, **5** and **7** is divided by means of a round septum **11** which incorporates a flange **13** for fastening it to the inside of the sleeve **1**. The septum is formed with a throat **15**. Thus is formed a motor compartment M and a coupling compartment C. A shaft **17** is mounted upon bearings **19** and **21** in the end bells **5** and **7**, respectively. The sleeve **1** in motor compartment M supports the stator **23** of a motor **24**. This stator preferably includes a low voltage winding, e. g., 6.3 volts for energizing the filament of the electronic control tube, described hereinafter. This motor may be single or polyphase and of the capacitor-start-capacitor-run or capacitor-start-induction-run types, depending upon the particular application desired.

The rotor **25** of the motor **24** is keyed to a hollow quill **27**, the latter being carried upon bearings **29** and **31** on the shaft **17**. Bearing **29** is in the motor compartment M and bearing **31** is in the coupling compartment C. In the coupling compartment the quill **27** carries a magnetizable (iron) inductor drum **33**. This drum, with its connection **35** to the quill, forms a cup in which are located air-circulating openings **37**. Between the connection **35** and the quill **27** are ribs **39**, which form combined fan impeller blades and heat-radiating fins. These fins are closely adjacent to the septum **11**, through the throat **15** of which passes the quill **27**.

Keyed to the shaft **17** in the coupling compartment C is a magnetizable (iron) field member **41** made generally according to the construction shown in my U. S. Patent 2,606,948, dated August 12, 1952, This field member has an annular field coil **43** flanged by pole spiders **45** and **47** located on a hub **48**. The spiders have interdigitated pole-forming teeth **49** and **51**. Collector rings **53**, served by outside connections **55** through brushes **57**, serve to excite the coil **43** through leads **59**. Brushes **57** are mounted in the end bell **7**. Upon exciting the coil **43**, a toroidal flux field passes through the members **45**, **47**, **48**, **49**, **51** and **33**. Upon rotation of the drum **33** relative to the poles **49** and **51**, eddy currents will be generated in the drum which form a reactive magnetic field with respect to that emanating from the poles **49** and **51**, thus tending to drive the field member **41** with some rotary slip, which is in an inverse relationship to the field strength as determined by the ampere turns of coil **43**. Since the motor **24** drives the quill, which is responsible for rotation of the drum **33**, the field member **41** and hence the shaft **17** will be driven with slip, at an angular velocity depending upon the load on the shaft **17** and the excitation of coil **43**. The driving action is accompanied by heating of the drum **33** induced by the eddy currents therein.

In order (1) efficiently to dissipate the drum heat, (2) to reduce the temperature rise of the motor **24**, and (3) to cool the bearings **29** and **31**, I provide sets of openings **61** and **63** in the quill **27**, and two groups of air inlets **65** and **67** in the motor compartment M and a set of air outlets **69** in the coupling compartment C. By means of the centrifugally operating impeller blades **39**, fresh air is drawn through the inlets **65** and **67**. The cool air which enters at **65** passes through the quill and out its opening **63**. The motor stator and field assembly **23**, **25** acts as a diaphragm enforcing this flow of air through the quill **27**, thus abstracting heat from the core of the machine, which is usually difficult to accomplish. The cool air which enters at **67** passes through the throat **15**. All of this air ultimately passes out of the outlets **67**, and some will circulate around the inductor drum **33**, around the poles **49** and **51** and through the openings **37**, finally to escape from said outlets **69**. The direction of air flow is suggested by the arrows. The cooling thus effected is such that substantial savings may be made in the sizes of the parts for a given temperature rise, which renders the unit compact.

The end bells **5** and **7** are nonmagnetic (aluminum, for example) to prevent completion of any magnetic circuit through either of the bearings **19** or **21**. This considerably extends their lives. Also, carried on the left end of shaft **17** (between the end bell **5** and the left end of quill **27**) is the magnetic polar field member **71** of an A. C. generator **73**. The stator **75** of this generator **73** is bolted to the end bell **5**. The bearings **19**, **21**, **29** and **31** are of the type which are lubricated and sealed for life, so that they are incapable of allowing passage therethrough of any air.

Fig. 2 shows one form of a control for the unit illustrated in Fig. 1 which is preferably contained in a separate plug-in unit to be mounted on the motor-drive unit of Fig. 1. The function of this control is to maintain shaft **17** at a substantially constant predetermined rotational speed by varying the slip of the eddy-current clutch or coupling (by energization of field coil **43**) in response to motor loading.

The control basically comprises a thyratron **77** (including an anode **79**, a cathode **81** and a control grid **83**), a pair of resistors **85** and **87**, a potentiometer **89** and a control element **91**. One side of an A. C. source indicated at L–1, L–2 is connected through a wire **93** to cathode **81**, while the other side of the A. C. source is connected by means of wire **95** through field coil **43** to anode **79**, thus forming a half-wave rectifier circuit for energizing coil **43**. Resistor **85** and potentiometer **89** are series-connected between cathode **81** and grid **83**. Con-

trol element **91** and resistor **87** are series-connected by means of wires **88** and **90** across potentiometer **89**. A second source of A. C., shifted in phase with respect to the aforementioned A. C. source, is applied across resistors **85** and **87**. This is accomplished, for example, by connecting a wire **97** between cathode **81** and one side of a filament transformer secondary **99**, and connecting a second wire **101** and a condenser **103** to wire **88**. The primary of transformer **99** (not shown) is preferably connected to A. C. source L–**1**, L–**2**, the transformer thus functioning to energize thyratron filament **105**.

The control element **91** preferably comprises A. C. generator **73** and a rectifier **107**, the D. C. output potential thereof being filtered by a condenser **109**. A resistor **111** may also be utilized in the series circuit between cathode **81** and grid **83** to provide a greater useful adjusting range of potentiometer **89**. A grid-blocking resistor **113** is connected in the cathode-grid circuit. Field coil **43** preferably has a rectifier **115** shunt-connected therewith to provide a path for the inductive discharge of coil **43** during nonconducting periods of thyratron **77**.

A second control element **191**, comprising a secondary **117** of a current transformer **118** and a rectifier **119** connected in series between a second grid **121** and cathode **81**, may also be provided. Primary winding **120** is series-connected in one of the A. C. power leads to motor **24**. Alternatively, the starting winding system of motor **24** may also be used as a control element. Also, a watt-meter type of control may be used as a substitute for the current transformer **118**. Such a control is shown in U. S. Patent 2,469,706, for Electronic Tension Control Apparatus. A load resistor **123** and a filter condenser **125** are preferably connected across the output leads of control element **191**.

A pair of switch contacts **127** is interposed between anode **79** and coil **43** to serve as an on-off switch.

Operation is as follows:

Upon connecting an A. C. source to L–**1**, L–**2**, motor **24** is energized to drive inductor drum **33** through quill **27**. Shaft **17**, however, will remain substantially stationary until an electrical potential is impressed across coil **43**. This is accomplished by closing switch **127** to energize the Fig. 2 control. When A. C. is supplied initially to wires **93** and **95** the potential impressed between cathode **81** and control grid **83** is the out-of-phase A. C. signal obtained from transformer secondary **99** and condenser **103**, No D. C. grid bias is supplied by control element **91** as long as shaft **17** and A. C. generator **13** are stationary. The out-of-phase A. C. signal thus impressed on the cathode-grid circuit of the tube **77** will cause thyratron **77** to conduct during the periods that anode **79** is positive with respect to the cathode **81** and the A. C. grid signal exceeds in the positive direction the shut-off point of tube **77**. This point or potential of one such thyratron, the RCA–6012, is approximately minus 4 bolts. The thyratron **77**, therefore, serves as a half-wave rectifier, the conductive time of which is the function of the grid-cathode potential.

Upon conduction of tube **77** a potential is impressed across coil **43** and the resulting current flow therethrough will generate eddy currents in rotating drum **43** forming a reactive magnetic field with respect to that emanating from poles **49** and **51**, thereby tending to drive field member **41** (and also shaft **17** and A. C. generator **73**) with some rotary slip. The actuation of generator **73** produces an A. C. potential responsive to the rotational speed of shaft **17**, which is in turn a function of the loading thereof. The A. C. potential produced by generator **73** after rectification (by rectifier **107**) and filtering (by condenser **109**) serves as a D. C. bias supply for grid **83**. As the rotational speed of the shaft **17** increases, grid **83** is thus driven more negative with respect to cathode **81** until the equilibrium point is reached, at which time the speed of shaft **17** remains substantially constant at a predetermined value. This value is controlled by the setting of potentiometer **89** which serves as a speed-control potentiometer. Shaft **17** can, therefore, be caused to operate at any of a wide range of speed values and will retain the predetermined speed even though the loading varies. This is because an incipient increase or decrease in the speed of shaft **17** is reflected back to the control grid **83** (through control element **91**) to increase or decrease the current flow through coil **43** to compensate for such loading variations.

It can thus be seen that the signal applied between grid **83** and cathode **81** is a composite of D. C. output of control element **91** (connected across resistor **87** and potentiometer **89**) and the phase-shifted A. C. rider wave component across resistor **87**. As exemplary component values, resistor **85** is 1,000 ohms, resistor **87** is 10,000 ohms, resistor **111** is 4,700 ohms and condenser **103** is .1 mfd., which provides an approximate 90° phase-shifted voltage proportioned across resistors **85** and **87** in a 1:10 ratio. That is, approximately 10% of the A. C. potential is developed as a fixed rider wave across resistor **85** and the balance of the potential is developed across resistor **87**. It will be understood that a single tapped resistance is the equivalent of resistors **85** and **87** and that this 1:10 ratio could be varied conveniently by changing the values of resistors **85** and **87** or by positioning the tap of a single tapped resistance. The potentiometer **89**, having a value of about 250,000 ohms, therefore, will effectively vary the A. C. rider wave potential of resistor **87** as its setting is changed. This arrangement provides an A. C. rider wave of lesser amplitude at high speeds than at low speeds.

In order to avoid overloading motor **24**, the torque control element **191** has been provided. Upon the current drawn by motor **24** through current transformer **118** exceeding a pretermined value, the voltage drop across resistor **123** (rectified by component **119**) is impressed between the second grid **121** and cathode **81** so that an increased negative potential is applied to grid **121** upon increased current flow through winding **120**. When this negative potential exceeds a predetermined value, tube **77** will cease to conduct.

Contacts **127** may be used, if desired, for inching purposes, or a push button switch for this purpose may be connected across contacts **127**.

The control of Fig. 2 is, therefore, an exceptionally simple control system, including basically only a thyratron, resistors **85**, **87** and **113**, potentiometer **89**, and control element **91**. The control is so compact and simple that it can be utilized conveniently as a plug-in unit with leads to appropriate connections to motor **24**, generate **73** and the A. C. supplies. The control characteristics of this unit are, however, surprisingly good, providing a speed regulation which is less than 50 R. P. M. from no load to full load (25 R. P. M. regulation from one-fourth load to full load). The unit will operate directly from a conventional 110 volt system or from a 220 volt system (if motor winding center tap is utilized) without the need of an auxiliary transformer. Also, the requirement for a D. C. reference voltage circuit is eliminated as well as the need of a tube timer (because of the low plate voltage). The predetermined speed is continuously variable over a 10:1 speed range, with a minimum speed of approximately 150 R. P. M. or lower if necessary.

The Fig. 3 control corresponds to that of the Fig. 2 embodiment with only the following modifications: providing for the connection of any one of the alternate control elements of Figs. 4–6 through wires **88** and **90**, omitting control element **191** (and its associated components **123** and **125**), and connecting grid **121** directly to cathode **81**. By utilizing speed-control element **291** of Fig. 4, which employs a D. C. generator **173** (rather than the A. C. generator-rectifier circuit of control element **91**) speed control is obtained as described previously in respect to Fig. 2.

The control element of Fig. 5, indicated by reference numeral **391**, comprises a resistor **217** series-connected with a rectifier **219**. By connecting resistor **217** in series with a lower lead to motor **24**, the variations in loading of motor **24** produce a proportionate current variation in resistor **217** which is arranged to provide a compensating grid control potential via wires **88** and **90** as described above. This control element **391** is, therefore, a torque-responsive rather than a speed-responsive device.

Fig. 6 illustrates another control element embodiment, indicated at reference numeral **491**, adapted for connection to the Fig. 3 circuit through wires **88** and **90**. Control element **491** comprises a tapped resistor **317** and a rectifier **319** connected in series. Resistor **317** is connected across a second winding of motor **24**. The current flow through resistor **317** and, therefore, the resulting potential are a function of the motor loading, the higher the load the higher the voltage. It will be noted that rectifier **319** is reversed because of this inverse relationship.

The controls of Figs. 5 and 6, which are basically

torque-control elements, operate like the control element **191** described above, except that they control conduction of tube **77** by means of grid **83** rather than by grid **121**.

Cross reference is made to my copending divisional application, Serial No. 404,494, filed January 18, 1954, entitled Controlled Motor-Drive Unit.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A control for dynamoelectric apparatus having a D. C. field coil and a rotary member the speed of which is controlled by the field coil, comprising a thyratron having an anode, a cathode and a control grid, a source of A. C. and said field coil being series-connected with said thyratron anode and cathode, a control element having a D. C. output potential responsive to the loading of said dynamoelectric apparatus, a first resistor and a potentiometer being series-connected between said thyratron cathode and grid, a second resistor and said control element being series-connected across said potentiometer, and a second source of A. C. having a phase differing from said first A. C. source being connected across said first and second resistors.

2. A control for a motor energized from an A. C. source, comprising an eddy-current clutch between said motor and a load, a D. C. field coil for said clutch, a thyratron having an anode, a cathode and a control grid, said field coil and said thyratron anode and cathode being series-connected across said A. C. source, a control element having a D. C. output potential responsive to the loading of said motor, a first resistor and a potentiometer being series-connected between said thyratron cathode and grid, a second resistor and said control element being series-connected across said potentiometer, and a second source of A. C. having a phase differing from said first A. C. source being connected across said first and second resistors.

3. A control as set forth in claim 2 wherein the control element is a D. C. generator.

4. A control as set forth in claim 2 wherein the control element is an A. C. generator series-connected with a rectifier.

5. A control as set forth in claim 2 wherein the control element is a series circuit comprising a resistor and a rectifier, said rectifier being connected in series with said first A. C. source.

6. A control as set forth in claim 2 wherein the control element is a series circuit comprising a resistor and a rectifier, said resistor being connected across one winding of said A. C. motor.

7. A control as set forth in claim 2 wherein the control element comprises a resistor series-connected with a rectifier, and a current transformer having a secondary connected across the resistor and rectifier and having a primary connected in series with said first A. C. source.

8. A control for a motor energized from an A. C. source, comprising an eddy-current clutch between said motor and a load, a D. C. field coil for said clutch, a thyratron having an anode, a cathode and a control grid, a source of A. C. and said field coil and said thyratron anode and cathode being series-connected across said A. C. source, a rectifier shunt-connected across said field coil, a control element having a D. C. output potential responsive to the loading of said motor, a first resistor, a second resistor, a potentiometer, and a grid-blocking resistor being series-connected between said thyratron cathode and grid, a third resistor and said control element being series-connected across said potentiometer and said second resistor, and a second source of A. C. having a phase differing from said first A. C. source being connected across said first and third resistors.

9. A control as set forth in claim 8 wherein the ratio of resistances of the first and third resistors is approximately 1:10.

10. A control for a motor energized from an A. C. source, comprising an eddy-current clutch between said motor and a load, a D. C. field coil for said clutch, a thyratron having an anode, a cathode, a filament and a control grid, said field coil and said thyratron anode and cathode being series-connected across said A. C. source, a control element having a D. C. output potential responsive to the loading of said motor, a first resistor and a potentiometer being series-connected between said thyratron cathode and grid, a second resistor and said control element being series-connected across said potentiometer, a second source of A. C. connected to said filament, one side of said filament being connected to said cathode and the other side being connected through a condenser to the connection between said second resistor and said control element.

11. A control for a motor energized from an A. C. source, comprising an eddy-current clutch driven by said motor and having an output shaft connected to drive a load, a D. C. field coil for said clutch, a thyratron having an anode, a cathode and a pair of control grids, said field coil and said thyratron anode and cathode being series-connected across said A. C. source, a speed-control element having a D. C. output potential responsive to the rotational speed of the output shaft, a first resistor and a potentiometer being series-connected between said thyratron cathode and one control grid, a second resistor and said speed-control element being series-connected across said potentiometer, a second source of A. C. having a phase differing from said first A. C. source being connected across said first and second resistors, a torque-control element having a D. C. output potential responsive to the current drawn by said A. C. motor, said torque-control element being connected between said thyratron cathode and the other control grid.

12. A control as set forth in claim 11 wherein the speed-control element is a D. C. generator.

13. A control as set forth in claim 11 wherein the speed-control element is an A. C. generator series-connected with a rectifier, and said torque-control element is a series circuit comprising a resistor and a rectifier, said rectifier being connected in series with said first A. C. source.

14. A control for a motor energized from an A. C. source, comprising an eddy-current clutch driven by said motor and having an output shaft connected to drive a load, a D. C. field coil for said clutch, a thyratron having an anode, a cathode, a filament and a pair of control grids, said field coil and said thyratron anode and cathode being series-connected across said A. C. source, a speed-control element having a D. C. output potential responsive to the rotational speed of the output shaft, a first resistor and a potentiometer being series-connected between said thyratron cathode and one control grid, a second resistor and said control element being series-connected across said potentiometer, a second source of A. C. connected to said filament, one side of said filament being connected to said cathode and the other side being connected through a condenser to the connection between said second resistor and said control element, a torque-control element having a D. C. output potential responsive to the current drawn by said A. C. motor, said torque-control element being connected between said thyratron cathode and the other control grid.

References Cited in the file of this patent

UNITED STATES PATENTS

2,286,778	Winther	June 16, 1942
2,289,330	Fischer	July 7, 1942
2,387,601	Moyer	Oct. 23, 1945
2,566,743	Okulitch	Sept. 4, 1951
2,636,138	Few	Apr. 21, 1953
2,641,759	Jaeschke	June 9, 1953