July 9, 1940. A. S. RIGGS 2,206,920

APPARATUS FOR ELECTRICAL CONTROL

Original Filed Sept. 9, 1936

FIG. 1

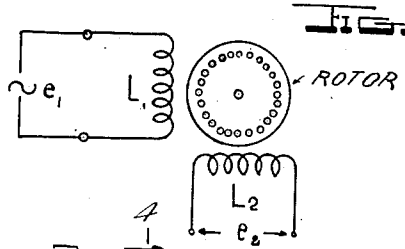


FIG. 2

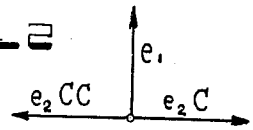


FIG. 3

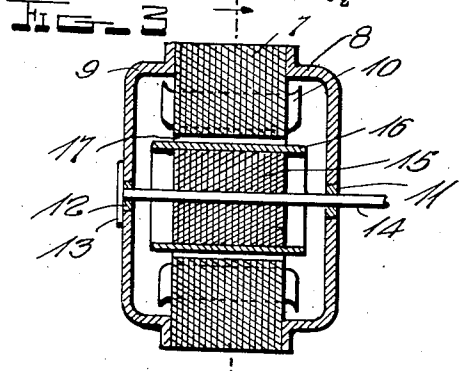


FIG. 4

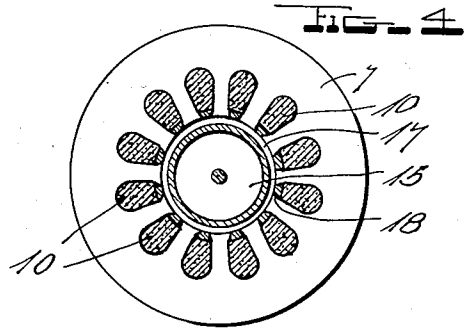


FIG. 5

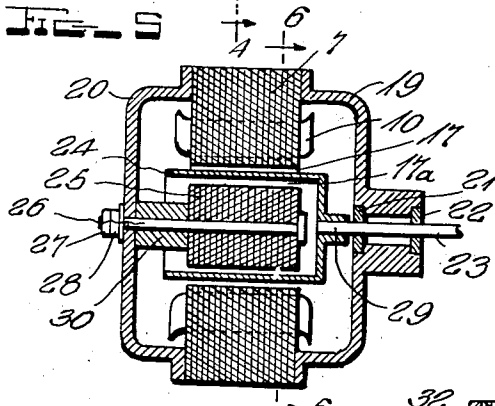


FIG. 6

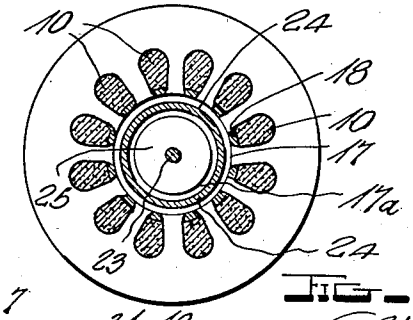


FIG. 7

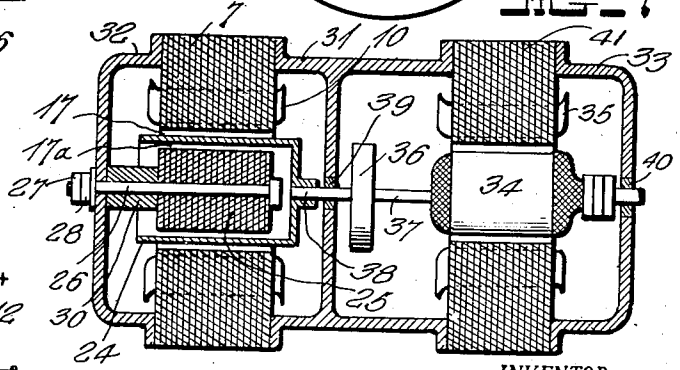


FIG. 8

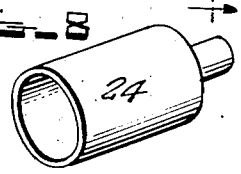
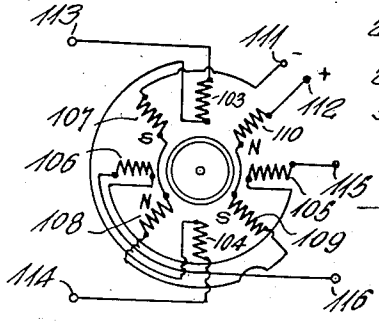


FIG. 9



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UNITED STATES PATENT OFFICE

2,206,920

APPARATUS FOR ELECTRICAL CONTROL

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Original application September 9, 1936, Serial No. 100,017. Divided and this application August 12, 1937, Serial No. 158,807

1 Claim. (Cl. 171—123)

My invention relates broadly to means for producing alternating current voltages of predetermined wave form, primarily for control purposes, as functions of rotational speeds, and more particularly to apparatus for obtaining high degrees of stability and accuracy in control systems for follow-up purposes.

This application is a division of my application Serial Number 100,017, filed September 9, 1936, for Method of and apparatus for electrical control.

One of the objects of my invention is to provide a construction of apparatus from which an alternating current voltage functional upon rotative speed may be derived from a rotating system for control purposes without taking torque from the rotating system.

Another object of my invention is to provide an apparatus for producing an alternating current voltage, as a function of rotational speed, having freedom from commutator ripple which is present in generating equipment of conventional character.

Another object of my invention is to provide means for producing an alternating current signal from a "Selsyn" data transmitting system, for control purposes, which is a function of the angular velocity of rotation of the "Selsyn" transmitter without in any way loading the "Selsyn" system by producing said voltage.

Other and further objects of my invention reside in the operation and construction of apparatus for an electrical control system as set forth more fully in the specification hereinafter following by reference to the accompanying drawing in which:

Figure 1 is a fundamental diagram by which the principle of operation of my device may be understood; Fig. 2 is a vector diagram explanatory of the circuit of Fig. 1; Fig. 3 is a vertical sectional view through one form of phase changing controller constructed in accordance with my invention; Fig. 4 is a transverse sectional view taken on line 4—4 of Fig. 3; Fig. 5 is a vertical sectional view of another form of phase changing controller embodying my invention; Fig. 6 is a transverse sectional view taken on line 6—6 of Fig. 5; Fig. 7 is a longitudinal sectional view taken through a combined phase changing controller and a "Selsyn" motor employed in the system of my invention; Fig. 8 is a perspective view of the rotor in the apparatus of my invention; and Fig. 9 is a detailed diagrammatic view showing the arrangement of the windings in my phase changing controller where it is desired to add a damping component.

My invention relates broadly to means for producing alternating current voltages, primarily for control purposes, as functions of rotational speeds and more particularly to apparatus for the electrical control circuits utilizing amplifier systems for the remote control of heavy objects, such as searchlights and guns, where there is frequently a need for a device producing alternating current voltages as functions of rotational speeds. A conventional commutator type generator is unsuitable for this purpose because the ripple produced by the commutator may detrimentally affect the control circuits.

By the use of a device of the character described herein, a smooth alternating current voltage depending upon rotational speed may be produced. Moreover my device requires negligible driving torque, inasmuch as it is not a true generator, but a speed actuated phase changing controller.

Due to the negligible torque required to drive my device, it is practicable to utilize it for the production of alternating current voltages as a function of rotational speed where the taking of high driving torque may give rise to inaccuracies in the control system.

For instance, in data transmitting systems operating from a so-called "Selsyn" system, the use of my invention permits of designing an electrical control for positioning heavy objects which may be operated in exact agreement at all speeds.

My invention utilizes the so-called generator action of an induction type alternating current motor, and is best understood by reference to the operation of such a motor from zero speed up to its synchronous speed.

Referring to Fig. 1, which is a diagrammatic drawing of a two phase squirrel cage type induction motor, the windings L_1 and L_2 are arranged so that their flux axes are at 90° relation to each other—consequently when the rotor is at rest and an alternating current voltage is applied to the winding L_1, which I term the primary, there is no voltage present at the terminals of L_2, which I term the secondary winding. If now the rotor is revolved, its motion in the primary flux produces a voltage due to rotation which is inductively conveyed from the rotor to the secondary coil L_2—this voltage is proportional to rotationel speed up to the speed corresponding to synchronous speed and is 90° out of phase with the voltage applied to the primary winding L^1.

The vector diagram of Fig. 2 shows the phase relation of the terminal voltages of the machine, the vector representing e_2 (the secondary, or speed voltage) is 90° from the primary voltage and varies in magnitude substantially as a linear function of speed, up to synchronous speed and reverses sign upon reversing direction of rotation.

Though generator action is present in producing the secondary or speed votage e_2 it is also a fact that a corresponding motor action is present—any power taken from the winding L_2 is supplied in reality from the power source connected to the primary L_1, and not from the source of original rotation of the rotor.

In practical use of the device for control purposes it is sometimes objectionable for the motor component to be present, since once started the device tends to run as a single phase A. C. motor. The motor component may be reduced to a negligible quantity by electrically loading the secondary winding, and may be still further reduced by the dynamic braking action of the rotor in revolving in a D. C. field.

In order to provide damping action for the device when required, I provide a separate winding upon the stator having a different number of poles than the A. C. windings as illustrated for example in Fig. 9 and energized from a suitable source of D. C. power. For instance, in one form of my invention I have wound the A. C. windings for two pole and the D. C. damper winding for four pole—both windings in the same slots.

In electrical control circuits employing amplification, the secondary or speed voltage of the machine must have a high degree of wave form purity—so that the "ripple" caused by the squirrel cage is seriously detrimental. In such cases I provide a rotor having laminated discs without slots and simulate the squirrel cage effect by a conductive sleeve pressed and/or shrunk over the laminated core. I show a rotor of such construction in Fig. 3.

In some instances even the rotation of the laminated portion of the rotor gives rise to production of detrimental wave form distortion, and to prevent this I provide a still further form of rotor consisting of a conducting sleeve rotatably mounted, with provision for the iron core corresponding to the rotor core remaining stationary with the stator and the machine, the construction is shown in Fig. 5. Where it is desired to provide a voltage functional upon the angular velocity (or rotational speed) of a "Selsyn" data system I propose to directly connect and rigidly attach a device of the type shown in Fig. 5 to a conventional "Selsyn" type receiver or synchro motor, as I have shown in Fig. 7.

Referring to the drawing in detail, Fig. 3 shows one form of my device for producing a voltage proportional to rotative speed, composed of the laminated stator 7 having distributed windings 10; the stator is held by means not shown, between the end frames 8 and 9. The rotor consists of the laminated core 15 which is pressed on the shaft 14; the laminated rotor core 15 is completely surrounded by the non-magnetic but electrically conductive cylinder or sleeve 16 which performs the function of the squirrel cage illustrated diagrammatically in Fig. 1. The rotor shaft is supported in the bearings 11 and 12, and a cap 13 is provided near the end of the shaft opposite the driving end. Fig. 4, having like parts similarly designated as Fig. 3 is a transverse section at 4—4 of Fig. 3. In Fig. 4 the general means of locating the windings is illustrated, the coils 10 being held in the slots by wedges 18 as in conventional motor practice. The rotor is free to revolve in the stator which it clears by the air gap shown at 17.

Fig. 5 is an improved form of my device in which the entire magnetic core is stationary, and having as a rotor only the conducting non-magnetic shell 24. Referring to Fig. 5, the stator core is made up of the laminated core 7, held between the end frames 19 and 20, and the laminated core 25 attached by the bolt 26 and nuts 27 and 28 to the frame 20. The laminated core 25 is the counterpart of the rotor core 15 in Fig. 3. The spacer 30 holds the inner core 25 in correct relation to the main stator core 7. The rotor consists of the conductive but non-magnetic cylinder 24 which is attached at 29 to the shaft 23 and supported on bearings 21 and 22. The construction shown in Fig. 5 provides a stationary magnetic structure composed of the main stator core 7 and the concentrically located inner core 25 with a double air gap 17 and 17a in which moves the rotor 24. Fig. 6 is a transverse section of Fig. 5 on the line 6—6 and clearly shows the concentric relation of the rotor 24, main stator core 7 and inner core 25.

Fig. 7 is a section of another form of my device which I refer to as a "data speed responsive controller," composed of a device as shown in Fig. 5 directly connected to a "Selsyn" type of repeater motor. Referring to Fig. 7 the stator core 7 is held between the end frame 32 and the "bonnet" 31; the inner core 25 is held by the bolt 26, and the nuts 27 and 28 to the end frame 32 and spaced therefrom by the spacer 30. The rotor 24 is attached to the shaft 37 at 38. The shaft 37 is mounted in the bearings 39 and 40 to rotate the rotor 24 and the rotor 34 of the "Selsyn" repeater motor. The "Selsyn" repeater motor is shown for purposes of illustration as composed of the stator 41 held between the end frame 33 and the bonnet 31 and the rotor 34 operating in the stator 41. A "surge" damping device as usually employed on "Selsyn" type repeater motors is shown at 36.

Fig. 8 is a perspective view of the rotor 24 of Figs. 5 and 7.

Fig. 9 is a diagrammatic showing of a speed responsive device made in accordance with my present invention having three complete sets of windings, a primary composed of the coils 103—104 connected to the terminals 113—114, a secondary composed of the coils 105—106 connected to the terminals 115—116, and a damper winding composed of the coils 107—108—109—110 connected to the terminals 111—112. The primary coils 103—104 are two pole and the secondary coils 105—106 are two pole windings at right angles to the primary, the damper windings compose a four pole winding having poles as shown and the primary and secondary and damper windings are all inductively non-reactive upon each other. The D. C. flux produced by the damper winding drags the rotor and prevents motor torque being developed by the speed responsive controller which might produce detrimental effects when driven by a "Selsyn" type repeater motor.

Though I have shown specific apparatus for illustration and description of the invention, I desire to be limited only by the scope of the appended claim.

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

A device for producing a voltage proportional

to rotational speed, comprising a stator having two independent sets of windings, the first set consisting of a pair of windings at 90° space relation having a like number of pairs of poles, and the second set consisting of a winding having a different number of pairs of poles from the first set, means for impressing an alternating current potential upon one of the windings of said first set of windings, means for utilizing the voltage across the other of said windings in said first set, and means for energizing said second set of windings with direct current, a rotor revolvably mounted in the common flux fields of all of said windings, and external means for driving said rotor for controlling the voltage across said other of said windings in said first set.

ALGER S. RIGGS.