

April 21, 1959

S. M. ORIGONI ET AL

2,883,634

LIMIT STOPS FOR ROTATABLE INDUCTIVE ELECTRO-MECHANICAL DEVICES

Filed Dec. 28, 1954

2 Sheets-Sheet 1

FIG. 1

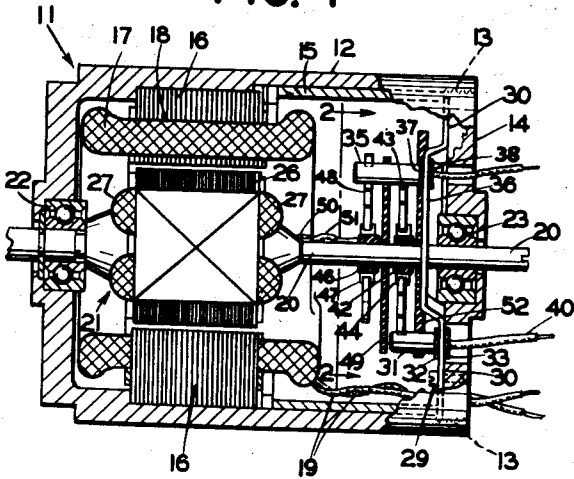


FIG. 2

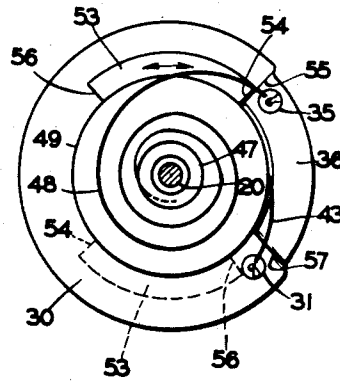


FIG. 3

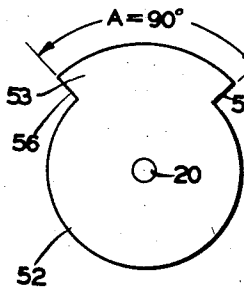


FIG. 3a

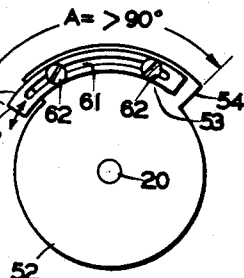
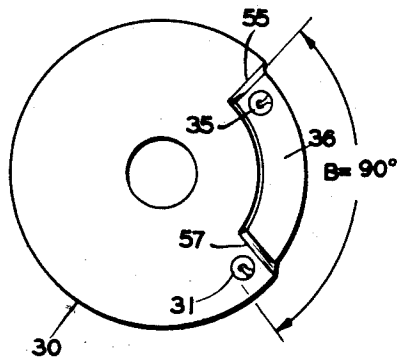


FIG. 4



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2 Sheets-Sheet 2

FIG. 5

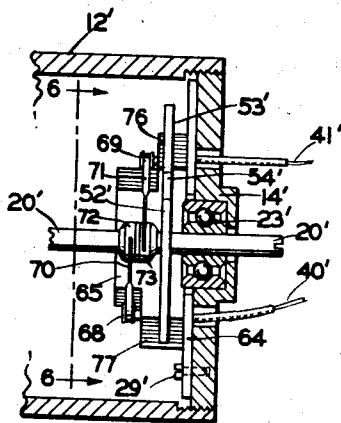


FIG. 6

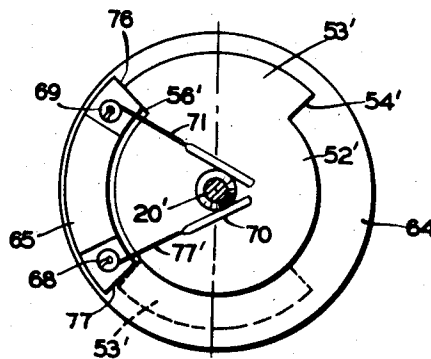


FIG. 7

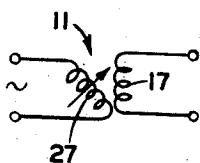


FIG. 7a

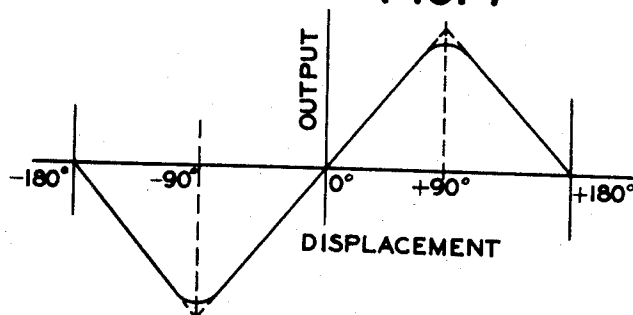


FIG. 8

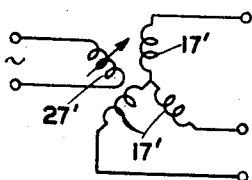
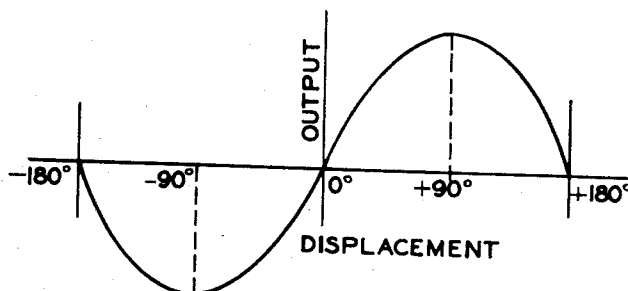


FIG. 8a



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1

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LIMIT STOPS FOR ROTATABLE INDUCTIVE ELECTRO-MECHANICAL DEVICES

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Application December 28, 1954, Serial No. 477,981

2 Claims. (Cl. 336—120)

This invention relates to rotatable inductive electro-mechanical devices and particularly to limit stop arrangements for rotatable transformer devices such as inductive synchro devices and linear-output type rotatable transformers and for servomotors and the like.

Synchro devices and other non-linear rotatable transformers have an output voltage vs. rotor displacement characteristic which is sinusoidal. That is, the output voltage is a function of the sine of the rotor displacement angle. The curve of the output voltage vs. rotor displacement characteristic for a linear-output type rotatable transformer is approximately triangular. In devices of either type, the output voltage is maximum and of one phase when the rotor is positioned in one direction $+49^\circ$ from its null or zero-output position and decreases for increased angular displacements of the rotor in such one direction beyond the $+90^\circ$ point. Similarly, when the rotor is positioned in the opposite direction -90° from the null or zero-output position, the output voltage is maximum but of opposite phase and decreases for increased angular displacements of the rotor in such opposite direction beyond the -90° point.

It will be appreciated that in many applications it is desirable to insure that the rotor is prevented from being displaced beyond for example the $+90^\circ$ point or the -90° point in order to preserve accurate correspondence between voltage output and rotor position and to prevent false indications in the system in which the device is used. Also, in linear-output type rotatable transformers it is desirable to confine the rotor to its linear range of angular positions. Moreover, in those rotatable transformer devices which employ hairsprings inside the housing of the unit for supplying current to the rotor winding in lieu of slip rings and brushes, there always exists the danger that an unsuspecting technician will pick up the unit for routine testing and will assume that it is the more common slip ring type device and hence will spin the rotor through several revolutions thereby rupturing the hairsprings after approximately three revolutions.

Limit pieces and stops have been employed in various applications but have generally been associated with an extension of the rotor shaft external to the housing of the device, such exposed stop arrangement resulting in a complete assembly which has relative bulk and extended overall length.

It is an object of the present invention to provide improved rotatable inductive electro-mechanical apparatus.

It is another object of the invention to provide a novel limit stop arrangement for limiting to a predetermined range the angular displacements of the rotor of an inductive electro-mechanical device.

It is another object of the invention to provide a novel compact limit stop arrangement which is located between the pair of bearings inside the housing of a rotatable inductive device.

It is another object of the invention to provide a novel limit stop arrangement for a rotatable inductive coupling

2

device which employs hairsprings for establishing electrical connection with the rotor winding.

It is another object of the invention to provide a novel limit stop arrangement for a rotatable inductive coupling device which employs slip rings and brushes for establishing electrical connection with the rotor winding.

It is another object of the present invention to provide a novel adjustable limit stop arrangement for a rotatable inductive device, the limit range preferably being adjustable externally of the housing of the device.

The foregoing and other objects and advantages of the present invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein certain forms of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawings are for illustration purposes only and are not to be construed as defining the limits of the invention.

In the drawings wherein like reference numerals refer to like parts,

Fig. 1 illustrates a side elevational view of a rotatable transformer device employing hairsprings and provided with a novel limit stop arrangement in accordance with the present invention, the device being shown in section except for the hairspring mounting and stop assembly;

Fig. 2 is a plan view of the hairspring mounting and stop assembly in engagement with the limit piece as viewed along the line 2—2 of Fig. 1;

Fig. 3 is a plan view of the sector member serving as the limit piece in the limit stop arrangement of Figs. 1 and 2;

Fig. 3a is a plan view similar to Fig. 3 and illustrates one form of limit piece which permits external adjustment of the limit range;

Fig. 4 is a plan view of the hairspring mounting and stop assembly of Figs. 1 and 2;

Fig. 5 is a partial side elevational view of the front end of a rotatable inductive device employing slips rings and brushes and provided with a novel limit stop arrangement in accordance with the present invention, the device being shown in section except for the limit piece and brush mounting and stop assembly;

Fig. 6 is a plan view of the brush mounting and stop assembly in engagement with the limit piece as viewed along the line 6—6 of Fig. 5;

Fig. 7 illustrates schematically one form of linear-output type rotatable transformer, while the curve of Fig. 7a is an approximately triangular variation representing the secondary output voltage vs. rotor displacement characteristic for the device of Fig. 7; and

Fig. 8 illustrates schematically one form of inductive synchro device, while the curve of Fig. 8a is a sinusoidal variation representing the secondary output voltage vs. rotor displacement characteristic for the device of Fig. 8.

Turning to Figs. 1—4 there is indicated generally at 11 a rotatable transformer device which may be a linear-output type rotatable transformer constructed and wound for example as disclosed and claimed in the copending application of S. C. Lajidge and P. G. Yeannakis, Serial No. 435,482, filed June 9, 1954, and assigned to the same assignee as the present invention. Alternatively, transformer device 11 may be a synchro device constructed and wound for example as disclosed and claimed in U.S. Patent No. 2,488,771 to J. P. Glass, Jr., or U.S. Patent No. 2,550,663 to P. F. Bechberger and P. G. Yeannakis, the foregoing patents being assigned to the same assignee as the present application.

Device 11 includes a cylindrical housing 12 having its front peripheral portion threaded at 13 to receive a threaded base or end cover member 14. Embedded in housing 11 and held in place by a fixed sleeve 15 is a cylindrical laminated stator core 16 of magnetically per-

meable material. The turns of secondary winding 17 are located in peripheral slots 18 provided in stator core 16. A pair of insulated lead wires 19 provide connection of the secondary winding 17 to an external circuit.

Rotatably mounted on a shaft 20 and in inductive coupling relation with the stator is a rotor 21 which may be of the salient pole type. Shaft 20 is supported for rotation at its inner end by a ball bearing assembly 22 mounted in the inner wall of housing 12 and by a ball bearing assembly 23 mounted in the outer cover member 14. Rotor 21 includes a laminated core 26 of magnetically permeable material on which are wound the turns of a primary winding 27.

Means will now be described for supplying electrical current to primary rotor winding 27 and for limiting rotor shaft 20 to a predetermined range of angular displacements in accordance with the invention. Rigidly attached to base plate 14 by suitable means such as screws 29 is a metal circular mounting plate 30. A fixed metal support post 31 has a reduced portion which extends through an aperture in the mounting plate 30. Post 31 is electrically insulated from plate 30 by means of a pair of insulation washers 32 and 33, the outer end of the reduced portion being turned over against washer 33 so that post 31 is rigidly supported by plate 30. Similarly, a fixed metal support post 35 is rigidly supported by an arcuate pushed-in offset portion 36 of plate 30, post 35 being electrically insulated from plate 30 by means of insulation washers 37 and 38. An insulated lead wire 40 passes through an aperture in end plate 14 and is electrically connected to post 31, while an insulated lead wire 41 passes through an aperture in end plate 14 and is electrically connected to post 35.

Rigidly mounted on shaft 20 is a hub 42 of electrical insulation material. A metal sleeve 44 is rigidly mounted on hub 42 and provided with an annular groove into which is hooked the inner end of a spiral hairspring 43 of good electrical conductivity. The outer end of hairspring 43 is secured in a slot in the mounting post 31. Also rigidly mounted on shaft 20 is an insulation hub 46 on which is rigidly mounted a metal sleeve 47. Hooked into an annular groove in sleeve 47 is the inner end of a second hairspring 48 which may be identical to hairspring 43. The outer end of hairspring 48 is secured to post 35 through a slot in post 35. Springs 43 and 48 are wound in the same direction so that they each exert a restraining torque upon shaft 20 in opposition to counter-clockwise rotation of the shaft. A flat disc 49 of electrical insulation material is rigidly mounted on shaft 20 between springs 43 and 48 to prevent electrical contact between the springs. A pair of insulated conductors 50 and 51 connect the two ends of primary rotor winding 27 to the metal sleeves 44 and 47, respectively. Accordingly, when a source of A.C. voltage of constant amplitude is connected across lead-in wires 40 and 41, a circuit for exciting primary winding 27 is completed as follows: from conductor 40 through post 31 and then through spring 43 to metal sleeve 44 and in turn to one end of primary 27 via conductor 50, the return path from the other end of primary 27 being traced via conductor 51 through metal sleeve 47 and through spring 48 and in turn to lead-in wire 41 via post 35.

Rigidly mounted on shaft 20 between spring 43 and the main body portion of mounting plate 30 is a flat disc 52 of electrical insulation material which prevents spring 43 from making electrical contact with the main body portion of mounting plate 36. In accordance with the present invention disc 52 is provided with a radially projecting sector portion 53 which extends through an arc A equal to 90°. When the primary rotor winding 27 is angularly displaced -90° from its null or minimum coupling position with respect to secondary winding 17 so as to be effectively parallel to secondary 17 for maximum coupling therewith and hence for a maximum induced secondary voltage of one phase, then in this po-

sition disc 52 occupies the angular position shown in Fig. 2 with the radial edge 54 of its sector portion 53 urged into abutment with the radial edge 55 of the offset portion 36 of the hairspring mounting plate 30. Edge 55 thus serves as a lower limit stop for sector disc 52 functioning as a limit piece.

When shaft 20 is angularly displaced in a counter-clockwise direction from its position in Fig. 2, sector 53 leaves stop edge 55. When shaft 20 and the primary rotor winding 27 have been angularly displaced a total of 180° from the position of Fig. 2 so as to be positioned, as indicated by the dotted lines in Fig. 2, +90° from the null position so that the induced secondary voltage is again maximum but of opposite phase, then in this position the radial edge 56 of the disc sector portion 53 is urged into abutment with the spring mounting post 31 which is located at an angle B of 90° measured in a clockwise direction from the lower limit stop edge 55. Post 31 thus serves as an upper limit stop for the limit piece disc 52.

It will thus be seen that there has been provided a novel compact internal limit stop arrangement located between the pair of bearings 22, 23 for the rotor shaft 20. The hairspring mounting assembly serves the additional function of a stop mechanism and the conventional insulation disc between the outer hairspring 43 and the mounting plate 30 has been modified so as also to function as a limit piece cooperating with the stop mechanism. It will be appreciated that the hairspring mounting assembly 30, 31 and 35 may be modified so that other portions serve as the limit stops. For example, post 31 may be radially located farther away from shaft 20 so that the leading edge 56 of sector portion 53 does not engage post 31 but rather comes into abutment with the radial edge 57 of the offset portion 36 of mounting plate 30, edge 57 serving as an upper stop edge similar to lower stop edge 55 being spaced at the desired angle B from stop edge 55. Alternatively, the mounting plate 30 may be constructed entirely in one plane without the offset portion 36 and post 35 may be lengthened so that post 35 replaces edge 55 as the lower limit stop for edge 54 of limit piece 52.

The present invention also contemplates varying the range of angular positions to which rotor shaft 20 is limited. For example, as indicated in Fig. 3a the angle A between the effective limit surfaces of the limit piece 30 may be varied. In Fig. 3a the limit piece comprises the insulation disc 52 together with an auxiliary arcuate element 60 of electrical insulation material. Element 60 is provided with an arcuate slot 61 and is held on disc 52 by means of two screws 62 which pass through the slot and are threaded into disc 52. An arcuate slot may be provided in cover 14 and plate 30 to permit insertion of a screw-driver or other adjustment tools. When screws 62 are loosened, element 60 may be angularly displaced until the desired angle A is obtained between the limit edge 54 and the radial edge 63 of element 60. The screws are then tightened. It will thus be seen that edge 63 replaces edge 56 as the leading edge of the limit piece 52, 60. Hence, angle A may be adjusted to exceed 90° if it is desired to decrease the limit range for shaft 20 below 180° of rotation. If it is desired to make the range below -90° also adjustable, then it is simply necessary in the original design to make the angle between edges 54 and 56 sufficiently less than 90°, for example 50° so that adjustment of element 60 causes edge 63 to replace edge 56 to increase angle A any desired amount above 50°. Alternatively, the limit range for shaft 20 may be adjusted by making the spring mounting plate assembly adjustable so that the angle B may be varied instead of angle A.

In Figs. 5 and 6 the invention is applied to a rotatable transformer device of the type which employs slip rings and brushes rather than hairsprings as the means for completing the circuit to the rotor winding. The device may

be either a non-linear or linear output type rotatable transformer device. Secured to the front-end cover 14' by screws 29' is a mounting plate 64. Secured to plate 64, or integral therewith, is an arcuate brush-mounting member 65 of electrical insulation material. A pair of metal rivets 68 and 69 are mounted on recessed end portions of member 65 and are electrically connected as by solder, respectively, to a pair of insulated lead-in wires 40' and 41'. Rivets 68 and 69 support, respectively, a pair of elongated metal brushes 70 and 71 which make contact, respectively, with a pair of slip rings 72 and 73 connected respectively to the two ends of the rotor winding (not shown).

The brush-mounting member 65 has at its ends a pair of radial edges or end surfaces 76 and 77 which serve, respectively, as upper and lower stop edges or surfaces for limiting the insulation disc 52' which serves as a limit piece similar to limit piece 52 of Figs. 1-3. As shown in Figs. 5 and 6, edges 76 and 77 are spaced 90° apart, and edges or end surfaces 54' and 56' of sector portion 53' are spaced 90° apart. When the rotor shaft 20' is positioned -90° from its null or zero-output position, edge 56' engages edge 76 as the lower limit stop as shown in Fig. 6. When shaft 20' has been rotated 180° in a clockwise direction to the position shown in dotted lines in Fig. 6 so that the rotor is +90° from its null position, then edge 54' engages edge 77 as the upper limit stop. The limit range for the device of Figs. 5 and 6 may be made adjustable by a construction similar to those described in connection with Figs. 1-4. If the rotors of the devices of Figs. 1-6 are to be exposed to high ambient temperatures and wide variations in temperature, the electrical insulation members 49, 52, 52' and 65 may be composed of a material such as "Mellanine" glass laminate.

Although certain forms of the invention of the present application have been illustrated and described in detail by way of example, it is to be expressly understood that the invention is not limited thereto. Various changes may be made in the design and in the arrangement of parts without departing from the spirit and scope of the invention as defined by the appended claims as will now be understood by those skilled in the art.

We claim:

1. A rotatable transformer device comprising a housing, a stator including at least one stator winding mounted within said housing, a rotor including at least one rotor winding, a rotatable shaft for rotatably supporting said rotor within said housing with said rotor winding in inductive coupling relation with said stator winding, elec-

trical energy conductive means located inside said housing and operatively connected to said windings, said means including a pair of hairsprings, each of said hairsprings being of an electrically conductive material and having one end secured to said shaft, electrical conductors connecting said one end of each of said hairsprings to said rotor winding, means secured to the other end of each of said hairsprings for mounting the respective hairsprings within the housing, said mounting means including stop portions, a pair of rotatable disc members, each of the disc members being of an electrical insulation material carried by said shaft and rigid therewith, one of the disc members being positioned intermediate the hairsprings to shield the hairsprings from making electrical contact one with the other and the other of said disc members being positioned between one of the hairsprings and the housing to shield the hairsprings from making electrical contact with said housing, said disc members including limit elements, one of said limit elements adapted to engage one of the stop portions of the mounting means to limit rotation of the disc members in one sense and the other limit element adapted to engage another of the stop portions of the mounting means to limit rotation of the disc members in an opposite sense so as to prevent breakage of said hairsprings by excessive rotation of said shaft and to limit rotation of said rotor to within a predetermined inductive coupling range.

2. A device according to claim 1 wherein said limit elements and stop portions cooperate to limit the angular displacement range of said rotor to a maximum angular position of approximately 90° in one direction from a null angular position of the rotor and to a maximum angular position of approximately 90° in the opposite direction from said null angular position, and at least one of said limit elements adjustably mounted on one of said disc members so as to provide means for varying the extent of said limit range.

References Cited in the file of this patent

UNITED STATES PATENTS

912,717	Murphy	Feb. 16, 1909
1,604,552	Hammarlund	Oct. 26, 1926
1,754,105	Holland	Apr. 8, 1930
2,164,165	Rodgers	June 27, 1939
2,509,425	Fagen	May 30, 1950

FOREIGN PATENTS

914,279	France	June 17, 1946
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