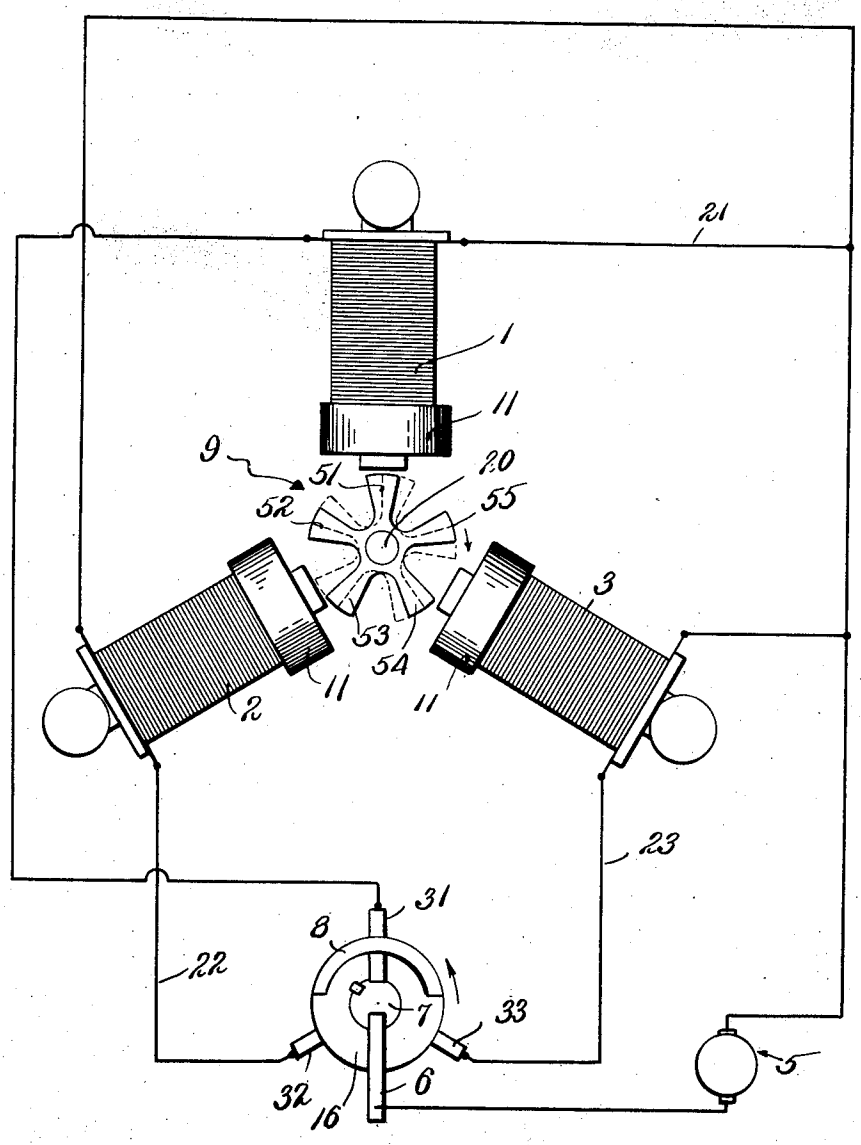
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DISTANCE MEASURING APPARATUS

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DISTANCE-MEASURING APPARATUS

Application filed December 15, 1926. Serial No. 154,966.

This invention relates to apparatus for reproducing mechanical movement at a distance and more particularly pertains to the reproduction or transmission of the rotary movement of a single propeller shaft or the mean rotary movement of several propeller shafts of a ship to the actuating member of a ship's instrument. Heretofore it has been common in the art to provide a series of electrical contacts which are successively opened and closed by the rotation of the propeller shaft or by the rotation of a member connected through differential mechanism with a series of propeller shafts in order to have a rotary speed proportional to the average of propeller shaft speeds; these contacts being adapted successively to energize and de-energize the magnets of a step-by-step motor for operating the ship's instrument so that the armature of the step-by-step motor may revolve at a speed corresponding to that of the propeller (or propellers). While an approximate reproduction or transmission of propeller shaft movement is possible under such conditions, the abrupt energization and de-energization of the magnets in succession results in the application of an irregular torque to the armature of the step-by-step motor. At certain critical speeds the momentum of the rotating armature causes it to pass beyond its proper stopping point or it may tend to set up a secondary oscillatory movement or vibration imposed upon the primary rotary movement of the armature, or, in other words, as a result of the movement of the armature to a position to which it is attracted by a newly energized magnet, there may be a tendency for it to overrun or to rotate beyond the exact position to which it is designed to be attracted by the energized magnet, the first phenomenon being generally characteristic of high speed operation of the apparatus, and the second being likely to occur during operation at low speeds. While such a secondary movement would not be a serious factor in many kinds of mechanical devices and in apparatus where only a fair degree of accuracy is required, it has been found that in ship's instruments in which a high degree of accuracy is necessary and more particularly in the type of instrument wherein an overrunning clutch is employed to transmit the movement of the propeller shaft and of the armature of the step-by-step motor in one direction only, the inaccuracies resulting from this secondary motion or throw-by are cumulative and result in a considerable error in the reading of the instrument during the course of a comparatively long journey.

The present invention is designed to obviate these difficulties and to provide a step-by-step motor having comparatively few magnets in which the torque imparted to the armature may be comparatively smooth and uniform and in which any tendency to provide a secondary oscillatory movement or throw-by is avoided. To this end the present invention involves a step-by-step motor adapted to be synchronously operated by a propeller shaft or a member controlled thereby, which is provided with a series of magnets adapted to be successively energized and de-energized, adjoining magnets, however, having overlapping periods of energization whereby one magnet acts as a brake upon the armature while the other magnet tends to attract the adjoining part of the armature thereto, whereby a more uniform torque is imparted to the armature. These magnets are preferably provided with means to render them slow-acting, as for example a short-circuited secondary coil to set up an induced secondary current which will oppose the voltage of the main or primary circuit of the magnet, thereby causing the gradual upbuilding of the magnetic field and upon the breaking of the circuit the gradual reduction thereof, rather than the abrupt energization and de-energization which previously have been characteristic of this class of devices. While slow acting and slow releasing magnets of this type are preferred, obviously in accordance with the principles of the invention other means of providing a gradual upbuilding and a gradual reduction of the magnetic fields may be used to provide an equivalent result.

Further objects and advantageous features attributable to the invention will be apparent

to those skilled in the art upon a reading of the subjoined description and claim in conjunction with the accompanying drawing, in which:

The figure is a diagrammatic view of the improved apparatus for reproducing the speed of a moving part, the wiring being shown schematically in conjunction with the diagrammatically illustrated parts.

While the invention disclosed herein is adapted to be used in a wide variety of installations wherein it is essential or desirable accurately to reproduce or transmit mechanical movement at a distance from the moving part which originates said movement; the invention is particularly advantageous when used in conjunction with ship's instruments of the general type disclosed in my copending application, Serial No. 722,942, filed June 28, 1924, for distance measuring apparatus for ships, etc., which discloses a controlling element for the instrument which is rotated by a step-by-step motor and from which movement is transmitted to overrunning clutches so that the movements in one direction of the armature of the step-by-step motor are cumulatively reproduced in the movement of the parts operated through the clutches.

Referring to the accompanying drawing for purposes of illustration of the inventive principle involved, it may be presumed that the rotary controller member 7 is to have its motion reproduced or transmitted at a distance. For example, the member 7 may be the propeller shaft of a ship or a member mechanically rotated in proportion to the mean rotary speed of several propeller shafts, and the shaft 20, which is conveniently illustrated as being the armature shaft of a step-by-step motor, is to be rotated at a speed closely synchronized with the movement of the shaft 7. For this purpose suitable electric connections and contacts are provided to transmit energy from the member 7 to the magnets 1, 2, and 3 of the step-by-step motor 9. Such a transmission of energy may conveniently take place by the means illustrated wherein a contact bearing disk 16 of insulating material is keyed upon the shaft 7 and bears a contact segment 8 of suitable conducting material, which is electrically connected through the brush 6 with any suitable source 5 of electrical current. Equally spaced about the disk 16 are the contacts 31, 32, and 33 which correspond in number to the number of magnets in the step-by-step motor and are adapted successively to be engaged by the segment 8. In the present case for purposes of illustration, three contacts and three magnets have been shown, but obviously the number and circumferential spacing thereof may be varied as desired without departing from the inventive principles involved. Contacts 31, 32, and 33 are connected with the magnets 1, 2, and 3 by electrical circuits 21, 22, and 23 respectively so that engagement of each contact with the segment 8 will result in energization of the corresponding magnet.

Preferably each of the magnets is provided with a ring of copper 11 at the end adjoining the armature. This ring of copper is insulated from the winding of the magnet and is adapted to provide an induced short-circuited secondary current which will oppose the primary current at the closing of the primary circuit and will therefore cause the delayed building up of the magnetic flux or field, while similarly upon opening of the circuit, the reduction in the current of the primary windings of magnets will cause a secondary current which will tend to result in a gradual reduction of the magnetic field. The rotor or armature is provided with a series of radially disposed poles or arms 51, 52, 53, 54, and 55 which are greater in number than the magnets and are spaced at intervals which do not correspond to the spacing of the magnets nor does the angle of spacing of the armature arms form an even divisor of the angle of spacing of the magnets. For example, as shown, the armature is provided with five of these outstanding arms while there are three magnets.

The contact segment 8 preferably is so dimensioned and proportioned that at times during the rotation of the member 16 two circuits will be closed, for example, circuits 21 and 22 through contacts 31 and 32, then one circuit will be closed, for example, through contact 32, whereupon two circuits will again be closed through contacts 32 and 33 and so on, resulting in the energization of magnet 1, then magnets 1 and 2, then magnet 2, and thereafter magnets 2 and 3. By this arrangement of successively energizing single magnets and pairs of magnets, more gradual rotation of the armature shaft results; for example, assume that the initial armature position is as disclosed in the full-line view of the figure, arm 51 is being attracted by magnet 1 which is the only magnet being energized through circuit 21, contact 31, segmental connection 6, etc. Continued rotation of contact disk 16 in anti-clockwise direction as indicated by the arrow will result in the closing of circuit 22 and energization of magnet 2 which will tend to attract the adjoining armature arm 53 while the magnet 1 acts as a brake upon arm 51 so that the armature rotates in a clockwise direction to the position indicated in dotted lines; the arms 51 and 53 coming to a position wherein they are at equal distances from the centers of the adjoining magnets 1 and 2 respectively. Further rotation of the disk 16 and in an anti-clockwise direction results in breaking of circuit 21 and de-energization of magnet 1, whereupon the armature rotates for a further dis-

tance of 12° and is drawn to a position wherein arm 53 is in concentric alignment with magnet 2. Thereupon continued rotation of the contact disk 16 results in the energization of magnet 3 and a tendency to draw arm 55 toward that magnet, the magnet 2 in turn acting as a brake and preventing movement of the armature so that arm 55 does not pass into alignment with magnet 3 until the circuit 22 is broken. Thus it is obvious that the design of the contact member and the magnets permits a gradual step-by-step movement for each twelve degree movement of the propeller shaft, moreover, the copper rings 11 cause gradual upbuilding and reduction of the magnetic fields, so that these movements do not take place abruptly in succession but rather gradually, and so that the resulting torque imparted to the shaft 20 is comparatively uniform and there is no tendency for the sudden movement of the armature resulting from the abrupt energization or de-energization of the magnets to cause a secondary oscillatory movement or throw-by.

Although the shafts 7 and 20 are herein illustrated as rotating in opposite directions, they obviously may be rotated in the same direction by suitable rearrangement of the electrical circuits and, in either case, reversal of movement of shaft 7 will cause a change in the direction of rotation of shaft 20, movement of the former in either direction thus being reproduced by the latter.

Thus an exceedingly accurate reproduction or transmission of movement is possible by a step-by-step motor of comparatively simple design, permitting the mechanism of the ship's instrument or the like to have a very accurate and smooth action, which is free from objectionable vibration or noise.

I claim:

A step motor comprising a rotor and a stator, one having a series of electromagnets distributed about the axis of the rotor, a short-circuited secondary associated with each electromagnet, and means for energizing the magnets in predetermined sequence so that each magnet is deenergized an interval after the next succeeding magnet is energized less than the total interval of energization, whereby the energization of the successive magnets overlap for a comparatively short time to provide a braking action at the instant of energization and the short-circuited secondaries cause the rotor torque to be applied and relinquished gradually.

Signed by me at Boston, Massachusetts this 27th day of November, 1926.

GEORGE WALKER