Dec. 14, 1948. F. G. PATTERSON ET AL 2,456,430

TELEMETERING APPARATUS

Filed Oct. 15, 1947

Fig. 1.

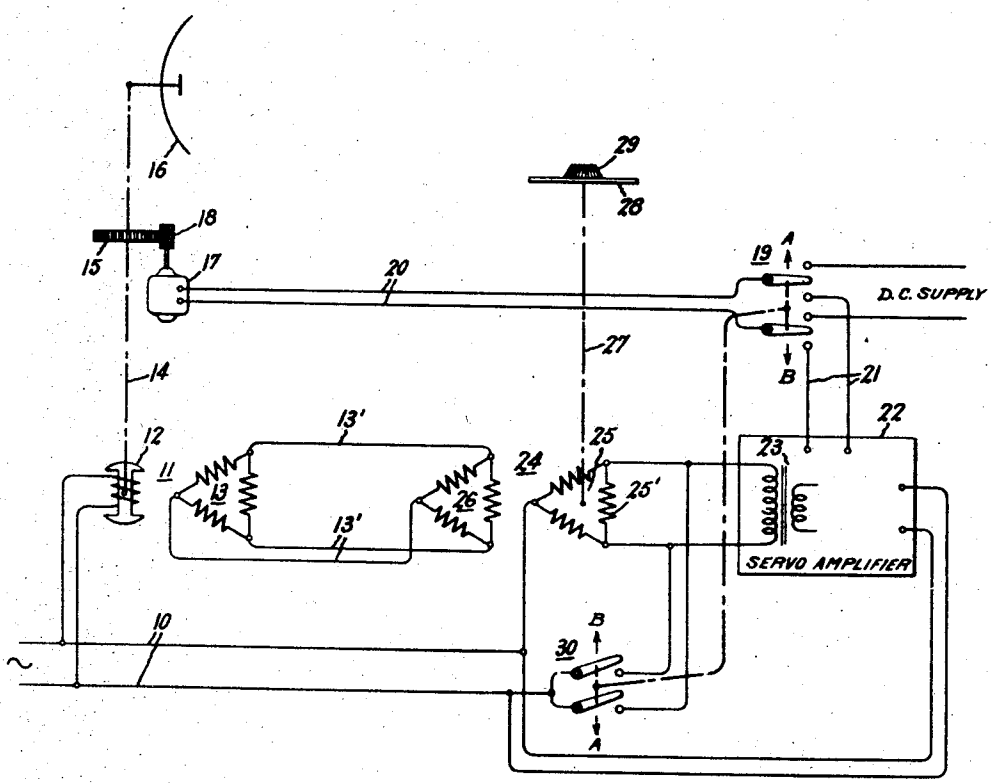
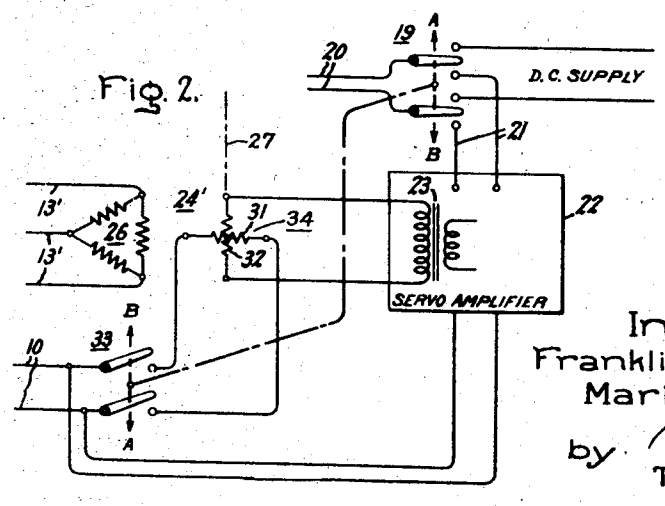



Fig. 2.




Inventors:
Franklin G. Patterson,
Marion W. Sims,
by Parcell & Mack
Their Attorney.

Patented Dec. 14, 1948 2,456,430

# UNITED STATES PATENT OFFICE

2,456,430

## TELEMETERING APPARATUS

Franklin G. Patterson, Schenectady, N. Y., and Marion W. Sims, Fort Wayne, Ind., assignors to General Electric Company, a corporation of New York

Application October 15, 1947, Serial No. 779,950

7 Claims. (Cl. 318—24)

1

This invention relates to telemetering apparatus and more particularly to such apparatus utilizing servo-mechanisms.

In apparatus of the type referred to above, it has been customary to utilize a great many components and complex circuits. For example, in a position indicator and servo system for controlling and indicating the bearing in azimuth of a remotely located rotating antenna, the following components are known to be used. For indicating the bearing of the antenna with respect to azimuth, a Selsyn generator is mechanically coupled to said antenna. Said Selsyn generator is electrically coupled to a Selsyn motor which responds to the bearing of the antenna as transmitted by said Selsyn motor. The Selsyn motor, in turn, is mechanically coupled to an indicating device appropriately calibrated to provide visual indicia of said antenna bearing. In the servo portion of such a system, a second Selsyn generator is mechanically coupled to a handwheel, said Selsyn being electrically coupled to a Selsyn control transformer which responds, electrically, to the position of said handwheel. The function of the Selsyn control transformer is to compare the relative position of the antenna shaft with the position of the handwheel as conveyed electrically. The output from said transformer is an error voltage proportional to the difference between the positions. This error voltage is then applied to a control amplifier. The control amplifier, in turn, controls the power flow to a servomotor which rotates the antenna.

In the present invention, one of the features thereof is to provide telemetering apparatus utilizing a minimum of servomechanisms such as above described.

It is, therefore, an object of the present invention to provide greatly simplified apparatus of the type above described.

Another object is to provide a new and improved apparatus circuit of the type above described.

A further object is to provide apparatus of the type described which utilizes a minimum of components.

A still further object is to provide an apparatus circuit which will enable the components therein to perform multiple functions.

Other and further objects and advantages of the present invention will become apparent, and the aforegoing will be understood in relation to the following exemplification thereof, reference being had to the drawing in which Fig. 1 is a schematic diagram of the electrical circuits for carrying out the present invention and Fig. 2 represents a modification of one of the components of the present invention.

2

Referring now to said drawing, a circuit 10 is provided for supplying a source of alternating current potential. Coupled to circuit 10 is a self-synchronous generator 11 provided with a rotor 12 of the salient pole type and a stator 13 provided with a three coil distributed winding. The aforementioned device is commonly referred to as a Selsyn generator, and will be designated as such hereinafter.

Essentially, such a device is similar to a small two-pole alternator. The rotor is connected to a shaft 14 to which is attached a gear member 15, and in the illustrative embodiment, a parabolic antenna 16. The synchro generator 11 is energized by the single-phase alternating current circuit 10 to produce a set of three alternating voltages which are in phase or phase opposition with the energizing voltage. The respective phase polarities and amplitudes of the three voltages identify the angular position of the rotor shaft 15 and this position can be transmitted to a remotely located component as will be described below.

Motivation of said shaft 14 and the components attached thereto is furnished by a direct current motor 17, the type of motor used being arbitrarily selected for this particular embodiment. Other types of motors utilizing either direct or alternating current may be utilized in carrying out the principles of the present invention. The shaft of motor 17 has affixed thereto a gear member 18 which engages the gear 15 thereby to impart motion to same when said motor 17 is energized by a source of direct current conducted thereto by proper manipulation of a switch 19 and through a direct current circuit 20.

The switch 19 may be double-pole double-throw type and when actuated between points A and B serves to energize the motor 17, respectively, from the direct current supply or an output circuit 21 of a servo amplifier 22. The servo amplifier has been purposely represented by the box 22 in order to simplify the description of this particular embodiment of the invention, since such amplifiers are well known to those skilled in the art to which they pertain. Essentially, the function of such an amplifier is to amplify and determine the phase of an error voltage applied to an input circuit 23 of said amplifier, and to conduct said amplified error voltage to a direct current generator (not shown) or so-called amplidyne generator to provide power to energize the motor 17 when switch 19 is in position B.

Means for indicating the bearing of the antenna 16 are provided by a dial member 28 attached to a shaft 27 of a so-called differential type synchro unit 24. The last-named device 24 is arranged to respond to the output of the synchro generator affixed to the shaft 14 of the antenna 16, The device 24 is provided with a rotor 25 and a stator 26, both having three-coil distributed windings. The dial member 28 is suitably inscribed to indicate the position of the antenna 16 with respect to a predetermined reference point. A knob-like member 29 is attached to the shaft 27 and dial 28 to provide for manual manipulation of the rotor 25, as will be explained presently.

The rotor 25 is adapted to be energized by the alternating current circuit 10 through a second switch 30 when said switch is in position A. The switch 30 is arranged to co-act with the switch 19 so that the manipulation thereof simultaneously places them in either position A or B. The stator 26 is connected through an electrical circuit 13' to the stator 13 and is energized in accordance with the voltages set up in the last-named stator and in accordance with the position of the associated rotor 12.

Ordinarily, it is quite feasible to utilize a differential type synchro unit to perform either function of indicating or controlling the position of a remotely located device, for example, a rotatable antenna. For indicating purposes, this is done by exciting one of the three circuit windings of the rotor of said differential unit in phase with the excitation of the rotor of a synchro generator. Since the currents flowing through the remaining windings of the differential unit's rotor combine with the current in the excited winding in such a manner, the winding becomes effectively, a single phase winding capable of responding in the same manner as the rotor of a synchro motor. Assume now that the position of the antenna is in coincidence with the position indicated on a dial coupled to a shaft on the rotor of the differential unit. This is known as the equilibrium position of the shaft. Now, if the excitation supplied to both rotors is removed from the winding of the rotor of the differential type synchro unit and said winding connected to a servo amplifier, the differential type synchro unit will now function as a control transformer and will have what is known as a zero error signal position. The rotor of the synchro generator generally will cause a flux condition to be present in the differential unit of such direction that it will induce a voltage in the winding connected to the servo amplifier. This voltage when impressed across the input of the servo amplifier will cause a motor coupled to the rotor of the synchro generator, to rotate same until it reaches a position, with respect to its stator, where it no longer produces a flux condition whose direction will induce a voltage in the winding of the differential unit's rotor. This is the zero error signal position. However, this last recitation of events indicates that the antenna is no longer in coincidence with the indication on the dial. The zero error signal position of the shaft, connected to the differential unit, is no longer the same as the equilibrium position of said shaft. Normally, this displacement is approximately 90 degrees. In order to bring the antenna and indicator into coincidence again under the above described circumstances, it would be necessary for the operator to make a manual adjustment of either the antenna on



its shaft or the dial on the shaft of the differential unit. If the connections are rearranged to permit the differential unit to function again as an indicator, the same displacement between antenna position and dial indication would recur. It will be readily appreciated that under the circumstances above described, the differential unit can only operate in one capacity without the necessity of manually resetting either the antenna or dial.

By a novel use of the differential type synchro unit 24, in combination with the switching arrangement provided by the switches 19 and 30, the present invention provides an apparatus greatly simplified in terms of circuit control. The manipulation of the switch 30 provides the means whereby the magnetic axis of the rotor 25 may be readily displaced electrically thus causing the equilibrium position of said rotor, as an indicator to coincide with the zero error signal position as a control unit. Thus, with the switch 30 in position A, the magnetic axis of rotor 25 assumes a position corresponding to the magnetic axis of the rotor 12 to provide a continuous indication of the position of antenna 16. With the switch 30 in position B, the winding 25' is the effective winding of the rotor and has a magnetic axis in quadrature with respect to the previous magnetic axis when said switch was in position A. In position B the rotor 25, through the shaft 27, controls the position of the antenna 16. As a result of the aforesaid novel circuit arrangement, the rotational relationship about the mechanical axes of the antenna 16 and indicator 28 will remain the same regardless of the manipulation of the switch 30.

In the illustrative embodiment above described, the synchro generator 11, motor 17 and its cooperating components and the antenna 16 are located at a point remote from the observer or operator. At the observer's position are located the differential type synchro unit 24, the indicating dial 28, the servo amplifier 22, and the combination of switches 19 and 30.

Assume it is desired to scan a given area, for example, in azimuth. The two switches 19 and 30 are moved to position A. In this position the differential type synchro unit 24 functions as an indicator unit and as the antenna 16 is driven around by the direct current motor 17, the indicating dial 28 will indicate the direction it is pointing at all times in response to the voltages produced by the rotor 12 in the windings of the stator 13. These last-mentioned voltages are electrically transmitted to the winding of the stator 26 by the electric circuit 13' and cause the rotor 25 to reproduce the angular position of the shaft 14 to which the antenna 16 is attached. The function of the differential type synchro unit in position A is now that of a synchro generator operating as a receiver.

When the switches 19 and 30 are moved to position B the excitation is removed from the windings of the stator 25 and in this position the differential type synchro unit 24 acts as a synchro control transformer. Ordinarily, a synchro control transformer is excited by the three alternating output voltages of a syncho generator, such as the device 11. When connected as shown on the drawing, the rotor of a synchro control transformer has induced therein an alternating voltage, the phase polarity and peak value of which serve to identify the angular difference between its shaft and that of the synchro generator. Thus it converts the synchro generator output into a

voltage identifying the direction and magnitude of the position difference between said last-mentioned shafts. Therefore, the position of the rotor of the synchro generator will cause the stator field of the control transformer to undergo a similar displacement. This field will then cut the transformer rotor winding to induce in the latter a voltage proportional to its projection along the magnetic axis of said winding.

With the switch in position B, the motor 17 is no longer energized by the direct current supply. Now, if the knob 29 be rotated, it will alter the position of the windings of the rotor 25 with respect to the field of the stator 26 and produce an error voltage of an amplitude and phase proportional to the direction and amount of the rotation. This error voltage is electrically conducted to the input 23 of the servo amplifier which in turn produces a direct current voltage whose polarity is in accordance with the phase relation between the winding of rotor 25 and the field of stator 26. This last-mentioned voltage is supplied to the motor 17 from the output circuit 21 through switch 19. As a result, the motor 17 is energized and rotates the antenna 16 and rotor 12 through the agency of the shaft 14. When the rotor 12 assumes a position with respect to the windings of the stator 13 to produce a field in the windings of the stator 26, which no longer cuts the winding of the rotor 25, a zero error voltage will result and the motor 17 will no longer receive energy from the servo amplifier 22. When this occurs, the position of antenna 16 will coincide with the indication on the dial 28. Thus, manipulation of the knob 29, when the switches 19 and 30 are in position B, provides the means necessary to control, remotely, the position of antenna 16 at will.

In Fig. 2 there is illustrated a modification of the so-called differential type synchro unit 24. The modified unit 24' comprises two single phase windings 31—32 on the rotor 34 whose space phase relation is in quadrature with respect to each other. This modification further simplifies the circuit and provides, as in the above described embodiment of Fig. 1, a rotor capable of having its magnetic axis displaced without altering the rotational relation about the mechanical axis thereof. In the modification a switch 33 coacting with the switch 19 performs the same function as hereinbefore described. The switch 33 serves to make or break the alternating current circuit 10. In the B or broken circuit position, the winding 32 becomes operative and the modified unit 24' functions as a control device as previously described, the winding 32 coacting with the input circuit 23. In the A or make position of the switch 33, the winding 31 is energized and functions to indicate the position of antenna 16. The winding 32 becomes inoperative since the servo amplifier 22 is no longer in the circuit by reason of the position of switch 19 which, coacting with switch 33, is also in the A position. It can now be observed that the above described modification produces the same results as the combination of the switch 30 and differential type synchro unit 24.

As described above and by way of illustration only, the present invention provides a telemetering apparatus which is economical in the number of componenets utilized and very simple to operate. Although, the illustrative embodiment describes the use of the apparatus for controlling and indicating the position of a remotely located antenna, it will be apparent that such apparatus



may be readily modified to telemetering in many fields requiring control and indication of remotely positioned equipment.

While there has been shown and described particular embodiments of the present invntion, it will be obvious to those skilled in the art that changes and modifications may be made without departing from said invention in its broader aspects, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the present invention.

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

1. Position telemetering and control apparatus comprising transmitting and receiving Selsyn units, switching means having a plurality of contact positions associated with the receiving unit rotor to shift the effective magnetic axis of the receiving unit rotor selectively to positions ninety degrees apart, an alternating current circuit to energize the transmitting unit rotor and when the switching means is in a first of its positions also to energize the receiving unit rotor in phase with the energization of the transmitting unit rotor, and a servo system adapted when the switching means is in a second of its positions to rotate the transmitting unit rotor responsive to error signal voltages induced in the receiving unit rotor, so that the apparatus operates to either indicate or control selectively the position of the transmitter rotor and to maintain the transmitting unit rotor and the receiving unit rotor in the same relation of angular coincidence for both modes of operation.

2. Telemetering apparatus comprising a plurality of electrical'y inductive devices having relatively movable primary windings at least one of which has a pair of single phase windings whose respective magnetic axes are axially displaced substantially ninety degrees with respect to each other, an alternating current circuit for energizing said primary windings in phase with each other, a plurality of rotating means coupled to said primary windings and adapted to rotate coincidentally in response to the in-phase motion of said primary windings, and switching means associated with the pair of single phase primary windings of one of said devices for shifting the phase relation between said primary windings in a manner to alter the function of the device having said pair of single phase primary windings from motor operation to transformer operation without affecting the coincidence of said rotating means.

3. Telemetering apparatus comprising a plurality of synchro units having relatively movable rotor windings, an alternating current circuit for energizing said rotor windings in phase with each other, a plurality of rotating means coupled to said rotor windings and adapted to rotate coincidentally in response to the in-phase motion of said rotor windings, a direct current circuit, means for actuating a first of said rotating means in response to the output of said direct current circuit, a second direct current circuit, and switching means associated with one of said rotor windings for disconnecting the alternating current circuit therefrom and connecting said second direct current circuit thereto, thereby to maintain the coincidence of said rotating means while shifting the phase relation of said rotor windings.

4. Telemetering apparatus comprising a Selsyn generator, a differential type generator adapted to function as a control transformer and indica-

tor, said generators being provided respectively with a rotor and a stator, an alternating current circuit for energizing said rotors in phase with each other, a plurality of rotating means coupled to said rotors and adapted to rotate coincidentally in response to the in-phase motion of said rotors, a direct current circuit, means for actuating the rotor of said Selsyn generator in response to the output of said direct current circuit, a second direct circuit, and switching means associated with the rotor of said differential generator for disconnecting the alternating current circuit therefrom and connecting said second direct current circuit thereto to cause said differential generator to function as a control transformer, thereby to maintain the coincidence of said rotating means while shifting the phase relation of said rotor windings.

5. Telemetering apparatus comprising a Selsyn generator, a differential type generator, having respectively a single phase rotor and a three circuit rotor, an alternating current circuit for energizing said rotors in phase with each other, a plurality of rotating means coupled to said rotors and adapted to rotate coincidentally in response to the in-phase motion of said rotors, and switching means having a plurality of contact positions associated with said three circuit rotor, said switching means being adapted, in one position, to cause said three circuit rotor to function as a single phase rotor in phase with said first-named single phase rotor and in another position as a single phase rotor shifted in phase substantially ninety degrees with respect to said first-named rotor while still maintaining the coincidence of said rotating means.

6. A telemetering system comprising a plurality of synchro units the shaft of a first of which is mechanically coupled to a combined indicating and control device and the shaft of a second of which is coupled to an electric motor, a direct current circuit adapted to energize said electric motor, an electric circuit connecting said synchro units and adapted to bring said indicating and control device to a position of equilibrium when



functioning as an indicating device, a second direct current circuit, and switching means associated with said electric circuit and said direct current circuits for disconnecting said electric circuit and first-named direct current circuit from the synchro unit coupled to said device and connecting said second-named direct current circuit to said synchro unit, thereby to cause said unit to function as a control device while maintaining the same relative rotational relationship between the shaft positions of said synchro units.

7. A telemetering system comprising a plurality of synchro units the shaft of one such unit being mechanically coupled to a combined indicating and control device and the shaft of a second such unit being coupled to a remotely located device adapted to be rotated by an electric motor, a direct current circuit for energizing said motor, an electric circuit connecting said synchro units and adapted to bring said indicating and control device to a position of equilibrium when functioning as an indicating device, a second electric circuit adapted to respond to an error signal voltage and capable of producing a direct current potential in response to said signal voltage, and switching means associated with said electric circuits for disconnecting said first-named electric circuit from the synchro unit coupled to said device and connecting said second-named electric circuit to said unit, thereby to cause said unit, in response to said direct current potential, to function as a control device while maintaining the same relative rotational relationship between the shaft positions of said synchro units.

FRANKLIN G. PATTERSON.
MARION W. SIMS.


REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 1,637,039 | Hewlett et al. | July 26, 1927 |