Feb. 8, 1949. T. O. McCARTHY 2,460,798

RADIO DIRECTION FINDER

Original Filed May 13, 1944

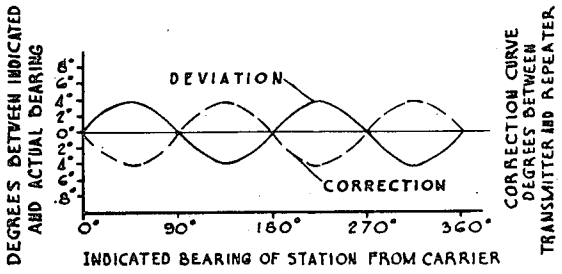


Fig. 2

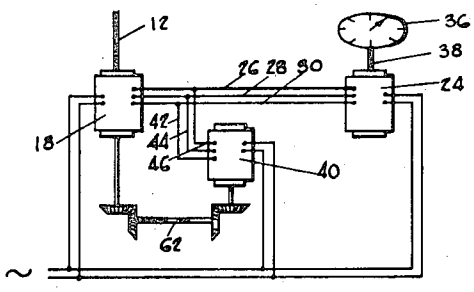


Fig. 3

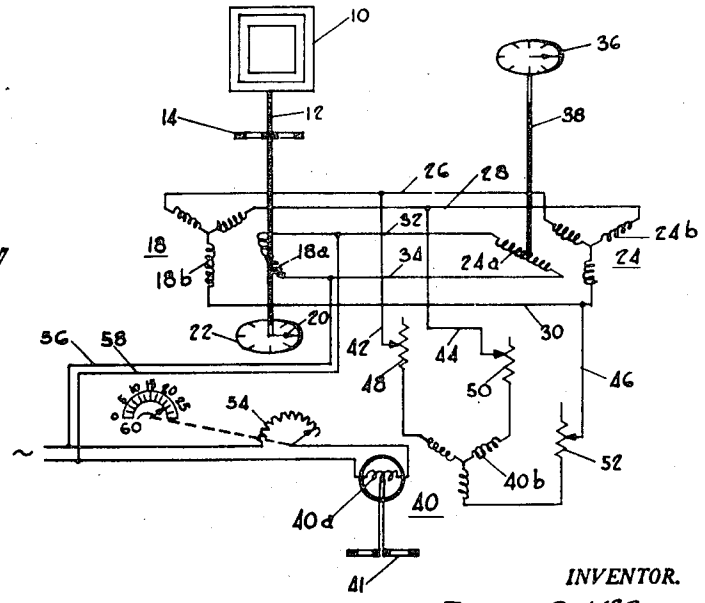


Fig. 1

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Patented Feb. 8, 1949 2,460,798

UNITED STATES PATENT OFFICE

2,460,798

RADIO DIRECTION FINDER

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Original application May 13, 1944, Serial No. 535,529. Divided and this application March 12, 1946, Serial No. 653,921

13 Claims. (Cl. 343—114)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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This invention relates in general to electrical systems for transmitting angular motion which include a transmitter unit and one or more repeater units, and in particular to such a system in combination with radio direction finders: This application is a division of my copending application, Serial No. 535,529, filed 13 May 1944.

A well known type of such a system includes transmitter and repeater units which are usually alike and each comprises a single-circuit field winding and a polycircuit armature winding, one of which constitutes a stationary element known as the stator and the other a movable element known as the rotor. The field windings of the transmitter and repeater are excited from a suitable source of alternating current and the respective armature windings are connected together.

These systems are used for many purposes and, under normal conditions, the repeater unit will follow the transmitter unit faithfully. In other words, motion of the transmitter through a 30° angle will cause the repeater to also move through a 30° angle in the same direction, and so on.

In some angular motion transmission systems, it is desired not to have the repeater follow the transmitter degree for degree. For example, in a remote-reading compass system such as described in my above-mentioned copending application, Serial No. 535,529 it is desirable to introduce a correction for well-known compass errors.

Likewise in direction-transmitting systems such as used in ordnance for target designation, the transmitted direction must be modified to allow for horizontal and for vertical parallax before the gun, range finder, or searchlight will point at the target being designated by the locater instrument. Such a compensating system for correcting parallax error is described and claimed in my copending application, Serial No. 653,922, filed 12 March, 1946, which is likewise a division of copending application, Serial No. 535,529, filed 13 May 1944.

Similarly, in radio direction finders there exists an error that resembles a deviation error found in the compass art and that is, in fact, called a deviation error. This error can be corrected, compensated for, or removed so as to provide a direction indication that is approximately true.

It is an object of this invention, therefore, to provide a novel electrical apparatus for use in self-synchronous direction transmitting systems on radio-direction finders to compensate for errors therein wherein the repeater unit will indicate true radio direction rather than the direction of the antenna loop.

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Further objects and advantages of this invention, as well as its construction, arrangement and operation, will be apparent from the following description and claims in connection with the accompanying drawing, in which

Fig. 1 is a diagrammatic illustration showing one embodiment of the invention as applied to a radio direction finder.

Fig. 2 shows a quadrantal deviation curve and correction curve therefor of a type that may be present in certain installations of a direction finder as shown in Fig. 1.

Fig. 3 shows a further arrangement for producing a quadrantal correction curve such as shown in Fig. 2.

The radio direction finder is a device used extensively in surface and air navigation to determine the bearing of a transmitting radio station from the ship or plane. In its simpler form it consists essentially of a rotatable loop antenna that can be turned in azimuth by the operator. The loop antenna is connected into a radio-frequency receiving set so as to provide an output signal which, by properly turning the antenna can be varied so as to produce a more or less sharp maximum or minimum indication. When the minimum signal has been obtained, the relative bearing of the signal station can be determined by referring the position in azimuth of the antenna to a scale fixed in the ship or plane; and the true bearing can be obtained by referring the antenna direction to a scale fixed in space about a north and south line in a horizontal plane, such as a repeater compass operated by a gyro compass.

Due to the effects of the ship's structure, funnels, masts, hand rails, radio antenna, etc., the indications of the radio direction finder are frequently in error by an amount that can be accurately determined for a given ship and transmitter frequency by a method of calibration in wide use. When the errors obtained by calibration are plotted as ordinates against the indicated direction as abscissae, a curve is obtained. Calibration curves of ships vary in amplitude and frequency but the quadrantal one illustrated in Fig. 2 is typical of curves that may be obtained.

As shown in the drawing in detail, and particularly in Fig. 1, the direction-finder system includes an antenna loop 10, supported by a shaft 12, the latter being mounted for rotation by its vertical axis by any suitable journal means

not shown. A handwheel 14 may be used for turning the shaft 12 and loop 10. The rotor element 18a of a self-synchronous transmitter, generally designated as 18, rotates with the shaft 12 and the instant bearing of the loop 10 may also, if desired, be indicated by pointer 20 on a dial 22.

The transmitter unit 18 consists of a single-circuit field winding or rotor element 18a, and a stationary Y connected polycircuit armature winding 18b, the three components of this latter winding being tapped at 120° points. Alternatively, the field and armature winding may be reversed, i. e., the armature winding may be the rotatable element and the field winding the stationary element.

A repeater unit 24, similar to transmitter unit 18, and likewise including a rotatable field winding 24a and a stationary polycircuit armature winding 24b, has its polycircuit armature winding electrically connected to the corresponding winding of transmitter 18 by conductors 26, 28 and 30. The rotatable field winding of the transmitter and repeater are connected by conductors 32 and 34 and to a suitable source of A. C. An indicator 36 is connected to the rotatable field 24a by means of a shaft 38.

In the normal operation of a self-synchronous direction-transmitting system, the rotatable element of the transmitter and repeater units are maintained in a synchronous relationship so that any angular displacement in the transmitter unit affects an equal angular movement in the repeater unit. However, in the described system, synchronous operation between the transmitter and repeater is not desired. Instead, it is desired that such a cyclic asynchronous relationship be provided as to compensate for deviation error so that the repeater unit will indicate substantially correct bearing of the transmitting radio station. In order that the repeater unit may indicate the correct bearing in, for example, the case shown in Fig. 2, wherein the solid line indicates deviation error for each bearing through 360°, it is necessary that a cyclic asynchronous relationship equal and opposite the value of the deviation error be maintained between the transmitter and repeater units. The value of this desired asynchronism for each point through 360° is indicated by the dotted line in Fig. 2.

In accordance with this invention, the necessary correction is applied electrically between the transmitter and repeater units by means of a correction device connected into the three conductors that couple the armature windings of the transmitter and repeater units.

In particular, the correction device comprises a transformer 40, which may be a unit similar to repeater and transmitter units 18 and 24 and which includes a rotatably adjustable primary winding 40a and a secondary winding 40b. A handwheel 41 is provided for adjusting the angular position of the primary winding 40a. Conductors 42, 44 and 46 connect the three components of the secondary winding 40b to the connections between the armature windings of the transmitter and repeater units through series connected rheostats 48, 50 and 52.

Excitation for the primary 40a of the transformer 40 is obtained from an A. C. source of suitable frequency through a rheostat 54. This source also supplies the exciting current to rotatable field windings 18a and 24a of the transmitter and repeater units, respectively, through conductors 56 and 58. A hand-setting arm 60 may be provided for varying the resistance of rheostat 54.

In operation, the pointer 20 of dial 22 indicates the actual bearing of the antenna loop 10. In a direct-reading radio direction system, in order to determine the true radio direction this reading would be corrected by determining the deviation error from the curve in solid line in Fig. 2 and by then applying a correction of opposite sign.

However, in the installation shown in Fig. 1, the direction and movement of the antenna loop 10 are transmitted by the self-synchronous unit 18 to the repeater 24 located remotely from the antenna mechanism. Since the calibration or deviation curve shown in solid line in Fig. 2 is quadrantal in nature, correction voltages that produce a quadrantal curve opposite in sign, such as, the curve shown in broken line in Fig. 2 are necessary. One way that this is accomplished in accordance with this invention is by setting the primary 40a of the correction transformer 40 to a desired position by turning handwheel 41 and/or adjusting the resistances 48, 50, 52 and 54. When thus adjusted, the correction transformer 40 develops voltages at the free terminals of the winding 40b that set up circulating currents in the winding 18b of the transmitter 18 inasmuch as the rotor 18a is not free to orientate itself to minimize such currents. Substantially no such circulating currents are set up in the winding 24b of repeater 24, since its rotor 24a is normally free to rotate, and can thus orientate itself to minimize such currents.

The circulating currents in the winding 18b produce voltage changes therein that tend to alter the voltages that would normally be developed at the free terminals of said winding 18b in response to displacement of rotor 18a. The magnitude and sense of the voltage alterations thus produced depend on the magnitude and direction of the circulating currents, which, in turn, are functionally related to the instant position of the rotor 40a relative to that of the rotor 18a.

The altered terminal voltages of winding 18b are transmitted to the winding 24b of the repeater 24 and cause rotation of the winding 24a to a position corresponding to an equilibrium condition depending on the altered voltages instead of the normal voltages at the transmitter 18.

It will thus be understood that, as the transmitter rotor 18a rotates through one complete revolution, the repeater rotor 24a responds to the altered values of the voltages at winding 18b, and is in step with the transmitter rotor 18a only at certain positions, while at all other positions in the cycle, the repeater rotor 24a either leads or lags the transmitter rotor by angles depending on the angular deviation between the positions of the transmitter and correction transformer rotors.

Changing the angular position of the primary winding 40a affects the phase and frequency of the correction curve as shown in Fig. 2, while a change in the values of the resistances varies the amplitude and also affects the phase and frequency of the correction curve. Thus, adjustments may be made to compensate the system in accordance with deviation curves other than that shown in Fig. 2. For example, by proper adjustment of the series resistances 54, 48, 50 and 52 correction curves can be obtained which repeat only once per cycle, as the remote-reading-compass-deviation correction curve illustrated in

my aforementioned parent application, Serial No. 535,529, filed 13 May 1944.

Another means for producing quadrantal correction curves is by causing the primary of the corrector transformer 40 to rotate relative to the secondary of this transformer as a function of the rotation of the transmitter 18. This arrangement may be affected through a suitable transmission 62 between the two rotor elements, as shown in Fig. 3, which drives the rotor element 40a of corrector transformer 40 at a one-to-one ratio with the rotor element 18a of transmitter 18, but in an opposite direction. In Fig. 3, for the purpose of simplicity of illustration, the transmitter 18, repeater 24, and correction transformer 40 are shown in block form.

Curve shapes and frequencies other than quadrantal can be obtained from the arrangement shown in Fig. 3 by changing the ratio of rotation of the rotors of transmitter 18 and correction transformer 40 and their relative directions of rotation.

It is to be understood that various modifications and changes can be made in this invention without departing from the spirit and scope thereof as set forth in the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. In a radio direction-finder system subject to a cyclic deviation error characterized by predetermined values of amplitude, phase and frequency and including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising transmitter and repeater units, means conductively connecting said transmitter and repeater units, said transmitter unit being coupled to said antenna means and said repeater unit being coupled to said direction indicator, whereby said direction indicator is normally movable in synchronism with said antenna means to indicate the instant bearing of said antenna means, and means conductively connected in parallel with said conductive connecting means for producing a cyclic asynchronous relationship between said units of an amplitude, phase, and frequency substantially equal and opposite to said deviation error, whereby said direction indicator will indicate substantially correct radio direction.

2. In a radio direction-finder system including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising a transmitter unit having relatively movable armature and field elements one of which is coupled to said antenna means, a repeater unit having relatively movable armature and field elements one of which is coupled to said direction indicator, electrical connections between the armature elements of said units, means for energizing the field elements of said units whereby the repeater unit normally follows motion of the transmitter unit, and means for modifying the voltages between the armature of said repeating device and the armature of said transmitting device as a function of the angular position of said antenna means to correct for deviation error whereby said direction indicator will indicate substantially correct radio direction.

3. In a radio direction finder system including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising a transmitter unit having relatively movable armature and field elements one of which is coupled to said antenna means, a repeater unit having relatively movable armature and field elements one of which is coupled to said direction indicator, electrical connections between the armature elements of said units, means for energizing the field elements of said units whereby the repeater unit normally follows motion of the transmitter unit, means for producing deviation correction voltages which vary with the bearing of said antenna means, and means combining said correction voltage with the voltages between the armature elements of said transmitter and repeater units, whereby said indicator will indicate substantially correct radio direction.

4. In a radio direction finder system including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising a transmitter unit having relatively movable armature and field elements one of which is coupled to said antenna means, a repeater unit having relatively movable armature and field elements one of which is coupled to said direction indicator, electrical connections between the armature elements of said units, means for energizing the field elements of said units whereby the repeater unit would normally follow motion of the transmitter unit, and deviation correction means comprising a transformer having relatively movable primary and secondary elements, said primary element being energizable with said field elements, and means combining the secondary voltage output of said transformer with the voltages between the armature elements of said transmitter and repeater units, whereby said direction indicator will indicate substantially correct radio direction.

5. In a radio direction finder system including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising a transmitter unit having relatively movable armature and field elements one of which is coupled to said antenna means, a repeater unit having relatively movable armature and field elements one of which is coupled to said direction indicator, electrical connections between the armature elements of said units, means for energizing the field elements of said units whereby the repeater unit would normally follow motion of the transmitter unit, and deviation correction means comprising a transformer having relatively movable primary and secondary elements, said primary element being energizable with said field elements, means for adjusting the output voltage of said transformer, and means combining the secondary voltage output of said transformer with the voltages between the armature elements of said transmitter and repeater units, whereby said direction indicator will indicate substantially correct direction.

6. In a radio direction finder system including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising a transmitter unit having relatively movable armature and field elements one of which is coupled to said antenna means, a repeater unit having relatively movable armature and field elements one of which is coupled to said direction indicator, electrical connections between the armature elements of said units, means for energizing the field elements of said units whereby the repeater unit would normally

follow motion of the transmitter unit, and deviation correction means comprising a transformer having relatively movable primary and secondary elements, means for driving said primary element in fixed relation with said movable element of said transmitter unit, and means combining the secondary voltage output of said transformer with the voltages between the armature elements of said transmitter and repeater units, whereby the said direction indicator will indicate substantially correct radio direction.

7. The system as in claim 6 wherein said driving means comprises mechanical transmission means interconnecting the movable elements of said transmitter unit and said transformer.

8. In a radio direction finder system subject to a deviation error and including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising electrically connected transmitter and repeater units, said transmitter unit being connected to said antenna means and said repeater unit being connected to said radio direction indicator, whereby said direction indicator normally synchronously indicates the direction in which said radio antenna is pointing, means electrically connected between said transmitter and repeater units for producing a cyclic asynchronous relationship between said units of an amplitude, phase and frequency substantially equal and opposite to the deviation error whereby said radio direction indicator will indicate substantially correct radio bearing, said last means comprising a transformer having relatively movable primary and secondary elements, and means for combining the secondary voltage output of said transformer, with the voltages between said transmitter and repeater units.

9. In a radio direction finder system subject to a deviation error and including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising a transmitter unit having relatively movable armature and field elements one of which is coupled to said antenna means, a repeater unit having relatively movable armature and field elements one of which is coupled to said direction indicator, electrical connections between the armature elements of said units, means for energizing the field elements of said units whereby the repeater unit normally synchronously follows the motion of the transmitter unit, and means for producing a cyclic asynchronous relationship between said transmitter and repeater units of a phase, frequency and amplitude substantially equal and opposite to deviation error whereby said direction indicator will indicate substantially correct radio direction, said last means comprising a transformer having a rotor element adapted to be maintained in predetermined fixed position relative to the transmitter field element, means for energizing said rotor from a common source with that energizing the field elements of said transmitter and repeater units and means combining the secondary voltage output of said transformer with the voltages between the armatures of said transmitter and repeater units.

10. In a radio direction finder system subject to a deviation error and including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising a transmitting unit having a single circuit field winding rotatable with said antenna means and a stationary "Y" connected polycircuit armature winding, a repeater unit having similar field

and armature windings the rotatable field of which is coupled to said direction indicator, electrical connections between the corresponding polyphase armature windings of said units, means for energizing the field windings of said units whereby the repeater unit normally synchronously follows the motion of the transmitter unit, and means for producing a cyclic asynchronous relationship between said transmitter and repeater to correct deviation error whereby said direction indicator will indicate substantially correct radio direction, said last means comprising a transformer unit similar to said transmitter and repeater units having a single circuit primary and a polycircuit secondary, means for adjusting said primary to a predetermined angular position, electrical connections connecting said transformer primary in parallel with the field windings of said transmitter and repeater units, electrical connections connecting each component of said secondary to the corresponding connections between the armature windings of said repeater and transmitter, a variable resistance in series circuit with said transformer primary, and a variable resistance in series circuit with each component of said transformer secondary.

11. Apparatus of the character described, comprising means for generating a signal, a movable antenna, a motion-translating device having data-transmitting and data-repeating elements and an electrical connection defining a data-transmitting channel between said data-transmitting and data-repeating elements, said data-transmitting element being coupled to said antenna to transmit positional data therefrom to said repeating element, and means conductively connecting said signal-generating means to said data-transmitting channel.

12. Apparatus of the character described, comprising means for generating an electric signal, a rotatable antenna, a motion-translating device having data-transmitting and data-repeating elements and an electrical connection therebetween, said data-transmitting element being coupled to said antenna to transmit positional data therefrom to said repeating element, and means including variable resistances conductively connecting said signal-generating means to said data-transmitting channel in shunt with said transmitting and repeating elements, said connecting means defining with said transmitting element and said generating means a closed loop wherein circulating currents are set up.

13. In a radio direction finder system including rotatable directional antenna means and a radio direction indicator, a direction transmission system comprising a transmitter unit having relatively movable armature and field elements one of which is coupled to said antenna means, a repeater unit having relatively movable armature and field elements one of which is coupled to said direction indicator, electrical connections between the armature elements of said units, means for energizing the field elements of said units whereby the repeater unit normally follows the motion of the transmitter unit, means for producing a deviation correction voltage that varies with the bearing of said antenna means, and means combining said correction voltage with the voltage output from the armature element of said transmitter unit, whereby said indicator will indicate the correct radio direction.

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(References on following page)

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,242,530	Libby	May 20, 1941
2,297,414	Zanovsky	Sept. 29, 1942
2,299,083	Elm	Oct. 20, 1942
2,383,857	Hardy et al.	Aug. 28, 1945
2,390,543	Kraeger	Dec. 11, 1945
2,408,813	Riggs	Oct. 8, 1946