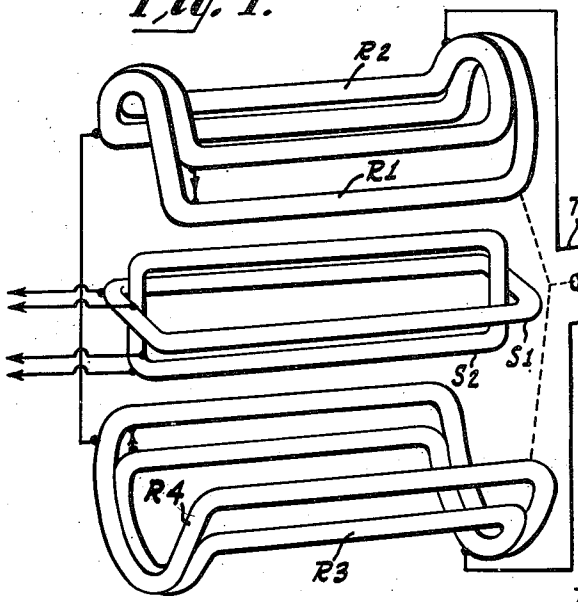
Feb. 7, 1950 S. W. SEELEY 2,496,920

PHASE SHIFTER

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Fig. 1.



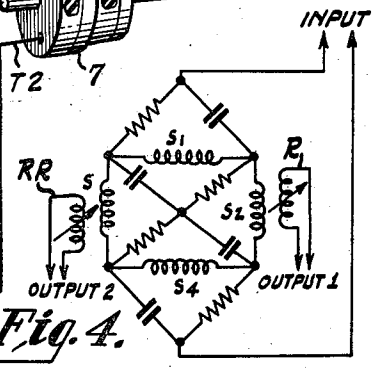


Fig. 4.

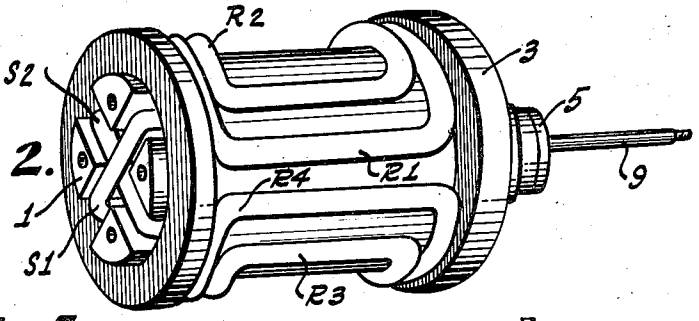


Fig. 2.

Fig. 5.

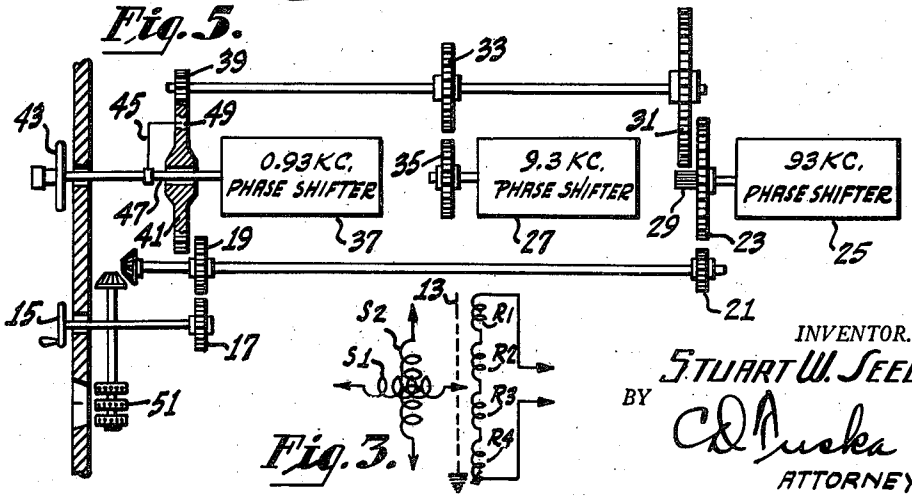


Fig. 3.

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PHASE SHIFTER

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Fig. 6.

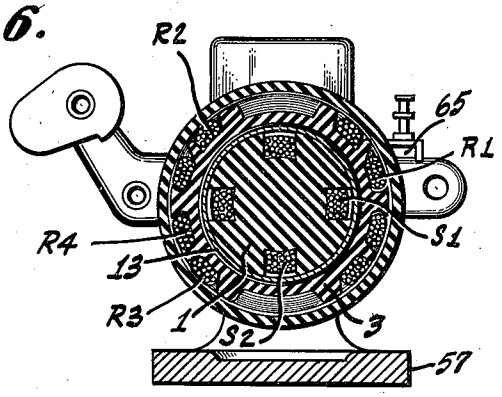


Fig. 7.

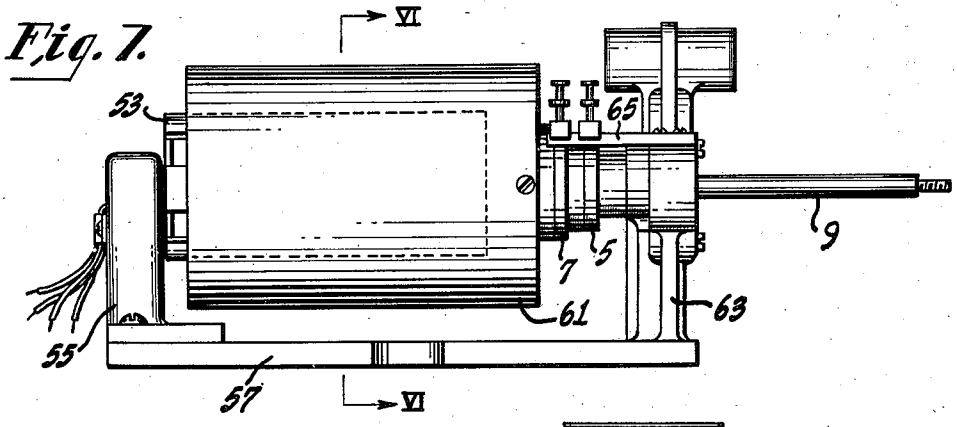
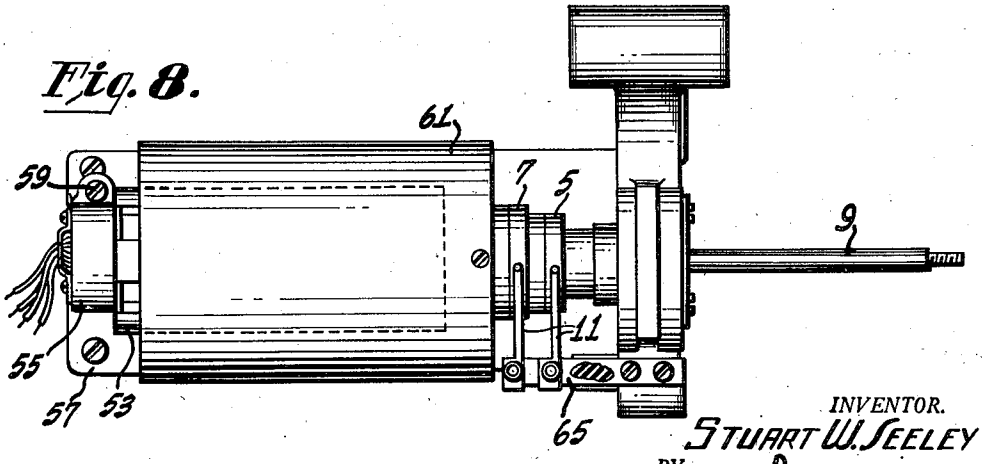


Fig. 8.



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UNITED STATES PATENT OFFICE

2,496,920

PHASE SHIFTER

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Application July 29, 1944, Serial No. 547,255

1 Claim. (Cl. 178—44)

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This invention relates to phase shifting devices and more particularly to a plurality of phase shifters which are connected to a unitary control for shifting the phases of currents of different frequencies through predetermined and related ranges.

Among the devices used for shifting the phase of electrical voltages are goniometer type devices in which quadrature phase currents are applied to the crossed windings and in which the currents of the required phase are obtained from the other winding of the goniometer type device. In such devices the relation between angular position of the rotor and the phase of electrical current is not apt to be linear unless precautions are taken to obtain a uniform field. While departures from linear rates may not be too objectionable in the case of single phase shifters, it is highly desirable in the case of a plurality of phase shifters to provide them with linear characteristics if they are to be connected together and operated by unicontrol means. Moreover, in some electrical networks, it may be desirable to shift simultaneously the phases of currents of different frequencies throughout predetermined ranges, as for example in the radio navigation device disclosed in the copending application of Stuart W. Seeley, Serial No. 381,020, filed February 28, 1941, now Patent No. 2,405,239, issued August 6, 1946, and entitled Position determining system.

Among the objects of the present invention are to provide an improved single control multiple phase shifter; to provide improved means for shifting the phases of a plurality of currents of different frequencies through a predetermined and related range; to provide a unitary control for an improved phase shifter in which a plurality of goniometer type phase shifters are ganged together with means for making the relative angular rates of rotation of the rotor windings of the phase shifters correspond to the frequencies of the applied currents; and to provide a plurality of phase shifters with a unitary control and with supplementary means for adjusting the initial positions of the phase shifter windings.

The invention will be described by referring to the drawing in which Figure 1 is a schematic perspective view of the windings and slip rings of the phase shifter of the invention; Figure 2 is a perspective view of one of the phase shifters of the invention; Figure 3 is a schematic wiring diagram of the phase shifter; Figure 4 is a bridge circuit for applying quadrature phase currents

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to a pair of phase shifters; Figure 5 is a schematic view, partly in section, of a preferred embodiment of the unitary control multiple phase shifter; Figure 6 is a sectional view, taken along lines VI—VI of the phase shifter employed in the invention; and Figures 7 and 8 are respectively elevation and plan views of the phase shifter. Similar reference characters are applied to similar elements in the drawings.

Referring to Figs. 1 and 2, a pair of windings S1 and S2 are disposed at right angles to each other on an insulated support 1 so that there is no mutual coupling between the windings. An insulated rotor winding support 3 is provided with grooves (see Fig. 6) for maintaining the position of four rotor windings R1, R2, R3 and R4. The rotor windings are connected in series-aiding. The terminals of the rotor windings T1 and T2 are respectively connected to slip rings 5, 7. The slip rings are mounted on insulated members which are secured to the rotor shaft 9. Collector brushes 11 are arranged to contact the slip rings.

If the phase shifter is used to shift the phase of high frequency currents, for example, 93 kilocycles per second, it is desirable to include an electrical shield 13 which is interposed between the rotor and stator windings to minimize capacity coupling which tends to distort the desired linear relation between the phase shift angles and the angular positions of the rotor windings. The schematic connections of the phase shifter windings are shown in Fig. 3. While it is preferable to make the rotor field just as uniform as possible to obtain a linear relation between phase shift and angular position, the use of two large and two small windings is a type of rotor winding, which represents a solution more practical than a theoretically ideal type of rotor winding and which exhibits a field of sufficient uniformity for most applications of the invention.

The phase shifter may be completed by any suitable means for applying currents of quadrature phase to the stator windings S1 and S2. In some arrangements, it is possible to use two of the phase shifter devices to obtain output currents which are separately shifted in phase. In that event a preferred phase splitter network or bridge is shown in Fig. 4. One phase shifter is represented by the stator windings S1, S2 and by a rotor winding R; the other phase shifter is represented by stator windings S1, S4 and by rotor winding RR. In the actual device the windings

of each of the two phase shifters correspond to the schematic circuit of Fig. 3.

The bridge circuit for the phase splitter and pairs of phase shifters is described and claimed in application Serial No. 548,183, filed August 5, 1944, now Patent No. 2,450,616, issued October 5, 1948, by Stuart W. Seeley, and entitled Electrical networks for phase shifters, and is assigned to the same assignee as the instant application.

A preferred embodiment of a ganged phase shifter is illustrated in Fig. 5. The three phase shifters are controlled by means of a single handwheel 15. The single control means 15 is connected through engaging gears 17, 19, 21 and 23, which are shown out of engagement only for clarity of illustration, to the rotor of the first phase shifter 25. The rotor of the first phase shifter 25 is connected to the rotor of the second phase shifter 27 by 10 to 1 reduction gears 29, 31, 33 and 35. A further 10 to 1 reduction is brought about between the rotor of the second phase shifter 27 and the rotor of the third phase shifter 37 by connecting the first and third rotors through gears 29, 31, 39 and 41. Thus arranged, the first rotor has an angular rate which is ten times the second, and a hundred times the third when they are driven by the unicontrol wheel 15. These rates are proportional to the frequencies 93, 9.3 and 0.93 kilocycles per second which are respectively applied to the first, second and third phase shifters. Thus arranged, the relative phases of the several applied currents are maintained as the first phase shifter is adjusted to a new phase condition.

In the foregoing arrangement, the third rotor is provided with a separate control knob 43. The control knob may be pulled forward whereby the rotor is disengaged from the gear wheel 41. The gear and rotor may be re-engaged by pushing the control knob 43 inwardly and rotating until a detent member 45, fixed to the rotor shaft 47, engages a locating aperture 49 in the gear. The separate control of the third phase shifter eliminates excessive cranking of the unicontrol wheel 15 when the third rotor only is to be adjusted. A counter 51 indicates the movements of the several phase shifters.

Referring to Figs. 7 and 8, the stator assembly 53 includes a hollow shaft (not shown) which is mounted on an upright 55. The upright is fastened to a base 57. The hollow shaft is fitted into a split bearing in the upright and is clamped in any desired angular relation with respect to other stators by means of a clamping screw 59 which tightens the split bearing. The rotor assembly 61 is included within an insulated cylinder and is secured to the shaft 9. The shaft is journalled in ball bearings which are mounted within a second upright 63. The second upright, which is also mounted on the base 57, forms a suitable support for an insulated member 65 which holds the slip ring collectors 11. The second upright may include bearings for two or more shafts, illustrated in Fig. 5. Thus each goniometer type device forms a unit of the several phase shifters of Fig. 5.

In setting up the multiple phase shifter the effective gear ratio between successive rotors should be proportional to the applied frequencies if the relative phases of the applied currents are to be maintained as the device is adjusted to shift the phase of a selected frequency. If the phase shift is to be made without maintaining the relative phase relation between applied currents of different frequencies the rotors may be coupled directly together or through any desired gear ratios. In either adjustment, the stators may be aligned separately so that any desired initial phase relation may be obtained. Although it is more convenient to rotate the winding which can be connected through a single pair of slip rings and collectors, it should be understood that either set of windings may be moved with respect to each phase shifter and therefore the term stator is not limited to the windings to which quadrature phase currents are applied.

The invention covered herein may be manufactured and used by or for the Government of the United States for any governmental purpose without payment to me or assigns of any royalty thereon.

I claim as my invention:

A phase shifting device including in combination a plurality of goniometer type phase shifter units each including an inner stator element comprising a pair of crossed coils and an outer rotor element comprising a pickup coil, said pickup coil consisting of a distributed winding for providing a substantially uniform field in the region of said crossed coils, means for applying quadrature phase currents of different frequencies respectively to each pair of crossed coils of said units, unicontrol means connected to said rotor elements, said unicontrol means comprising gears interposed between the respective rotor elements for adjusting said rotor elements at angular rates proportional to said different frequencies, split-sleeve mountings for each of said stator elements for adjusting independently the relative initial angular position of said stator elements whereby the initial phase shifts may be made to coincide, the train of gears comprising said unicontrol means having a drive means connected to one end of the gear train, and means for disconnecting at will the final gear of the said gear train from the associated rotor element whereby the remaining rotor elements may be driven at will independently of said associated rotor element.

STUART W. SEELEY.

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