Feb. 22, 1949. J. AHIER ET AL 2,462,058

SYSTEM FOR COMPARISON OF PHASE SHIFT OF ELECTRIC QUANTITIES

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Fig. 1

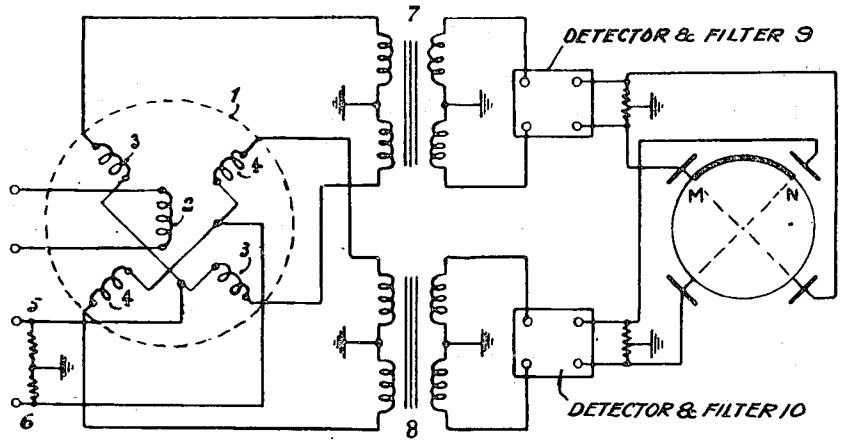


Fig. 2

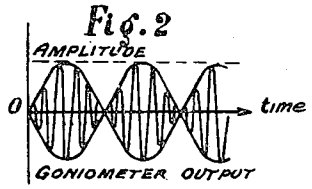


Fig. 3

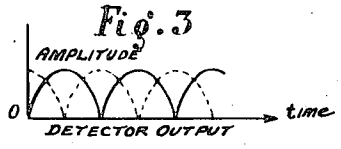


Fig. 4

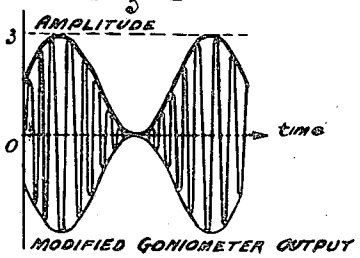


Fig. 6

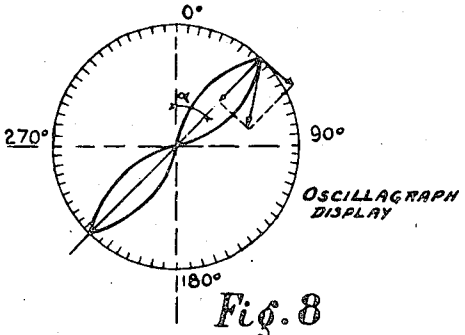


Fig. 7

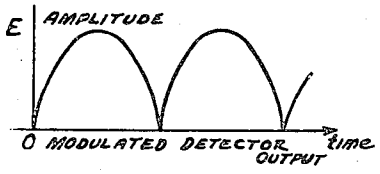
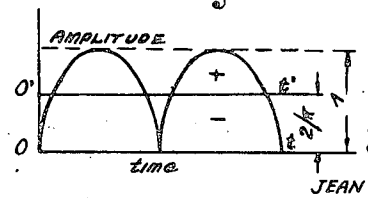


Fig. 8



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SYSTEM FOR COMPARISON OF PHASE SHIFT OF ELECTRIC QUANTITIES

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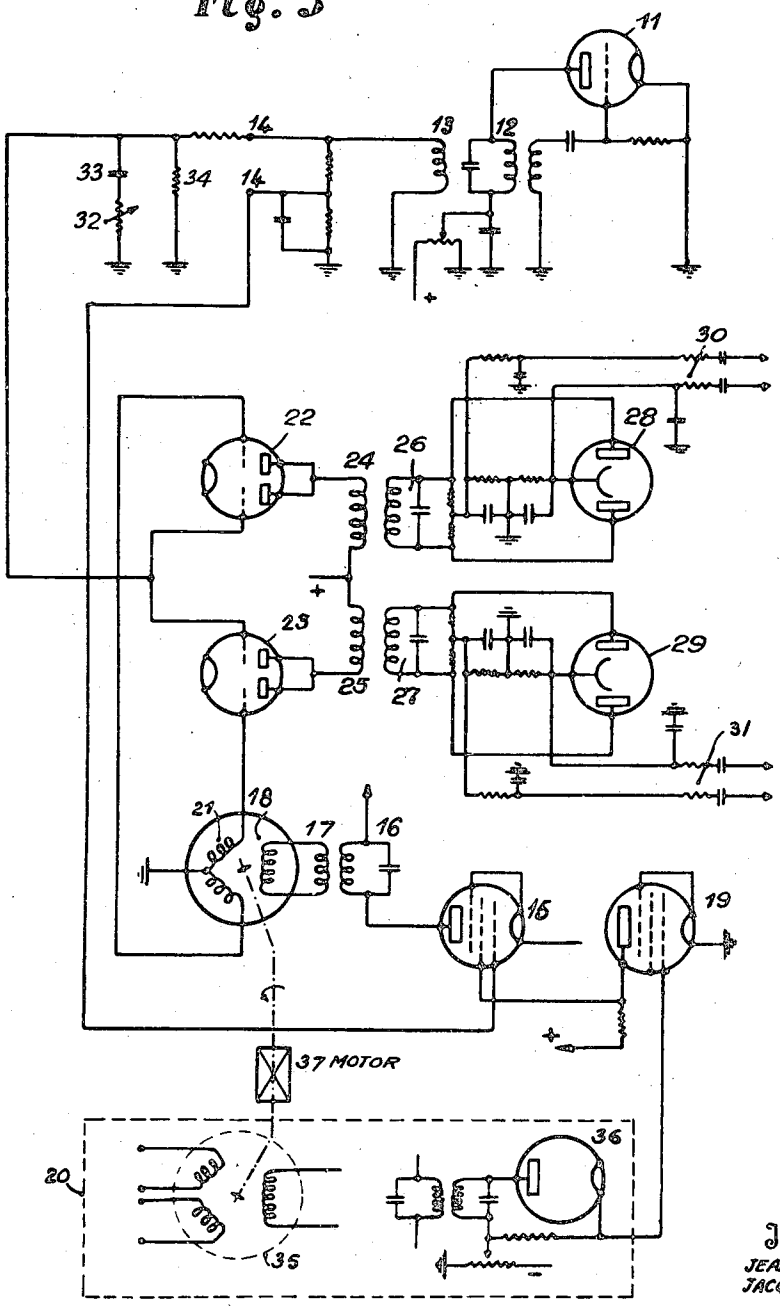
Fig. 5



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SYSTEM FOR COMPARISON OF PHASE SHIFT OF ELECTRIC QUANTITIES

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4 Claims. (Cl. 172—245)

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The present invention relates to changes, improvements and modifications in phase shift comparison circuits particularly for direction finders.

The object of the present invention is more specifically to provide purely electronic generators of 2-phase currents in order to avoid the drawbacks of the previously employed generators, which were alternators having an awkward wave shape, or of resistance-equipped collectors of difficult mechanical construction. It provides generators of 2-phase currents that represent an improvement over the structures described in British patent specification No. 556,759 issued to Rene Hardy.

In said patent specification, provision was made for feeding with a modulated wave the rotor of an induction distributor whose two orthogonal stators are additively coupled symmetrically to the rotor's circuit, the modulated wave having superposed on it a high frequency current of constant amplitude in phase with the modulated oscillation.

The disadvantage of the operation of the system disclosed in said patent specification is due to the fact that the introduction of the modulated wave into the two channels by the induction distributor (or reversed finder) is rather difficult in practice because it is necessary, in order to obtain high quality scanning on the indicator, to be able to adjust the amplitude and the phase of the modulated wave with respect to the carrier wave.

The device disclosed in said patent specification provided for applying the same high frequency current to the reversed finder's rotor and also to the mid-points of the stator's two orthogonal windings. According to one of the features of the present invention, this high frequency current is no longer applied to the mid-points of the stator's two orthogonal windings, but provision is made for adding the carrier wave to the modulated wave electronically. This arrangement makes it possible to control the scanning of the indicator by two uncoupled channels.

According to this feature of the invention, the uncoupling is effected by means of two distinct electronic discharge spaces, these two discharge spaces having a single output circuit for each scanning channel.

According to another feature of the invention, the adjustment of the relative phase of the carrier wave with respect to the modulated wave is preferably effected in the circuit that transmits the carrier wave to the stators of the distributor.

According to still another feature of the invention, the modulated wave is applied to the distributor's rotor by means of a loose coupling device in order to make practically negligible the variations of impedance resulting from changes in the position of the rotor.

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These features, as well as others, are explained in detail in the following description given with reference to the appended drawings, in which:

Fig. 1 is a schematic of a phase comparison circuit designed according to the teachings contained in said patent specification.

Figs. 2, 3, 4, 7 and 8 are various diagrams employed in the description.

Fig. 5 is a schematic of a circuit employing features of the invention.

Fig. 6 shows the indication obtained on the screen of a cathode ray tube in radio direction finding systems that employ features of the invention.

Referring to Fig. 1, a 2-phase current generating device 1 comprises a distributor, e. g. an induction generator of a reversed radiogoniometric finder type. Current proceeding from a high frequency generator is sent into rotor 2 of this distributor, and this rotor 2 is driven at a constant speed in synchronism with the rotor of the goniometer's finder.

The current that passes in rotor 2 induces in stators 3 and 4 currents whose amplitude is at all times dependent on the position of the said rotor with respect to the windings of the stators.

At the terminals of the secondary windings of transformers 7 and 8, which are connected to the terminals of the windings of stators 3 and 4, there accordingly appear voltages of the frequency of the abovementioned generator that are of equal amplitude and are modulated, as shown in Fig. 2, for one of the output voltages of the transformer. It can be seen that such a voltage represents a modulated wave without carrier of the form:

$$\sin \omega t \sin \Omega t$$

After detection and filtering in suitable circuits, shown at 9 and 10, the voltages intended for application to the deflecting elements of the cathode ray oscillograph or other indicator have the shape shown in Fig. 3. In this Fig. 3, one of the voltages is shown in heavy lines and the other in dotted lines, their stagger by a quarter of a period resulting from the relative orthogonal position of stators 3 and 4 of the distributor.

However, an arc only equal to a quarter of the circumference, as shown at MN in Fig. 1, would be scanned on the oscillograph's spot by these voltages if they did not become reversed, in other

words, if they were not sinusoidal. From the high frequency generator that feeds rotor 2 there is accordingly tapped a voltage that is applied between terminals 5 and 6, which are connected to the mid-points of the windings of stators 3 and 4. This gives at the outlet of transformers 7 and 8 a modified voltage of the shape shown in Fig. 4, provided there is a correct adjustment of amplitude and phase. After detection and elimination of the direct component, this voltage becomes reduced to the top portion of the envelope curve shown in heavy lines and having the shape of the desired sinusoid.

The two sinusoidal voltages thus obtained are 2-phase. Their application to the deflecting elements of the cathode ray indicator makes it possible to produce a rotating field that is capable of giving the spot a circular deviation at a constant angular speed.

In order to facilitate the adjustment of the amplitude and the phase of the modulated wave with respect to the carrier wave, certain features of the present invention aim at providing the circuits that actually constitute the above 2-phase generator in such a way that the modulated and the carrier channels are uncoupled. Fig. 5 accordingly shows an example of a circuit provided to satisfy this condition.

In this Fig. 5, 11 indicates the high frequency oscillator stage that furnishes the carrier wave. To oscillatory circuit 12 of this stage there is coupled an inductance 13 which, at terminals 14, energizes a circuit, one branch of which serves for exciting an electron discharge tube 15. The tuned plate circuit 16 of this tube is coupled to an inductance 17, that serves for symmetrically energizing rotor 18 of the induction distributor.

Amplifier tube 19 serves for applying to tube 15 a modulation of a suitable kind, e. g. one proceeding from a signal received by a radiogoniometric receiver, shown schematically at 20.

For the distributor to give two correct modulation curves, it is accordingly necessary for the source coupled into rotor 18 to furnish a constant current in accordance with the angular position occupied by the rotor at a given moment, and independent of its coupling to one or other of the stators. According to one of the features of the present invention, this condition is satisfactorily met by providing a loose coupling between inductance 17, which has a few turns, and the tuned circuit 16. This makes negligible the variations of impedance that in this circuit cause changes of position of rotor 18 in the distributor.

One end of each stator 21 of the distributor is grounded, and the other is connected to the grid connection of tubes 22 and 23 respectively. These tubes 22 and 23 are shown as double tubes, each comprising two grids and two anodes. At terminals 14, the other branch of the carrier wave's circuit energizes in parallel the two opposite grids of the double tubes 22 and 23. The two channels are thus kept de-coupled, although being additive in voltages in the plate circuits of tubes 22 and 23. The plates of these tubes are respectively connected in parallel, and they deliver output into inductances 24 and 25, which act as primary windings with respect to the tuned windings 26 and 27 that symmetrically energize the plates of the double diodes 28 and 29 respectively. At the output of the diode stages there are disposed resistance-capacitance circuits 30 and 31 which serve for removing the last traces of high frequency from the obtained low frequency curve before it is applied to the deflecting elements of the indicating oscillograph.

It is evident that in order to obtain modulated high frequency voltages of the same phase on the grids of tubes 22 and 23, it is necessary to carefully arrange the distributor and the symmetrical wiring between stators 21 and tubes 22 and 23.

Furthermore, the carrier voltage applied to the grids of tubes 22 and 23 has to be exactly in phase with the two modulated high frequency pulsations, because the obtaining of a strictly circular scanning on the indicator is dependent on the perfect phase setting of the high frequency of the two channels. A deviation of 5°, for example, gives a curve that is very different from a circle, and in practice the tolerance is about half a degree. On the other hand, the amplitude of the modulated high frequency is not critical. If the two sinusoids are slightly different, this difference is easily taken up in the amplifier that has to energize the deflection circuits of the oscillograph. It is sufficient for the obtained modulation to be always less than, or at most equal to, 100%. By the addition of the carrier wave to the modulated wave there is thus produced a wave of the form:

$$\sin \omega t(1+m \sin \Omega t), \text{ with } m \leq 1$$

The phase equality between the two halves of the modulated channel is easily taken care of, since the two waves pass over identical circuits. On the other hand, the carrier wave follows a path that is different from that of the modulated wave. It is consequently necessary to provide an adjustment of the phase relation between these two channels. Since a phase adjustment almost always brings about a variation of amplitude, and since the diameter of the scanning circle on the indicator is dependent on the modulated amplitude, one of the features of the present invention provides for disposing the adjustable phase shifting network on the carrier channel, e. g. as shown at 32, 33 and 34. When variable resistance 32 has a zero value, capacitance 33 is in parallel with resistance 34. When resistance 32 has its maximum value, the capacitance in parallel with resistance 34 is then minimum. Since the coupling inductance 13 is common to the two branches of the phase shifting circuit, adjustment of resistance 32 acts surely and effectively on the relative phase of the two channels.

All these details of embodiment are of course only given by way of example of some of the numerous means that can be imagined in the application of the present invention, particularly in radio direction finding.

It is evident that it is possible to use single tubes instead of double tubes for the two discharge paths provided in 22 and 23 in the illustrated example, the plates of these single tubes being associated in pairs in a similar manner to that described.

In cases in which a circuit of this kind is employed in connection with a radiogoniometric receiver 20 preceded by a finder 35 or by rotating aerials, the voltage at the output of detector tube 36 of the receiver, when applied by tube 19 to mixing tube 15, has an arched shape like that shown in Fig. 7. Rotor 17 has then to rotate in synchronism with the said finder 35 or the said goniometric aerials. The synchronism can be effected mechanically by keying the two rotors on the shaft of one same motor 37.

These low frequency arch-shaped voltages modulate the rotor channel of the described cir-

cuit and effect the appearance on the screen of the cathode ray tube of a tapered 8-shaped figure, as shown in Fig. 6. However, as well known in the art, certain precautions have to be taken, without the insertion of a transformer or a capacitance in the direct current amplification circuit, otherwise the low frequency voltage issuing from the receiver, which is of single polarity with respect to axis O*t*, would become transformed into a voltage, like that shown in Fig. 8, having an alternate polarity with respect to shaft O'*t'*, and this would produce a more complex figure on the screen of the oscillograph. According to one of the features of the invention, the diagram of Fig. 5 furnishes an example of embodiment of a link circuit between detector tube 26 and the reversed finder's rotor 18 that complies with these conditions.

Finally, another feature of the invention provides for applying the arch-shaped voltage obtained at the output of receiver 20 to the input of the reversed finder's rotor 18. This condition is indispensable in the above described example for effecting on the screen of the oscillograph the transformation of the circular image into a tapered 8-shaped image, as shown in Fig. 6.

Although the invention has been described for one example of embodiment, it is evident that it is by no means limited thereto, and that the same is capable of numerous variants and modifications without departing from the scope of the invention.

Wht is claimed is:

1. A phase comparison system for comparing the phase of a locally generated wave with the

phase of an applied signal, comprising a high frequency generator, a generator having a rotary field coil and two orthogonal stator coils, a coupling circuit for coupling said high frequency generator to said field coil, means for applying said signal to said field coil, a pair of electron discharge tubes coupled respectively to said stator coils to derive therefrom output waves having a ninety degree phase relation and amplitude patterns dependent upon the phase of said applied signal and the envelope wave locally generated in said generator, and means for supplying energy from said high frequency generator to said electron discharge tubes to provide substantially sinusoidal variations to said output waves.

2. A system according to claim 1 wherein said coupling circuit comprises an electron discharge device provided with a primary tuned to said high frequency, and a secondary loosely coupled to said primary and conected to said field coil.

3. A system according to claim 2 wherein said means for applying said signal to said field coil, comprises a circuit for applying said signal to said electron discharge device to modulate said high frequency energy.

4. A system according to claim 1 further comprising a phase adjusting network in said last named means to adjust the phase of the high frequency energy supplied thereby relative to the high frequency components applied from said stator coils.

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No references cited.