April 6, 1948. R. C. LONGFELLOW 2,439,255

CAPACITOR SWITCH

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Fig. 1.

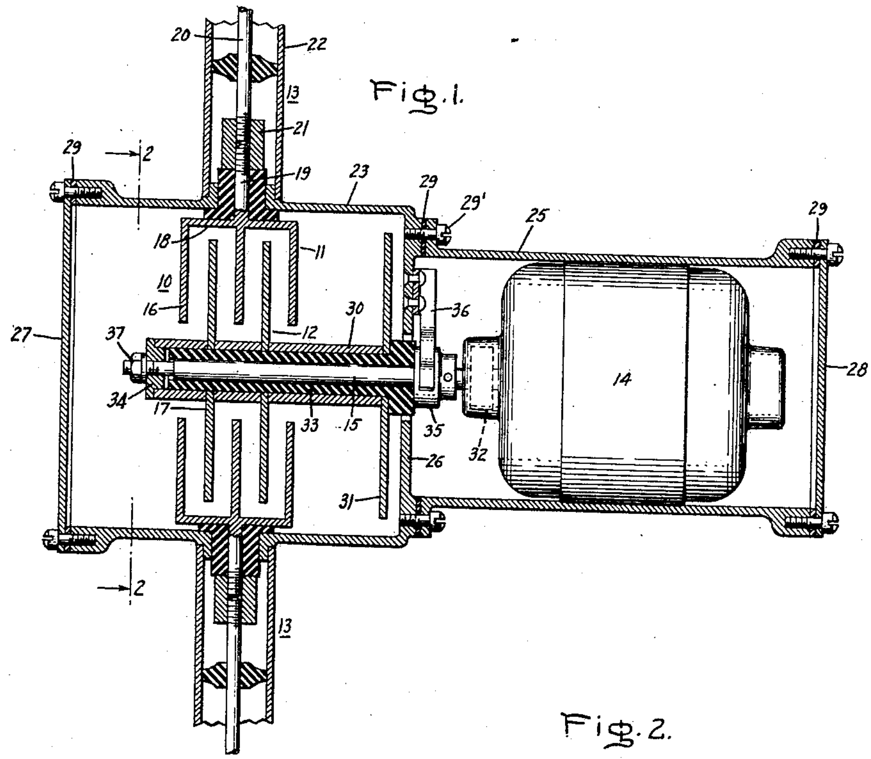
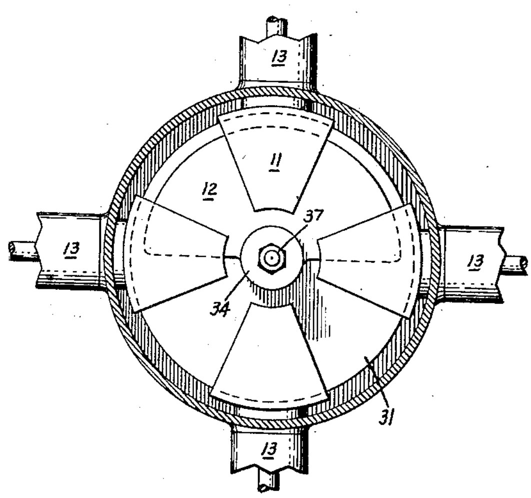


Fig. 2.



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CAPACITOR SWITCH

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8 Claims. (Cl. 178—44)

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My invention relates to reactance devices and more particularly to such devices for use at short wave lengths.

In my United States Letters Patent No. 2,412,160, granted December 3, 1946, entitled Directive radio systems, and assigned to the same assignee as my present application, I have disclosed a directive antenna array in which the direction of the axis of directivity of the array may be altered by changing the transmission lines leading to the array. That is, different portions of the array are supplied alternately through respective transmission lines, the lines through which no energy is supplied at any time being rendered inoperative. Means is employed whereby the energy is supplied through the various lines in rotational sequence, the arrangement being such that the axis of directivity of the array is rotated by this rotation of the lines.

This means comprises means for varying the impedance across each of the lines, at a desired point thereof, between very high and low values to render the line either operative or inoperative as desired. To this end, stub transmission lines are connected at said points respectively and extend to a rotating reactance device whereby the impedance across the opposite end of such stub lines is varied in rotational sequence between such low and high values, the length of the stub lines being such that the change in impedance of the reactance device is translated to the respective transmission line to vary its condition of operation.

This reactance device comprises a condenser having a motor driven rotor electrode which cooperates in sequence with each of a plurality of stator electrodes. The rotor is grounded and connected to one conductor of each line while each stator electrode is connected to the opposite conductor of the respective line whereby the impedance between said conductors of the different lines is varied in rotational sequence by rotation of said motor driven electrode.

My present invention has for its object to provide an improved reactance device, which, while not limited thereto, may be employed for the purposes above explained and which has longer life and assures greater reliability of the system.

Another object of my invention is to provide a reactance device of such construction as to reduce the flow of currents through the rotating shaft thereof and hence through the bearings of the motor by which the shaft is driven. In this way injury to the bearings of the motor produced by such currents is avoided.

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The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 shows a partially sectioned elevation of a switch constructed in accordance with my invention and Fig. 2 is an end view of a portion thereof.

In the drawing I have indicated at 10 a reactance device having a plurality of stator members 11 and a rotatable member 12 arranged for electrically controlling the currents flowing in a plurality of coaxial lines 13, here shown as four, the inner conductors of the lines being connected to the stator members 11. Rotation of the member 12 for switching of the high frequency currents carried by the lines 13 is effected by means of a motor 14 having a shaft 15 for supporting the member 12. The transmission lines 13 are connected to circuits, not shown, carrying high frequency currents, such as an antenna array, for example, and the capacitor switch 10 provides a means for rapid shifting of the order of energizing adjacent pairs of radiators of such an array for the purposes and in the manner disclosed in my above-mentioned copending application.

The fixed or stator members 11 may comprise one or more plates 16 having the general form of a sector of a circle and the rotor member 12 may comprise one or more conductor plates 17, semicircular in shape as shown in Fig. 2, or of any other desirable shape such that the plates 17 are capacitively coupled to the adjacent plates 16. The individual plates 16 are held in spaced relation by means of the shoulder members 18 and a rod-like member 19 is provided for connecting the stators 11 with the inner conductor 20 of the transmission lines 13. Preferably, the plates 16, the shoulder members 18 and the rod member 19 are formed as a unitary structure. Conductors 19 and 20 may be connected together in any suitable manner, for example, as by threaded engagement with a connecting link 21.

In order to hold rigidly the stator members 11 in spaced relation with each other, as well as to provide means for conductively connecting the outer conductors 22 of the coaxial transmission lines 13, a cylindrical metal casing or housing member 23 is provided having a plurality of spaced openings through which the connection of conductor 19 with conductor 20 is effected, the tubular conductor 22 being secured to the housing 23 around such openings in any desirable manner, such as by brazing or soldering. Suitably shaped insulators are provided to surround the conductor 19 in these openings, maintaining conductor 19 in a predetermined spaced relation with tubular member 22, and maintaining the shoulder members 18 in spaced relation with respect to the housing 23.

In order to maintain the shaft 15 in a fixed position with respect to the inner edges of the plates 16, thereby to fix the position of plates 17 with respect to plates 16, a metallic sleeve member 25 is welded to the frame of motor 14 and bolted to an inwardly projecting portion 26 of housing 23, thus forming a closure member for the respective end of housing 23. Since a capacitor switch of the type thus far described is usually operated in a gaseous atmosphere of controlled pressure, end plates 27 and 28 are provided to close the ends of the casing 23 and the sleeve member 25, gaskets 29 being provided to maintain the enclosure in a gas-tight condition.

For purposes which will become apparent, an outer rotor shaft, in the form of a metallic tubular sleeve 30, surrounding shaft 15, is provided and serves as an electrically conductive path between plates 17 of capacitor switch 10 and plate member 31, which forms with the end wall 26 a grounding capacitor for the switch 10, the grounding capacitor having a low capacitive reactance at the frequency of the current flowing in the system.

In the operation of the circuit thus far described, the desired path for the high frequency currents is between the inner conductor 20 and outer return conductor 22 of a particular transmission line 13. The currents flow along the inner conductor 20 through the connecting conductor 19, the stator plates 16, the rotor plates 17, along the tubular member 30, through the grounding capacitor plate 31 to the wall 26, the housing 23, and back to the outer conductor 22. There is another shunt path through which the currents may flow. This path goes from conductor 20 to the member 30 as described before. Instead of passing from the grounding capacitor plate 31 to the housing 23, this shunt current passes to the inner rotor shaft 15 on through the motor bearings 32 to the enclosing shield 25 and back through screws 29' to the main housing 23 and the outer conductor 22.

In the presence of high frequency currents of large magnitude in the first circuit, the voltages induced in the shunt circuit are of sufficient magnitude to cause the oil film in the bearings 32 to break down and high frequency currents of considerable magnitude to flow in the shunt path. In the presence of such currents, considerable arcing occurs between the bearing surfaces with resultant pitting of the surfaces. As a consequence, after a very short life, failure of the motor bearings results and the switch becomes inoperative.

In order to prevent the flow of this undesirable current through the shunt path described above, in accordance with my invention, the space between the inner shaft 15 and the outer shaft member 30 is filled by a sleeve 33 of any suitable insulating material, preferably a ceramic bonded mica insulating material, such as Mycalex. Also, the length of the shaft member 30 is made equal to an electrical quarter wave length of the high frequency current present on the lines 13. Thus, the inner shaft 15 and the outer shaft member 30 form the inner and outer conductors respectively of a concentric transmission line, having a length equal to a quarter wave length of the wave having the operating frequency of the system. The end of this line remote from the bearings 32, that is at the left end of the shaft 15, is short circuited by a metal plug member 34 carried on shaft 15 and having shoulders for engaging the end of sleeve 30. At the opposite end of the transmission line, the plate 31 is conductively connected to member 30 and extends parallel to the end-wall portion 26 of the housing 23.

In accordance with well-known transmission-line theory, the short circuit across the one end of the above described transmission line is inverted by the quarter wave length line to appear as an impedance of high value at the other end of the line. Thus, by this construction a large impedance is inserted in the shunt path previously pointed out and is effective to eliminate almost entirely currents flowing in this shunt path.

In order to remove any currents which may still tend to flow through the motor bearings 32 because of inaccuracies in the length of the quarter wave transmission line or because of variation in the operating frequency of the system, another path in shunt to bearing 32 is provided by means of the slip-ring 35, securely attached to the shaft 15 at the end of the insulating sleeve 33, and the brush member 36 conductively connected to the wall 26 and bearing upon the slip-ring 35. The slip-ring 35 preferably is of some good commutator material, such as copper, and the brush member 36, of a suitable brush material, such as copper or carbon.

In the assembly of the switch, after the slip-ring 35 has been secured to the shaft 15 and the sleeve 33 slipped over the shaft into abutment with slip-ring 35, the sleeve 25, bearing the motor frame 14, is bolted in place on the housing 23. The unit comprising the outer shaft member 30, the disk 31 and the plates 17 is then slipped over the insulating sleeve 33, after which the short circuit plug 34 is inserted and a bolt 37 used to hold the parts together as a rigid structure. Before the stator members 11 may be placed in position, the shaft 15 is rotated to a position such that the plates 17 do not prevent the insertion of a particular stator member.

It will thus be seen that the structure described above provides a capacitor switch in which the motor shaft of the unit is electrically isolated from high frequency currents, while mechanical rigidity of the structure is maintained. By means of a quarter wave section of the transmission line, a short circuit, at the end of the line remote from the bearing, is inverted to appear as a high impedance in series with the shunt conductive path which includes the motor bearings 32. By the use of this structure in a capacitor switch employed in a signalling system operating at a frequency of 400 megacycles, the current flowing through the motor bearings of the unit was reduced from a value which rapidly destroyed the bearings to a value which caused no harm.

While I have described the transmission line comprising the inner shaft 15 and the outer shaft member 30 as having a length of a quarter wave length, it will be apparent to those skilled in the art that this length may be any multiple of a quarter wave length. When the length is a half wave length, the plug member 34 is of some suitable insulating material. Thus, a high impedance is connected across this remote end of the line and the half wave line is effective to cause this impedance to appear as a series impedance of high value in the above-mentioned shunt path.

While I have shown a particular embodiment of my invention, therefore, it will of course be understood that I do not wish to be limited thereto since various modifications may be made, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. In combination, a capacitance device having a conducting shaft, a rotating electrode supported by said shaft and separated therefrom by insulating means, said electrode being subjected to electromotive force relative to said shaft of short wave length, and a conductor extending along said shaft conductively connected to said electrode but insulated along its length from said shaft to form a transmission line, said line having a length equal to a quarter of a wave length, or multiple thereof, of said electromotive force, and the impedance across one end of said line being such relative to the length of the line as to reduce the flow of current in said shaft produced by reason of said electromotive force.

2. In combination, a capacitance device having a conducting shaft mounted in bearings, a rotor electrode supported by said shaft and separated therefrom by insulating means, said rotor being subject to electromotive force relative to ground, a conductor conductively connected to said electrode and extending along but insulated along its length from said shaft to form therewith a transmission line, said shaft and conductor having such length and the impedance therebetween relative to said length at the end remote from said bearings being such that a current flowing from said shaft through said bearings to ground is reduced by the impedance of said transmission line.

3. In combination, a capacitance device having a conducting shaft mounted in bearings, a rotor electrode supported by said shaft and separated therefrom by insulating means, said rotor electrode being subjected to short wave electromotive force relative to ground and being grounded through impedance, and means to reduce the flow of current produced by said electromotive force from said rotor through said shaft and bearings to ground, said means comprising a conductor connected to said rotor and supported by and extending along said shaft in insulated relation thereto to form therewith a transmission line having a length relative to a wave length of said electromotive force materially to increase the impedance between said rotor and shaft to said flow of current.

4. In combination, a switch for high frequency current comprising fixed and rotatable members, means for enclosing said switch and for supporting said fixed member, means attached to said enclosing means and including a shaft for rotating said rotatable member, and means for preventing the flow of current through said shaft to said enclosing means comprising a tubular member supported by and surrounding a portion of said shaft and forming therewith a transmission line, said rotatable member being conductively connected to said tubular member and being separated from said shaft by insulating means, said line being short circuited at one end and of such length that said short circuit appears as a high impedance connected in series circuit between said rotatable member and said enclosing means.

5. In combination, a switch for high frequency currents comprising fixed and rotatable members, means for enclosing said switch and for supporting said fixed member, means attached to said enclosing means and including a shaft for rotating said rotatable member, and means for preventing the flow of current along said shaft to said enclosing means comprising a tubular member surrounding a portion of said shaft and forming therewith a transmission line, said rotatable member being conductively connected to said tubular member and being separated from said shaft by insulating means, said line being short circuited at one end and of such length that said short circuit appears as a high impedance connected in series circuit between said rotatable member and said enclosing means, and reactance means of low value connected between said line at its other end and said enclosing means.

6. In combination, a reactance device for high frequency current comprising fixed and rotatable members, means for enclosing said device and for supporting said fixed member, means attached to said enclosing means and including a shaft for rotating said rotatable member, and means for preventing the flow of current along said shaft to said enclosing means comprising a conductive member supported from a portion of said shaft and forming therewith a transmission line, said line being short-circuited at one of its ends and being connected to said enclosing means through a reactance at its other end, said line being of such length that said short circuit appears as a high impedance connected in series circuit between said rotatable member and said enclosing means.

7. In a capacitor switch for high frequency currents comprising fixed and rotatabe condenser plates, means including a shaft for rotating said rotatable plates, and a housing surrounding said plates and having means for supporting said shaft, said shaft and supporting means forming an undesired path for high frequency currents in parallel with said plates, means for preventing the flow of current through said path, said means comprising a metallic sleeve surrounnding a portion of said shaft and forming therewith a transmission line having a length equal to a quarter of a wave length at the frequency of said currents, said rotatable plate being conductively connected to said sleeve at a point intermediate the ends thereof, and means for short circuiting said line at the end remote from said supporting means, said line being effective to invert said short circuit to appear as an impedance of large magnitude in said path.

8. The combination, in a capacitor switch for high frequency currents, of a housing, a stator member supported in said housing, a rotor member, said stator and rotor members forming a first conductive path for said currents, a rotatable shaft mechanically coupled to said rotor member, means for supporting said shaft in said housing, and means for preventing the flow of said currents from said rotor member through said shaft to said housing, said means comprising a tubular member conductively connected to said rotor and extending over said shaft and insulatingly spaced therefrom, said shaft and tubular member forming a transmission line having a length equal to a quarter wave length at the frequency of said currents, and impedance means of low value connected across said line at the

end remote from said supporting means, said line being effective to invert said impedance to appear as an impedance of large value connected in series circuit with said rotor and said housing.

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