Nov. 18, 1958 W. C. ARRASMITH 2,861,267

ADJUSTABLE BALANCED DOUBLET ANTENNA WITH IMPEDANCE MATCHING MEANS

Filed Sept. 8, 1953 2 Sheets-Sheet 1

Fig. 1.

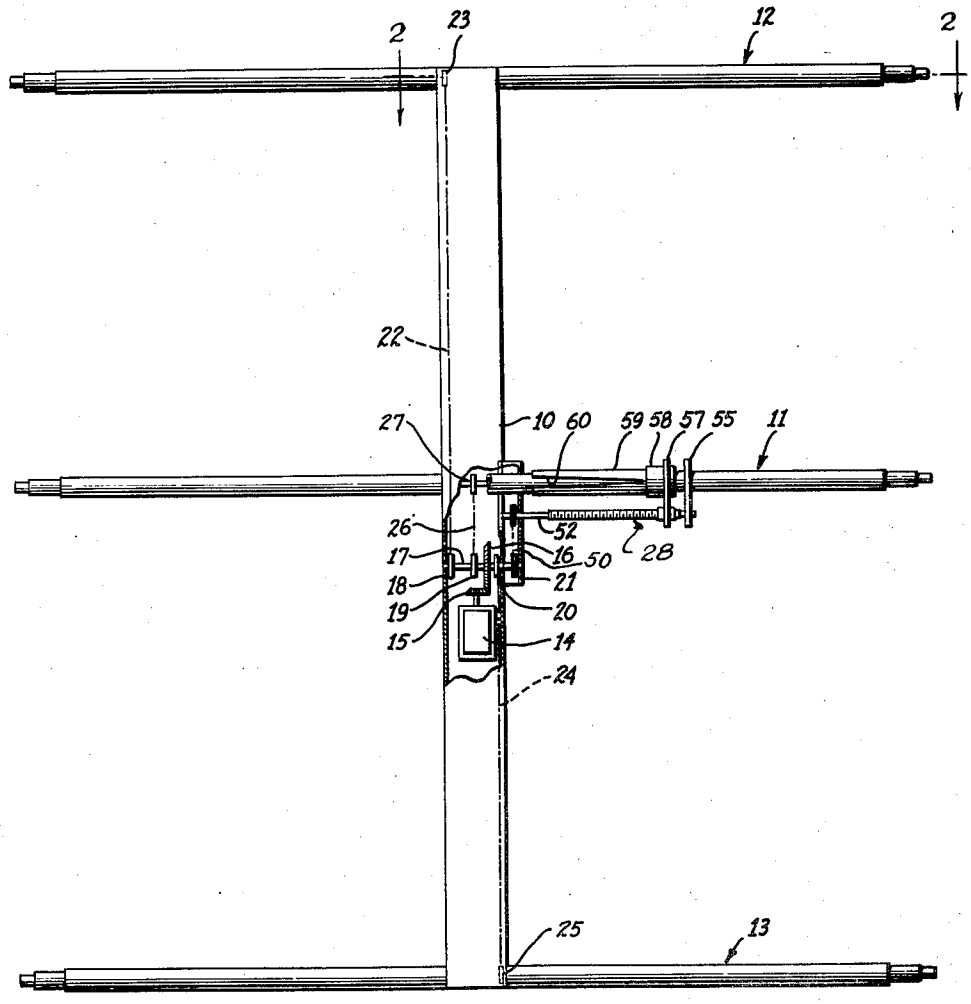
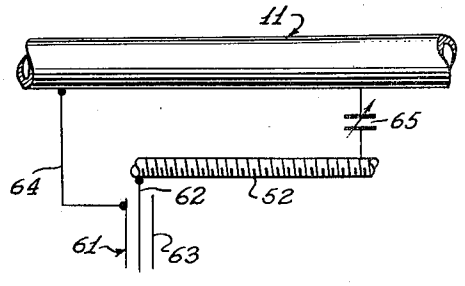


Fig. 6.



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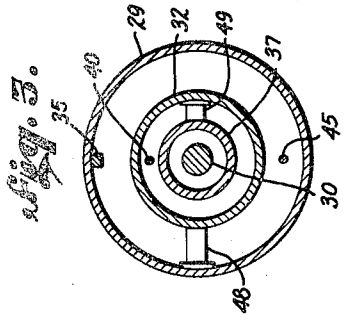


Fig. 3.

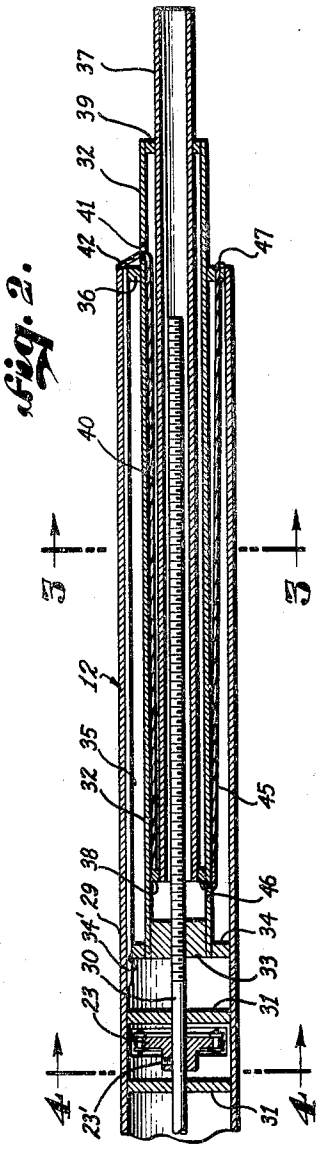


Fig. 2.

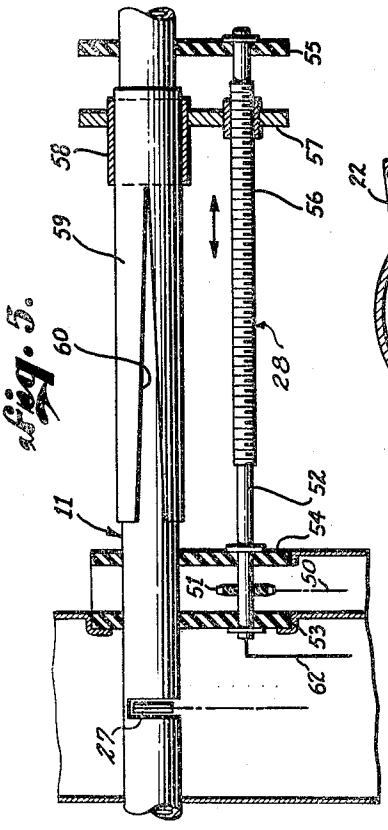


Fig. 5.

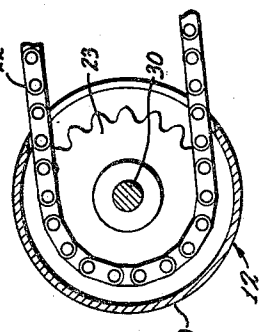


Fig. 4.

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United States Patent Office

2,861,267

Patented Nov. 18, 1958

2,861,267

ADJUSTABLE BALANCED DOUBLET ANTENNA WITH IMPEDANCE MATCHING MEANS

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Application September 8, 1953, Serial No. 378,832

12 Claims. (Cl. 343—822)

This invention relates to antennas and more particularly to a remotely controlled high frequency dipole antenna system which may be tuned over an extremely broad frequency spectrum.

In order to provide maximum efficiency in a high frequency antenna, it is imperative that the antenna be tuned to the particular wave length of the frequency being received or transmitted. In the case of dipole antennas, this proper tuning involves two factors: first, the overall length of the dipole should be made substantially equal to a half-wave length; second, the transmission line feeding the antenna, should be impedance matched to the dipole arm elements. In the case of directional dipole antenna arrays, the additional elements of the array should also be tuned by the proper adjustment of their physical overall length to maintain maximum directional effect.

High frequency dipole antennas adjustable in length for tuning purposes are well known in the art. However, many of these prior art antennas are generally not tunable over relatively broad frequency ranges for the reason that their extension arm elements are not generally adapted for extension beyond a distance twice their own length. Further, in many prior art devices, the arms are made individually extendable. Therefore, unless the extension of each arm element is substantially the same from the center feeding point for the transmission line, the impedance match between the transmission line and elements is upset. Since changing the physical length of the dipole arms also changes the conditions of input impedance to the dipole, it is also necessary to readjust the impedance match between the transmission line and the dipole elements each time a change in length is made.

The present invention has as its primary object to provide a vastly improved adjustable type dipole antenna in which the overall length of the antenna may be varied more than twice its minimum overall length.

Another object is to provide in such an antenna, directional elements which are simultaneously adjusted in length with the main antenna elements whereby maximum directivity obtains throughout the frequency spectrum covered.

Still another object is to provide positive means for insuring that each arm element of the dipole is extended exactly the same distance from the center of the dipole.

Another object is to provide an impedance matching means in combination with the dipole length adjusting means for simultaneously insuring an impedance match between the driven dipole and the feeding transmission line.

These and further objects and advantages of the present invention are attained by providing a single driving motor and a series of threaded shafts, a single shaft being provided for each dipole in the event the invention is employed with a directional array. The threads are cut in opposite directions on each end of the shaft and work into intermediate tubes disposed in telescopic relationship with each of the dipole arms. Turning of the shaft will thus cause the intermediate telescoping tubes to extend in opposite directions. A further inner tube is provided in each of the intermediate tubes and is adapted to be extended by a flexible cable arrangement to permit a length of almost three times the minimum length of the antenna to be achieved. Where directional and reflector dipole elements are employed, their corresponding shafts are coupled by any suitable means to the motor for simultaneously varying the overall length of these elements in a similar manner.

The design of an array consisting of dipole, reflector, and director members usually calls for the reflector to be longer than the dipole in terms of percentage of the length of the dipole (usually 4–5%). Similarly the director should be shorter by about the same percentage. Since this differential is in terms of percentage, the reflector as it is extended, must move through a greater distance than the dipole. Similarly the director must move through a shorter distance. These differential movements are achieved by the present invention through a drive means which moves each member at a different rate during length adjusting motion.

Also adapted to be driven by the motor is a tuning means comprising a capacitor element which is varied by changing its dielectric. Simultaneously with variations in the capacity there is also varied the input connection point to the driven dipole whereby the impedance match between the transmission feeding line and the driven dipole elements is maintained automatically throughout changes in length.

Other features and advantages of the present invention will be hereinafter apparent from the following description, particularly when taken in connection with the accompanying drawing, in which:

Figure 1 is a plan view of a preferred embodiment of the present invention as employed in a dipole array;

Figure 2 is an elnarged detailed cross-section of one of the dipole arms of the director dipole taken along the line 2—2 of Figure 1;

Figure 3 is a cross-section of the dipole arm taken along the line 3—3 of Figure 2;

Figure 4 is a similar cross-section of the dipole arm of Figure 2 taken along the line 4—4 thereof;

Figure 5 is an enlarged fragmentary elevational view partly in section of the impedance matching means on the driven elements of the array shown in Figure 1; and

Figure 6 is a circuit diagram somewhat schematically illustrating the impedance matching means shown in Figure 5.

While the principles of the invention will be described in connection with a dipole array, it is to be understood that the particular mechanism may be employed in a single dipole antenna. Referring to Figure 1 there is shown a typical dipole directional antenna array comprising a hollow supporting cross beam **10**. This beam may be formed of insulating material and in the present invention is preferably square in cross-section and of sufficient size to house various components of the extending mechanism.

At approximately the center portion of the beam **10** there is secured a main or driven dipole **11**, and to each of the ends of the beam respectively, there is supported a director dipole **12** and reflector dipole **13**. This array may be mounted on any conventional type vertical support for rotation about a vertical axis, such vertical axis being normal to the plane of the drawing of Figure 1. The particular rotating mechanism for orienting the antenna array forms no part of the present invention and is therefore not shown or described.

Mounted preferably within the square cross beam support **10**, is a reversible electric motor **14** for rotating, through bevel gears **15** and **16**, a shaft **17** disposed sub-

stantially parallel to the driven arm elements of dipole 11. As the gears, shaft and motor are housed within the cross beam 10 these members are protected from adverse weather conditions.

The shaft 17 has secured thereto a series of spaced sprocket wheels or pulleys 18, 19, 20, and 21. The wheel 18 is coupled through a driving chain 22 to a further sprocket wheel or pulley 23 mounted within the director dipole 12. Similarly, the sprocket wheel 20 is coupled through a driving chain 24 to a sprocket wheel or pulley 25 mounted within the reflector dipole 13. The sprocket wheels 23 and 25 are thus rotated simultaneously and in the same direction as the shaft 17. The sprocket wheel 19 on shaft 17 is connected through a chain 26 to a sprocket wheel 27 in the main driven dipole 11, while the end sprocket wheel 21 is coupled to a tuning mechanism designated generally by the numeral 28 in Figures 1 and 5. This tuning mechanism 28 will be described in greater detail as the description proceeds.

The above described arrangement of pulleys and sprocket chains enables all three of the dipole arm elements of dipoles 11, 12, and 13 to be actuated simultaneously. Since each of the dipole arms includes identically the same mechanism for varying its length, description of one will suffice for all.

This actuating mechanism is illustrated in Figure 2, and one arm of the director dipole 12 has been chosen for this purpose. This arm comprises a hollow conducting outer member or tube 29 in which the srocket pulley 23 is mounted. This pulley is fixedly keyed by a set screw 23' to a threaded shaft 30 supported in coaxial relation within the dipole arm 12 by means of spaced journal blocks 31. The outer member or tube 29 of the dipole is provided with an opening, referring now to Figure 4, for passing the chain 22 driving the sprocket wheel 23 and consequently the shaft 30.

Coaxially disposed within the outer tube 29 is an intermediate tube 32 provided with an end block 33 threadedly receiving the shaft 30. The tube 32 is partially maintained in coaxial relationship with the outer tube 29 by means of an annular bearing member 34 secured to and circumscribing the inner end of tube 32. The bearing member 34 is formed with a groove or notch 34' for receiving a keying ridge 35 longitudinally fixed to the inner wall of the outer tube 29. The ridge 35 coacts with the groove 34' to permit sliding movement of the bearing member 34 with the tube 32 while holding the latter against rotation. The free end of the outer tube 29 is provided with a bearing member 36 secured to the inside periphery of tube 29 and adapted to support the tube 32 in sliding and coaxial relationship.

To permit the effective electrical length of the dipole arm to be increased more than twice its minimum length, there is provided an inner tube 37 coaxially supported within the tube 32 by annular supporting discs 38 and 39. The annular disc 38 is secured to the periphery of the inner end of the tube 37 and is in sliding engagement with the inner surface of the intermediate tube 32, while the outer disc 39 is secured to the inner wall surface at the free end of the tube 32, and is in sliding engagement with the outer surface of the tube 37.

To effect telescoping extension of the inner tube 37 with respect to the tubes 29 and 32, a flexible cable 40 is connected at one end to the bearing member 38 and passes between the tubes 32 and 37 to a small eye or thimble opening 41 adjacent the outer end of tube 32. The cable is passed through this opening 41 and the other end thereof is secured to the outer tube 29 as indicated at 42.

It should now be seen that rotation of the shaft 30 through threaded engagement with the block 33 will longitudinally move the tube 32 in one direction or the other depending upon the direction of rotation of the shaft. With the shaft 30 driven in the direction to produce outward movement of the tube 32, the extent of the cable 40 carried within the tube 32 will be shortened to bring about simultaneous extension of the inner tube 37 relative to the tube 32.

To insure positive retraction of tube 37, a second cable 45 is provided and one end of this cable is secured to the support member 38 and then passed through a small eye or thimble opening 46 at the inner end of the tube 32. The cable 45 passes between the outer tube 29 and the intermediate tube 32 and is secured at its other end to the support member 36 as indicated at 47. With this arrangement it will be apparent that retraction of the intermediate tube 32, through rotation of the shaft 30, will cause the cable 45 to pull the inner tube 37 into the tube 32 thereby effecting positive retraction of the element.

The relative positions of the various telescoping tubes, shaft 30, and cables 40 and 45 is clearly shown in the cross-sectional view of Figure 3. To insure that the various tubes will be electrically continuous in their retracted as well as extended positions as well as in any intermediate position, the supporting members 34, 36, 38, and 39 may be made of electrical conducting material. Alternatively, these discs may be formed of insulating material and suitable resilient contact fingers, such as shown at 48 and 49 in Figure 3 and secured to the inner portions of the tubes 29 and 32 respectively, may be used for effecting the proper electrical connection between the various tubes.

Referring now to Figure 5, the sprocket driving chain 50 driven by sprocket pulley 21 (Figure 1) drives a sprocket pulley 51, preferably formed of a suitable fibre or other non-conductive material, secured to a threaded shaft 52 journaled in electrical insulating support plates 53 and 54. The shaft 52 is further journaled at its far end by an electrically insulating plate 55. A portion of the shaft 52 is threaded as indicated at 56. An electrically conducting plate 57 supports a metallic sleeve 58 surrounding the antenna element 11. This plate is also threadedly supported on the shaft 52 as shown. The sleeve 58 forms one plate of a condenser and encircles a dielectric material or covering 59 provided with a longitudinal V-cut channel 60. The dielectric covering 59 is rigidly fixed to the dipole element 11 and the metallic sleeve 58 adapted to slide longitudinally therealong.

With this arrangement it will be evident that turning the sprocket pulley 51 in one direction or the other will rotate the shaft 52 and, due to the threaded engagement of the threads 56 with the plate 57, move the sleeve 58 longitudinally along the dielectric covering 59 as indicated by the arrows. Because of the increasing width of the V-groove in the dielectric material 59, as the sleeve 58 moves inwardly towards the center of the dipole structure, the amount of dielectric material between the sleeve 58 and the metallic dipole arm element 11 varies thereby changing the capacity between the sleeve 58 and this element.

Referring to the schematic diagram shown in Figure 6, the variable condenser formed by the sleeve 58, the dielectric covering 59 and the metallic dipole element 11 is represented schematically at 65. In this figure, the transmission line for feeding the driven dipole takes the form of a coaxial line 61 comprising an inner conductor 62 and outer sheath 63. The inner conductor 62 is connected to the inward end of the shaft 52. Any suitable connector means may be used to connect the conductor 62 to the shaft 52. The outer sheath 63 is connected directly to the dipole element 11 as shown at 64. It is seen accordingly, that movement of the sleeve 58 as shown in Figure 5, varies the effective travel path of the current flow through the shaft 52 and the dipole element 11. This causes the inductive reactance of the circuit shown in Figure 6 to vary. At the same time, the value of the capacitance 65 is varied in accordance with the movements of the sleeve 58 along the dipole ele-

ment 11. In this way, the tuned circuit is obtained regardless of the effective length of the dipole element 11 and the positioning of the sleeve 58 on the dipole element.

Since sprocket wheel 51 is driven simultaneously with the length adjusting mechanism, both the inductance and capacity are simultaneously changed with a change in the length of the over-all antenna. By adjusting the geometry of the various parameters, this change in the inductance and capacity is made such that a substantially perfect impedance match between the transmission line 61 and the driven dipole is maintained throughout variations in the length of the antenna.

The operation of the over-all system will be clear from the above description. When it is desired to tune the antenna for receiving or transmitting a lower frequency or longer wave length, for example, the motor 14 is operated to produce the proper direction of rotation of the shaft 17, thereby simultaneously rotating the shaft 30 within the elements of director 12 and the other similar shafts (not shown) in the elements of dipoles 11 and 13, all in the same direction.

As will be seen, referring now to Figure 2, rotation of the shaft 30 in the proper direction will cause the intermediate tube 32 to telescope outwardly. The corresponding intermediate tube in the other arm of this dipole is also moved outwardly because of opposite pitch of the threads provided on the other end of the shaft 30. Movement of the intermediate tubes outwardly will cause the innermost tubes 37 to be moved at twice the velocity relative to the outer tubes 29 in view of the flexible cables 40 and their manner of connection as previously described. Since the other dipole elements are all provided with identical mechanical arrangements as described for the arm 12, the elements of the dipole arms 11 and 13 will be extended simultaneously with the elements of the arm 12.

At the same time, in view of the rotation of the shaft 17, the sprocket pulley 51 in tuning mechanism 28 is also caused to rotate to move the sleeve 58 along the dielectric covering 59 thereby changing the capacity. The threads 56 on the shaft 52 are in such a direction and the V-groove of such configuration that the antenna input inductance and capacitance is matched to that of the transmission line throughout the lengthening and shortening of the dipole arms.

When it is desired to tune the antenna to a higher frequency, the arms are caused to retract by simply reversing the reversible motor 14. In this case, the flexible cable 45 will pull the innermost tube 37 within the tube 32 as the tube 32 is retracting into the element 12 due to the reverse motion of the shaft 29.

In an array consiting of dipole, reflector, and director members it is generally preferred to form the reflector of a greater length than the dipole in terms of percentage of the length of the dipole. Similarly the director member should be shorter than the dipole by about the same percentage. The actual differences in the lengths of the members of the array will, of course, vary as the lengths of these members vary, but yet the percentage differences should remain the same. In the present invention the percentage differences in the lengths of the members are maintained substantially uniform as the lengths are varied but the actual extent of the differences are changed as the length of the members are adjusted. This differential movement of the members is preferably brought about by suitably varying the diameters of the sprocket wheels 23, 27, and 25. Thus the sprocket wheel 23 is of such a diameter relative to the diameters of the sprocket wheels 27 and 23 as to drive the elements making up the director 12 at a rate lesser than the rate of movement of the elements of the dipole 11 and the reflector 13. Thus, although the extent of the change in the length of the director 12 is lesser than the extent of the change in the dipole 11 and the reflector 13, the percentage difference in the lengths of the three dipoles remain substantially constant.

It is thus seen that the present invention provides a rugged, positively acting, tunable antenna array in which the various arms may be extended to greater than twice their minimum length. The frequency spectrum to which the antenna may be tuned is therefore enormously broadened. Furthermore, a proper impedance match is correspondingly maintained for any position of the dipole arms insuring maximum power transfer between the antenna and transmission line.

Although the now preferred embodiment of the present invention has been shown and described herein, it is to be understood that the invention is not to be limited thereto, for it is susceptible to changes in form and detail within the scope of the appended claims.

I claim:

1. In a dipole antenna fed by a transmission line and including means for varying the length of the antenna dipole arms: means for maintaining an impedance match between said antenna and transmission line as the length of the antenna arms is varied, comprising: a dielectric covering surrounding a portion of one of the antenna arms; a conducting sleeve slidably disposed on said covering whereby a capacitance is formed between said arm and sleeve; and covering having a channel of varying width longitudinally cut therein; and means for moving the sleeve longitudinally over said covering and cut out channel as the antenna length is varied.

2. An antenna according to claim 1, in which one conductor of the transmission line is connected directly to the dipole and the other conductor is electrically continuous with said sleeve to provide a variable capacitance with movements of the sleeve relative to said covering and cut-out channel.

3. In an antenna, an arm element including: a elongated outer tube, an intermediate tube coxially disposed within the outer tube; an inner tube coaxially disposed within the intermediate tube; and a shaft coaxially disposed within said tubes and mounted for rotation to said outer tube, said shaft having a portion threadedly engaging said intermediate tube; means for rotating the shaft; keying means preventing said intermediate tube from rotating with respect to the outer tube whereby rotation of the shaft will move the intermediate tube in an axial direction; a flexible cable secured at one end to the far end of said outer tube, passing through an opening in the far end of the intermediate tube, passing between the intermediate and inner tubes, and secured at its other end to the inner end of the inner tube; a dielectric covering over a portion of the outer tube, said covering having a V groove cut longitudinally therein; a conducting sleeve about said covering; and means coupled to the means for rotating the shaft for moving said sleeve longitudinally over said dielectric covering and V groove whereby the capacitance between said sleeve and outer tube is made variable; a transmission line for transferring energy from or to said antenna, one conductor of the transmission line being connected to the outer tube and the other conductor being connected to the sleeve whereby operation of the means for rotating the shaft will simultaneously vary the length of the antenna and the value of said capacitance to maintain an impedance match between the transmission line and antenna.

4. An antenna according to claim 3, including an additional flexible cable secured at one end to the inner end of the inner tube, passing through an opening in the rear end of the intermediate tube, passing between the intermediate and outer tubes, and secured at its other end to the far end of the outer tube.

5. In an antenna including a director element, a driven element, and a reflector element arranged in substantially coplanar, spaced, parallel relationship, and a transmission line connected to said driven element: means for simulta-

neously varying the lengths of said elements and means for simultaneously maintaining an impedance match between said transmission line and said driven element, whereby the antenna may be tuned over wide frequency spectrum, comprising shafts respectively carried by said elements, said shafts being coupled for simultaneous rotation and having oppositely wound threads on their opposite end portions; extension members associated with each element and threadedly secured to said end portions of the shaft whereby rotation of the shaft moves said extension members in opposite directions; an additional shaft coupled to be rotated with the shafts carried by the elements; and means carried by said additional shaft and variable in position upon rotation of said additional shaft to form a variable capacitance with said driven element.

6. An antenna according to claim 5, in which said elements each comprise an outer tube and said extension members each comprise an intermediate tube coaxially mounted telescopically in said outer tube, an inner tube coaxially mounted telescopically in said intermediate tube, said intermediate tube including an end block in threaded engagement with said shaft, a cable secured at one end to the far end of the outer tube and passing through an opening adjacent its far end in the intermediate tube to pass between the intermediate tube and inner tube, said other cable end being secured to the inner end of the inner tube, whereby movement of the intermediate tube a given distance with respect to the outer tube causes said inner tube to move twice said given distance.

7. An antenna according to claim 6, in which there is provided a further flexible cable secured at one end to the inner end of the inner tube and passing through an opening in the intermediate tube adjacent its near end to pass between the intermediate tube and outer tube, the other end of said further flexible cable being secured to the outer end of the outer tube.

8. In an antenna receiving power from input means such as a transmission line and including means for varying the effective length of the antenna, means for maintaining an impedance match between the antenna and the input means with variations in the effective length of the antenna, including, a dielectric covering disposed in enveloping relationship to at least a portion of the effective length of the antenna and having a variable pattern at different positions along the conductor, a conductive sleeve slidably disposed on the covering to form a capacitance with the antenna, and means for varying the relative disposition of the sleeve on the covering in accordance with variations in the effective length of the antenna to produce variations in the value of the capacitance dependent upon the pattern of the covering.

9. In an antenna as set forth in claim 8, the input means such as the transmission line having a first conductor in electrical continuity with the antenna and a second conductor in electrical continuity with the sleeve to produce a circuit having variable inductive and capacitive reactances in accordance with changes in the effective length of the antenna.

10. In an antenna, a first tube, at least a second tube disposed within the first tube in telescopic relationship to the tube, an insulator disposed to the first tube and having a pattern varying in a particular manner with progressive distances along the tube, a sleeve mounted on the insulator for movement along the first tube to form a variable capacitance with the tube, means for driving the second tube relative to the first tube to vary the effective length of the antenna and for simultaneously driving the sleeve along the first tube to produce corresponding variations in the capacitance, and means connecting the capacitance and the antenna in an electrical circuit.

11. In an antenna as set forth in claim 10, a third tube disposed within the second tube in telescopic relationship to the second tube and movable with the second tube relative to the first tube, and means for producing a further movement of the third tube relative to the first and second tubes in accordance with the movement of the second tube relative to the first tube.

12. In an antenna as set forth in claim 10, a third tube disposed within the second tube in telescopic relationship to the second tube and movable with the second tube relative to the first tube, and means for producing a further movement of the third tube relative to the first and second tubes in accordance with the movement of the second tube relative to the first tube, the last mentioned means including at least one cable extending through the second tube and connected at opposite ends to the first and third tubes.

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