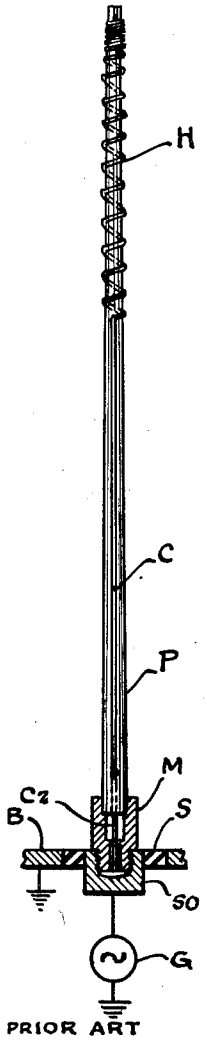
April 20, 1965 E. F. HARRIS ETAL 3,179,941

HELICAL ANTENNA WITH ADJUSTABLE LENGTH BY SWITCHING

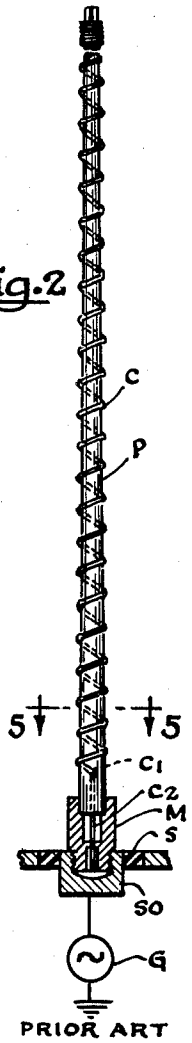
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Fig.1



PRIOR ART

Fig.2



PRIOR ART

Fig.3

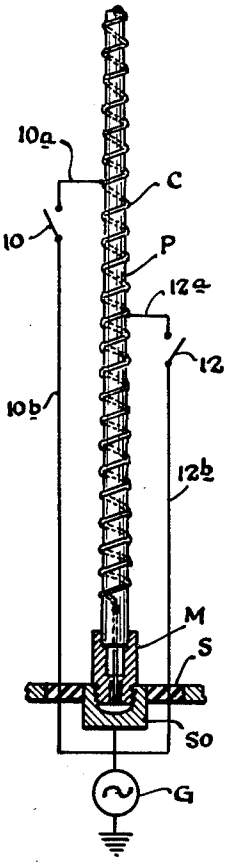


Fig.4

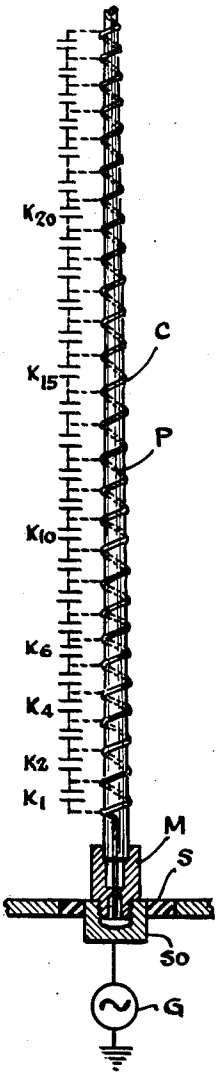
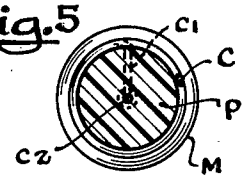


Fig.5



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HELICAL ANTENNA WITH ADJUSTABLE LENGTH BY SWITCHING

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Fig. 7

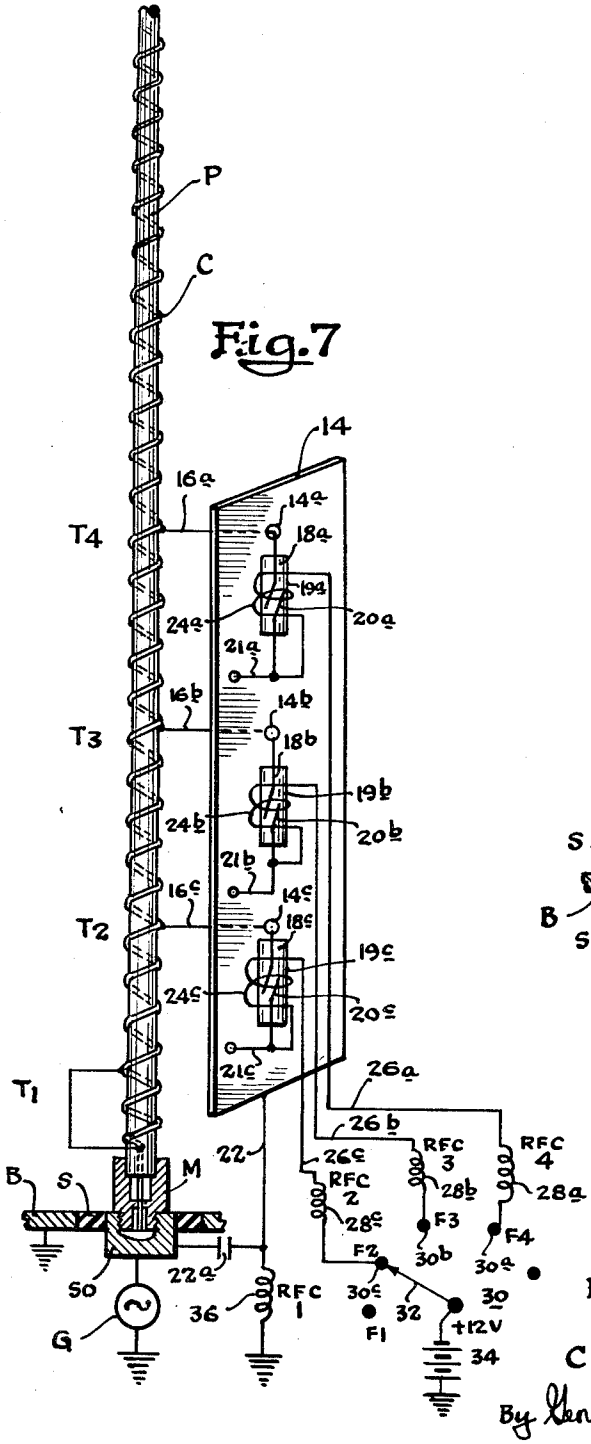
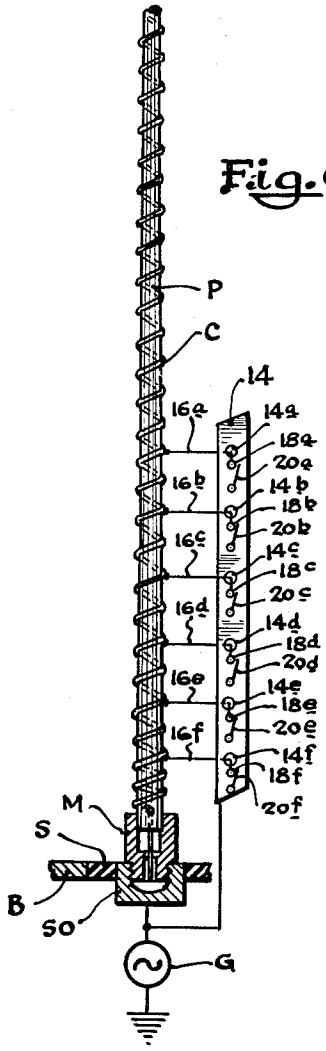


Fig. 6



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HELICAL ANTENNA WITH ADJUSTABLE LENGTH BY SWITCHING

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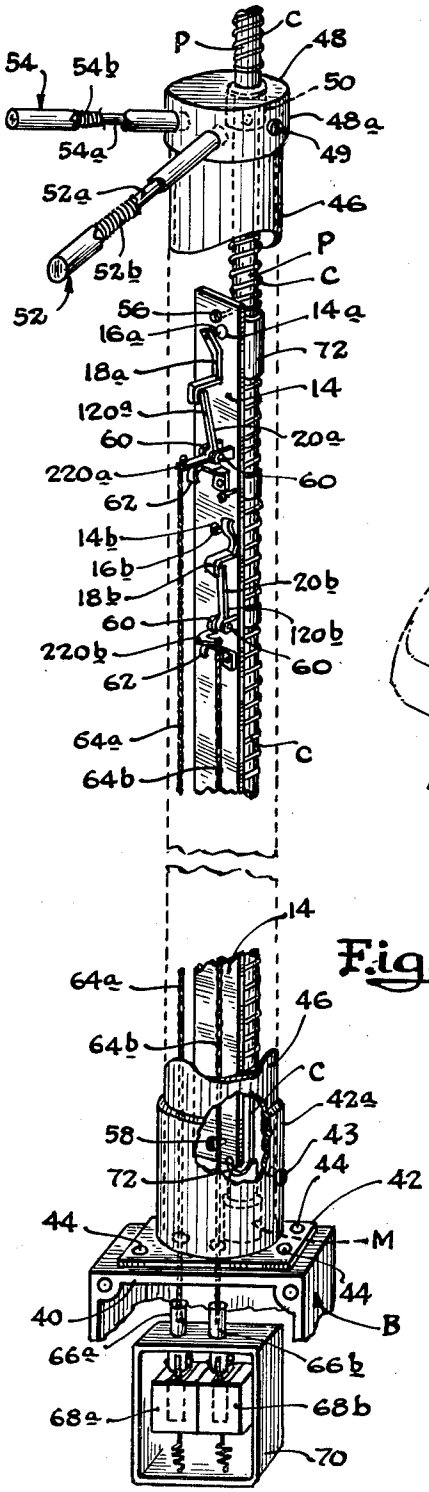


Fig.9

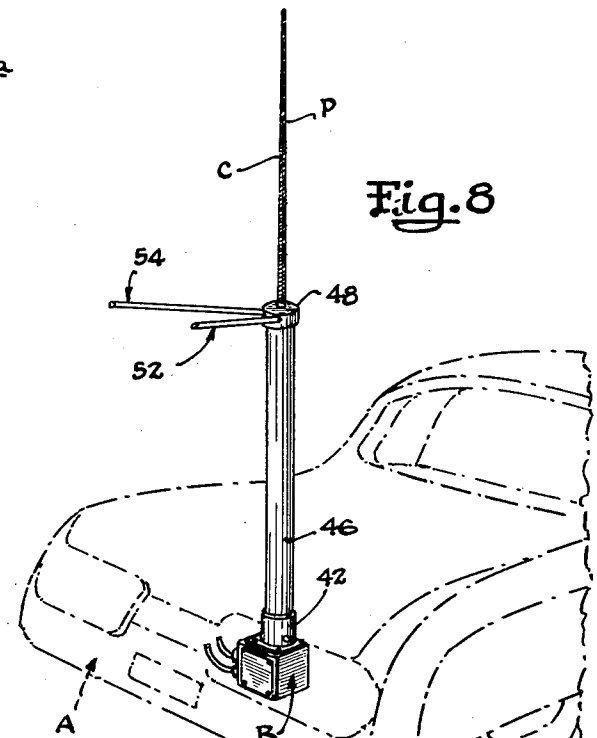


Fig.8

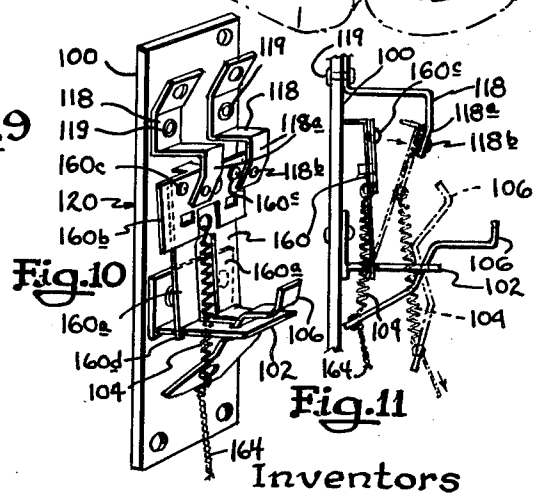


Fig.10

Fig.11

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3,179,941

HELICAL ANTENNA WITH ADJUSTABLE LENGTH BY SWITCHING

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Filed Aug. 17, 1962, Ser. No. 217,572
12 Claims. (Cl. 343—723)

This invention relates to an improved multifrequency antenna construction.

It is frequently necessary to provide an antenna capable of radiating or receiving any one of a number of frequencies with a high degree of efficiency. One antenna construction suitable for this purpose is that described and claimed in Edward F. Harris Patent 2,966,678. In the preferred form of this antenna, a plurality of helices are mounted outboard the base and are effective, respectively, in resonant action to provide high efficiency operation at selected frequencies as described in Patent 2,966,678. Even this construction, however, provides action at only a limited number of frequencies and accordingly does not fulfill the market need when action is required at other frequencies.

In accordance with the present invention, an antenna is provided which is capable of efficient operation at frequencies beyond those permitted by the antenna construction of Patent 2,966,678. In its preferred form, herein described in detail, the antenna of the present invention uses an elongated insulating post which is mounted upon and extends upwardly from the base. An antenna conductor, such as a copper wire, is wound helically about this post to define a helical antenna.

A sheet-like conductor, preferably a self-sustaining flat plate of aluminum, extends from the base a substantial distance up the post. The width of this conductor is such that it spans only a part of the periphery of the post. The sheet-like conductor has a plurality of spaced notches, slots or windows. Conductors extend, respectively, from the point on the helical conductor at each notch, slot or window through the same and in insulated relation to the sheet-like conductor. Each of these latter conductors in the preferred form of the present invention forms a fixed terminal which is adjacent the respective window. Further, in accordance with the preferred form of the present invention, rockable crank-like movable switch elements electrically connected to the sheet-like conductor are mounted on the sheet-like conductor adjacent each window and on the side outboard the antenna conductor. These elements are normally biased to a contact-breaking position in which the entire helical antenna length is effective. In the preferred form of the present invention, these elements are selectively rockable to contact-making position through the medium of control elements in the base of the structure which may be actuated respectively. When any one of the control elements is actuated (as by solenoid elements in the base), the corresponding switch unit moves to contact-making position and the helical antenna is connected to the sheet-like conductor at the corresponding point. Varying lengths of helical conductor are thus made effective in antenna operation and the unit thereby rendered effective at different resonant frequencies.

It is, therefore, a general object of the present invention to provide an improved multifrequency antenna unit.

A more specific object of the present invention is to provide an improved multifrequency antenna capable of operating, selectively, at a wide variety of resonant frequencies.

A still more specific object of the present invention is to provide a multifrequency antenna in which an antenna conductor is helically or otherwise disposed in an elongated envelope and selected portions thereof are made effective, at will, to vary the resonant frequency.

Still another object of the present invention is to provide an improved antenna in accordance with the foregoing objects in which elements operable from the base of the antenna are effective to vary the active portion of the antenna and thereby select the resonant frequency.

It is still another object of the present invention to provide an antenna having at least some of its portions of helical conformation, switch elements effective to render portions of the antenna operative and inoperative, means to isolate the switch elements, respectively, from the field of the antenna, and mechanical means operable to actuate the switch elements.

Still another object of the present invention is to provide an improved multifrequency antenna particularly suitable for mounting on vehicles which embodies features of construction, combination and arrangement rendering it inexpensive in construction, reliable in operation, and highly efficient in electrical performance at each of the various selectible operating frequencies.

The novel features believed to be characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its construction and its mode of operation together with further objects and advantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is a somewhat diagrammatic view in partial cross-section of an antenna of the helical type with a non-helical portion adjacent the base;

FIG. 2 is a view similar to FIG. 1, but showing an antenna that is helical throughout its length;

FIG. 3 is a view similar to FIGS. 1 and 2, but illustrating in diagrammatic form how switch elements may be applied to vary the resonant frequency of an antenna of the types illustrated by FIGS. 1 and 2;

FIG. 4 is a somewhat diagrammatic view like FIG. 2, but showing in schematic form the capacities effective along the length of the antenna;

FIG. 5 is an enlarged view in cross-section through axis 5—5, FIG. 2;

FIG. 6 is a somewhat diagrammatic view like FIG. 2, but showing a sheet-like conductor along the side of the antenna and the switch elements provided in accordance with the present invention;

FIG. 7 is a somewhat diagrammatic view similar to FIG. 6, but showing an antenna constructed in accordance with one form of the present invention to provide multifrequency operation;

FIG. 8 is a view in perspective of an antenna constructed in accordance with the preferred form of the present invention, showing in phantom an automobile upon which the same is mounted;

FIG. 9 is an enlarged fragmentary view in perspective of the antenna of FIG. 8 with parts broken away to show more clearly the construction thereof;

FIG. 10 is a view in perspective of the preferred switch construction for use in the apparatus of FIG. 9; and,

FIG. 11 is a side elevational view of the switch of FIG. 10.

Referring now to FIG. 1, there is shown one form of helical antenna of the type previously used. In this form of antenna a conducting base B carries an insulating sleeve S in which a conducting socket SO is received. This socket has a female threaded opening into which the conducting male antenna member M is threaded. An insulating post

P of glass fiber or similar insulating material having low radio frequency losses extends upwardly from the member M as shown. The radiating conductor C (for example, a copper wire) is connected at its bottom end to member M, it extends in substantially straight relation up a lower portion of the post P and in a top section H has a helical conformation as shown. The antenna is excited for transmission, for example, by a suitable radio frequency generator, indicated diagrammatically at G, which produces radio frequency voltages in relation to the base B.

FIG. 2 shows another form of helical antenna which is like that of FIG. 1, but in which the conductor C spirals throughout the length of the post P. In this construction the resonant frequency for a predetermined total length of post P is lower than with the antenna of FIG. 2.

As shown in cross-section in FIG. 5, the conductor C extends at portion C1 through a suitable radial opening in the lower part of the post P and then reaches downwardly to member M in portion C2 where it is connected thereto. This construction is the same for both the antenna of FIG. 1 and that of FIG. 2.

In each of the above prior art constructions, the antenna is fundamentally a single frequent device, or at least can be operated only on harmonically related frequencies. As disclosed and claimed in Patent 2,966,678, above referenced, it is possible to provide a limited increase in these resonant frequencies through the use of additional helical or other elements near the top of the antenna, but such increase in some instances is insufficient to satisfy the operating requirements.

FIG. 3 shows in diagrammatic form an antenna like FIG. 2, but in which switches **10** and **12** are provided to connect points on the antenna conductor C to the base. In the case of switch **10**, this is effected through conductor **10***a* and conductor **10***b*, the latter being connected to the base part of the antenna adjacent generator G as shown. In the case of switch **12**, this connection is accomplished through conductors **12***a* and **12***b*, the later being connected to the generator G as shown. In theory, it would appear possible to provide an effective choice of resonant frequencies through this simple switch arrangement, that is, one would support that with switch **12** closed, the antenna of FIG. 3 would operate as if it had the configuration of antenna of FIG. 1, with the helical antenna portion starting at the point of connection of conductor **12***a* to the helical conductor C. Similarly, the closure of switch **10**, in theory, would seem to make the antenna of FIG. 3 operate like that of FIG. 1 with the helical portion terminating at the point of connection of conductor **10***a* to helical conductor C. It has been found, however, that this theoretical operation does not in fact occur. When switch **10** is closed, to be sure, it is possible to get some effective antenna operation. However, with the switch **12** closed and switch **10** open, it has been found that unacceptable operation takes place. It is thought that this is due to the discontinuities formed in the antenna by conductors **10***a* and **10***b* and switch **10** and the effects of stray capacities. These capacities, indicated diagrammatically and partially as **K1**, **K2**, **K3**, etc., FIG. 4, are important in determining both the resonant frequency of the antenna and the impedance of the antenna with the result that disturbances to these capacities cannot be tolerated in an effective design.

In the unit shown schematically in FIG. 6, the construction of the radiating portion of the antenna (i.e. conductor C) is like that of FIGS. 2 and 3. However, a sheet-like conducting member **14** is mounted alongside the lower portion of the antenna as shown. This sheet-like structure may, for example, be a plate of aluminum, copper, or other effective conducting material. It is provided with a series of holes or windows **14***a*, **14***b*, **14***c*, **14***d*, **14***e*, and **14***f*, each of size sufficient to receive a wire as hereinafter set forth. As shown, the plate **14** is elongated and is electrically connected to the lowermost portion of the antenna, that is to generator G. A series of electrically conducting links, or conductors, **16***a*, **16***b*, **16***c*, **16***d*, **16***e*, and **16***f* extend from the antenna conductor C through each one of the openings **14***a*, **14***b*, etc. As shown in FIG. 6, each of these conductors is connected from the opening to a close point on the radiating conductor C (which may be slightly above or below the opening). As shown, each of the conductors **16***a*, **16***b*, etc. defines a fixed contact **18***a*, **18***b*, etc., located adjacent the corresponding window **14***a*, **14***b*, etc., on the side of the sheet-like conductor **14** outboard the helical conductor C of the antenna and post P. Switches shown diagrammatically at **20***a*, **20***b*, **20***c*, **20***d*, **20***e*, and **20***f* are located on the sheet-like member **14** on the side outboard conductor C to permit the selective connection of the insulating fixed contacts **18***a*, **18***b*, etc., to the sheet-like conductor **14**.

It has been found that with a construction such as that of FIG. 6, the respective switch elements may be actuated to control the frequency of antenna operation without encountering disturbances in distributed capacity or otherwise degrading antenna performance. That is, as the switches **14***f*, **14***e*, **14***d*, **14***c*, **14***b*, and **14***a* are sequentially closed (singly or otherwise), the resonant frequency of the antenna is progressively increased without greatly disturbing the voltage standing wave ratio, the antenna impedance at resonance, or other important antenna characteristics. In general, the antenna operation is similar to that obtained with an antenna of the type shown in FIG. 1 in which the length of the helical portion is variable at will.

FIG. 7 shows one form of practical multifrequency antenna constructed in accordance with the principles of above-described in connection with FIG. 6. In this antenna the post P is supported by and received in the male plug M as described above in connection with FIGS. 1 and 2. The threaded socket SO is insulatingly supported on base B, and receives the male member M as shown. The conductor C is spirally wound on the post P as above described in connection with conductor C, FIG. 2.

The sheet-like conductor **14** of aluminum or similar material is suitably supported (by means not shown) adjacent and parallel to the post P as shown in FIG. 7. This conductor is sufficiently spaced from the post P and has a sufficiently short width to cause it to span in the circumferential direction only a small part of the periphery post P. The sheet-like conductor **14** has spaced windows **14***a*, **14***b* and **14***c* as shown. Electrically conducting links, or conductors, **16***a*, **16***b*, and **16***c* extend from the portions of conductor C closest to windows **14***a*, **14***b* and **14***c* through these windows, respectively, to the upper contacts **18***a*, **18***b* and **18***c* of the switches **19***a*, **19***b* and **19***c*, respectively. The other contacts **20***a*, **20***b* and **20***c* of these switches, respectively, are connected to the sheet-like conductor **14** by the conductors **21***a*, **21***b* and **21***c*, respectively.

The lowermost point on the sheet-like conductor **14** is connected by conductor **22** and capacitor **22***a* to the socket SO.

The switches **19***a*, **19***b*, and **19***c* are glass-enclosed reed relays. These relays are received in a hermetically sealed glass envelope with an inert atmosphere. The relay contacts are in the form of flexible reeds which snap into position to make contact upon application of an external magnetic field. In the absence of the magnetic field, each switch assumes the non-conducting position due to the bias of the reeds. In the structure of FIG. 7, the external magnetic fields for the respective relays are created by current flow through solenoid windings **24***a*, **24***b* and **24***c*. As shown, these windings are each connected at one end to the sheet-like conductor **14** and at the other end are connected through conductors **26***a*, **26***b* and **26***c*, respectively, and the radio frequency chokes **28***a*, **28***b* and **28***c*, to the fixed terminals **30***a*, **30***b* and **30***c* of the selector switch in-

dicated generally at 30. The movable contactor 32 of the switch 30 is connected to ground through energizing battery 34. Radio frequency choke 36 connects the conductor 22 to ground.

It will be noted that as the selector switch arm 32 is rotated to make contact with a selected one of the contacts 30*a*, 30*b* or 30*c*, or is rotated to a position making no contact, a circuit is defined from source 34 through the appropriate radio frequency chokes 28*a*, 28*b* and 28*c*, and the appropriate solenoid 24*a*, 24*b* and 24*c*, and radio frequency choke 36 to energize a selected one of the solenoids 24*a*, 24*b* and 24*c*, or to energize none of them. Thus the position of the arm 32 determines whether any of the solenoids are energized, and if so, fixes the particular solenoid energized.

The antenna of FIG. 7 is energized from the radio frequency source indicated generally at G.

It will be observed that with the apparatus of FIG. 7, it is possible through selective rotation of arm 32 to close a selected one of the switches and thereby connect a selected one of the conductors 16*a*, 16*b* and 16*c* to the antenna base. As above described in connection with FIG. 6, the effective length of the spiral portion of the antenna of FIG. 7 is thereby varied to provide control of the resonant frequency.

FIGS. 8 and 9 show the preferred embodiment of the present invention.

In this construction, the base B is in the form of a cubical metal housing which is mounted by suitable means (not shown) on the automobile shown in phantom in FIG. 8. The roof portion 40, FIG. 9, of the base B receives a pipe support fitting 42, which has its bottom flange portion secured thereto by a series of bolts 44, which at their headed ends overlay the bottom flange portion of bracket 42, and at their threaded lower ends are threadedly received in roof 40 of base B. The fitting 42 defines an upstanding support sleeve 42*a*, which receives telescopically the elongated, upstanding, insulated tube 46. The latter is secured to the sleeve 42*a* by set screw 43 or by an appropriate cement, such as an epoxy resin. At its upper end, the tube 46 receives cap 48 having depending skirt portion 48*a*, which is secured to tube 46 by set screw 49. Fitting 42 and cap 48 may be of metal, such as cast aluminum alloy. The tube 46 is of insulating material having low high frequency loss factor and good mechanical properties. Phenolic plastics may, for example, be used.

Internally, the tube 46 receives the insulating post P upon which the conductor C is spirally wound. The post P and conductor C are constructed as in FIG. 2, and the male member M (shown in phantom in FIG. 9) is received in a suitable female socket SO (not shown in FIG. 9, but shown in FIG. 2) which is insulatingly supported in the top 40 of the housing, constituting the base B. The cap 48 has an opening through which the post P extends as shown in FIG. 9. Also at this point, the post P has a conducting head 50 to which the conductor C is connected.

A pair of helical antenna units indicated generally at 52 and 54 extend outwardly from the post P at the region of cap 48. Each of these is defined by an insulating support member 52*a* and 54*a*, respectively, about which is wound a helical winding 52*b* and 54*b*, respectively. Preferably (though not necessarily) the supports 52*a* and 54*a* each have about a 30 degree angle to the horizontal. The windings extend to and are connected with the conducting head 50 at their inboard ends in the manner described more particularly in E. F. Harris Patent 2,966,678. As is also described in that patent, the portion of the conductor C above the head 50 provides resonant action in conjunction with the portion of the conductor C below cap 50 at one frequency; the helix 52*b* provides resonant action at a second frequency; and the helix 54*b* provides resonant action at a third frequency. Thus the unit defines a three-frequency multifrequency antenna apart from the further frequency control elements hereinafter described. The support members 52*a* and 54*a* are of fiberglass or similar material having the requisite mechanical strength and low high frequency losses.

A sheet-like conductor 14 extends partially up the side of the post P, FIG. 9, within the tube 46 as shown. It extends part way up the lower portion of the conductor C to terminate below cap 48. This conductor is sustained in place by upper and lower insulating mounting studs 55 and 58, respectively. These may, for example, be in the form of insulating dowels snugly received in appropriate holes in the post P and in the sheet-like conductor 14. Alternative support arrangements may be provided if desired.

The sheet-like conductor 14 has an upper window or opening 14*a* and a lower opening or window 14*b*. The conductors 16*a* and 16*b* are each connected at one end to the portion of conductor C adjacent the respective windows, and at the other end extend through the respective windows to be connected to the fixed contacts 18*a* and 18*b*, respectively.

The fixed contacts 18*a* and 18*b* receive, respectively, the movable contacts 20*a* and 20*b* to define switches (which are shown in simplified form in FIG. 9 for purposes of explanation). As shown, these movable contacts are in the form of crank arms each having a lengthy arm portion, 120*a* and 120*b*, and a short arm portion, 220*a* and 220*b*. The crank arms 20*a* and 20*b* are each rockably supported from the sheet-like conductor 14 by a pair of conducting support posts 60 which serve to support each crank arm for rotation about an axis substantially parallel to sheet-like conductor 14 and to the top portion 40 of base B. Suitable conducting pins (not shown) are received in posts 60 and each crank arm to provide this support. Each of the contacts 20*a* and 20*b* is biased in the clockwise (non contact-making) direction by a suitable pressure spring 62 as shown. Each such spring is secured at one end to the sheet-like conductor 14 and extends outboard the same to bear against the part 220*a* or 220*b* to urge the crank arm 20*a* or 20*b* to non-contacting position.

The outboard portions 220*a* and 220*b* receive cords 64*a* and 64*b*, respectively. These extend downwardly through tube 46 and the top 40 of base B to the solenoid operated sleeves 66*a* and 66*b*, respectively. Sleeves 66*a* and 66*b* are actuated by the solenoids 68*a* and 68*b* which are contained in the housing box 70.

The solenoids 68*a* and 68*b* are of conventional construction with suitable solenoid windings and movable armatures (not shown). The armatures are linked to sleeves 66*a* and 66*b*, respectively, and are biased in the upward direction by suitable springs (not shown). When current flow is applied to the windings, the armatures are moved downwardly, thereby pulling members 66*a* and 66*b* in the downward direction. The cords 64*a* and 64*b* are accordingly pulled down, thereby rocking the switch arms 20*a* and 20*b* in the counterclockwise contact-making direction in accordance with the energization of the solenoids.

It will be observed that when neither solenoid is energized, conductors 16*a* and 16*b* are not connected to the sheet-like conductor 14. The antenna of FIGS. 8 and 9 is then operable at a single resonant frequency associated with the full length of the conductor C disposed beneath head 50. When the solenoid 68*b* is energized, cord 64*b* is pulled and contact 20*b* is rocked to contact-making position. This causes the portion of conductor C below the conductor 16*b* to act largely as a straight conductor similar to that in the lower portion of FIG. 1. A new resonant frequency now becomes available, such frequency being higher than the corresponding frequency when neither solenoid is energized. When the solenoid 68*a* is energized, cord 64*a* is pulled, switch element 20*a* makes contact, the portion of conductor C below conductor 16*a* acts generally as if straight, and the antenna of FIGS. 8 and 9 has three resonant frequencies. These

three frequencies are higher than the corresponding frequency when solenoid 68*b* is energized and correspond to the resonance associated with helices 52*b*, 54*b*, and the portion of conductor C above cap 48, respectively. Thus a total of five resonant frequencies is made available.

The lower portion of sheet-like conductor 14, FIG. 9, is connected to the lower portion of conductor C through the medium of conductor 72. Alternatively, the support post 58 may be conducting and connected to conductor C at its lower portion.

The construction of FIGS. 8 and 9 has an advantage when the antenna is used for transmitting. Effective operation is provided without problems of ionization that can occur with reed relays such as are used in the construction of FIG. 7. This is, of course, not a problem with the arrangement of FIG. 7 for reception or at very low transmitting power.

The cord 64*a* and 64*b*, FIG. 9, is preferably a plastic line. Woven or braided polyamide fiber (e.g. nylon), polyester fiber (e.g. Dacron), and the like may be used as desired.

It has been found with the construction of FIGS. 8 and 9 that considerable voltage may be developed across the gap between the top portion of sheet-like conductor 14 and the adjacent portion of conductor C. It has been found, however, that glass-bonded mica material (Micalex) may be used as the support 56, and is capable of withstanding these voltages at substantial transmitter power.

In a practical antenna construction, the antenna of FIGS. 8 and 9 was constructed so that the top portion of conductor C, helix 52*b* and helix 54*b*, provided frequencies in the 10, 15, 20, 40 and 80 meter amateur bands. The 10, 15, and 20 meter band frequencies are provided when both solenoids are energized, the 40 meter band frequency is provided when 68*b* is energized, and the 80 meter frequency is provided when 68*a* and 68*b* are de-energized.

It has been discovered that the impedance match of an antenna such as that in FIGS. 8 and 9 tends to become less favorable as the lower frequency range is approached. It has been discovered that additional capacity between the helical winding (conductor C) and the sheet-like conductor 14 serves to overcome this problem. Such capacity is provided by the sleeve 72, FIG. 9. This sleeve is of copper foil or similar material. As shown, it is located adjacent to and extending below the uppermost part of sheet-like conductor 14, FIG. 7. The sleeve 72 is insulated from conductor C and conductor 14. This sleeve has not been found necessary in all designs, but is a useful adjunct to a practical unit designed to have a uniform impedance match, for example 50 ohms, and a low voltage standing wave ratio over frequencies extending over a wide range.

It will be observed that the sheet-like conductor 14 is of elongated form, and encompasses only part of the periphery of post P. It has a radio frequency voltage, and thus serves as a part of the radiating structure. The sleeve, accordingly, does not significantly impair the radiating efficiency of the antenna.

While the above description is largely confined to operation of the antenna as a radiator, it is, of course, effective as a receiving antenna. It will be understood that both transmitting and receiving action is provided by the antenna of the present invention and that it may be used for either purpose.

The following construction was used in a practical antenna suitable for use in the 10, 15, 20, 40, and 80 meter amateur bands:

Base B	Cast aluminum alloy about 4 inches on the side.
Tubular section 46	About 2 inches of diameter 2½ feet long of fiberglass tubing.
Extension above the cap 48	A helical whip antenna of 5 foot length resonating at about 20 meters.
Unit 54	10 inches long, 3/10 inches diameter with 10 inches of #22 gage copper conductor wound spirally.
Unit 52	8 inches long, 3/10 inches diameter with 8½ inches of #20 gage copper conductor wound spirally.
Plate 14	⅛ by 1 by 28" aluminum, mounted with its top edge about 1 inch below cap 48 and spaced about 11/16 inches from the axis of post P.
Post P	Fiberglass rod about ⅝ inches diameter in the portions within sleeve 46.
Conductor C	800 inches of #16 gage copper conductor wound spirally in the portions within the tubular section 46.
Conductor 16*a*	Located about 1 inch below cap 48.
Conductor 16*b*	Located about 8 inches below conductor 16*a* (about 20 inches of conductor C below conductor 16*a*).
Sleeve 72	3 inches in length, located immediately below conductor 16*a* insulated from conductor C by 4 inches of conductor coating.

It was found that with the above construction, the resonant frequencies achieved were:

With neither solenoid energized	3.8 mc.
With solenoid 68*a* energized	14.2 mc., 21.4 mc. and 28.6 mc.
With solenoid 68*b* energized	7.2 mc.

In the above construction the fixed contacts 18*a* and 18*b* were insulated from the conducting plate 14 by insulating material sandwiched between these contacts, respectively and the conducting plate.

FIGURES 10 and 11 are views in perspective and side elevation, respectively, of a switch especially suitable for use in the antenna of FIG. 9. The switch is designated generally as 120. It has a pair of fixed contacts 118 which are riveted to the insulating support 100, by the rivets 119. These two fixed contacts have downwardly-extending portions 118*a* as shown. The movable switch member is indicated generally at 160. As shown, it has leg portions 160*a*, which are joined by the cross member 160*b*, the latter having a pair of contacts 160*c* which mate with the contacts 118*b* as shown in FIG. 11. The legs 160*a* have downwardly-extending portions that straddle the fixed bracket 102, these portions being indicated at 160*d*. The bracket 102 is notched at its outboard edges to receive these leg portions, to anchor the movable member 160 for rocking movement about an axis coincident with member 102.

The member 160 is rocked between the non-contacting position shown in solid lines in FIG. 11 and the contact-making position shown in the dashed lines through the medium of the spring 104. This spring is hooked at its upper end to the web portion of the member 160 located below the cross member 160*b* and at its bottom end is hooked to the rocking member 106. The latter receives the cord 164.

When the cord 164, FIGS. 10 and 11, is relaxed, the spring 104 pulls the rockable member 106 in counter-clockwise direction. This brings the lower end of the spring to the position shown in FIG. 11, where it pulls

the member 160, FIG. 11, in the counterclockwise direction to the non-contacting position. When the cord 164 is pulled, the arm 106 is pulled to the dashed line position of FIG. 11. The bottom portion of the spring 104 is now drawn to the opposite side of the pivot point of member 160, the member 160 rocks in the clockwise direction to the dashed line position of FIG. 11 and contact is made.

In the use of the switch of FIGS. 10 and 11 on the antenna of FIG. 9, one of the fixed contacts 118 is connected to the conductor C and the other is connected to the plate 14. Accordingly, when the cord 164 is pulled, the conductor 16*a* or 16*b*, FIG. 9, as the case may be, is electrically connected to the plate 14 and the electrical operation described above in connection with FIG. 9 results. The switch of FIGS. 10 and 11 is advantageous because it provides a low-loss construction, a substantial dielectric strength, and is simple and self-operating.

In the appended claims the conductor C is described as defining an envelope. In the specific forms of the invention herein described, this is accomplished through the spiral or helical conformation of the conductor C. Alternatively, the envelope may be defined by some other sinuous shape that is effective to give the conductor a greater electrical length than the physical distance between points spaced axially on the post P.

In the above description the sheet-like conductor 14 is described in its preferred form as having windows through which the connections are made to the main antenna conductor. As above indicated, it is also possible to use notches or slots extending from the margin of the plate 14, into which the connections fit. It is also possible to construct the antenna with the connections extending around the edge of the conductor 14 to the main antenna conductor and still obtain many of the benefits of the antenna construction herein described.

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

1. A multifrequency antenna including:
a base;
an elongated insulating post supported by and extending from the base;
an antenna conductor having portions wound on the post to define an antenna;
a sheet-like conductor carried by the base and extending at least part way upon the insulating post to span at least part of said portions of the antenna conductor, said sheet-like conductor spanning a part of the periphery of the post and being connected to the antenna conductor adjacent the base, said sheet-like conductor having a plurality of windows spaced from the base and confronting said portions of the antenna conductor;
electrically conducting links connected to the antenna conductor adjacent the windows, respectively, and extending through said windows, respectively, to define contact elements insulated from the sheet-like conductor and adjacent said windows;
switch elements cooperably associated with said contact elements and mounted on the sheet-like conductor on the side outboard the insulating post;
means operable from a location remote from the sheet-like conductor effective to actuate said switch elements and contact elements at will to establish contact from said links, respectively, to the sheet-like conductor;
an insulating housing tube extending from the base, embracing the sheet-like conductor, and terminating above the same in a substantially closed roof.

2. A multifrequency antenna including:
a conducting base defining a housing;
an elongated insulating post supported by and extending from the base;

an antenna conductor having portions wound on the post to define an antenna;
a sheet-like conductor carried by the base and extending at least part way up the insulating post to span at least part of said portions of the antenna conductor, said sheet-like conductor spanning a part of the periphery of the post and being connected to the antenna conductor adjacent the base, said sheet-like conductor having a plurality of windows spaced from the base and confronting said portions of the antenna conductor;
electrically conducting links connected to the antenna conductor adjacent the windows, respectively, and extending through said windows, respectively, to define fixed contact elements insulated from the sheet-like conductor and adjacent said windows;
movable switch elements having two operating positions mounted on the sheet-like conductor on the side outboard the insulating post and each effective in one position to establish contact with one of said fixed contact elements to establish contact from said links, respectively, to the sheet-like conductor and in the other operating position to have no contact therewith, said switch elements being mechanically biased to one of said operating positions; and
cord elements extending from said switch elements, respectively, to said base and effective, when pulled to move the switch elements, respectively, from said last one of said operating positions to the other operating positions.

3. A multifrequency antenna including:
a conducting base defining a housing;
an elongated insulating post supported by and extending from the base;
an antenna conductor having portions wound on the post to define an antenna;
a sheet-like conductor carried by the base and extending at least part way up the insulating post to span at least part of said portions of the antenna conductor, said sheet-like conductor spanning a part of the periphery of the post and being connected to the antenna conductor adjacent the base, said sheet-like conductor having a plurality of windows spaced from the base and confronting said portions of the antenna conductor;
electrically conducting links connected to the antenna conductor adjacent the windows, respectively, and extending through said windows, respectively, to define fixed contact elements insulated from the sheet-like conductor and adjacent said windows;
movable switch elements having two operating positions mounted on the sheet-like conductor on the side outboard the insulating post and each effective in one position to establish contact with one of said fixed contact elements to establish contact from said links, respectively, to the sheet-like conductor and in the other operating position to have no contact therewith, said switch elements being mechanically biased to one of said operating positions;
solenoid units within the base;
and cords extending between the solenoid units and the switch elements, respectively, actuation of a solenoid unit being operable to pull the cord connected to said unit and actuate the switch element associated with said cord.

4. A multifrequency antenna including:
a base;
an elongated insulating post supported by and extending from the base;
an antenna conductor having portions wound on the post to define an antenna;

a sheet-like conductor carried by the base and extending at least part way up the insulating post to span at least part of said portions of the antenna conductor, said sheet-like conductor spanning a part of the periphery of the post and being connected to the antenna conductor adjacent the base, said sheet-like conductor having a plurality of windows spaced from the base and confronting said portions of the antenna conductor;

electrically conducting links connected to the antenna conductor adjacent the windows, respectively, and extending through said windows, respectively;

electrically operable switch elements located in the side of said sheet-like conductor outboard said post and effective in one condition of electrical energization to connect said links, respectively, to the sheet-like conductor and in another condition of electrical energization to make no such connection; and,

electrical energizing means located solely on the side of the sheet-like conductor outboard the post and effective to energize said switch elements, respectively.

5. A multifrequency antenna comprising in combination:

a base;

an antenna conductor insulated from the base and extending therefrom to define at least in part an elongated envelope with an end remote from the base;

a sheet-like conductor extending alongside the envelope substantially from the base and at least part of the distance to said end of the envelope, said sheet-like conductor having at least one window remote from the base and being electrically connected to the antenna conductor adjacent the base, the sheet-like conductor extending partially about the periphery of the envelope;

and a conductor extending from the antenna conductor adjacent the window through the said window in insulated relation therewith;

and means disposed on the side of the sheet-like conductor outboard the antenna conductor and adjacent the window and effective at will to connect said last conductor to the sheet-like conductor.

6. A multifrequency antenna comprising in combination:

a base;

an antenna conductor insulated from the base and extending therefrom to define at least in part an elongated envelope with an end remote from the base;

a sheet-like conductor extending alongside the envelope substantially from the base and at least part of the distance to said end of the envelope, said sheet-like conductor having a plurality of windows remote from the base and being electrically connected to the antenna conductor adjacent the base, the sheet-like conductor extending partially about the periphery of the envelope;

conductors extending from the antenna conductor adjacent the windows, respectively, through the windows, respectively, in insulated relation therewith;

and means disposed on the side of the sheet-like conductor outboard the antenna conductor and adjacent the windows, respectively, and effective at will to connect said last conductor to the sheet-like conductor.

7. A multifrequency antenna comprising in combination:

a base;

an antenna conductor insulated from the base and extending therefrom to define at least in part a helix with an end remote from the base;

a sheet-like conductor extending alongside the envelope substantially from the base and at least part of the distance to said end of the envelope, said sheet-like conductor having a plurality of windows remote from the base and adjacent the helix and being electrically connected to the antenna conductor adjacent the base, the sheet-like conductor extending partially about the periphery of the envelope;

conductors extending from the antenna conductor adjacent the windows, respectively, through the said windows, respectively, in insulated relation therewith;

and means disposed on the side of the sheet-like conductor outboard the antenna conductor and adjacent the windows, respectively, and effective at will to connect said last conductor to the sheet-like conductor.

8. An antenna structure selectively operable at any one of a plurality of frequencies, comprising in combination:

an antenna conductor defining an elongated envelope with spaced ends and having at least two points intermediate the ends spaced by a shorter distance than length of antenna conductor therebetween;

a sheet-like conductor in juxtaposed relation to said envelope, spanning a portion of the periphery thereof, and extending from one end of the antenna conductor to the one of said two points most remote from said one end, said sheet-like conductor having windows, respectively at said two points;

conductors extending, respectively, from said two points and through said windows;

and switch means located adjacent said windows, respectively, and on the side of the sheet-like conductor outboard the envelope, said switch means each being effective at will to establish a connection from said last conductors, respectively, to the sheet-like conductor adjacent the corresponding window thereof.

9. An antenna structure selectively operable at any one of a plurality of frequencies, comprising in combination:

an antenna conductor defining at least in part a helix;

a sheet-like conductor in juxtaposed relation to said helix, spanning a part of the periphery thereof, and extending from one end of the antenna conductor to at least a part of said helix, said conductor having a plurality of windows in registration with the helix;

conductors extending, respectively, from said antenna conductor adjacent the windows through said windows;

and switch means located adjacent said windows, respectively, and on the side of the sheet-like conductor opposite the antenna conductor, said switch means each being effective at will to establish a connection from said last conductors, respectively, to the sheet-like conductor adjacent the corresponding window thereof.

10. An antenna structure selectively operable at any one of a plurality of frequencies, comprising in combination:

an antenna conductor defining at least in part a helix;

a sheet-like conductor in juxtaposed relation to said helix, spanning a part of the periphery thereof, and extending from one end of the antenna conductor to at least a part of said helix, said conductor having a plurality of windows in registration with said helix;

conductors extending, respectively, from said antenna conductor adjacent the windows through said windows;

switch means located adjacent said windows, respectively, and on the side of the sheet-like conductor opposite the antenna conductor, said switch means each being effective at will to establish a connection from one of said last conductors, respectively, to the sheet-like conductor adjacent the corresponding window thereof; and,

a conducting sleeve in telescopic relation to the helix defined by the antenna conductor in the region adjacent the window most remote from said one end and extending partially towards said one end.

11. A multifrequency antenna comprising in combination;

a base;

an antenna conductor insulated from the base and extending therefrom to define at least in part an elongated envelope with an end remote from the base;

a sheet-like conductor extending alongside the envelope substantially from the base and at least part of the distance to said end of the envelope, said sheet-like conductor being electrically connected to the antenna conductor adjacent the base, the sheet-like conductor extending partially about the periphery of the envelope;

and a conductor extending from the antenna conductor at a point remote from the base and in insulated relation to the sheet-like conductor to a point on the side of the sheet-like conductor outboard the antenna conductor and in juxtaposed relation to said point on the antenna conductor; and means disposed on the side of the sheet-like conductor outboard the antenna conductor and adjacent said last point and effective at will to connect said last conductor to the sheet-like conductor.

12. A multifrequency antenna including:

a base;

an elongated insulating post supported by and extending from the base;

an antenna conductor having portions wound on the post to define an antenna;

a sheet-like conductor carried by the base and extending at least part way up the insulating post to span at least part of said portions of the antenna conductor, said sheet-like conductor spanning a part of the periphery of the post and being connected to the antenna conductor adjacent the base;

a plurality of electrically conducting links connected to the antenna conductor at points spaced from the base, respectively, and in insulated relation to the sheet-like conductor to points on the side of the sheet-like conductor outboard the antenna conductor and in juxtaposed relation to said points on the antenna conductor, respectively, said links defining contact elements insulated from the sheet-like conductor and at said points, respectively;

switch elements cooperably associated with said contact elements and mounted on the sheet-like conductor on the side outboard the insulating post;

means operable from the base effective to actuate said switch elements and contact elements at will to establish contact from said last conductors, respectively, to the sheet-like conductor; and

an insulating housing tube extending from the base, embracing the sheet-like conductor, and terminating above the same in a substantially closed roof.

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