# United States Patent [19]

**Arnow**

[11] **3,858,220**

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[54] **TUNABLE SPIRAL DIPOLE ANTENNA**

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[52] **U.S. Cl.** .................. **343/802,** 343/823, 343/895
[51] **Int. Cl.** ............................................. **H01q 1/36**
[58] **Field of Search** ........... 343/794, 802, 803, 895, 343/823

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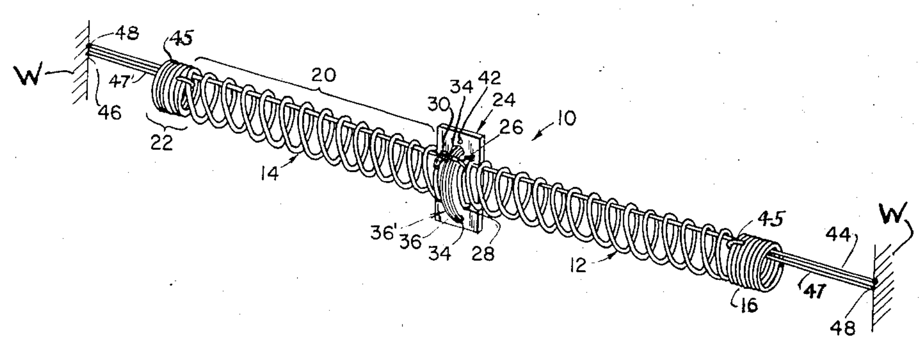
*Primary Examiner*—Eli Lieberman

[57] **ABSTRACT**

A tunable dipole antenna including dipole arms formed of a pair of helical coils whose diameter is small compared to the wave length of the frequency to which the dipole antenna is tuned and whose length can be adjustably extended. The coil includes a plurality of turns of flat spring wire. When the coils are extended to a desired length, the turns of flat spring wire can be adjusted such that a number of the turns are expanded while the rest of the turns are contracted near the outer edge. The number of expanded turns can be varied at the given length of the coil to obtain tuning to the desired frequency.

**11 Claims, 6 Drawing Figures**



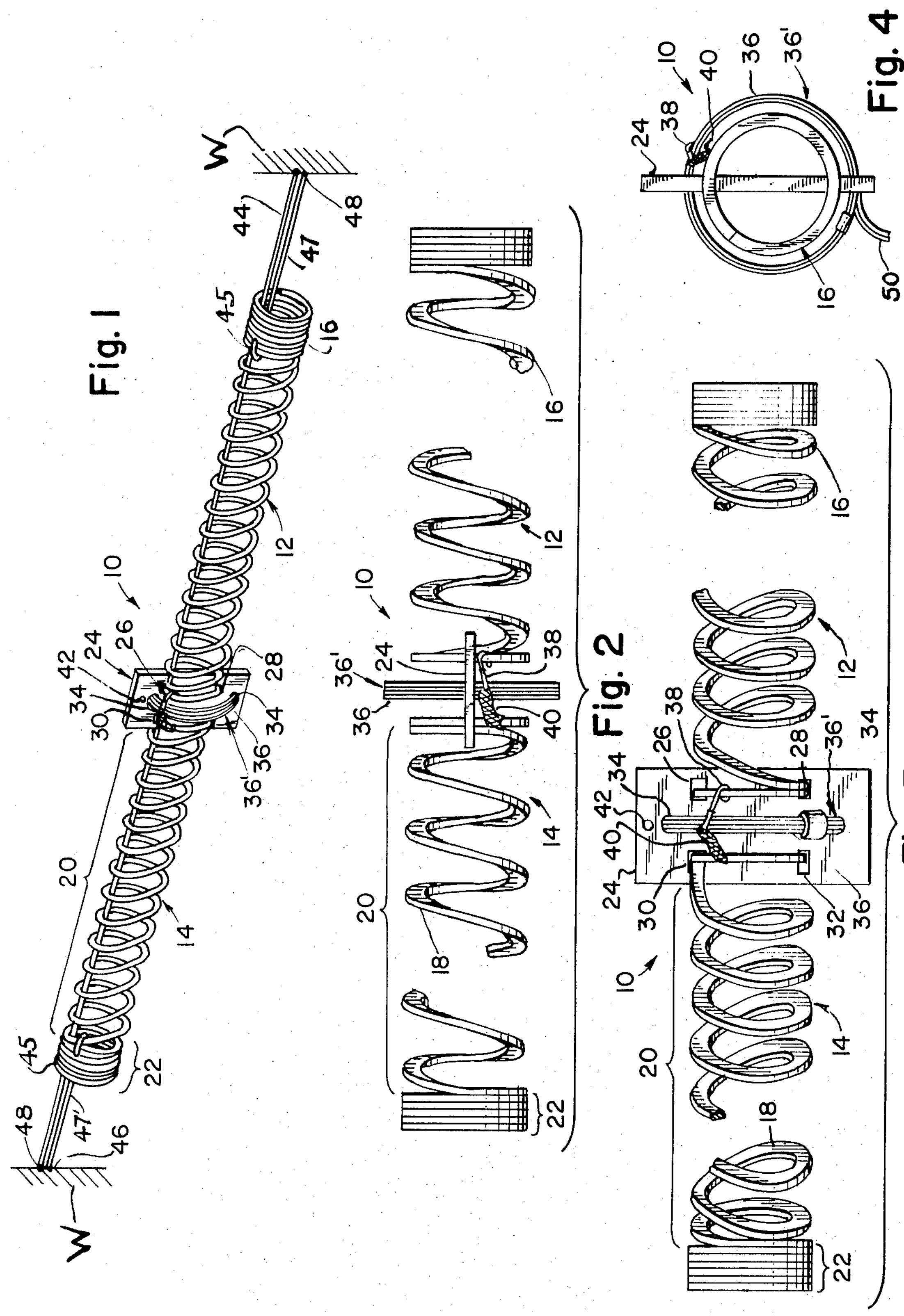


Fig. 1
Fig. 2
Fig. 3
Fig. 4
W
10
12
14
16
18
20
22
24
26
28
30
32
34
36
36'
38
40
42
44
45
46
47
47'
48
50

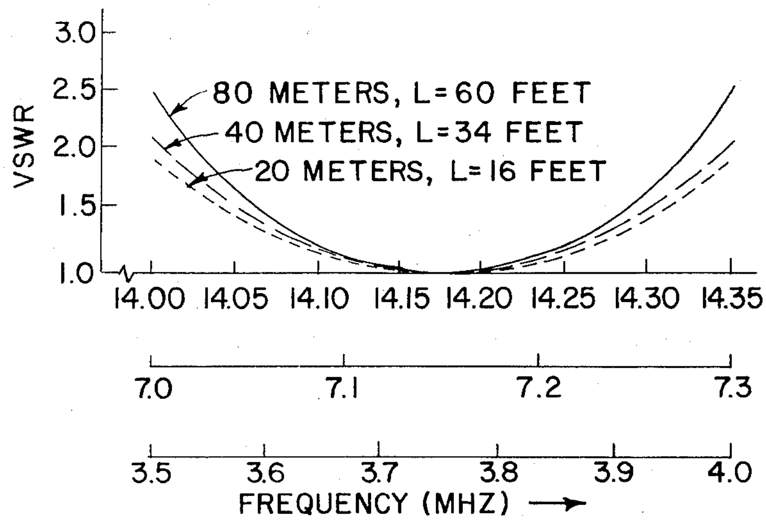

3.0
2.5
2.0
1.5
1.0
VSWR
80 METERS, L=60 FEET
40 METERS, L=34 FEET
20 METERS, L=16 FEET
14.00 14.05 14.10 14.15 14.20 14.25 14.30 14.35
7.0 7.1 7.2 7.3
3.5 3.6 3.7 3.8 3.9 4.0
FREQUENCY (MHZ)

Fig. 5

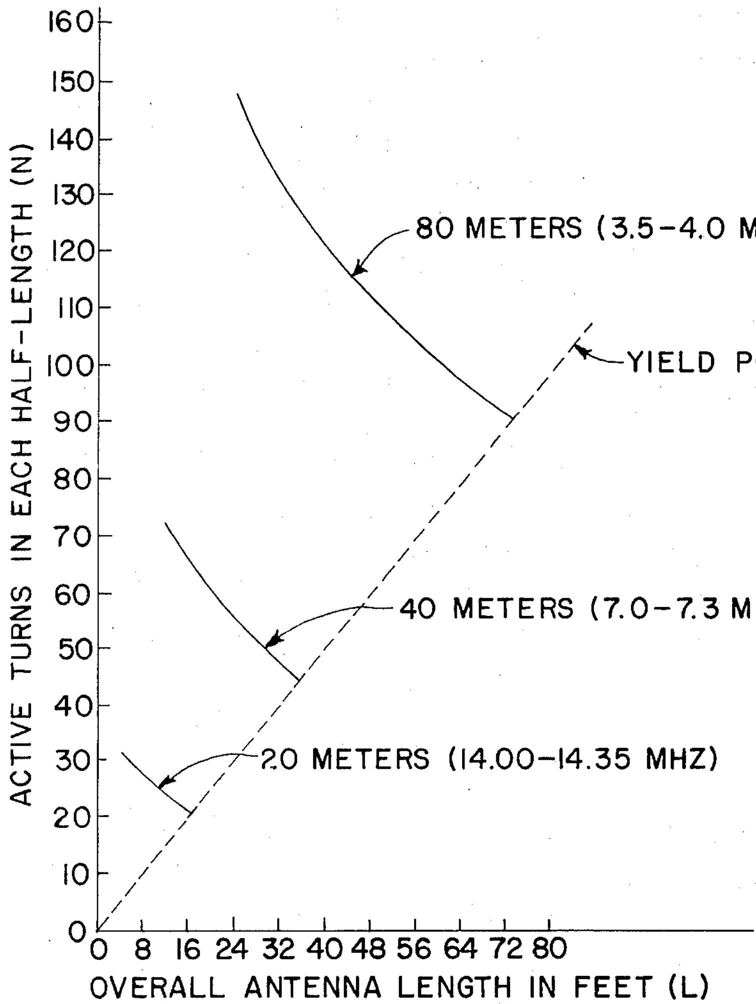

160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ACTIVE TURNS IN EACH HALF-LENGTH (N)
80 METERS (3.5–4.0 MHZ)
YIELD POINT LINE
40 METERS (7.0–7.3 MHZ)
20 METERS (14.00–14.35 MHZ)
0 8 16 24 32 40 48 56 64 72 80
OVERALL ANTENNA LENGTH IN FEET (L)

Fig. 6

# TUNABLE SPIRAL DIPOLE ANTENNA

## BACKGROUND OF THE INVENTION

This invention relates to dipole antennas and more particularly to a tunable dipole antenna which can easily be assembled and disassembled.

In the transmission and reception of radio waves, an antenna is utilized whose electrical length is usually a multiple of the half wave length of the frequency. For frequencies in the low megacycle range, the wave lengths are of the order of 20 to 80 meters and accordingly an excessively long antenna would be needed. Usually, a vertical antenna is utilized; however, the great height of the antenna requires strong support means and is difficult to erect and maintain.

In order to reduce the actual length of the antenna, various loading means have been utilized to effectively provide an electrical length as long as desired while at the same time reducing the actual length of the antenna. One such loading means utilizes helical wires which are usually wound about a supporting member. The frequency to which the antenna is tuned is a function of the number of turns of wire, the length of the supporting member, the spacing between the turns, and the diameter of the coil. Many of the helical coils forming an antenna utilize a helix coil whose diameter relative to the wave length is such as to provide an axial mode of radiation. For broad-side radiation, wherein the radiation pattern extends laterally on the sides of the coils, a helix diameter small compared to the wave length is utilized.

Because the coil is wound and must be stiff to provide support, the number of turns is fixed and the frequency to which the antenna is tuned cannot be varied. Thus, the number of turns is preset by the manufacturer and the only way to tune the antenna is for the user to cut the antenna to the desired length. However, once the antenna is cut to a given length, the antenna becomes fixed at that frequency and can't be utilized at another frequency.

Furthermore, an individual having an antenna of the type described wanting to change the location of the antenna must find another location wherein the length available is at least as long as the original location. Therefore, the possibility of varying the location of the antenna is extremely limited once the antenna has been fixed at a particular frequency. Also, the antenna is usually sensitive to metal objects located in the immediate vicinity thereof and can be affected by such metal objects. Thus, once an antenna is located at a given position, should additional metal elements such as wires, pipes, etc., be installed adjacent to the antenna, the antenna will be adversely affected and will no longer suitably operate at the fixed frequency. It is therefore not possible to fine-tune the antenna as conditions vary.

It is therefore an object of the present invention to provide a tunable dipole antenna which avoids the aforementioned problems of the prior art.

Another object of the present invention is to provide a tunable dipole antenna which provides broad-side radiation laterally to the antenna.

Yet a further object of the invention is to provide a tunable dipole antenna utilizing helical coils as the dipole arms wherein both the length of the coils and the number of turns can be adjusted.

Still a further object of the invention is to provide a tunable dipole antenna utilizing helical coils wherein after each coil is extended to a desired length, the number of active turns can be adjusted.

Yet another object of the invention is to provide a tunable dipole antenna having helical coils as the dipole arms wherein each coil includes a number of turns of flat spring wire in the form of two sections, namely an expanded section and a contracted section, and wherein the expanded section is self-adjusting such that the turns of helical wire have substantially equal pitch in the expanded section.

Another object of the invention is to provide a tunable dipole antenna utilizing helical coils as dipole arms and wherein the length of the dipole arms can be adjusted to fit a given location and wherein the tuning is achieved by varying the number of active turns in each coil.

A further object of the invention is to provide a tunable dipole antenna which can be assembled or disassembled in a relatively short period of time thereby making the antenna portable and easily storable.

Still a further object of the invention is to provide a tunable dipole antenna which can be utilized indoors or outdoors and combines good performance with practical size.

Yet another object of the invention is to provide a tunable dipole antenna which can be disassembled and stored in a relatively small space.

Yet a further object of the invention is to provide a tunable dipole antenna which provides good impedence match to **50** OHM systems by virtue of the inductive loading of the helical coils utilized as the dipole arms.

A further object of the invention is to provide a tunable dipole antenna which is compact, easily erectable and operates at both 80 and 40 meters.

Yet another object of the invention is to provide a method for tuning a dipole antenna comprising helical coils as the dipole arms.

A further object of the invention is to provide a tunable dipole antenna utilizing Slinky[R] type coils as the dipole arms.

Yet a further object of the invention is to provide a tunable dipole antenna which is portable and provides better performance and efficiency than similar antennas of the prior art.

These and other objects, features and advantages of the invention will, in part, be pointed out with particularity and will, in part, become obvious from the following description of the invention, taken in conjunction with the accompanying drawings.

## SUMMARY OF THE INVENTION

Briefly, the invention describes a tunable dipole antenna comprising helical coils as the dipole arms. The diameter of the coils is small compared to the wave length and the length of the coil can be adjustably extended. The coils are commonly fed with a supply feed line and are supported to extend outwardly from the common feed line. The coils are composed of flat spring wires formed into helical turns. When each of the coils are adjustably extended to the desired length, they each have a section of expanded turns and a section of contracted turns. The number of turns in the expanded section can be varied to provide the proper tuning of the antenna at a desired frequency for the adjusted length of the coils.

In a particular embodiment of the invention, when the helical turns in the expanded section are selected, the coils adjust themselves such that they have substantially equal pitch in the expanded section. The coils which are utilized are similar to the Slinky[R] coils utilized in various toys.

## BRIEF DESCRIPTION OF THE DRAWING

The invention is illustrated by way of example in the accompanying drawings which form part of the application and in which:

FIG. **1** is a perspective view of one embodiment of the tunable dipole antenna of the present invention.

FIG. **2** is a top view of the embodiment shown in FIG. **1**

FIG. **3** is a front view of the embodiment shown in FIG. **1**

FIG. **4** is a side view of the embodiment shown in FIG. **1**

FIG. **5** is a graph showing the results of tests conducted with a particular embodiment of the present invention, and

FIG. **6** is a graph showing a tuning curve for selecting the number of turns at a given frequency for a desired length.

In the various figures of the drawing, like reference characters designate like parts.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. **1** thru **4**, the tunable dipole antenna of the present invention is shown generally at **10** and comprises dipole arms shown generally at **12** and **14** each comprising a helical coil. The helical coil includes a plurality of turns of flat spring conductive wire **16** wherein the flat surface thereof, **18** is in a plane transverse to the longitudinal axis.

Each of the coils **12** and **14**, can be adjustably expanded such that the total length can fit a particular location available. When the coils are expanded two sections are formed in each coil. A first section **20** includes expanded helical turns and a second section **22** includes contracted turns. The number of turns in each section can be varied by taking each individual turn **16** and successively sliding it from one section to the other section. Thus, the number of turns desired in the expanded section can be selected and all of the remaining turns can be pushed together to a contracted section.

Thus, when the desired length of the coil is achieved by extending the entire coil, the number of turns in the expanded section become the active turns in the antenna dipole arm and the number can be varied. Therefore, it is seen that the number of turns in the expanded section can be varied for a given length of the coil. The maximum length to which the coil can be extended is limited by the physical structure of the coil such that the coils should not be permanently distorted. The minimum length is controlled by the amount of loss tolerable since energy loss increases with a greatly reduced coil length.

The coils are supported at their inner end by a card **24** made of non-conducting material. The card **24** contains a first set of openings **26, 28** on the right side thereof and a second set of openings **30, 32** at the left side thereof. The two coils are respectively wound through the openings such that at least one turn at the



end of each coil is threaded through the respective holes of the insulating card **24.**

Two additional holes **34** spaced in a vertical plane and approximately at the center of the insulating card support a coaxial wire **36** which is wound in a circle several times through the openings **34**, thus forming an inductor **36'**. The inner diameter of the coaxial turns **36** should preferably be about the same as the inner diameter of the coils **12, 14.** Furthermore, in the present embodiment the diameter of the coils is small compared to the wave length of the frequency to which the antenna is tuned such that the radiation pattern emitted from the dipole arms will be a broad-side pattern having the radiation mode in a plane transverse to the axis of the coil.

The inner conductor **38** of the coaxial cable **36** is electrically connected to one of the coils **12**, and the outer conductor **40** of the coaxial cable **36** is connected to the other one of the coils **14.**

A further opening **42** on the insulating card is available for supporting the insulating card and the coils extending therefrom. Also, for additional support, a non-conducting wire such as nylon cord **44**, can be passed through the coils and the coaxial coil and supported at the outer edges **46, 48** by fixed supports such as walls W or posts.

The inductor **36'** serves as a balun to provide a balanced feeding current to the dipole arms. The end **50** of the coaxial cable is connected to the system utilizing the antenna. By using the coiled turns **36'** of coaxial feed line **36**, a high inductive reactance is introduced which inhibits the flow of RF current on the outer conductor of the coaxial line.

In utilizing the dipole antenna described several turns of the coaxial cable is first threaded through the holes **34** in the center of the insulating card **24** and can then be taped using electrical tape to form a stable coil. A coaxial connector, as is known in the art (not shown) can be connected to the one end of the coaxial cable.

Each of the helical coils are then wound through the outer edges of the insulating card and a few of the turns of the coil on either side of the insulating card can be soldered together to prevent the coils from accidentally unwinding from the insulating card. The inner end of the coaxial cable is separated such that the coaxial center conductor is connected to one coil and the outer conductor is connected to the other coil.

The mounting area is selected and the insulating card is supported by means of the opening **42.** The nylon cord, by way of example, is tied to one support point and threaded through the entire coil and coaxial cable assembly, and then, tied to another support at the opposite end of the antenna. The overall space available for the antenna is determined and the coils are extended to the maximum length possible within this space, being cautious not to extend the coils too far to permanently deform the coil. The number of turns of the flat spring wire in the expanded section is then adjusted utilizing a voltage standing wave bridge or other meter such that over the frequency band desired the voltage standing wave ratio curve is centered. This can be achieved by adding or subtracting an equal number of turns from the end of each arm of the antenna. Adding additional turns to the active portion, namely the expanded section, will lower the resonant frequency, and subtracting turns will raise it. The antenna is properly tuned when the voltage standing wave ratio is either minimum at the center of the desired band, or minimized at a chosen operating frequency in the band.

Utilizing a 4 inch diameter coil of the type shown, the following chart indicates the approximate value needed for tuning the chart at 80 meters or approximately 3, 5 to 4.0 megahertz and at 40 meters or approximately 7.0 to 7.3 megahertz. In the chart, L indicates the overall antenna length in feet and N signifies the number of active turns in each half length. In addition, the relative efficiency is given.

CHART NO. 1 — APPROXIMATE TUNING CHART

| 80 Meters (3.5 — 4.0 MHz) | | | 40 Meters (7.0 — 7.3 MHz) | | |
|---|---|---|---|---|---|
| L | N | Relative Efficiency | L | N | Relative Efficiency |
| 70 | 92 | 0 db | 35 | 45 | 0 db |
| 68 | 94 | | 34 | 46 | |
| 66 | 95 | | 33 | 47 | |
| 64 | 97 | | 32 | 48 | |
| 62 | 98 | | 31 | 49 | |
| 60 | 100 | | 30 | 50 | |
| 58 | 102 | | 29 | 51 | |
| 56 | 104 | | 28 | 52 | |
| 54 | 105 | | 27 | 53 | |
| 52 | 107 | | 26 | 54 | |
| 50 | 109 | | 25 | 55 | |
| 48 | 112 | −3 db | 24 | 56 | −3 db |
| 46 | 114 | | 23 | 57 | |
| 44 | 116 | | 22 | 58 | |
| 42 | 118 | | 21 | 59 | |
| 40 | 121 | −6 db | 20 | 60 | −6 db |
| 38 | 124 | | 19 | 61 | |
| 36 | 126 | | 18 | 62 | |
| 34 | 129 | | 17 | 63 | |
| 32 | 132 | −15 db | 16 | 65 | −15 db |
| 30 | 135 | | 15 | 66 | |
| 28 | 139 | | 14 | 68 | |
| 26 | 143 | | 13 | 70 | |
| 24 | 147 | −20 db | 12 | 72 | −20 db |

It is seen from the above chart, that for the 80 meter band the dipole antenna will perform for any available length between approximately 24 feet and 70 feet and for the 40 meter band, the antenna will operate between approximately 12 feet and 35 feet. It is noted that the longer the overall antenna length, the less the number of active turns are needed to achieve proper tuning.

FIG. **6** indicates a graph incorporating the information of the chart and in addition providing information on the values needed for tuning at 20 meters or approximately 14–14.35 mHz. In the graph there is plotted as the Absicca the overall antenna length and as the ordinate the number of active turns in each half-length. The maximum length for each frequency is determined by the yield point line of the coil. Beyond that point permanent deformation of the turns in the coil would occur. The lower limit is also determined to a great extent by physical limitations. As the length of the coil is decreased, the number of active turns increases, however, when the coil becomes too short there is insufficient space to pack in the active turns. However, within the physical limits, there is a great variation of length available for a given frequency and the number of active turns within that length can also be greatly varied.

In utilizing the chart or the graph, the overall space available for the antenna is first measured and the number of turns in each half length is then determined in accordance with the chart or graph. The number of turns is counted starting from the center insulator card and the unused number of turns are bunched together



at the end of the antenna. The unused coils can be tied together using a portion of the nylon cord.

The setting given in the tuning chart or curves is a good first approximation for average installations. However, because of variations in the height above ground and the coupling to nearby objects, the actual resonant condition of the antenna may differ from that given in the chart. Therefore, after utilizing the chart or graph for a coarse tuning adjustment, the antenna is plugged into a voltage standing wave ratio bridge or meter and fine tuning is achieved by centering the voltage standing wave ratio curve as heretofore described.

The ends of the dipole antenna may display a high electric field. It may therefore be advisable to include some form of a metal top hat connected to the last turn of the coil. Extremely high levels of RF voltage may cause the tip of the antenna to burn. The top hat tends to lower the Q of the antenna thus reducing the voltage level at the far end. An aluminum pie tin mounted on a ceramic cone insulator may work for some applications.

Because of the helical loading provided by the spring and coil structure, a good impedance match is obtained to the typical 50 OHM systems. The power capacity of the antenna described is at least 1,000 watts CW or 2,000 watts PEP on SSB. Utilizing the antenna of the type described, it has been found that the voltage standing wave ratio bandwidth is as good, if not better, than that of normal dipole antennas which only operate at discreet lengths. For example, referring to FIG. **5** wherein a graph of voltage standing wave ratio against frequency in megahertz is shown, it is seen that for an 80 meter typical installation, wherein 60 feet of overall length was utilized, the voltage standing wave ratio is less than 2.5 to 1 over the full 80 meter band. For a 40 meter typical installation utilizing 34 feet of overall length, it is seen that the voltage standing wave ratio is less than 2.0 to 1 over the full 40 meter band. For a 20 meter typical installation utilizing 16 feet of overall length, the voltage standing wave ratio is less than 1.8 to 1.

The antenna is easily assembled and can be installed indoors in an attic or crawl space as well as outdoors. It can be disassembled and stored wherein, for the embodiment described, the two 4-inch diameter coils require 8 inches of length for storage.

Hooks **45** grasp the inner end of contracted coils **22.** Cords **47** have one end attached to the hooks and the other end fastened to fixed structure W. This arrangement secures the coils so that they are extended to the proper length.

The performance of the antenna can be optimized by installing it as high above ground as feasible and away from interfering objects including metal as well as extra thickness of roof and wall construction. While various lengths can be utilized for a specific band, it is noted, as pointed out in the chart, that the relative efficiency of the system is reduced at shorter lengths. Thus, the longer the overall length of the antenna the higher the efficiency of the system.

The overall length and effective height of the antenna can be increased by keeping the center of the antenna high and lowering the outer ends of the antenna coils towards the opposite low corners of the room or attic of the space wherein the antenna is located.

There has therefore been described a tunable dipole antenna which can easily be assembled and disassembled, and at each location the dipole antenna retuned by first extending the ends of the coils to the maximum length available being cautious not to extend the coil to permanently deform it. Then, the number of active turns are adjusted in both parts of the coil to achieve the proper tuning desired and to compensate for the local conditions including location and effect of the vicinity surrounding the antenna.

There has been disclosed heretofore the best embodiment of the invention presently contemplated. However, it is to be understood that various changes and modifications may be made thereto without departing from the spirit of the invention.

What I claim as new and desire to secure by Letters Patent is:

**1.** A dipole antenna capable of being adjustably tuned for a given frequency comprising, dipole arms formed of a pair of helical coils whose diameter is small compared to the wave length of the frequency being tuned and whose length can be adjustably expanded, common feed point means electrically connected to said coils for supplying current to the dipole arms, and supporting means for supporting the antenna such that said coils extend outwardly from said common feed point means, said coils being composed of flat spring wire formed into helical turns, each coil being adjustable to expand the pitch between the turns of one section of the coil to form a section of expanded turns and to contract the pitch between the turns of another section of the coil to form a section of contracted turns the number of turns in the expanded sections providing proper tuning of the antenna at the given frequency for the adjusted length of the coils.

**2.** A dipole antenna as in claim **1** and wherein the helical turns in the expanded section are self-adjusting such that they have substantially equal pitch within the expanded section.

**3.** A dipole antenna as in claim **2** and wherein the flat spring wire has the flat surface in a plane transverse to the longitudinal axis of the helical coil.

**4.** A dipole antenna as in claim **2** and wherein said common feed point means includes balun means pro-



viding a balanced feeding current to the dipole arms.

**5.** A dipole antenna as in claim **4** and wherein said balun means includes a coil of several turns of coaxial feed line.

**6.** A dipole antenna as in claim **2** and wherein said supporting means comprises insulating card means having openings through which at least one turn of each of said coils can be wound, said supporting means also supporting said common feed point means.

**7.** A dipole antenna as in claim **2** and wherein said supporting means includes non-conductive wire means extending through said coils and adapted to be attached to a supporting member.

**8.** A dipole antenna as in claim **2** and wherein the center of the antenna is in a higher plane than the outer ends thereof such that said coils extend both outwardly and downwardly.

**9.** A tunable dipole as in claim **1** and wherein said coils have a diameter of 4 inches.

**10.** A method for adjustably tuning a dipole antenna having a pair of helical coils as the dipole arms whose diameter is small compared to the wavelength and being composed of flat spring wire formed into helical turns, each coil being adjustable to expand the pitch between the turns of one section of the coil to form a section of expanded turns and to contract the pitch between the turns of another section of the coil to form a section of contracted turns, comprising the steps of:

a. extending the overall length of the coils to a desired amount;

b. measuring the voltage standing wave ratio (VSWR) at the feedpoint of the dipole arms, and

c. varying the number of turns in the expanded section of each coil such that the voltage standing wave ratio (VSWR) is minimized across the desired frequency band.

**11.** A method as in claim **10** and wherein said step of extending the overall length extends the length of the coils to a maximum amount available at a given location but not permanently deforming the coil.

* * * * *