March 18, 1969 D. H. WELLS 3,434,145

DOUBLE LOOP ANTENNA ARRAY WITH LOOPS PERPENDICULARLY AND SYMMETRICALLY ARRANGED WITH RESPECT TO FEED LINES

Filed Aug. 1, 1966 Sheet 1 of 5

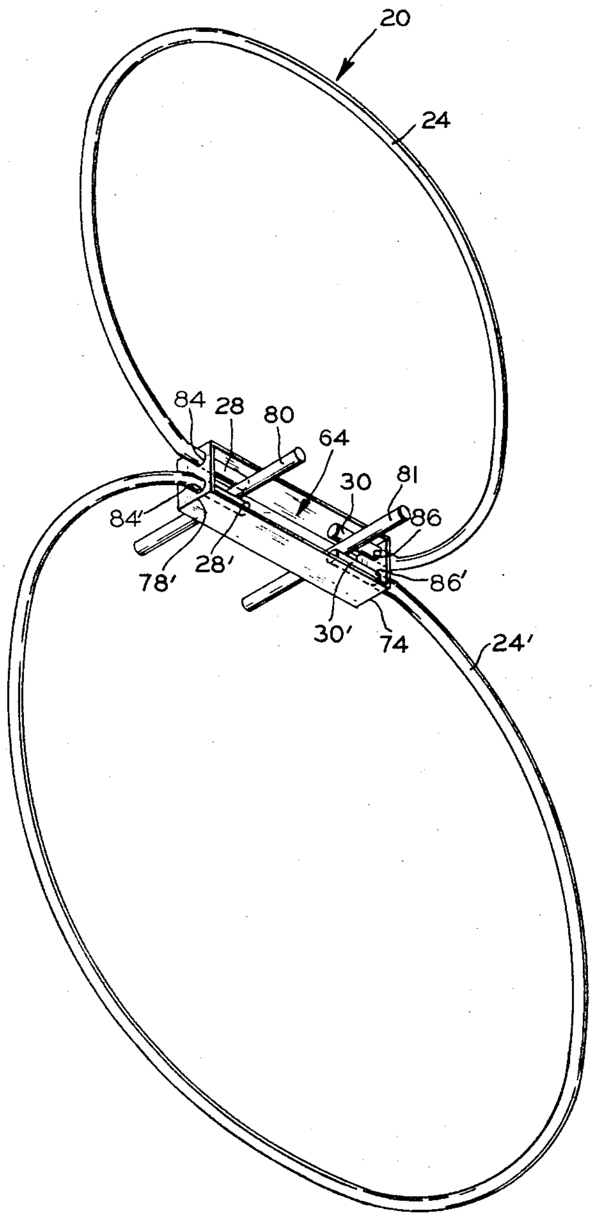


FIG. 1

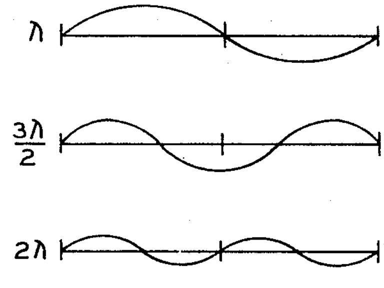


FIG. 1a

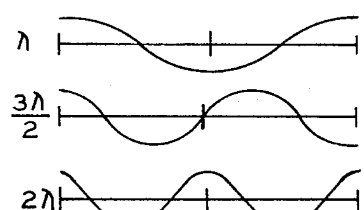


FIG. 1b

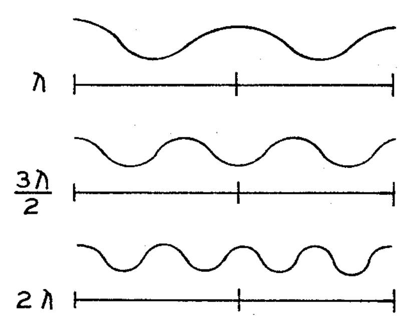


FIG. 1c

INVENTOR.
DONALD H. WELLS

BY Hugh A. Kirk
ATTORNEY

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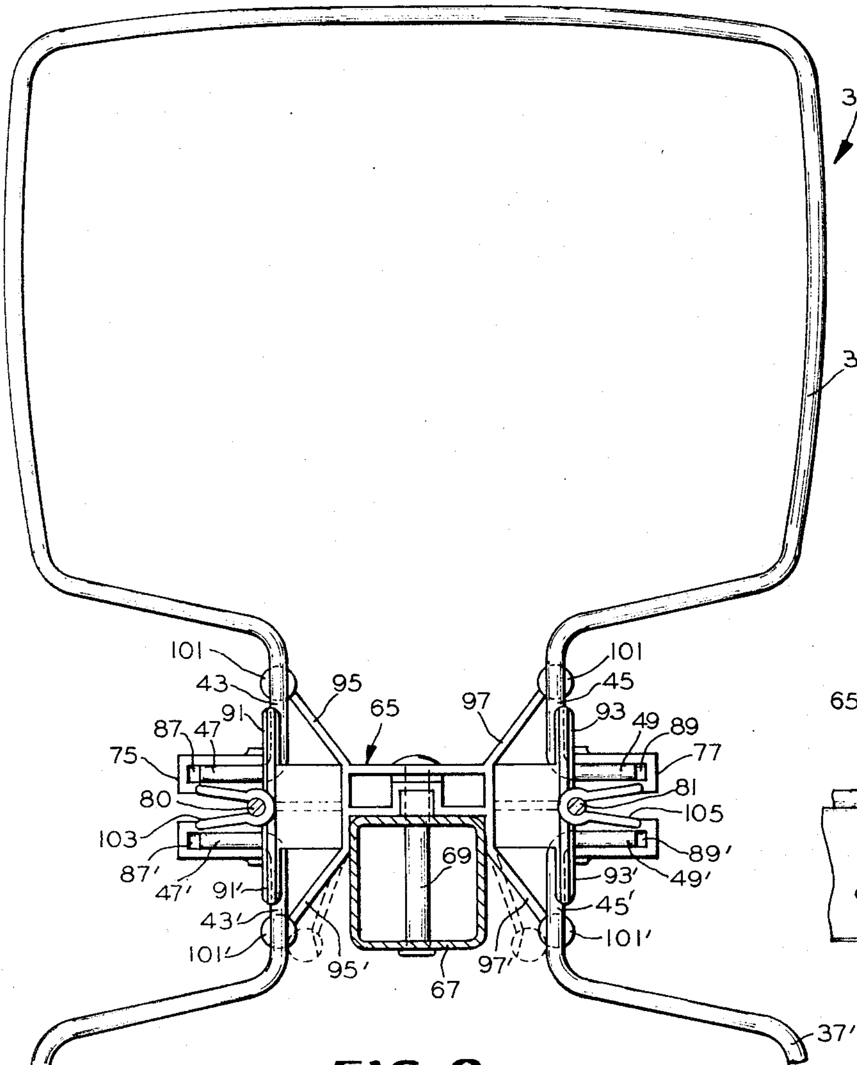


FIG. 2

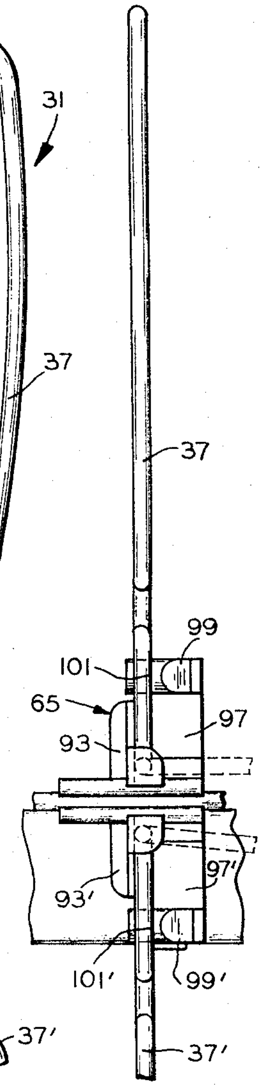


FIG. 2a

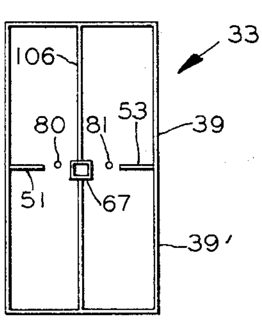


FIG. 3

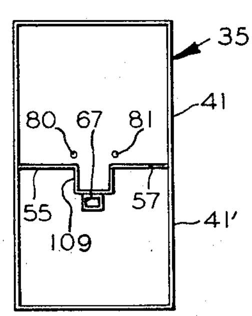


FIG. 4

INVENTOR.
DONALD H. WELLS

BY

ATTORNEY

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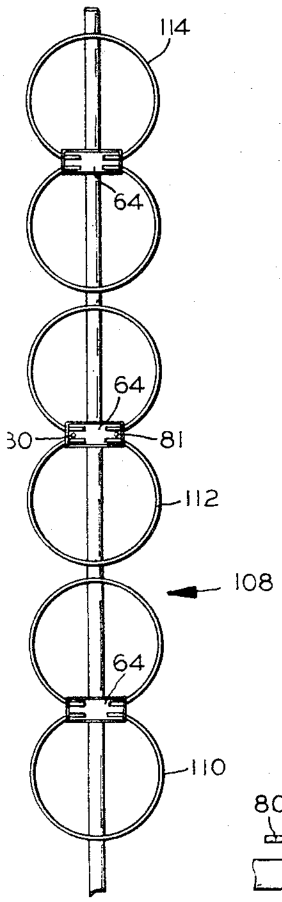

FIG. 5

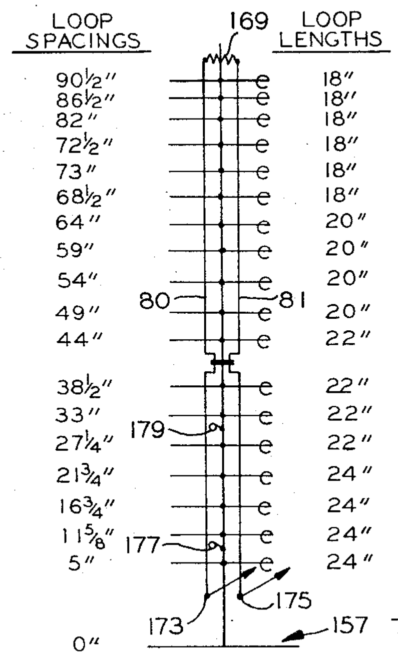


FIG. 9b

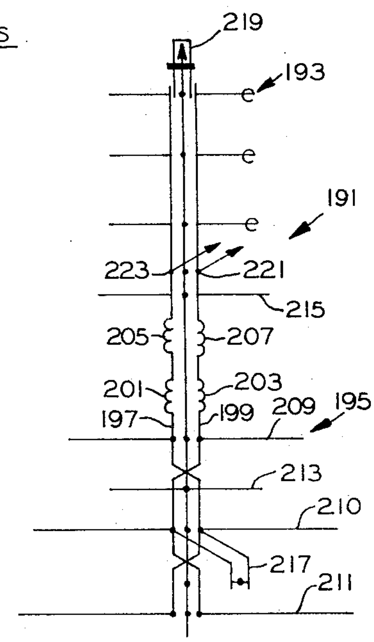

FIG. 10a

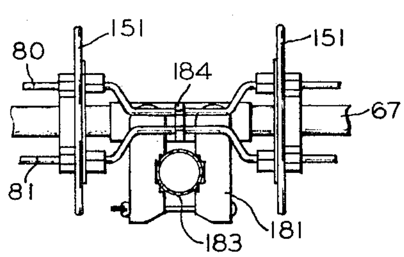

FIG. 9a

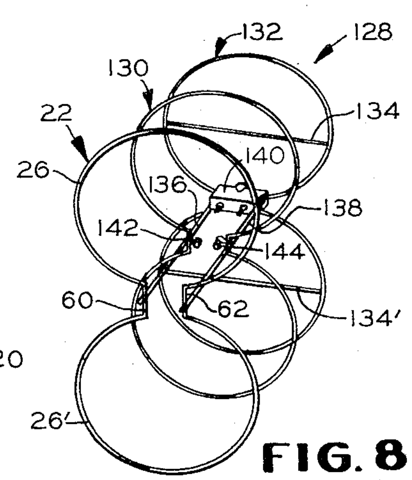

FIG. 8

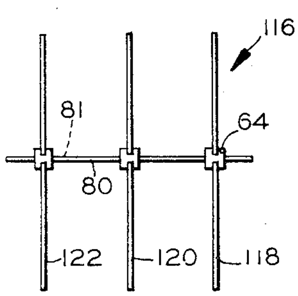

FIG. 6

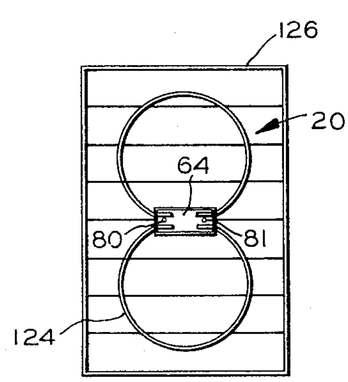

FIG. 7

INVENTOR.
DONALD H. WELLS

BY Hugh A. Kirk
ATTORNEY

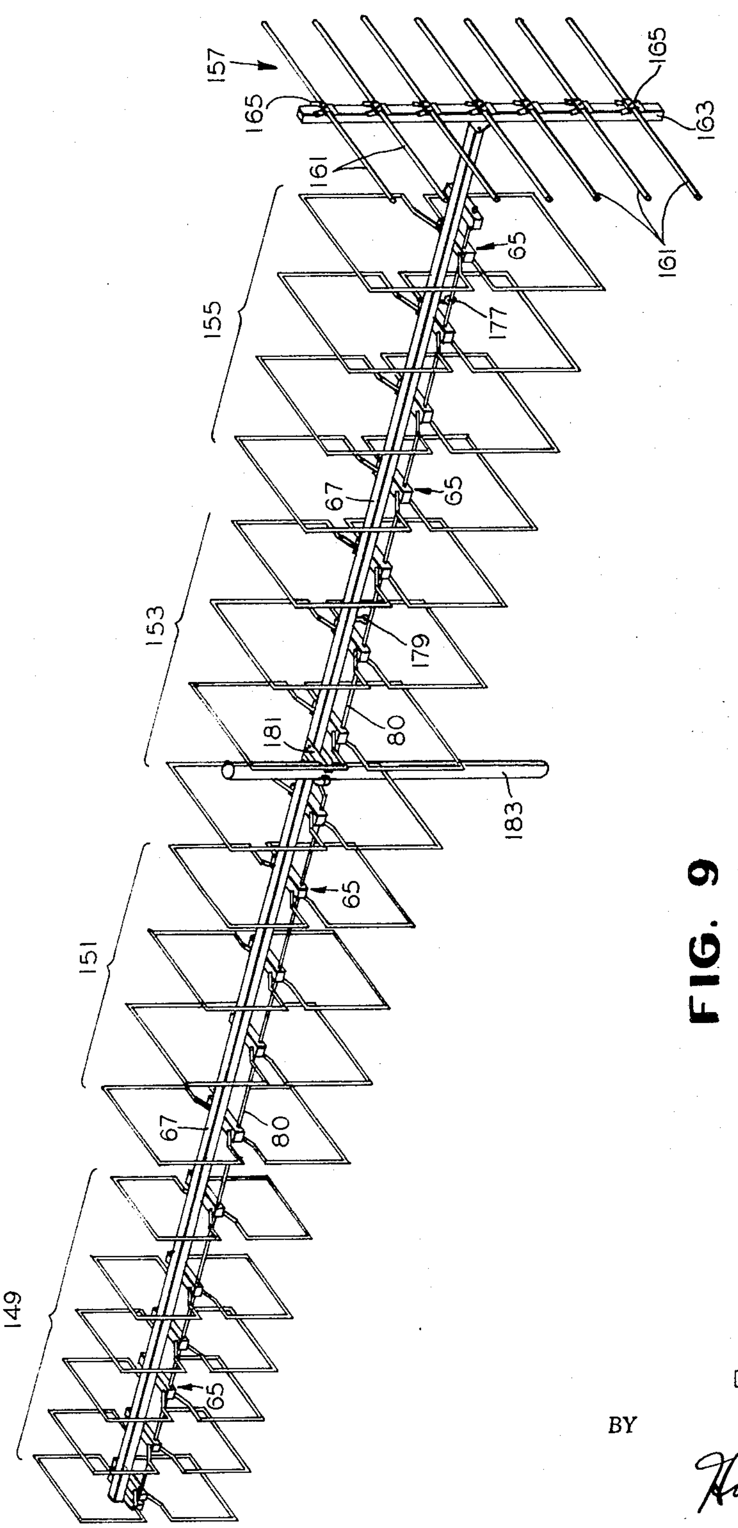


FIG. 9

INVENTOR.
DONALD H. WELLS

BY Hugh A. Kirk
ATTORNEY

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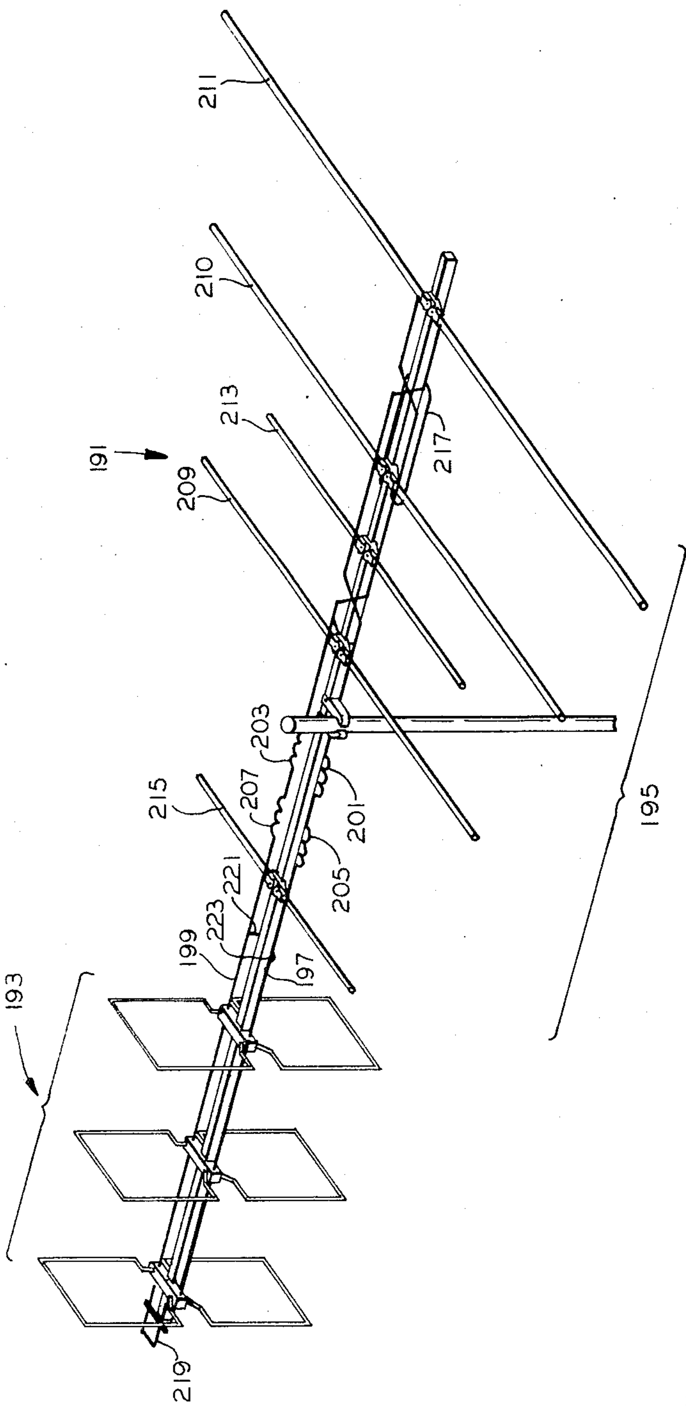


FIG. 10

INVENTOR.
DONALD H. WELLS

BY

Hugh A. Kirk
ATTORNEY

United States Patent Office

3,434,145

Patented Mar. 18, 1969





3,434,145

# DOUBLE LOOP ANTENNA ARRAY WITH LOOPS PERPENDICULARLY AND SYMMETRICALLY ARRANGED WITH RESPECT TO FEED LINES

Donald H. Wells, Oregon, Ohio, assignor to S & A Electronics, Inc., Oregon, Ohio, a corporation of Ohio

Filed Aug. 1, 1966, Ser. No. 569,251
U.S. Cl. 343—726 17 Claims
Int. Cl. H01q *21/06*

## ABSTRACT OF THE DISCLOSURE

This invention relates to an open loop antenna and the means of electrically connecting it to a pair of lead conductors, which means may include a specific dielectric support connection therefor. More particularly, it deals with an array of such loop antennas capactively and/or integrally coupled together to form one or more figure 8 configurations so as to produce a high gain over a wide frequency band.

## BACKGROUND OF INVENTION

The increased use of the UHF in television broadcasting has created a need for an efficient antenna which will give a high gain over a broad band of frequencies and continue to do so even after a prolonged period of exposure to the weather. A high gain is achieved over a broad band generally by connecting a plurality of antenna elements together in an antenna array. Up to the present time the known style of the antenna elements and the method of stacking and coupling antenna elements together via feed or transmission lines has greatly restricted the number of elements which may be effectively coupled together in an array. One of the problems involved in producing a high gain broad band antenna is the fact that ultra high frequency (UHF) wave energy is readily lost, attenuated or otherwise altered at the antenna. This is particularly true at points in the antenna where the wave energy is transferred to or from feed lines through electrical contacts which may become corroded and partially or completely open during use. A change in the conductive properties of such electrial contacts after the antenna is put into operation, will cause the precisely established phase relationships between coupled antenna elements to be altered, which change will cause a reduction of the antenna's original efficiency.

## DESCRIPTION OF INVENTION

### *Objects and advantages*

It is an object of this invention to produce an antenna which will provide a high gain over a frequency band having a ratio of about 2:1 between high and low frequencies.

Another object of this invention is to produce a directional antenna which has narrow horizontal and vertical response patterns.

Another object is to produce an antenna which retains its original performance efficiency even after prolonged exposure to the weather.

Another object is to produce a uni-directional antenna array having a non-resonant reflector and/or a loading means to provide a high front to back ratio.

Still another object of this invention is to produce an antenna array in which a large number of antenna elements may be coupled together by a pair of lead conductors which are sufficiently isolated from the antenna elements to avoid one element of the array from attenuating another element in the array, so that each element will maintain its Q without becoming de-tuned.

It is another object to produce an array of open loop antennas in which pairs of loop antenna elements are connected together at their high impedance points either directly or through a capacitance and also connected through a capacitance to a pair of lead conductors, so that some of the energy in one loop is radiated to another loop.

It is another objet to produce an antenna having a foldable open loop antenna element, the ends of which are each supported and capactively coupled to a pair of parallel feed conductors by a unique dielectric connecting means.

Still a further object of this invention is to produce a UHF open loop antenna array which may be coupled in combination with very high frequency (VHF) and/or (FM) frequency modulation radio antennas.

Still a further object of this invention is to produce a loop antenna of an improved mechanical design which has a novel appearance, encompasses a maximum frontal area with a limited peripheral length, is compact, easy to assemble, mechanically rugged and has little wind resistance.

### *Brief description of the views*

The above mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be understood best by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view looking upwardly from the right of one embodiment of this invention comprising two equal length generally circular open loop antennas disposed a common plane and rigidly held in a spaced relationship with respect to each other and with respect to an intermediate pair of lead conductors by a dielectric bracket;

FIGS. 1*a*, 1*b*, and 1*c* are electrical wave diagrams for the relative values of the current, voltage, and impedance, respectively, in an antenna for one, three halves, and two wave lengths of applied radio energy;

FIG. 2 is a front elevational view of a double loop antenna with a part broken away, of another embodiment of this invention, similar to that of FIG. 1, but with generally square loops which are foldably held by a resilient dielectric bracket;

FIG. 2*a* is a side elevational view of the antenna of FIG. 2 showing additional details of the resilient bracket;

FIG. 3 is a front elevation view on a reduced scale of a double loop antenna of a further embodiment of this invention, also similar to FIGS. 1 and 2, but with the loops joined together rather than spaced apart, and having a conductive support connected between low impedance points of each loop;

FIG. 4 is a front elevation view of a double loop antenna of still a further embodiment, similar to the antenna of FIG. 3, but with a folded quarter wave length supporting stub integrally connected between the high impedance ends of the loops;

FIG. 5 is a front elevation view on a reduced scale of an array of three double loop antennas similar to FIG. 1 vertically disposed in a vertical plane on a mast with the inner double loop antenna capacitively coupled to a pair of lead conductors and inductively coupled to the outer double loop antennas;

FIG. 6 is a side elevation view on a reduced scale of an array of three double loop antennas similar to the antenna of FIG. 1 spaced apart one quarter of the mean applied wave length, in a horizontal row and capacitively coupled to a pair of parallel lead conductors;

FIG. 7 is a front elevation view on a reduced scale of a unidirectional array having an antenna similar to FIG. 1 disposed in front of a grid type reflector;

FIG. 8 is a perspective view of an array embodying the present invention, of a row of three double coplanar loops integrally connected to each other and to a pair of parallel lead conductors with the double loops at one end shunted to produce a reflector;

FIG. 9 is a perspective view of a broad band unidirectional UHF array with a plurality of groups of double loop antennas similar to FIG. 2 parallelly disposed and horizontally spaced apart about one quarter of the mean wave length of the applied radio band, and having a nonresonant reflector at one end;

FIG 9*a* is an enlarged underside view of the mast and mast clamp of the array shown in FIG. 9 showing the offset lead conductors and their insulative support;

FIG. 9*b* is a schematic electrical diagram of the array in FIG. 9 showing the spacing, loop lengths, a loading means between the ends of the lead conductors at the front end of the array, and feed line terminals and reflector at the opposite end;

FIG. 10 is a perspective view of a combination VHF (very high frequency) and FM (frequency modulation) dipole antenna and UHF antenna array of double loop antennas similar to FIG. 2, having common lead conductors with insulating coils substantially between the VHF and UHF sections of the array; and

FIG. 10*a* is a schematic electrical diagram of the antenna of FIG. 10 showing also the cross phasing between the VHF antenna dipole elements, the parallel phasing between UHF loop antennas, and a high impedance quarter wave length stub capacitively coupled between the open ends of the lead conductors adjacent the UHF loop antennas.

## *Detailed description*

### FORMS

The characteristic geometry of the individual planar loop elements of this invention is important because the effectiveness of an antenna element is dependent upon the planar area it encompasses, just as the gain of an antenna array is dependent upon the volumetric displacement of the array.

FIGS. 1 and 8 show coplanar double loop antenna assemblies **20** and **22** comprising generally circular symmetric loop open elements **24** and **24′**, and **26** and **26′**, respectively, each loop of which encompasses a maximum area for a limited peripheral length. The otherwise circular loops **24** and **24′** may each have straight foot sections **28** and **30**, and **28′** and **30′**, respectively, adjacent their openings.

FIGS. 2, 3 and 4 show similar coplanar double loop antenna assemblies **31**, **33** and **35** comprising generally square open loops **37** and **37′**, **39** and **39′**, and **41** and **41′** respectively, each loop of which encompasses an area satisfactorily near a maximum for a limited peripheral length, but deviates slightly from a maximum for the sake of manufacturing expediency or for other practical reasons. The generally square open loops **37** and **37′** shown in FIG. 2 have slightly arcuate sides and rounded corners with a pair of parallel continuations or supporting legs **43** and **45**, and **43′** and **45′** extending outwardly symmetrically from the opening of the loops **37** and **37′**. Each of the legs **43** and **45**, and **43′** and **45′** may terminate, respectively, in a perpendicular foot section **47** and **49**, and **47′** and **49′**.

The generally square loops of antenna assemblies **33** and **35** each have jointly shared sections **51** and **53**, and **55** and **57** adjacent their respective loop openings which sections may be made of a single wire or rod as shown in FIGS. 3 and 4 or they may be made of two closely adjacent parallel wires or rods.

The characteristic geometry of these double loop antenna assemblies **20**, **22**, **31**, **33** and **35** is a figure 8 configuration with a discontinuity at the cross-over. Each such assembly comprises two open loop antennas symmetrically disposed in a plane closely adjacent each other with their open ends facing each other. The discontinuity may comprise a lateral opening in the cross-over section of the figure 8 as shown in FIGS. 3 and 4 where the spacing between loops **39** and **39′**, and **41** and **41′** is zero and the ends of one open loop are integrally joined with the ends of the other loop forming the jointly shared sections **51** and **53**, **55** and **57**, respectively. The double loop antenna assembly **22** in FIG. 8 also has a lateral opening in the cross-over region of the figure 8, but the loops **26** and **26′** are spaced apart, with the open ends of loop **26** being joined to adjacent ends of loop **26′** by means of integrally connected short spanning bars **60** and **62**. The discontinuity may be a longitudinal opening in the figure 8 such as shown in FIGS. 1 and 2 where the open loops **24** and **24′**, and **37** and **37′**, are spaced from each other a short distance and not conductively connected. In all cases the discontinuity or longitudinal opening between the ends of an individual loop, exceeds the lateral spacing between the two coplanar loops of the double loop antenna assembly, which latter spacing may be small or zero.



The open loop antennas are made from a conductive material, such as an aluminum tube or wire rod having a diameter of about ⅛″ and with a length which resonates at about the mean wavelength of the frequency it is to detect.

### THEORY

FIGS. 1*a*, 1*b* and 1*c* are diagrams showing respectively the current, voltage and impedance along a conductive dipole or any radio antenna, as it responds to frequencies having wave lengths of $\lambda$, $3\lambda/2$ and $2\lambda$. For these three wavelengths, the magnitude of the impedance reaches a peak at the outboard ends of the dipole and this impedance condition makes the outboard ends of the dipole an ideal feed point, especially in a broad frequency band application where the ratio between high and low frequencies is two to one.

The voltage distribution along a loop antenna having a length corresponding to $\lambda$, $3\lambda/2$ and $2\lambda$ is not adversely changed by bending but remains substantially the same as that along a straight antenna of the same length.

The horizontal directional radiation or response pattern for a straight dipole at frequencies producing standing waves $\lambda$, $3\lambda/2$ and $2\lambda$ has a poor directional radiation pattern with four equally spaced major lobes each disposed at an angle of 45° to the dipole element. However, when the dipole is bent in a vertical plane to form an open loop, such as the circular open loops **24** and **26** shown in FIGS. 1 and 8 or the generally square open loops **37**, **39** and **41** shown in FIGS. 2, 3 and 4, the directional radiation or response pattern comprises two major lobes each perpendicular to the plane of the loop which pattern signifies a substantial increase in the directionality of the wave propagation. The response pattern of such a single loop antenna may be sharpened or made narrower in the vertical plane by the addition of another symmetrical loop antenna disposed in the same vertical plane as that of the first loop and forming an antenna assembly, such as the above described figure "8" antenna assemblies. Thus radiated waves are polarized in a plane tangent to the open ends of the loops, and radiate perpendicular to the plane of the double loop assembly.

Since the electrical properties of both loops of the double loop assembly are the same, the ends of the one or top loop may be coupled to the corresponding adjacent ends of the other or bottom loop (see FIGS. 3, 4 and 8) and/or to a transmission line. Even substantial portions adjacent the corresponding ends of the top and bottom loops may be conductively joined together or may be made as a single member as shown in FIGS. 3 and 4.

### COUPLING

The high impedance ends of each loop antenna may be capactively (see FIGS. 1, 2, 3, 4) or conductively (see FIG. 8) coupled to a pair of lead conductors. Capacitive coupling may be accomplished by a dielectric support bracket **64** or **65** (see FIGS. 1 and 2) having means for supporting and holding each loop end a fixed small distance of about one eighth of an inch from its respective lead conductor. This spacing provides a capacitance between the line and the loop end of the antenna of about 0.5 of a micromicrofarad. The dielectric brackets **64** and **65** may be molded in the form of a generally rectangular cross-piece from a plastic material having a dielectric constant preferably near 3.8 (dry air having a dielectric constant of 1.0). The bracket **65** may be fitted partially around a supporting member **67** or boom and be held in a fixed position thereon by a fastening means such as a rivet **69**. The ends **72** and **74**, and **75** and **77** of each bracket **64** and **65**, respectively, may extend outwardly a substantial distance on either side of a support and may contain seats, apertures, grooves, or holes for the loop ends, and transverse grooves, holes or slots spaced between them for one of each of a pair of phasing lines or lead conductors **80** and **81**.

The bracket **64** shown in FIG. 1 may be made of a relatively rigid plastic having seats or fixed holes **84**, **84'**, **86**, **86'** capable of holding the antenna loops **24** and **24'** in a planar relationship with respect to each other by firmly gripping their inturned ends or feet **28**, **28'**, **30** and **30'**.

The dielectric bracket **65** shown in FIG. 2 may be made of a resilient plastic and have a means for containing, retaining or seating the ends of feet **47**, **47'**, **49** and **49'** of the pair of loops **37** and **37'** so they may be pivoted into a vertical or operating position shown in full lines in FIG. 2*a* from a horizontal, folded or parallel to boom position shown in dashed lines. This foldability facilitates packaging and shipping of antenna arrays such as shown in FIG. 9 comprising a substantial plurality of such loop antennas. The pivot means may include a pair of horizontally aligned spaced apart open ended trough or slots **87** and **89**, and **87'** and **89'** adjacent the top and bottom of the bracket **65** into which slots the ends or capacitive feet **47** and **49**, and **47'** and **49'** may be readily inserted by squeezing the ends of the loop toward each other, aligning them with their respective slots, and releasing them to spring into the open ends of the slots where they are retained in part by the outward inherent spring force of the loops themselves. A vertical abutment means **91** and **93**, and **91'** and **93'** may be located adjacent the open end of each slot along with a cooperating resilient latch finger **95** and **97**, **95'** and **97'** which has an inclined contact surface **99**, **99'** for being engaged by the legs **43** and **45**, and **43'** and **45'** of the loops **37** and **37'**. The rotation of the loops from the folded position towards the operating position causes the legs of the loop to contact the inclined surfaces **99** and **99'** (see FIG. 2*a*) on the spring latches which are wedged inwardly until the loop element contacts the abutment means at which point a detent section **101** and **101'** (see FIGS. 2 and 2*a*) in each spring latch falls behind its respective leg of the loop element to hold the loop in the vertical or operating position.

The troughs **87** and **89** may be vertically spaced apart from troughs **87'** and **89'** a sufficient distance to accommodate a lead conductor **80** or **81** between each pair of adjacent loop ends, such that a fixed capacitance of about 0.5 micromicrofarad is established between each loop end and its respective lead conductor. A clothespin type gap means **103** and **105** opening towards the outer ends of the bracket **65** may be provided so that each of a pair of lead conductors **80** and **81** may be snapped into place and firmly held in the bracket. This structure promotes ease of assembly and economy especially when a large number of double loop assemblies are stacked in a columnar array. A rigid lead conductor made of about ⅛" aluminum rod was found to be well suited for this purpose and also provides some additional rigidity to the array.

The support for the double loops in FIG. 3 comprises a conductive rod or bar **106** integrally connected to midpoints of loops **39** and **39'**, i.e. between their low impedance portions, which bar **106** may be directly and fixedly connected to the boom **67**. The common free ends **51** and **53** of the loops **39** and **39'** may be capacitively or conductively coupled to the lead conductors **80** and **81**, respectively, and spaced from the boom **67** and bar **106**.



The support bracket for the double loop assembly **35** shown in FIG. 4 may comprise a folded conductive U-shaped stub section **109** $\lambda/4$ in length with its ends integrally connected to the free ends of sections **55** and **57** of the loop assembly and its base portion integrally connected to the boom **67**. The inner ends of sections **55** and **57** may be insulatively supported or capacitively joined to a pair of lead conductors **80** and **81**.

## ARRAYS

The double loop planar antennas shown in FIGS. 1, 2, 3 and 4 are bi-directional. A substantial gain may be realized by stacking such antennas in a vertical plane or in a horizontal column.

FIG. 5 shows a vertical array **108** comprising three double loop antenna assemblies **110**, **112** and **114** like the antenna assembly **20** shown in FIG. 1. The center antenna **112** may be capacitively coupled to a pair of lead conductors, while the outer antennas **110** and **114** are only inductively connected to the center antenna **112**. Similar arrays with more elements such as with five or seven antennas are also practical.

FIG. 6 shows a bi-directional array **116** of three double loop antennas **118**, **120** and **122**, like antenna **20**, which are stacked in a horizontal column with each antenna capacitively coupled to the same pair of lead conductors **80**, **81**.

Antenna arrays may be made unidirectional by the addition of a nonresonant reflector, such as shown in FIG. 7, where a capacitively coupled double loop antenna **124** is disposed about $\lambda/4$ (one quarter wavelength at the mean frequency) in front of a semi-grid type inductance or reflector **126**.

FIG. 8 shows a unidirectional array **128** comprising two integrally connected double loop antennas **22** and **130** in front of a reflector **132**, all in an aligned row spaced $\lambda/4$ from each other. The reflector may have the same outside configuration as the other antennas **22** and **130**, but also having centrally located horizontal shunts **134** and **134'** across each of its loops. A pair of conductor rods **136** and **138** may be integrally connected, one on each side of the central section of each double loop antenna **22** and **130** and similarly to the shunted reflector **132**. The array may be supported by a mast clamp **140** integrally connected, such as by welding, to the rear side of the reflector **132** adjacent the ends of conductor rods **136** and **138**, so that the sections of rods **136** and **138** between the antenna **130** and reflector **132** together with the clamp **140** across the ends of these sections, forms a U-shaped quarter mean wave length shunt from the center double loop **130**. Terminals **142** and **144** for connecting lead-in wires may be integrally attached at the junctions of lead conductors connected to the center antenna **130**.

The tapered unidirectional array **147** shown in FIG. 9 has a plurality of groups of double loop antennas spaced along a horizontal boom **67** and capacitively coupled to a pair of parallel phasing lines or lead conductors **80** and **81**. The front end of the array may contain a group of six small equal size double loop antenna assemblies **149**, like the one **31** shown in FIG. 2, having a loop length corresponding to the wave length of the highest frequency to be detected in the operational frequency band, for example, about 25% more length than shown in FIG. 9*b*. Then the second, third and fourth groups **151**, **153**, **155** each may comprise four similar double loop antennas having loop lengths corresponding respectively to the remaining successive quarter segments in the operational frequency band, for example in FIG. 9*b*, up to about 25% less than the lowest operational frequency to be detected. Thus, the lengths of the loops along the boom **67** in this specific array, having a frequency band width of about 2:1, may vary from about one to three halves of the mean wave length of the applied frequency band. The double loop antenna assemblies may be horizontally spaced along the boom **67** at approximately one fourth of their wave length, such as is shown schematically in FIG. 9*b*. The loops of each group are the same size to facilitate manufacturing but a more smoothly tapered array could be produced if the loops were made sequentially larger, going from the front to the back of the array. Similar tapered arrays but with fewer double loops may also be used to produce substantial gain.

In this and other arrays of this invention a deliberate mismatch is provided between each loop antenna and the lead conductors so only a portion of the electrical energy in an antenna loop is transmitted through the capacitance to the lead conductors, while a substantial portion of the energy is radiated back into space in phase to the adjacent antenna loops. Thus the signal is reinforced as it travels along the array. Also the lead conductors are sufficiently isolated by their capacitive couplings through the supporting brackets **65**, to reduce or prevent an attenuating interaction between them, which interaction has been a serious problem in the past in lengthy arrays.

The front to back ratio of the array is improved by a non-resonant reflector assembly **157** provided at the back of the array **147** spaced approximately one-fourth of a wave length from the last double loop antenna. The non-resonant reflector may have an odd number of horizontal reflector bars **161** spaced vertically apart and attached to a short mast **163** by means of a pivotal bracket **165** having a pair of spring tabs for embracing opposite sides of the mast **163** and holding the bars **161** in operating position. The reflector assembly **157** may be removably attached to the rear end of the boom **67** by a bracket means **167** located adjacent the center reflector bar.

The front to back ratio may be further improved in lengthy arrays such as shown in FIG. 9, by providing a resistive load **169** (see FIG. 9*b*) across the end of the lead conductors **80** and **81** opposite the feed line terminals **173** and **175** which are located adjacent the reflector **157** (see FIG. 9*b*). The resistive load may comprise a 270–300 ohm ¼ to ½ watt deposited carbon resistor which gives the array **147** a front to back ratio of about 17:1.

The array feedline may be supported by stand-off insulators **177** and **179** attached to the boom **67** and may extend forward through the lower row of antenna loops to a point adjacent the center of balance of the antenna where a mast clamp **181** may be provided to attach the horizontal boom **67** to a vertical mast **183**. The lead conductors **80** and **81** may be symmetrically offset supported by an insulator **184** towards each other adjacent the mast clamp **181** (see FIG. 9*a*) when necessary to clear the vertical mast.

The array **147** shown in FIG. 9 will produce a 14 decibel gain as compared to a reference dipole, and will operate over a frequency band having a ratio between high and low frequencies of 2:1. It has a high Q and produces a high gain relative to its volumetric displacement.

FIGS. 10 and 10*a* show a combination UHF and VHF antenna array **191** having the UHF portion **193** of the array compatibly connected to the VHF and/or FM portion **195** of the array by means of a pair of phasing bars or lead conductors **197** and **199** having intermediate coiled sections **201**, **203**, **205** and **207** for isolating the UHF wave energy in portion **193** from the VHF wave energy in portion **195**. The UHF portion **193** may comprise a plurality, such as three, of double loop antennas like antenna **31** in FIG. 2 disposed in a horizontal column at the front end of the array and spaced $\lambda/4$ apart. The VHF and/or FM portion **195** may be located at the back end of the array **191** and may comprise a plurality of dipoles **209**, **210** and **211** of various lengths arranged



in conjunction with a plurality of parasitic elements **213** and **215**. One or more parasitic elements **215** may be arranged in front of the isolating coils **201**, **203**, **205** and **207**. The intermediate dipole **210** may have a tuning stub **217** conductivity connected to its inboard ends. The VHF dipoles may be alternately cross connected by criss-crossing the lead conductors **197** and **199** but the lead conductors **197** and **199** may be parallel through the UHF portion **193**, because the double loop antennas do not require criss-cross phasing. The spaced apart lead conductors **197** and **199** may have a capacitively coupled high impedance stub section **219** at the front end of the array **191** and a pair of lead line terminals **221** and **222** intermediate the UHF portion **193** and the VHF portion **195** of the array.

While there is described above the principles of this invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of this invention.

What is claimed is:

**1.** An antenna comprising:
(A) a pair of lead conductors (**80, 81**),
(B) a pair of open loop elements (**20, 31**) disposed in a common plane perpendicular to the direction of wave propagation and forming a figure 8 configuration with the open ends of said loops at the center of said configuration, and
(C) means (**64, 65**) for capacitively coupling the corresponding adjacent ends of each loop element of said pair together and to a correspondingly one of said lead conductors.

**2.** An antenna array comprising:
(A) a pair of parallel lead conductors (**80, 81**) disposed parallel to the direction of wave propagation,
(B) a plurality of coplanar double open loop antennas (**20, 31**) each disposed perpendicular to the direction of wave propagation, and
(C) means (**64, 65, 136–138**) for coupling said antennas to said conductors.

**3.** An antenna array according to claim **2** wherein said coupling means is a capacitive coupling (**64, 65**) having a capacitance of about 0.5 micromicrofarad between the ends of said loops and said conductors.

**4.** An antenna array according to claim **2** wherein said coupling means is a conductive coupling (**136, 138**) through integrally joined components.

**5.** An antenna array according to claim **2** wherein said coupling means electrically mismatches said loop antennas with respect to said lead conductors.

**6.** An antenna array according to claim **2** wherein the range of loop lengths corresponds to between about one and 3/2 of the mean wavelength of the applied frequency band.

**7.** An antenna array according to claim **2** wherein said loops have a geometric configuration which encompasses a near maximum area for a limited peripheral loop length.

**8.** An antenna array according to claim **2** wherein said double loop antennas are spaced apart one quarter wavelength along said conductors.

**9.** An antenna array according to claim **2** including a non-resonant reflector (**132, 157, 211**) means at the rearward end of said pair of conductors.

**10.** An antenna array according to claim **2** including a resistance load (**169**) having a value equal to the impedance of said pair of conductors and located opposite the feed end of said array.

**11.** A unidirectional high gain broad band receiving antenna array (**147, 191**) comprising:
(A) a pair of parallel lead conductors (**80, 81**) having a pair of feed line terminals (**173, 175**) adjacent one end,
(B) a plurality of coplanar double loop antennas (**20, 31**) each having a length corresponding to between

about one and three halves of the mean wavelength of the applied frequency band,

(C) dielectric bracket means (**64, 65**) capacitively coupling said loop antennas to said conductors, whereby each double loop antenna is disposed perpendicular to the direction of wave propagation and spaced substantially one quarter wavelength apart in a row which is parallel to the direction of wave propagation,

(D) a non-resonant reflector means (**157**) at the rearward end of said array, and

(E) a loading means (**169, 219**) between the lead conductors at an end remote from said terminals.

**12.** An antenna array according to claim **11** wherein said dielectric bracket means maintains a fixed capacitance between the respective ends of said loops and said lead conductors of about five-tenths micromicrofarad.

**13.** An antenna array according to claim **11** wherein said dielectric bracket means has a means for unfolding said loop elements from a substantially coplanar position with respect to each other and to said lead conductors.

**14.** An antenna array according to claim **13** wherein said dielectric bracket comprises:

(A) means for rotatingly mounting and spacing adjacent ends of said loop elements,

(B) resilient arms for holding said loop elements in one of two limiting rotatable positions in said mounting and spacing means, and

(C) a pair of snap groove means adjacent said mounting and spacing means for retaining said lead conductors capacitively coupled to said ends of said loop elements.

**15.** An antenna array according to claim **11** wherein said loading means substantially matches the load of the associated feed lines.

**16.** A resilient dielectric capacitive coupling member (**65**) for a loop antenna (**31**) and a pair of lead conductors (**80, 81**) on a support (**67**), comprising:



(A) means (**69**) for anchoring the central portion of said member to said support,

(B) means (**87, 89, 87′, 89′**) for rotatingly mounting and spacing adjacent ends of said antenna,

(C) resilient arms (**95, 97, 95′, 97′**) for holding said antenna in one of two limiting rotatable positions in said mounting and spacing means, and

(D) a pair of snap groove means (**75, 77, 103, 105**) adjacent said mounting and spacing means for retaining said conductors capacitively coupled to said ends of said antenna.

**17.** A combination UHF and VHF receiving antenna array (**191**) comprising:

(A) a UHF portion (**193**) having a plurality of open loop antennas (**20, 31**) disposed at the front of said array,

(B) a VHF portion (**195**) located rearward of said array and having a plurality of dipole antennas (**209, 210**),

(C) a pair of lead conductors (**197, 199**) coupling said UHF loop antennas and said VHF dipole antennas together, said lead conductors having a plurality of isolating coils (**201, 203, 205, 207**) intermediate said UHF and VHF portions, and

(D) a pair of feedline terminals (**221, 223**) conductively connected to said lead conductors adjacent said UHF portion.


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ELI LIEBERMAN, *Primary Examiner.*

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