Dec. 13, 1949 A. G. KANDOIAN 2,490,815

LOOP ANTENNA

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Fig. 1.

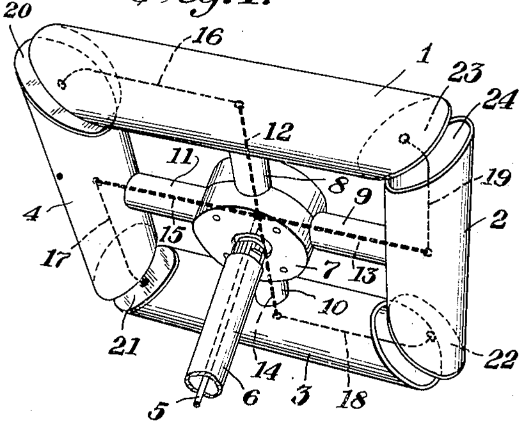


Fig. 6.

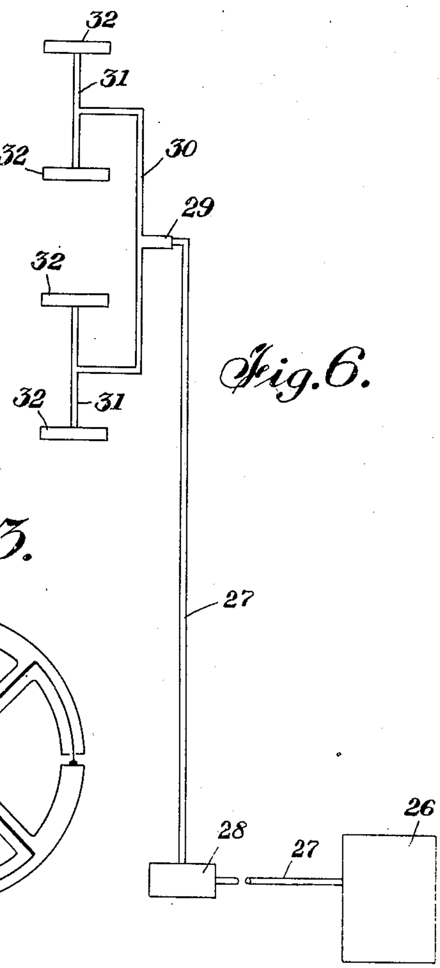


Fig. 2.

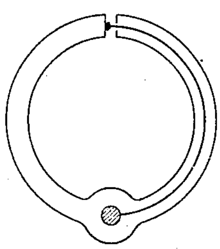


Fig. 3.

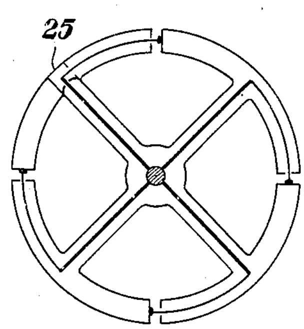


Fig. 4.

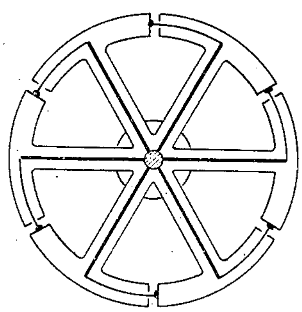
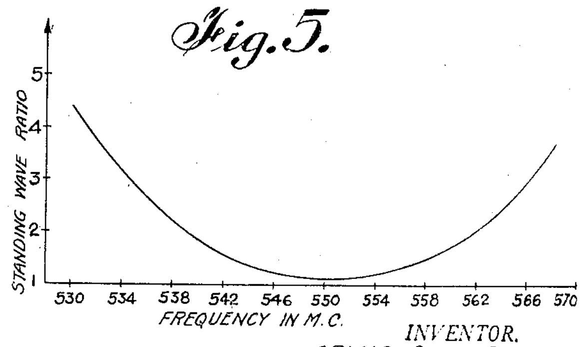


Fig. 5.



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LOOP ANTENNA

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13 Claims. (Cl. 250—33)

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This invention relates to loop antennas and more particularly to shielded loop antennas of the type designed to operate over a wide band of high frequencies.

In the past, the loop type antenna design has presented the problem of feeding it properly and conveniently to get the substantially uniform clockwise for counterclockwise current distribution characteristic of a true loop or what is technically known as a "magnetic dipole." The difficulty has been in getting a good balanced feed, necessitating such feeding expedients as "cross overs" in the balanced feeder which carried the power to the radiating elements. This cross over frequently was a major source of electrical or mechanical troubles.

Another difficulty with the use of loop antennas in the past has been the requirement for a balanced line which is ordinarily more expensive to manufacture and is less readily available than the simple coaxial line.

Further difficulties were experienced, in the degree to which a balance was required in the transmission line and in the matching of the antenna impedance to that of the feeder. As a result of the above problems rather complicated mechanical designs were frequently necessary.

It is an object of the present invention to provide a loop antenna for frequency modulation and television purposes which is efficient over a relatively wide band of high frequencies and which overcomes the above described difficulties.

It is a further object to provide a loop antenna which is distinguished by the simplicity of its mechanical design and construction and which lends itself to an easy "stacking" of a large number of antenna units for the achievement of directivity in an axial plane.

In accordance with the invention, I provide a suitable number of tubular circumferentially arranged magnetic dipole type radiators which are fed in parallel from an axially located junction point supplied by a common type coaxial transmission line. Each of the radiators is connected to the coaxial line by means of an individual coaxial conducting arm, all of which are connected in parallel with respect to the coaxial power supply feed line. One of the features of the invention is that the radiators as well as the supply arms form part of the coaxial feeding system as well as the mechanical structure.

These and other features and objects of this invention will become more apparent as the invention is described in greater detail in connection with the accompanying drawing, wherein:

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Fig. 1 is a perspective view of the mechanical construction of a four element loop antenna in accordance with my invention;

Fig. 2 is a schematic representation of a loop antenna of my invention comprised of a single circular member, while Figs. 3 and 4 are schematic representations of four and six member circular loops respectively;

Fig. 5 is a graph showing the relation between the standing wave ratio and operating frequency for a loop antenna in accordance with my invention; and

Fig. 6 is a schematic showing of an antenna array employing a stack of four vertically arranged loops.

Referring now to the drawing, the loop antenna of Fig. 1 is shown to comprise four hollow tubular radiators 1, 2, 3 and 4, arranged in a quadrilateral form.

These radiators which are preferably each a ½ wavelength long at the mid-frequency of the operating band are fed coaxially and in parallel from a common coaxial feeder line comprised of an inner conductor 5 and a shield 6. The coaxial line 5, 6 is coupled into a junction box 7 into which are coupled four coaxial conducting arms 8, 9, 10 and 11.

These conducting arms are similarly each comprised of an outer shield as well as an inner conductor 12, 13, 14, and 15 which are connected in parallel to the central conductor 5 of the coaxial feed line within the junction box 7. The shields of these arms are conductively coupled to the shield of the coaxial line through the outside shield of the junction box 7. The inner conductors 12, 13, 14 and 15 continue toward the center of the respective radiating elements and then each turn to one side to run axially along the inside of the radiators for ½ the length thereof as at 16, 17, 18 and 19 to terminate in a conducting plate 20, 21, 22, and 23 disposed in the near end of the succeeding radiating element. These radiating members are separated from one another by short gaps as at 24 between the open end of one and the closed end of the adjacent radiators.

Other possible forms of this type of antenna may be seen in Figs. 2, 3, and 4 where a circular form has been illustrated as embodied in single, four and six member loops.

The circumference of the single member loop is preferably in the neighborhood of ½ wavelength or less, the multiple member loops being made up of substantially ½ wavelength radiators. No limitations other than practical exist for the number of members making up a loop. Thus a loop antenna of any diameter may be constructed and the old limitation of a diameter less than ½ wavelength need not be observed in this case.

It is to be noted that all portions of the antenna are metallic and form a mechanical supporting structure and that the radiators themselves form part of the coaxial feeding system. If the size of the unit is such that its own structure is not sufficient to carry the mechanical load, the antenna lends itself easily to the addition of suitable bracing members which may form part of the electrical system without affecting its characteristics.

The four connecting arms **8**, **9**, **10** and **11** here function as impedance transformers between the feeder line of the radiators and are preferably made ¼ or an odd multiple of ¼ wave long, their impedance being held low by choosing a large diameter axial conductor for at least the first ¼ wavelength thereof as at **12**, **13**, **14** and **15** in relation to the conducting portions **16**, **17**, **18** and **19** within the radiators. These conducting arms may be connected to the tubular bodies of the radiating members by any known sheet metal fabrication at a point of low or null voltage thereon so that the shield of the entire system may be put at ground potential and serve as a return conductor, thus obviating the requirements for insulators. These arms may also, when desired, be connected to the radiators on the inside thereof as indicated at **25**, in Fig. 3. The arm, in this case, passed through an opening on the inside radius of the radiators and is attached by any desired means to the inside of the tubular conductor. The choice of these methods of connection is largely determined by the most favorable low voltage point on the radiator.

The connection of the transmission line to the radiators at the connecting plates **20**—**23** constitutes an actual short circuit between the inner and outer conductors of the coaxial conducting system. The impedance at the gap between radiators is normally quite high when the radiators are made substantially ½ wavelength and low when the radiators are substantially ¼ wavelength. The feeder within the radiator and also that within the supporting arm is made to have such a surge impedance as to match the centrally located main coaxial feeder. It is thus possible in the present type loop to obtain an antenna which is inherently matched to any common type of coaxial transmission line by the proper choice of surge impedances of the transmission line within the connecting arms and the conductors within the radiators without any further matching being necessary as in some previous loop designs. The radiation patterns of small loops of this type are well known and so far as the horizontal radiation is concerned, that is in the plane of the loop, the radiation pattern is substantially circular. The vertical radiation however, that is in the plane perpendicular to the loop, is a function of the diameter thereof. The vertical pattern of a loop whose diameter is any value d is given approximately by

$$F(B)=KIJ_1\left(\pi\frac{d}{\lambda}\cos B\right)$$

where K is a constant, I is a loop current, J_1 is a Bessel function of the first order, λ is the wavelength and B is a vertical angle, zero at the horizon. Highly directive patterns in the vertical plane may be obtained with this type of loop while retaining the omni-directional pattern in the horizontal plane. This may be done by vertical stacking of any desired number of loops. An example of this arrangement is shown in Fig. 6 wherein **26** is a transmitter; **27** a commercial type coaxial line; **28** a junction box and matching means; **29** is a ¼ wave impedance transforming line; **30** and **31** are suitable portions of a coaxial feed line; and **32** are four vertically stacked loop antennas of the type hereinabove described.

In Fig. 5 the operating characteristic of a typical loop antenna constructed in accordance with my invention and operating over a useful range of frequencies as between 530 and 570 mc., is shown as expressed in the relation between the standing wave ratio and operating frequency, the favorable wide band characteristic being immediately apparent.

It will be seen therefore from the above description that I have provided a loop type antenna which:

(*a*) Does not require balanced feeders;

(*b*) Does not require any stubs for matching and in which therefore the full band width capability of the loop may be realized;

(*c*) Does not require insulating mechanical supports;

(*d*) And which may be constructed to any desirable size diameter with essentially uniform current distribution.

While I have described above the principles of my 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 on the scope of my invention as set forth in the objects of my invention and the accompanying claims.

I claim:

1. An antenna comprised of a given number of discrete tubular members arranged in a loop and acting in cooperation to produce translation of radiant energy, and an energy feeding line for said loop comprised of a first and a second conductor, said first conductor being connected to each of the said tubular members intermediate the end thereof and said second conductor being connected to a corresponding end of each of said members.

2. An antenna according to claim 1 wherein said number of radiating members is one.

3. An antenna according to claim 1 wherein said first conductor is connected to said tubular members at a point of minimum voltage.

4. An antenna according to claim 1 wherein each of said members is substantially ½ a wavelength long at the operating frequency.

5. An antenna according to claim 1 wherein said energy feeding line is a coaxial line and said first and said second conductors comprise an outer shield and an axial conductor respectively.

6. An antenna comprised of a given number of hollow tubular members arranged in a loop and acting in cooperation to produce translation of radiant energy, each of said members having two ends and being substantially ½ a wavelength long, a coaxial energy feeding line for said loop having an outer shield and an inner axial conductor and coaxial impedance transforming means coupling each of said members at points intermediate their ends and said line, said means having an outer conducting shield connected to said first named shield and to said tubular members intermediate the ends thereof and an inner conductor connected to said axial conductor and an additional conductor connected between said

inner conductor and a corresponding end of each of said members.

7. An antenna according to claim 6 wherein the said conducting shield of said transforming means is connected to said tubular members at a point of minimum voltage.

8. An antenna according to claim 6 wherein said additional conductor is arranged axially inside a portion of one of said radiating members and is connected to another adjacent one of said radiating members.

9. An antenna comprising a plurality of discrete hollow tubular radiating members arranged in a loop, a coaxial energy feeding line for said loop having an outer shield and an inner axial conductor, and coaxial impedance transforming arms coupling each of said members at points intermediate the ends thereof and said line, each of said impedance transforming arms having an outer shield and an inner axial conductor, said last named shield being connected to first named shield and the corresponding member intermediate the ends of said member, and said last named axial conductor being connected to said first named axial conductor and an additional conductor connected between said axial conductor and one end of a member adjacent to the member to which the corresponding shield is connected.

10. An antenna according to claim 9 wherein said additional conductor as extended is partly disposed within each of said corresponding members.

11. An antenna according to claim 9, wherein said transforming arms are each ¼ wavelength long.

12. An antenna comprising at least two radiant acting members arranged in pairs to form a substantially closed planar periphery, successive ones of said acting members being connected together at one end, and spaced apart a small distance from the next adjacent member at their other ends, two conductor transmission line means for each pair of radiant acting members, means for connecting one conductor of said transmission line conductors to the connected ends of the corresponding pair of radiant acting members, conductor means within one of the members of said pair and in spaced relation thereto for interconnecting the other conductor of said transmission line and the next adjacent radiant acting member.

13. An antenna comprising a plurality of substantially horizontal radiant acting members each member having two interconnected elements, said members being arranged with their ends adjacent one another to define a substantially closed periphery, branch coaxial lines extending from the connection points of said elements to a common feeder point substantially symmetrically arranged within said periphery, the outer conductors of said branch lines being connected respectively to said members at the connection points of said elements, and a conductor arranged within one element of each member and connected at one end to the central conductor of its respective line and at the other end to the next adjacent member, a coaxial feeder line for supplying energy to and supporting the said antenna, and means for connecting the inner conductor of said coaxial line with the inner conductors of said branch lines and the outer conductor of said coaxial line with the outer conductors of said branch lines at said feeder point.

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