June 17, 1941. E. C. VROOMAN 2,246,151

TOWER ANTENNA

Filed May 24, 1939

Fig. 1.

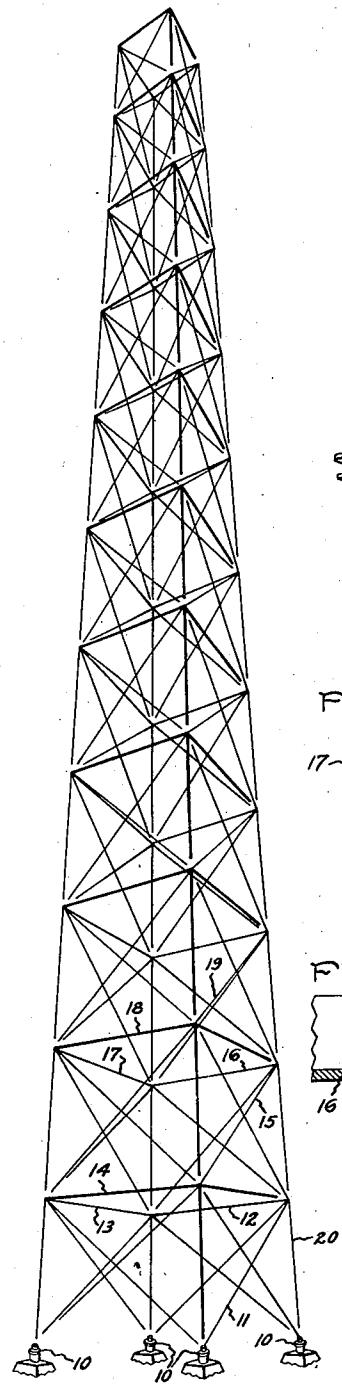


Fig. 2.

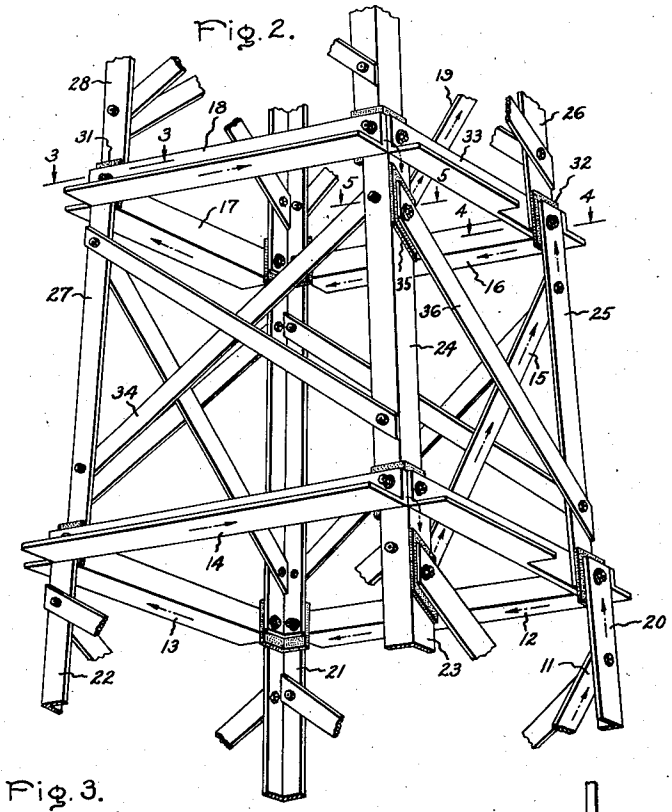


Fig. 3.

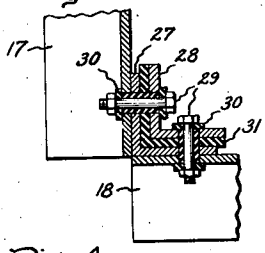


Fig. 4.

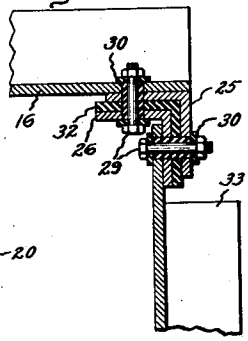


Fig. 5.

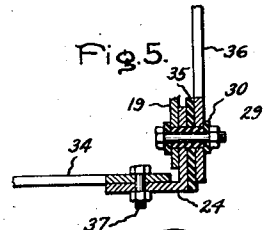


Fig. 6.

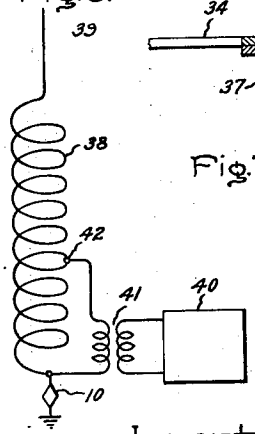
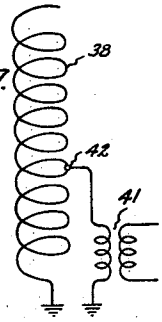


Fig. 7.



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His Attorney.

Patented June 17, 1941 2,246,151

UNITED STATES PATENT OFFICE

2,246,151

TOWER ANTENNA

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Application May 24, 1939, Serial No. 275,385

5 Claims. (Cl. 250—33)

The present invention relates to radio antennas of the tower type.

It is frequently convenient to construct a radio antenna in the form of a tower, particularly where a large amount of radiation is desired. Such an antenna tower can support its own weight and at the same time presents sufficient conducting area to carry large radio frequency currents. In such towers it may be desirable to provide a greater amount of inductance per unit of length of the tower than is usually attained. It is accordingly an object of my invention to provide means for increasing the inductance per unit of length of such antenna towers.

It is a further object of my invention to provide an improved tower antenna in which the distribution of radio frequency currents and voltages over the structure may be controlled in a simplified way.

It is also an object of my invention to provide an improved construction for a tower antenna whereby it may be manufactured very economically to give improved results and at the same time remain rugged and reliable.

Antenna towers comprising continuous vertical radiators of the type to which my invention is applicable are generally considered to have an ideal actual height of one half of a wave length, or more exactly, by some authorities, sixty-four one hundredths of a wave length of the wave at which the tower operates. This is for a straight vertical radiator. Of course, the addition of inductance in the length of the tower increases its effective length and thus reduces the actual height of the tower required to produce the desired radiation.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 is a perspective view of an antenna tower embodying my invention; Fig. 2 is a perspective view of a part of the tower; Fig. 3 is a sectional view taken along the line 3—3 in Fig. 2; Fig. 4 is a sectional view taken along the line 4—4 in Fig. 2; Fig. 5 is a sectional view taken along the line 5—5 in Fig. 2; Fig. 6 is a circuit diagram applicable to the tower structure shown by Fig. 1; Fig. 7 is an alternative circuit diagram to Fig. 6.

In Fig. 1 four insulators 10 serves as supports for an antenna tower which is constructed of the usual angle or strap shaped structural elements. These structural elements are fastened together in such a way as to form a rigid antenna tower including a plurality of sections. Certain of the elements are insulated at one end from the remainder of the structure, as is indicated in Fig. 1 by a gap between certain lines of the drawing. The insulation has sufficient mechanical strength to provide structural support for the antenna itself and for any additional forces which might necessarily be borne by the tower. It is preferred to use an insulation between the joints of these elements as manufactured in sheet form. A suitable sheet insulation of high mechanical and dielectric strength is one formed of compressed mica and glass. Organic materials are disadvantageous in that they carbonize their surfaces and lose their insulating quality. An inorganic material, such as mentioned above, stands weathering and corona in better fashion.

The structural elements of the tower are in themselves radiators of electric energy and a tortuous circuit is formed through the tower by omission of insulation at certain points. For example, a circuit may be traced through the tower beginning at the base at one of the insulators 10 through a structural element 11 which is connected at its upper end to an element 12. The circuit may be traced through structural elements 13, 14, 15, 16, 17, 18, 19, and so on to the top of the tower. It may be noted that the path of the circuit through the structural elements is generally helical. However, the path may be made of any configuration so as to provide a higher inductance per unit length than a straight antenna.

The material of which the structural elements are formed is preferably non-magnetic, in order to avoid hysteresis loss. Certain non-magnetic steels may be found of great advantage. If it is desired, iron may be used for the elements, since it is generally zinc coated. However, considerable iron loss may be expected. The presence of magnetic material inside the tower should be avoided as it may produce losses.

In Fig. 2 the strap-like structural element 11 is bolted directly to an upright angle-shaped element 20, which in turn is in electrical contact with the angle-shaped element 12. At the other end the element 12 is in electrical contact with the element 13, as well as with an upright element 21. The element 13 is in contact with the

element 14 and with an upright element 22. At the other end of the element 14 electrical connection is made to an upright angle-shaped element 23, which is insulated from an upright element 24 positioned just above it. The element 15 is bolted directly to the upright element 23 and, at its other end, is bolted to an upright element 25. Element 25 is insulated at its lower end from element 20 and at its upper end from an element 26, and makes contact with element 16. It may be seen by inspection that elements 11, 15 and 19 are analogous elements in adjacent turns of the circuit through the structure and that elements 12 and 16 are in the same way analogous elements.

In Fig. 3 a detailed sectional view is shown to illustrate the means by which the adjacent upright elements are insulated from each other and by which the horizontal elements are connected to the upright element just beneath them at such junctions as that between elements 17 and 18. Elements 17 and 18 and an upright element 27 are in contact. An upright element 28 is fastened to the assembly of elements 17, 18 and 27 by bolts 29, which are entirely insulated from the elements through which they pass by insulating tubes and washers 30. An angle-shaped piece of insulating material 31 lying between the upright elements 27 and 28 insulates them from each other.

Fig. 4 shows in a detailed sectional view the construction of the corner between upright elements 25 and 26. This corner is identical with that between upright elements 20 and 25. The upright element 25 is in electrical contact with element 16. An angle-shaped piece of insulation 32 separates upright element 25 from the upright element 26. A horizontal element 33 is in contact with the upright element 26. Bolts 29 cooperating with insulating tubes and washers 30, similar to those shown in Fig. 3, fasten the assembly together rigidly.

Referring to Fig. 5, a detailed sectional view is shown of the joint of the element 19 with the upright element 24. This joint is similar to that between element 15 and upright element 23. Element 19 and the upright angle-shaped element 24 are in electrical contact as are also elements 24 and 34. It may be noted here that the arrows in Fig. 2 indicating the path of current flow do not indicate the only possible metallic path in the circuit. However, the principal direction of current flow is indicated by the arrows, although a certain proportion of the total current would, of course, follow paths in shunt to those indicated by the arrows, such as the path downward through upright element 27 and then through element 34 to the upright element 24.

A flat piece of insulation 35 separates the upright element 24 from element 36, which would otherwise connect the upright element 24 to the next lower turn of the circuit. A bolt 37 maintains elements 24 and 34 in mechanical engagement and a bolt 29 with an insulating tube and washers 30 maintains elements 19, 24 and 36 in fixed relation.

In Fig. 6 the electrical path through the tower antenna is represented by a helical coil 38. The insulators 10 are indicated diagrammatically between the lower end of the coil 38 and the earth. The upper portion of the tower forms an additional electrical conductor 39 running vertically upward. This vertical conductor 39 may conveniently be formed of tower sections similar to those shown in Figs. 1 and 2 but having no insulators. A source of radio frequency energy 40 is coupled by means of a transformer 41 to the lower end of the coil 38 at the insulators 10 and to a point 42 several turns upward along the tower.

Fig. 7 illustrates a slightly different way of connecting the tower to a source of radio frequency energy wherein the insulators 10 may be omitted. The lower end of the tower or coil 38 is connected directly to earth. The point 42 is as before connected to one end of the secondary of transformer 41 and the other end of transformer secondary is connected to earth.

In some instances, as for example in the tower illustrated by Fig. 6 and discussed above, it may be desirable to provide portions of the tower structure with no insulators. The ends of the tower may have a helical electrical path, while a central portion not provided with insulators, provides only a vertical electrical path. Such a tower may, of course, be energized at the center rather than at the ends, if desired.

Alternatively it may be desirable to provide a tower grounded at the lower end and having a vertical portion not provided with insulators and a second portion thereabove which is provided with insulators to form a helical electrical path. This can be used effectively to shorten a tower to be used for a particular wave length.

Another construction possible with a tower built according to my invention is one of the form described in Letters Patent 2,125,804, issued August 2, 1938 to Clifford A. Nickle, and assigned to the same assignee as the present application. A tower having an upper portion forming a helical electrical path, and a lower portion forming a straight path, the tower being a vertical radiator less than one-quarter wave in length, is such an antenna. It is energized between earth and its lower portion and a capacity exists between earth and the top of the helical path such that it forms with the helical path a tuned circuit, whereby a considerably shortened structure is obtained.

It is possible by use of my invention to control the distribution of voltage and current to some extent over the tower. If it is desired, a voltage node may be produced at a point at which it may be desired to support the antenna.

In many applications this construction of a tower antenna is of great advantage where it is desired to construct an antenna with a larger amount of distributed inductance per unit length than is normally possible. The use of distributed inductance rather than concentrated inductance tends to distribute the high frequency current in greater proportion in the upper parts of the tower rather than across a concentrated inductance such as the coupling transformer which supplies energy to the antenna. Because the current may be made to distribute itself over the upper portions of the tower, a somewhat great amount of radiation is available. It is, of course, apparent that the cross-section of the tower may be made of any desired shape, and that the sections of which it is formed may be of any length. The shorter each section is made, the greater is the inductance of the tower per unit length.

While I have shown a particular embodiment of my invention, it will, of course, be understood that I do not wish to be limited thereto, since different modifications may be made both in the structural arrangement and instrumentalities employed, and I aim by the appended claims to

cover any such modifications as fall within the true spirit and scope of my invention.

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

1. A radiating tower structure having an actual height of less than one-half of a wave length of the frequency at which it operates, said tower comprising a framework of conducting structural elements mechanically interconnected at different points to form a rigid structure, the mechanical interconnections at certain of said points being conducting and those at other of said points being non-conducting, said conducting and non-conducting interconnections being so disposed in said tower that a continuous conducting path along said tower is formed through said elements in succession, said path having the general form of a coil with vertical axis thereby to increase the inductance per unit length of said tower.

2. A radiating tower structure having an actual height of less than one-half of a wave length of the frequency at which it operates, said tower comprising a framework of conducting structural elements mechanically interconnected at different points to form a rigid structure, the mechanical interconnections at certain of said points being conducting and those at other of said points being non-conducting, said conducting and non-conducting interconnections being so disposed in said tower that a continuous conducting path along said tower is formed through said elements in succession, said path proceeding around the exterior of said tower through various structural elements in succession and in the same rotational sense in a direction upward of the tower.

3. A radiating tower structure having an actual height of less than one-half of a wave length of the frequency at which it operates, said tower comprising a framework of conducting structural elements mechanically interconnected at different points to form a rigid structure, the mechanical interconnections at certain of said points being conducting and those at other of said points being non-conducting, said conducting and non-conducting interconnections being so disposed in said tower that a continuous conducting path along said tower is formed through said elements in succession, said path having the general form of a coil with vertical axis thereby to increase the inductance per unit length of said tower, and high frequency apparatus connected between spaced points on said tower, there being sufficient turns of said coil between said points to excite said tower into electrical oscillation.

4. A radiating tower structure having an actual height of less than one-half of a wave length of the frequency at which it operates, said tower comprising a plurality of structural sections one above the other, each section comprising structural elements and mechanical interconnections at various points therebetween to form a unitary portion of the structural length of said tower exclusive of structural elements of any other section the mechanical connections at certain points being conducting and at other points being non-conducting, the conducting and non-conducting connections in each of said sections being disposed in said section to produce at least one continuous conducting path about said tower, and means interconnecting said sections in such a way that said path is substantially a continuous spiral throughout the various sections.

5. A radiating tower antenna having an actual height of less than one-half of a wave length of the frequency at which it operates, said tower antenna including a plurality of structural sections, each of said sections comprising substantially vertical conducting members, lateral bracing conducting members, insulating joints between certain ends of said members, and conducting joints between the other ends of said members, said members and said joints being arranged to provide inherent rigidity in each of said sections, and said conducting joints being so arranged as to form a continuous substantially spiral conducting path at least once around said antenna in each section, whereby the inductance of said antenna is increased.

EDWARD C. VROOMAN.