March 2, 1948. C. B. WATTS, JR., ET AL 2,436,843

RADIO ANTENNA

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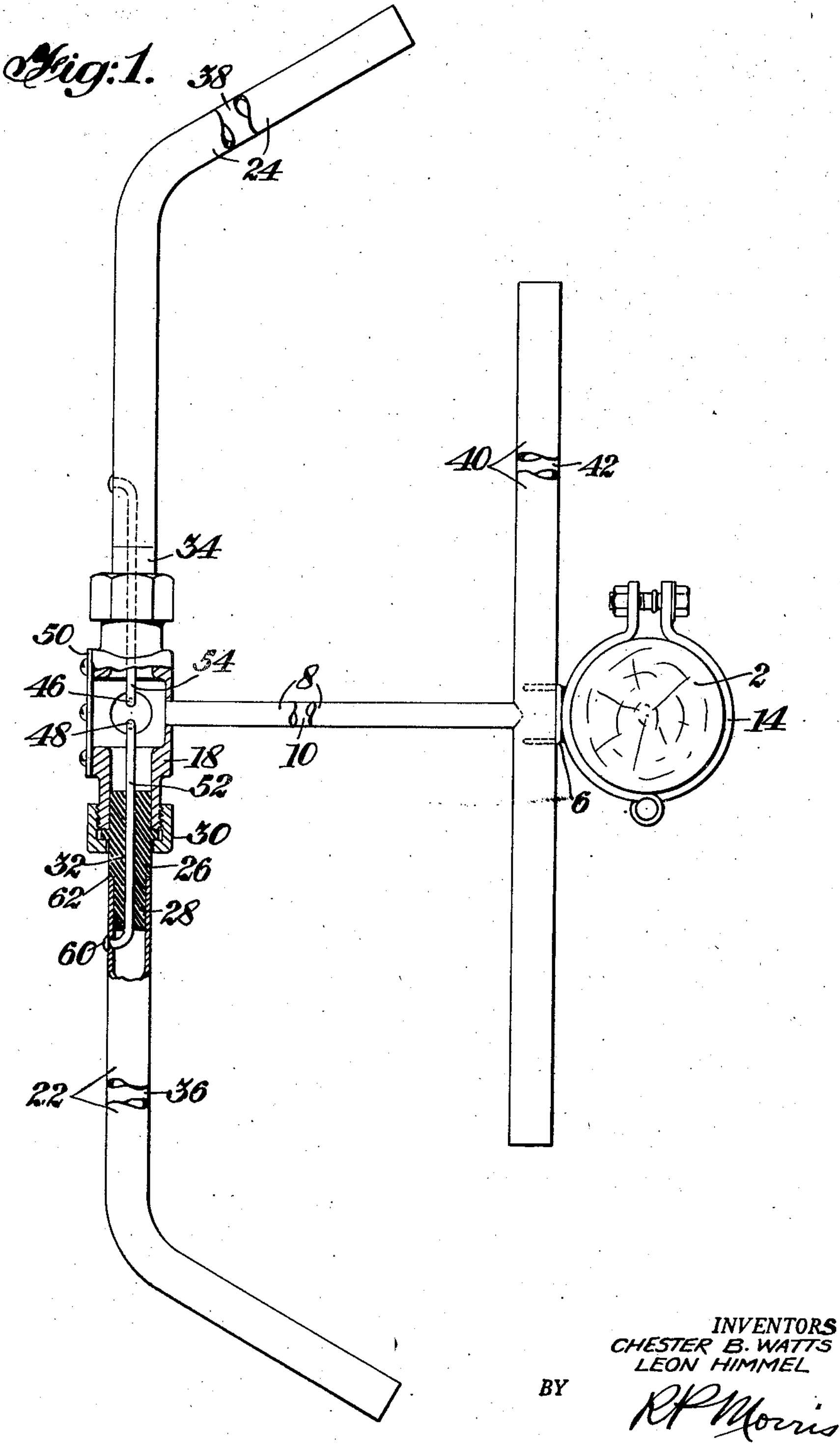
Fig: 1.



INVENTORS
CHESTER B. WATTS JR.
LEON HIMMEL

BY R P Morris

ATTORNEY

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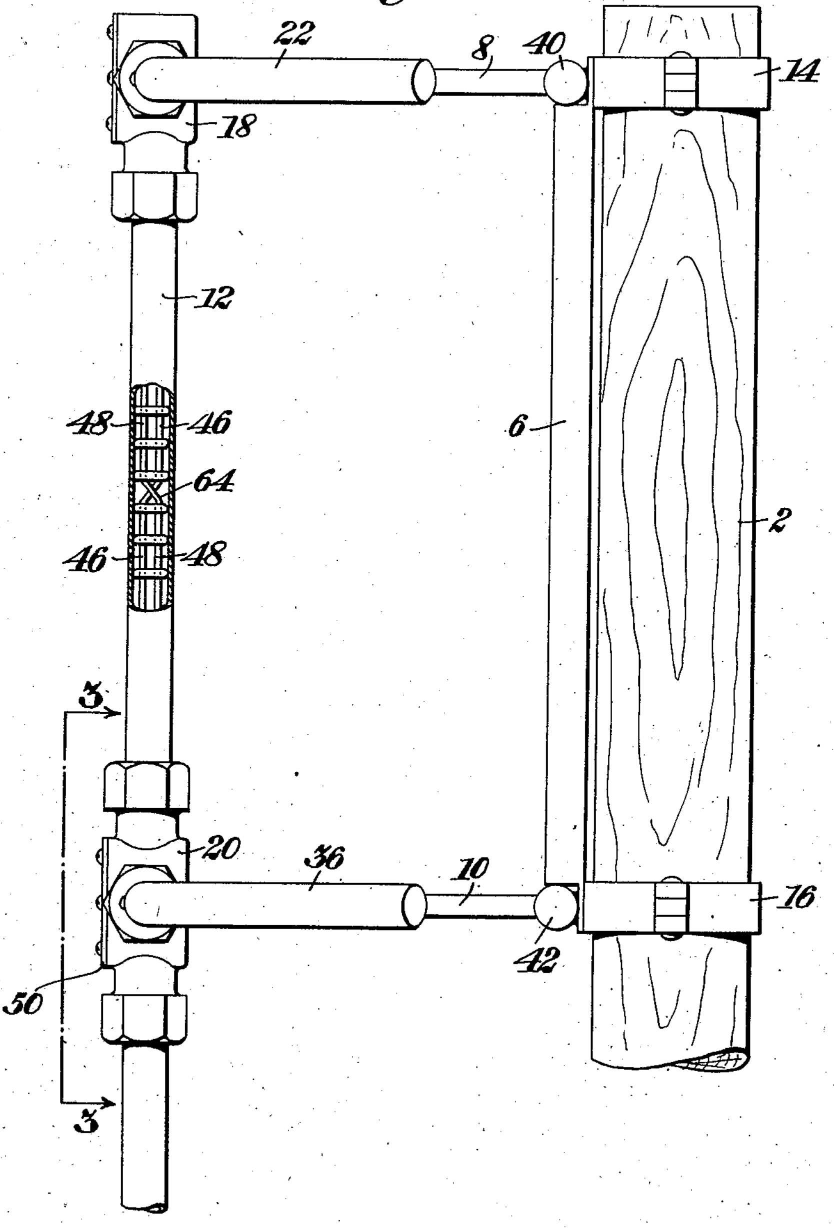
Fig:2.



INVENTORS
CHESTER B. WATTS JR.
LEON HIMMEL

BY RP Morris

ATTORNEY

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Fig: 3.

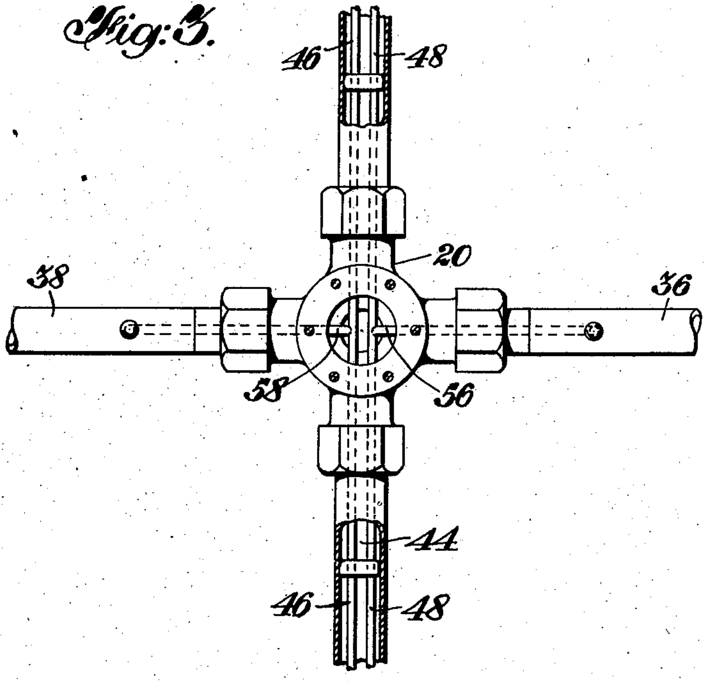
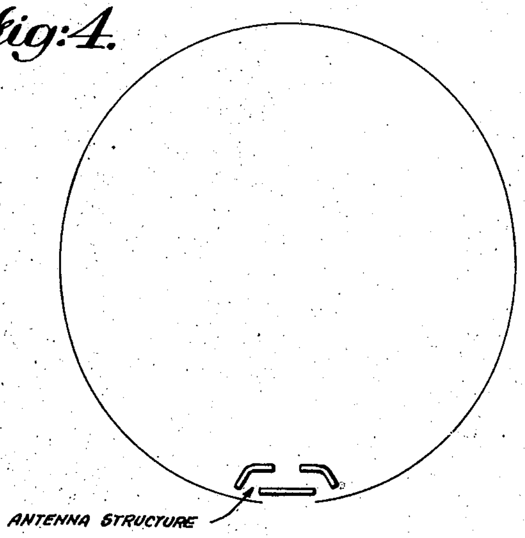


Fig: 4.



INVENTORS
CHESTER B. WATTS JR.
LEON HIMMEL

BY

ATTORNEY

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UNITED STATES PATENT OFFICE

2,436,843

RADIO ANTENNA

Chester B. Watts, Jr., East Orange, N. J., and
Leon Himmel, New York, N. Y., assignors to
Federal Telephone and Radio Corporation,
Newark, N. J., a corporation of Delaware

Application July 9, 1943, Serial No. 494,040

7 Claims. (Cl. 250—11)

This invention relates to radio antennas and in particular to directive antennas for operation at ultra-high frequencies.

An object of the invention is to provide a unitary antenna structure for operation at ultra-high frequencies.

Another object of the invention is to provide a directional antenna structure for radiating predominantly horizontally polarized waves.

A further object of the invention is to provide a directional antenna structure for radiating horizontally polarized waves whose energy is concentrated in a substantially horizontal plane.

A still further object of the invention is to provide an antenna system suitable for operation with a portable glide path transmitter.

These and other objects and features of our invention will be best understood from the following description of an embodiment thereof and as illustrated in the accompanying drawings, in which:

Figs. 1 and 2 are partially sectionalized plan and elevational views respectively of the antenna system of our invention.

Fig. 3 is a partially sectionalized view of the antenna structure as viewed from the plane 3—3 of Fig. 2, and

Fig. 4 illustrates a constant intensity field pattern in the horizontal plane resulting from radiation from our antenna structure.

The antenna structure of our invention is particularly useful in connection with portable instrument landing equipment such as is described in U. S. Alford Patent 2,294,882. This patent describes an antenna system for establishing a suitable glide path for the landing of aircraft in which two antennas are positioned one above the other in a manner such that the field patterns of the two antennas combine to produce the glide path. Both antennas operate on the same carrier frequency, but the radiation from each antenna is modulated at its own characteristic frequency and produces what is termed an equi-signal glide path. The antenna arrangement of our invention is particularly satisfactory for determining one of the field patterns of the glide path.

In the Alford patent above referred to, the radiation patterns resulting from each of the antennas disclosed therein are symmetrical, that is to say, the intensity of the radiated field is substantially equal in any two opposite directions from either antenna structure. However, the field pattern on one side only of the antenna system is employed for determining the glide path. The energy radiated from the opposite side of the antenna represents wasted energy, and furthermore, should there be any obstacles in the field of this energy, reflected radiation therefrom may produce deleterious effects such as undesired lobes of energy in the field of the desired glide

path. This problem of reradiation is very important in connection with portable equipment since an otherwise suitable location for a landing runway may be rendered unsuitable due to the reflections from objects located on the far side of the transmitter with respect to the runway.

With the antenna structure of our invention, the field pattern which determines the glide path extends substantially from one side only of the antenna and since there is little or no radiation from the opposite side, the problem of undesired reflections does not exist.

Referring now to Figs. 1 and 2, the reference character 2 represents a wooden mast or other supporting means for our antenna structure. A rectangular frame member composed of a spacing member 6, two supporting members 8 and 10, and a tubular member 12 supported on the mast 2 by two clamping devices 14 and 16 serves to mount the active radiating elements of our antenna system. Between the supporting members 8 and 10 and the tubular member 12 are positioned two junction boxes 18 and 20. These junction boxes may also be considered as part of the supporting structure and are for the purpose of assembling radiating antenna arms and a transmission line leading to said arms for energizing same.

Two bent antenna arms 22 and 24 are mounted on the junction box 18 in the manner shown by a sectionalized portion of Fig. 1. Referring to sectionalized portion, an insulating member 26 having a reduced portion 28 is pressed firmly within the tubular antenna arm 22. A nut 30 firmly clamps the antenna arm and insulating member 26 to the junction box 18 as illustrated. The insulating member 26 has a hole along the axis thereof through which a section of transmission line 32 extends as will be hereinafter described. The antenna arm 24 together with a second insulating member 34 is also clamped to the junction box 18 in a manner similar to that just described.

Two antenna arms 36 and 38, in all respects similar to antenna arms 22 and 24, are firmly clamped to the lower junction box 20 in exactly the same manner that the upper antenna arms 22 and 24 are clamped to the junction box 18. All antenna arms are insulated from their respective junction boxes by an insulating member similar to the member 26 described above.

The active portion of each antenna arm is substantially one-half wavelength at the operating frequency. Each arm is bent at a point approximately at its center in the manner shown so that the two inclined portions of any one arm includes an angle of substantially 120°. This angle is not critical and its exact value is subject to determination by experimentation. We have found, however, that in accordance with our invention an angle of substantially 120° produces the desired radiation pattern as illustrated in Fig. 4.

Also mounted on the antenna supporting structure are two linear reflecting elements **40** and **42**. In the construction illustrated, these reflecting elements in a sense actually form part of the supporting structures themselves since they are positioned between members **8** and **10** and the spacing member **6**. The reflectors **40** and **42** are preferably welded to the members **6**, **8** and **10** although other means of support could also be employed. The length of the reflecting elements **40** and **42** are substantially one-half wavelength at the operating frequency and these reflecting elements are positioned from the co-linear portions of the bent antenna elements approximately one-quarter wavelength at the operating frequency.

The above lengths which have been given in terms of wavelength are subject to some variation due to the fact that the electrical length of any radiating structure is usually somewhat greater than its actual physical length. This is due to end effects which tend to increase the electrical length of a radiating member.

The plane which is defined by the bent antenna arms **22** and **24** together with the reflector **40** is positioned substantially one-half wavelength from a parallel plane determined by the antenna arms **36** and **38** and the reflector **42**. The actual separation of these planes is determined by the requirement that radiation from all the antenna arms are substantially in phase coincidence. The upper and lower sets of antenna arms are energized from a balanced transmission line **44** comprising two conductors **46** and **48** as illustrated in Fig. 3, this latter figure being an elevational view of part of our antenna structure as viewed from the plane 3—3 in Fig. 2. The junction box **20** has its cover **50** removed to show the transmission line conductors within. The velocity of wave propagation along the line **44** is somewhat less than the velocity of wave propagation in free space and therefore that portion of the transmission line **44** extending between the upper and lower sets of antenna arms is somewhat less than a one-half wavelength at the operating frequency as determined by the length of a one-half wave in free space.

From a point on the transmission line conductors **46** and **48** within the junction boxes **18** and **20** are soldered or otherwise connected short lengths of transmission lines **52**, **54**, **56** and **58**. As illustrated in Fig. 1, the short length of transmission line **52** extends from conductor **48** to a point **60** on the antenna arm **22** where it is soldered or otherwise connected. The actual point of connection **60** is positioned from the end **62** of the arm **22** by an amount determined by the desired impedance match between the transmission line and the antenna arm **22**. All of the short lengths of transmission lines **52**, **54**, **56** and **58** are similarly connected to their respective antenna arms in the manner just described.

Since all antenna arms are energized in phase coincidence and since the spacing of the upper and lower arms is substantially one-half wavelength, it is necessary to have a crossover between the conductors **46** and **48** somewhere between the antenna arms, for example at the point **64** as shown in Fig. 2. By means of this crossover desired in phase voltages are applied to all of the antenna arms simultaneously.

Since the radiation from the upper antenna arms **22** and **24** is in phase with the radiation from the lower antenna arms **36** and **38** radiation in the vertical direction is very low. This radiation would be substantially zero were it not for the difference in wave propagation along the transmission line and the wave propagation in free space. Due to low downward radiation, wave reflections from the ground or from other objects which may be located beneath the antenna structure are greatly reduced. Likewise, since all antenna arms are radiating in phase coincidence, the field pattern produced by our antenna structure is a maximum in a general horizontal plane and to one side of the antenna structure due to the reflecting properties of the reflectors **40** and **42** as is well understood. Actually the surface of maximum radiation is not horizontal but inclines somewhat upwardly from the horizontal due to a certain amount of reflection from the earth's surface.

It is recognized that due to reflections from the ground resulting from the so-called mirror image of the antenna there generally will be several lobes of radiation in the vertical plane. It is the lower lobe which is usually employed in determining the field pattern for a glide path.

While we have described above the principles of our 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 our invention as set forth in the objects thereof and in the following claims.

We claim:

1. A directive antenna structure comprising two bent antenna arms lying in a common plane, the length of each arm being substantially one-half wavelength, each of said arms consisting of a first and a second portion inclined at an angle to each other, the first portion of one arm being colinear with the first portion of the other arm, a linear reflecting element, the length of said reflecting element being substantially one-half wavelength, said reflecting element being positioned substantially one-quarter wavelength from said colinear portions in said common plane and on the side of said colinear portions toward which said second portions extend, all of said lengths being in terms of the operating wavelength of said antenna system.

2. A directive antenna structure in accordance with claim 1 in combination with means for translating high frequency energy therewith, said translating means comprising a two conductor transmission line, one of said conductors being connected to one of said arms and the other conductor being connected to the other of said arms.

3. A directive antenna structure in accordance with claim 1 wherein the angle between the first and second portions of each of said antenna arms is substantially 120°.

4. In combination, a directive antenna structure and energizing means therefor, comprising two bent antenna arms lying in a common plane, the length of each arm being substantially one-half wavelength, each of said arms consisting of a first and a second portion inclined at an angle to each other, the first portion of one arm being colinear with the first portion of the other arm, a linear reflecting element, the length of said reflecting element being substantially one-half wavelength, said reflecting element being positioned substantially one-quarter wavelength from said colinear portions in said common plane and on the side of said colinear portions toward which

said second portions extend, all of said lengths being in terms of the operating wavelength of said antenna system, means for energizing said antenna arms, said energizing means comprising a balanced two conductor transmission line, one of said conductors being connected to one end of one of said arms, the other conductor being connected to the adjacent end of the other of said arms whereby the radiated waves from said antenna arms are in phase coincidence.

5. A directive antenna system in accordance with claim 4 in combination with a second substantially identical antenna structure as that recited in said claim, said second structure being positioned substantially one-half wavelength from the first named structure, and means for energizing said identical antenna structure in phase coincidence with the first named antenna structure, said energizing means comprising a transmission line perpendicular to the planes of each of said antenna structures.

6. A directive antenna system in accordance with claim 4 in combination with a substantially identical antenna structure as that recited in said claim, said substantially identical structure being positioned a plurality of quarter wavelengths from the first named antenna structure, the plane passing through said reflecting elements being substantially perpendicular to the planes passing through said antenna structures and means for energizing both antenna structures whereby radiation perpendicular to the plane of said antenna structures is substantially zero.

7. A directive antenna system comprising a frame member, two bent antenna arms lying in a common plane, the length of each arm being substantially one-half wavelength, each of said arms consisting of a first and a second portion inclined at an angle to each other, the first portion of one arm being colinear with the first portion of the other arm, a linear reflecting element conductively connected to said frame member, the length of said reflecting element being substantially one-half wavelength, said reflecting element being positioned substantially one-quarter wavelength from said colinear portions in said common plane and on the side of said colinear portions toward which said second portions extend, all of said lengths being in terms of the operating wavelength of said antenna structure, insulating means for connecting said antenna arms to said frame member and means for energizing said antenna arms at the adjacent ends thereof whereby said arms radiate in phase coincidence.

CHESTER B. WATTS, Jr.
LEON HIMMEL.

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