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Tacussel

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[54] **V-TYPE DIRECTIONAL ANTENNA**

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[52] **U.S. Cl.** **343/735;** 343/740; 343/809

[51] **Int. Cl.**^{2}..................... **H01Q 9/44;** H01Q 11/06

[58] **Field of Search** 343/731–740, 343/751, 792.5, 803, 804, 808, 809, 810, 343/811, 814

[56] **References Cited**

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[57] **ABSTRACT**

An antenna for highly directional radiation forming a narrow beam in a first plane and a wide beam in a second plane perpendicular to the first plane without back radiation and with minor lobes of low amplitude.

The antenna is formed by at least two basic V-antennas of which the radiators are respectively connected to each other by resistive loads attached about a quarter wavelength from the open ends of the radiators.

The antenna can be usefully employed for television reception and for intrusion detectors.

14 Claims, 7 Drawing Figures

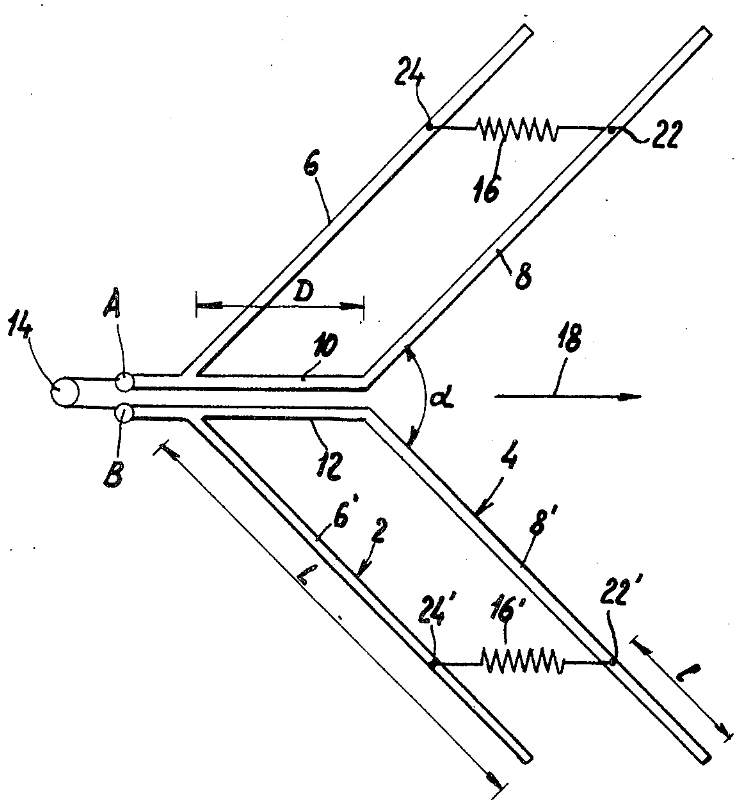


FIG.1

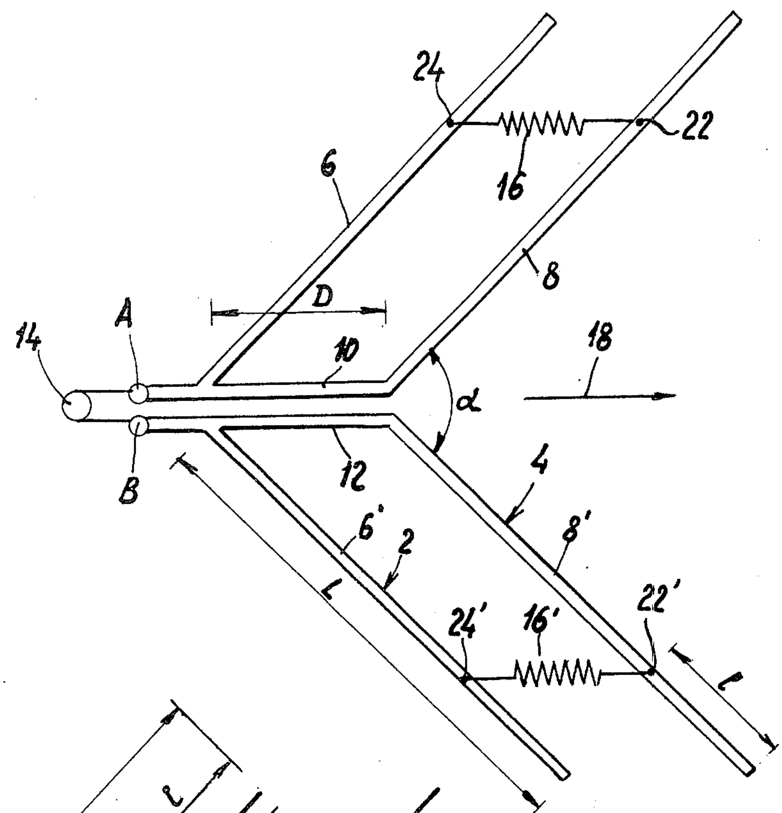


FIG.5

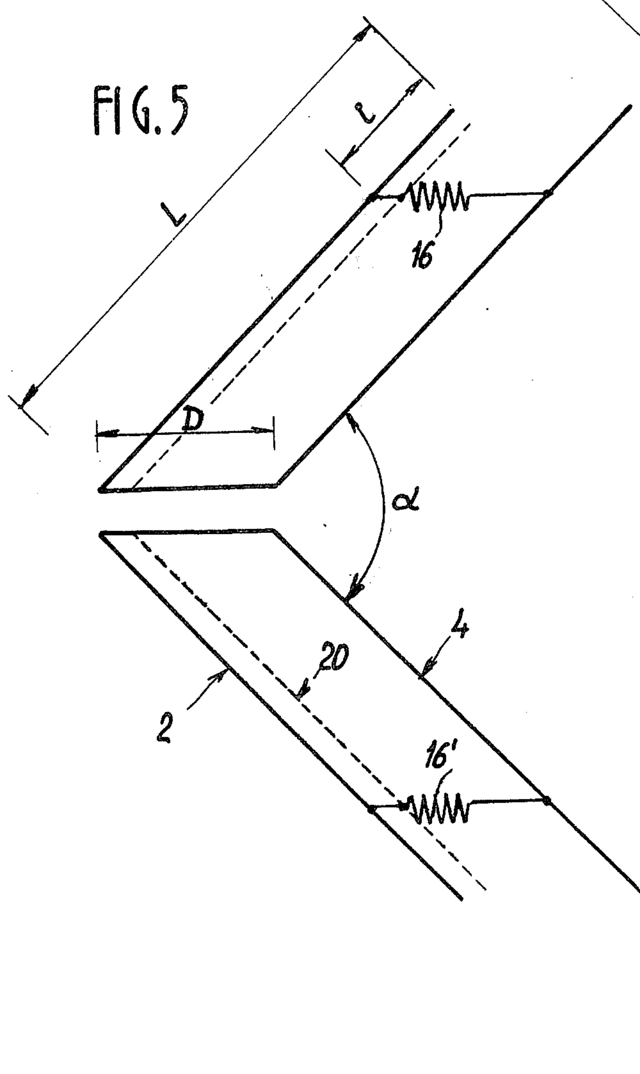
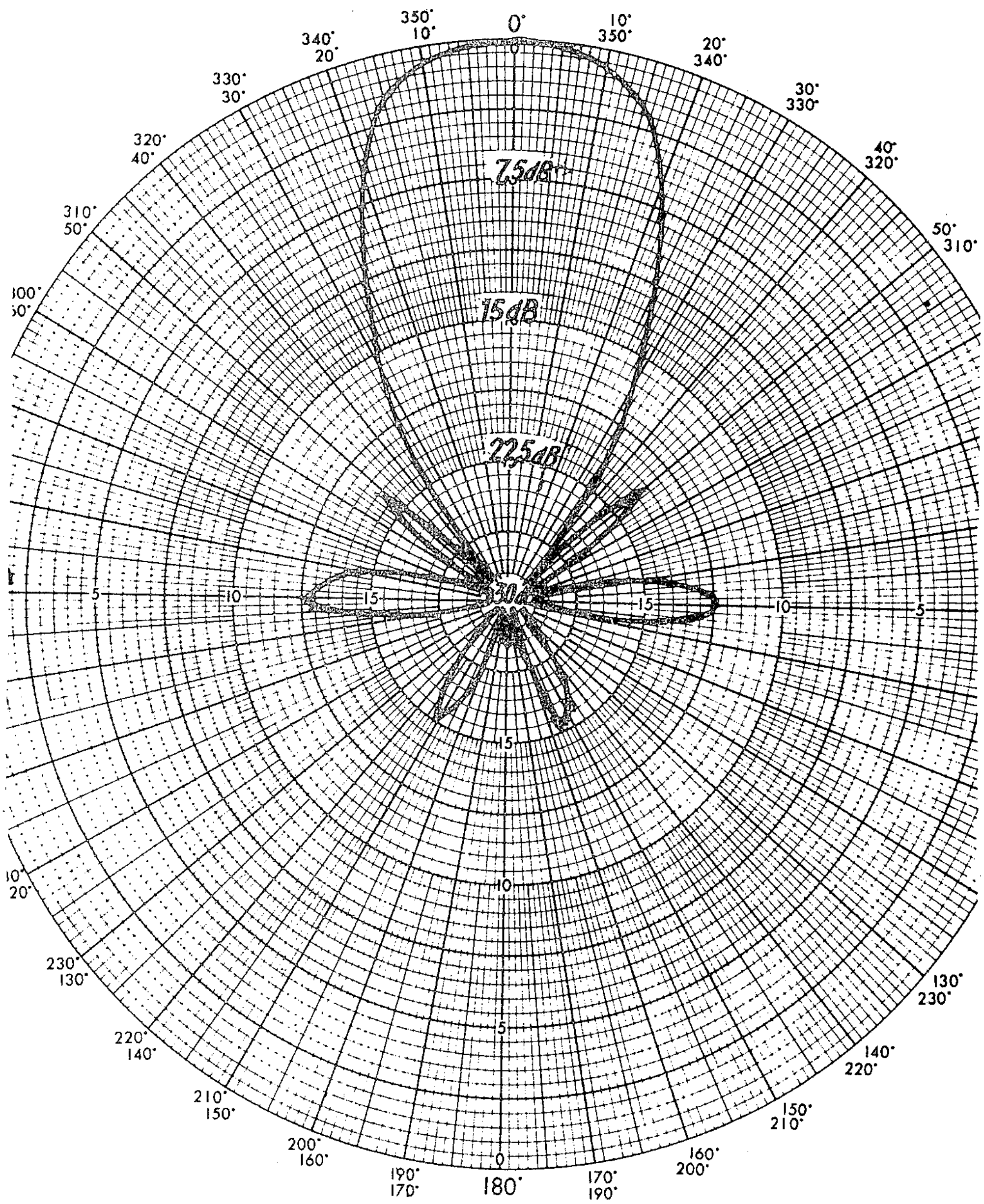


FIG. 2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210°
160°
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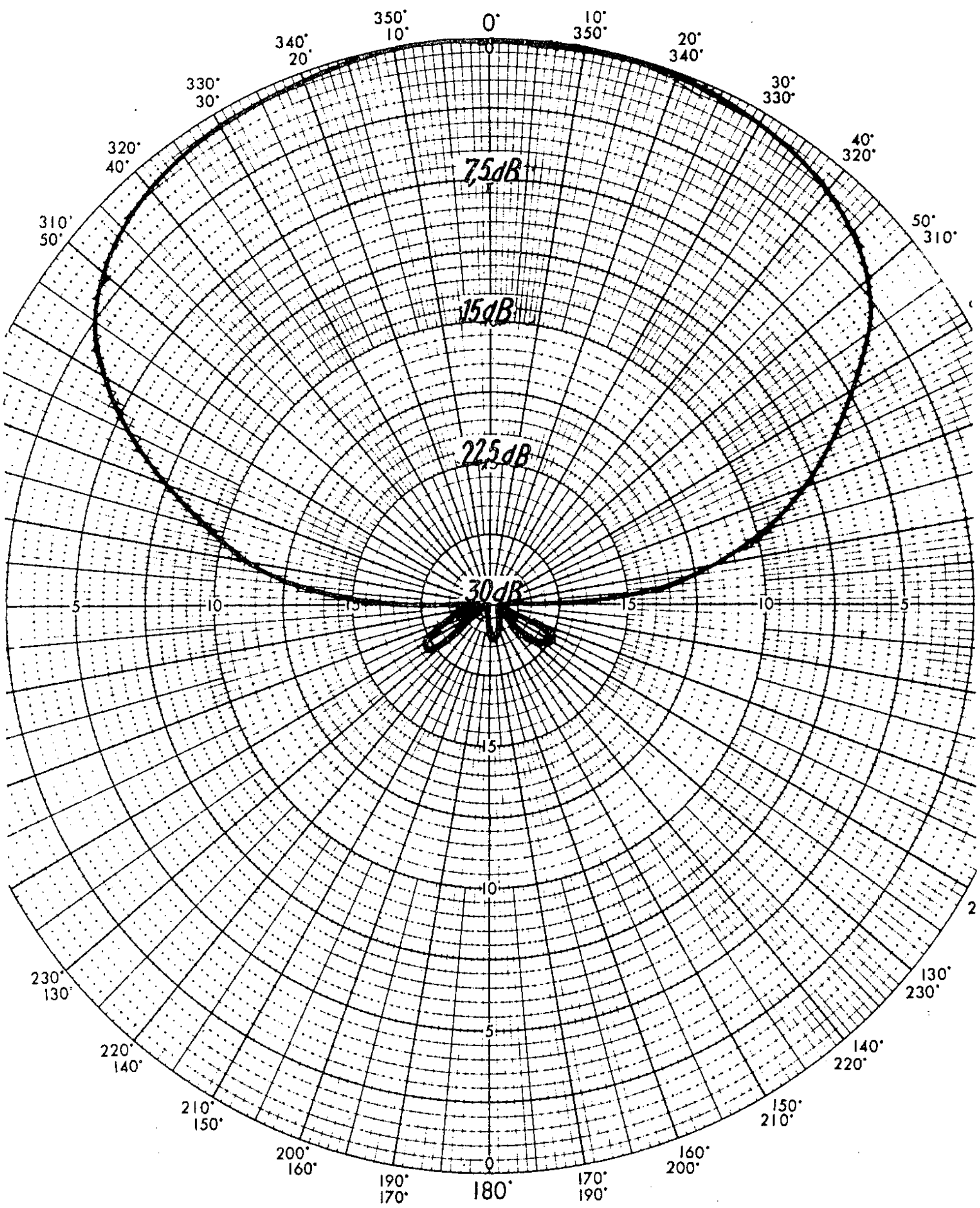
FIG. 3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22,5dB
30dB
230° 130°
220° 140°
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170° 190°
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150° 210°
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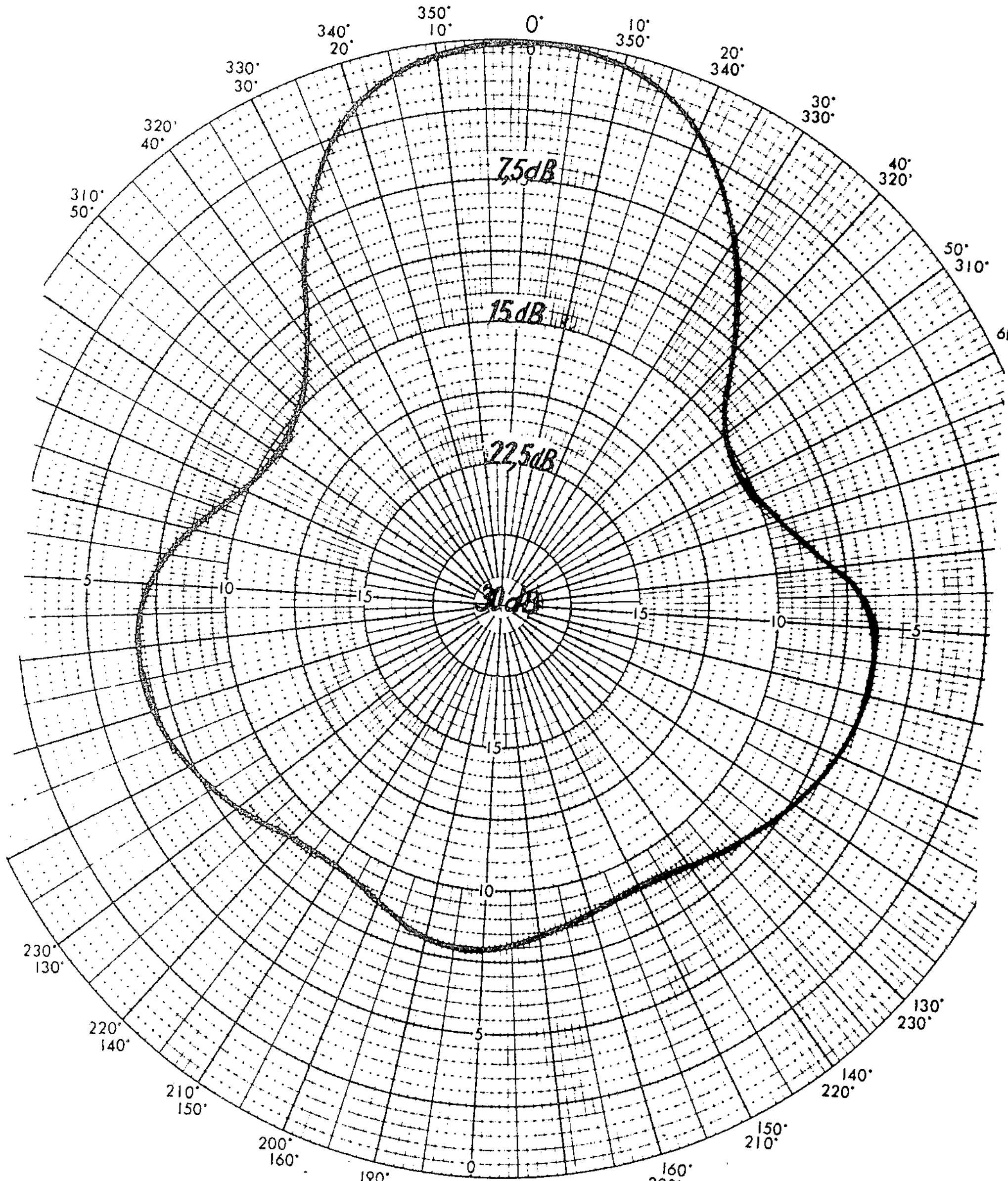
FIG. 4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130° 230°
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150° 210°
200° 160°
160° 200°
190° 170°
170° 190°
180°

FIG.6

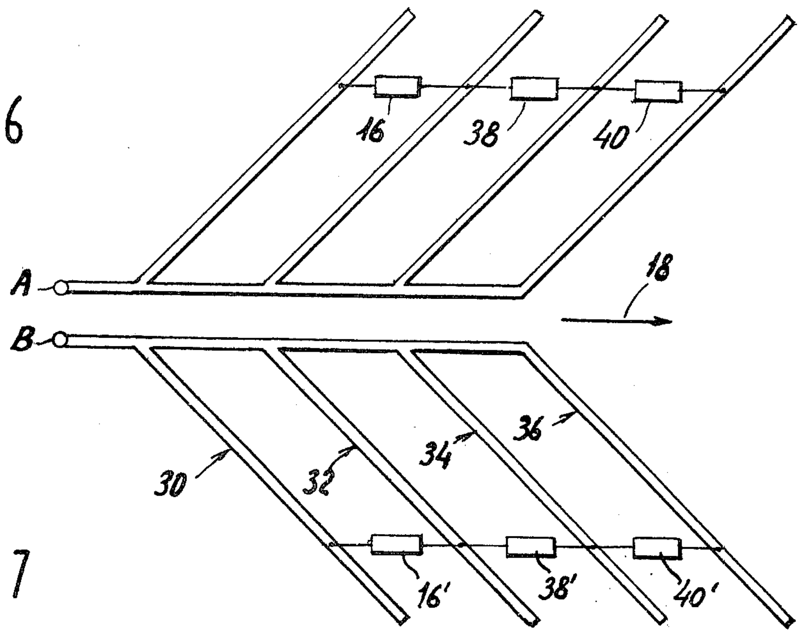
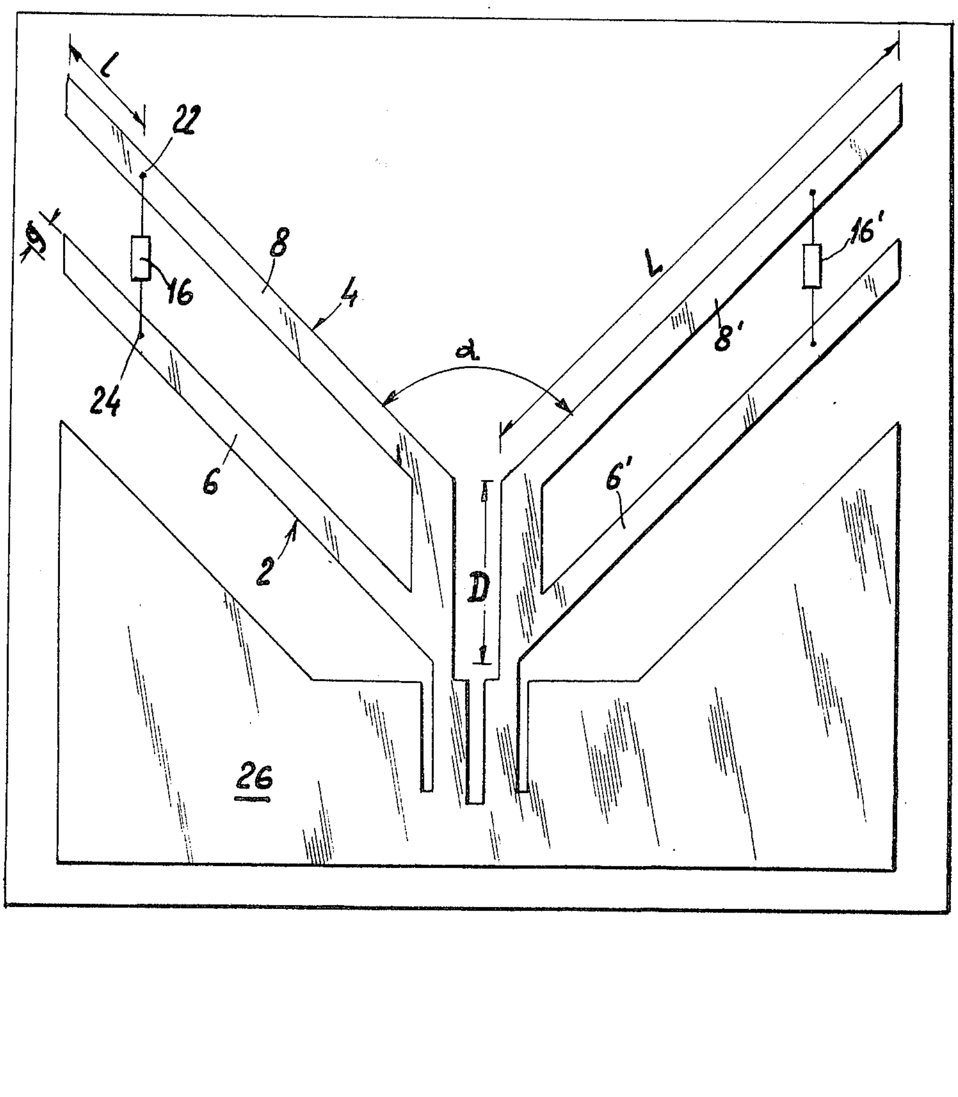


FIG.7



V-TYPE DIRECTIONAL ANTENNA

The present invention relates to a directional antenna wherein no back radiation exists and wherein the minor lobes are of small amplitude.

An antenna according to the present invention can be used for radiation and/or reception of electromagnetic signals at frequencies from hundreds of megahertz to more than a thousand megahertz.

Such an antenna is particularly adapted for use where high directivity is required, for example, in detecting apparatus for use in detecting presence or approach of a target and can be equally used for reception of VHF and UHF television transmissions.

An antenna is generally defined by its directive properties, its impedance, which must be matched to the supplying generator or to the receiver, and its ability to retain these characteristics over a wide frequency band.

Another characteristic, which depends on the type of antenna, is its efficiency, that is to say, the ratio between the transmitted or received energy in a given direction to the equivalent area of the antenna.

Different types of antenna exist which provide satisfactory characteristics but these are generally very complex.

When it is not necessary to use an antenna having high directivity a V-antenna can be used, the construction of which is simple.

The V-antenna is derived from a dipole antenna, the difference lying in that the radiators of several wavelengths in length, are disposed in V formation. The excitation source is placed in series with the two radiators at the vertex of the V (c.f. Antenna Engineering Hand Book Chapter 4-Jasik Editor — McGraw-Hill Book Company-1961).

To obtain maximum directivity, the vertex angle of the V is a function of the length of the radiators. The radiation diagram is bi-directional and has minor lobes of relatively high level when compared to the principal beam (approx.-6dB).

The bi-directional effect is due to the stationary wave condition which is set up in the radiators.

To obtain uni-directional radiation, several solutions have been proposed:

Firstly, longitudinal grouping of two or more antennas:

This solution, in spite of the difficulties encountered in minimising coupling effects between the antennas, allows the back radiation to be eliminated within a small range of frequencies about the tuned frequency of the group but does not suppress the minor lobes which are still important.

Secondly, setting up of a travelling wave condition on the radiators.

Several means have been used to obtain this result:

The insertion in series on each radiator at a distance of a quarter wavelength from the end of the radiator of a resistive load to absorb the wave reflected by the open end of the radiator (c.f. E. E. Altshuler. The travelling-wave linear antenna — I.R.E. transactions-Antennas and propogation—vol. AP-9 pp 324 to 329 —July, 1961).

Varying progressively the conductivity of a resistive element placed on the radiators in a manner that the wave is sufficiently attenuated at the ends of the radiators and thus reflections are small or nil (c.f. Liang —

Chi Shen I.E.E.E. transactions — Antennas and propogation—Sept., 1967—Vol. AP-15 No. 5 pages 606-611). However, these two solutions, while limiting the back radiation, result in a notable reduction in the gain of the antenna.

With the antenna according to the present invention, the back radiation is not only limited, but is practically suppressed without affecting the gain of the antenna.

According to the present invention there is provided a directional antenna comprising at least two longitudinally spaced dipole antennas each formed by a pair of radiators in V formation, the end of each radiator distant from the open end of the radiator being connected to the corresponding end of the radiator of the adjacent antenna and to one of the outputs of the antenna, wherein at least two adjacent antennas have corresponding radiators joined to each other by means of a resistive load connected to the radiators in the region of the open ends of the radiators.

In a preferred embodiment, only two basic identical antennas are used having straight radiators longitudinally spaced from each other by about a quarter of a wavelength of the central frequency of the operating band of the antenna.

In an antenna according to the invention good results are obtained if the value of the said resistive load is of the order of 400 to 800 ohms.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. **1** is a plan view of one embodiment of an antenna according to the present invention;

FIG. **2** is a radiation diagram in the plane of the radiators of the antenna of FIG. **1**;

FIG. **3** is a radiation diagram of the antenna of FIG. **1** but in a plane perpendicular to the plane of the radiators.

FIG. **4** is a radiation diagram, corresponding to FIG. **2**, of a known V-antenna;

FIGS. **5** and **6** show, in plan, other embodiments of the present invention; and

FIG. **7** shows an antenna according to the present invention formed by the photo-etching on a printed circuit board.

The antenna shown in FIG. **1** comprises two basic V-antennas **2** and **4** located in same plane.

The two antennas are longitudinally spaced by a distance D, the foot of the radiators **6** of the antenna **2** being connected to the foot of the corresponding radiator **8** of the antenna **4** by a connecting member **10** on which one of the outputs A of the antenna is located.

Similarly, the corresponding radiators **6'** and **8'** are connected by a connecting piece **12** having a second output B. The signal generator or receiver **14** for the antenna is connected to the terminals A and B.

According to the invention, the two antennas **2** and **4** have their corresponding radiators **6** and **8** connected to each other by a resistive load **16**, the two other corresponding radiators **6'** and **8'** being similarly connected by an identical resistive load **16'**. As can be seen from the figure, the connections of the resistances **16** and **16'** on the radiators are effected in the region of the open ends of the radiators, preferably at a distance, from their open ends, of about **0.2** to **0.4** of the length of the radiators.

The resistive loads **16** and **16'** serve to absorb the waves reflected from the ends of the radiators and also affect the distribution of currents on the radiators.

Thus, the longitudinal grouping of the two V-antennas results in a favourable current distribution and a travelling wave condition.

In order to form this longitudinal grouping, the two antennas **2** and **4** are separated by a distance D approximately equal to a quarter of the wavelength of the operating frequency this corresponding to about **0.30** to **0.45** of the length of a radiator, which, in turn, has a length of about **0.65** to **0.80** of the operating wavelength and, more specifically, between **0.7** to **0.75.**

An antenna, such as that shown in FIG. **1**, can be formed of rods or tubes assembled to make up the arrangement shown in the figure.

By way of example only, preferable dimensions for an antenna operating at a frequency f_o, of wavelength $\lambda_o$are:-

α	vertex angle of the V	90°
L	length of each radiator	0.75 λ_o
D	spacing between the two antennas	0.27 λ_o
d	diameter of each radiator	0.013 λ_o
e	spacing of connecting members 10 and 12	0.67 λ_o
l	distance between open ends of radiators and connections of resistive load	0.18 λ_o
R	value of resistances	680 ohms.

The value of connecting resistances **16** and **16'** is not critical and can be several hundreds of ohms. Similarly, the connecting pieces **10** and **12** between the two antennas do not have to have a precise characteristic impedance, a value of the order of between 200 and 300 ohms being preferable.

With a signal generator connected to the points A and B (FIG. 1) the radiation maximum is directed along the bisector **18** of the vertex angle V.

The radiation diagrams of this antenna are shown at FIGS. **2** and **3**, that of FIG. **2** being in a plane containing the radiators and that of FIG. **2** being a plane perpendicular to this plane.

The diagrams are limited to a frequency band within 7.5% of the central frequency.

The impedance of the antenna is constant within this band and the gain of the antenna is about **+10dB** at the highest frequency of the band.

By way of comparison, FIG. **4** shows the radiation diagram in the plane of the radiators of a known two radiator V-antenna, the so-called resistive-radiator-antenna, wherein the radiators have a length equal to one wavelength, and wherein the conductivity of a resistive element on the radiators is made to vary progressively. A known antenna of this type has been cited in the introduction of the specification.

Comparison of the radiation diagrams of the resistive-radiator V-antenna of FIG. **4** and that of FIG. **2** shows that the proposed antenna has, for example, greater directivity despite having shorter radiators — **0.75**λ_o instead of **1**λ_o. In particular, the beam width at half power is narrower, the nulls are more pronounced, the minor lobes are less than 10dB and the back radiation is practically non-existent.

These improvements are maintained for different lengths of the radiators, it being sufficient in this case to vary the vertex angle of the V so that the radiation maxima of each radiator coincide.

In the modification shown in FIG. **5**, a third basic Vantenna **20** is placed between the two antennas **2** and **4**, this additional antenna being shown in dotted lines in the figure. In this case, the spacing D between the two antennas **2** and **4** is still of the order of a quarter of a wavelength (for example 0.27λ_o as in the example cited above), whereas the spacing f between the antenna **2** and additional antenna **20** can be about one-sixteenth of a wavelength. The connections for the resistive loads **16** and **16'** are attached, as shown in the figure, to the three radiators of the antennas **2, 4** and **20,** the distance between the connection point of the resistive load and the end of the corresponding radiator being of the order of 0.15 and 0.25 of a wavelength, similar to the case where only two antennas are used.

Substantially identical results can be obtained from a two V-antenna group having different radiator lengths and vertex angles. The location of the connecting points **22, 24 22'** and **24'** (FIG. **1**) of the resistances is determined as described hereinbelow.

A large number of V-antennas, for example, four antennas **30, 32, 34** and **36** can be grouped in the same manner as for two antennas (FIG. **6**) with resistances **16,38,40, 16', 38', 40'**. With this configuration, a narrower radiation diagram at half power is obtained. The V-antennas are not necessarily made up of straight radiators and changes in direction along the lengths of the radiators can be introduced. For low frequencies, in the order of some hundreds of megahertz, the antenna can be made up a number of hollow or solid rods as shown in FIG. **1.** At higher frequencies (1000 MHz and above), the antenna can be formed from metal stampings.

At high frequencies, the antenna can be formed by photoetching on metal foil on an insulating substrate. This procedure is often used in printed circuitry in electronic equipment. An example is shown in FIG. **7**, wherein the antenna and the equaliser are incorporated on the same circuit thus allowing the antenna to be powered through a coaxial cable or an unmatched power source.

The dimensions of such an antenna, operating at a wavelength λ_o can be, for example:-

α	vertex angle of the V	90°
L	length of each radiator	0.69 λ_o
D	spacing between the two antennas	0.28 λ_o
g	width of each radiator	0.05 λ_o
e	distance between free ends of the radiators and connections of the resistive load	0.18 λ_o

Thus, an antenna for use with frequencies around 2,500 MHz can be obtained by photo-etching on printed circuit board of dimensions 160 × 140 mm.

Preferably, a conducting portion **26** is left on the board, sufficiently spaced from the radiators **6** and **6'** so as not to influence the radiation of the antenna but allowing direct connection, in keeping with known printed circuit techniques, of, for example, the terminals (not shown) of the transmitter and/or receiver associated with the antenna. It will be understood that certain of the circuits can be printed on the reverse of the board carrying the antenna.

The antenna according to the invention can be put to numerous uses:

It can be advantageously used for reception of television transmissions in place of the low output YAGI type antenna.

Further, its impedence varies only slightly with change in frequency and it can therefore be used with frequencies which are lower than that for which the antenna was designed if high directivity radiation is not always required for low frequencies. In particular, the antennas shown, for example, in FIGS. 1 and 5 can be used in rural regions for reception of VHF television transmissions and also for UHF transmissions, the indicated dimensions being adapted for the central frequency of the UHF transmissions.

Radiation diagrams, narrow in one plane and wide in the other, and the high gain of the antenna are characteristics which render the antenna particularly adapted for use as detecting apparatus operating at very high frequencies.

In effect, such an antenna is simple to manufacture and has a waveform diagram suited to this type of apparatus. It can cover in a horizontal plane, a wide area while having a substantially narrow beam width in the vertical plane. The narrow bean in the vertical plane eliminates false alarms in the case of use of the apparatus in old multi-storey buildings wherein floors and ceilings generally made of wood, are partially transparent to electromagnetic radiation.

The antenna according to the present invention can be used as the basic element in the formation of an antenna system.

It will be understood that the invention is not limited to the embodiments described and shown, and can be modified by the inclusion of variations known in the art according to particular applications, and without departing from the spirit of the invention.

What is claimed is:

1. A directional antenna comprising at least two longitudinally spaced dipole antennas each formed by a pair of radiators in V formation, the end of each radiator distant from the open end of the radiator being connected to the corresponding end of the radiator of the adjacent antenna and to one of the outputs of the antenna, wherein at least two adjacent antennas have a resistive load directly connected between their corresponding radiators in the region spaced from the open ends of the radiators.

2. An antenna as claimed in claim **1**, wherein the said radiators are straight.

3. An antenna as claimed in claim **2**, wherein the length of the radiators are identical.

4. An antenna as claimed in claim **1**, wherein the vertex angles of the V of each of the antennas are identical.

5. An antenna as claimed in claim **1**, wherein the longitudinal spacing between the two antennas is between **0.30** and **0.45** times the length of a radiator.

6. An antenna as claimed in claim **1**, wherein the vertex angle of the V formed by the two radiators of the antenna is about 90°.

7. An antenna as claimed in claim **1**, wherein the said radiators are made up of rods.

8. An antenna as claimed in claim **1**, wherein the said radiators are made up of tubes.

9. An antenna as claimed in claim **1**, wherein the antenna is formed by stamping from a metal plate.

10. An antenna as claimed in claim **1**, wherein the antenna is formed by photo-etching of a metal sheet on an insulating substrate.

11. An antenna as claimed in claim **10**, wherein located adjacent the base of the antenna, a conducting portion is formed from the metallic plate, the conducting portion being adapted to receive connections from electrical elements associated with the antenna.

12. A directional antenna comprising at least two longitudinally spaced dipole antennas each formed by a pair of radiators in V formation, the end of each radiator distant from the open end of the radiator being connected to the corresponding end of the radiator of the adjacent antenna and to one of the outputs of the antenna, wherein at least two adjacent antennas have a resistive load connected between their corresponding radiators, said load located on each of the said radiators at a distance from the open ends of the radiator of about 0.2 to 0.4 times the length of the radiator.

13. An antenna as claimed in claim **1**, wherein the length of each radiator is between 0.65 and 1.0 times the wavelength of the central frequency of the operating band of the antenna and wherein the connecting points of the said resistive load are located, in relation to the open end of the corresponding radiator at a distance of between 0.15 and 0.25 times said wavelength.

14. An antenna as claimed in claim **12**, wherein the said resistive load has a value of several hundreds of ohms.

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