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V. F. CLIFFORD ET AL

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WIDEBAND FOLDED MONOPOLE ANTENNA

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2 Sheets-Sheet 1

Fig. 1

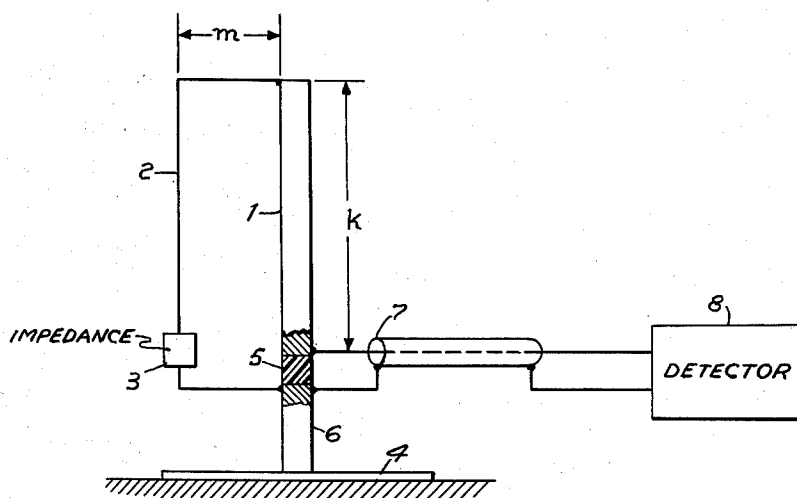
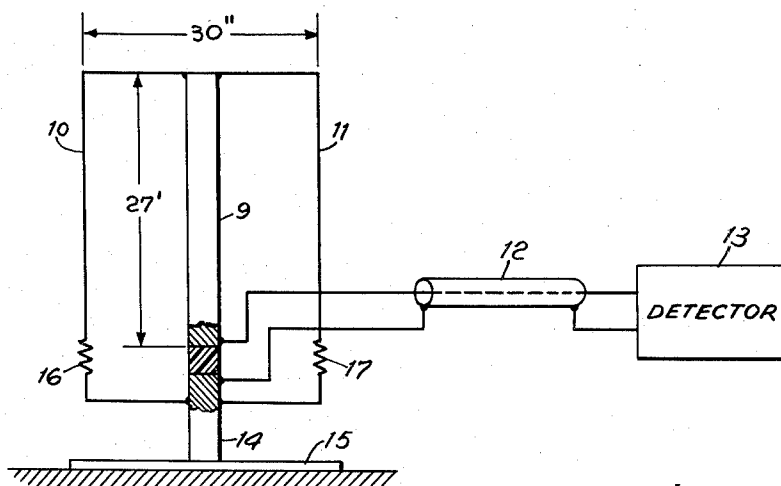


Fig. 2



Inventors
VERNON F. CLIFFORD
SEYMOUR A. COTTLER
GEORGES A. DECHAMPS
By *Philip M. Bolton*
Attorney

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V. F. CLIFFORD ET AL

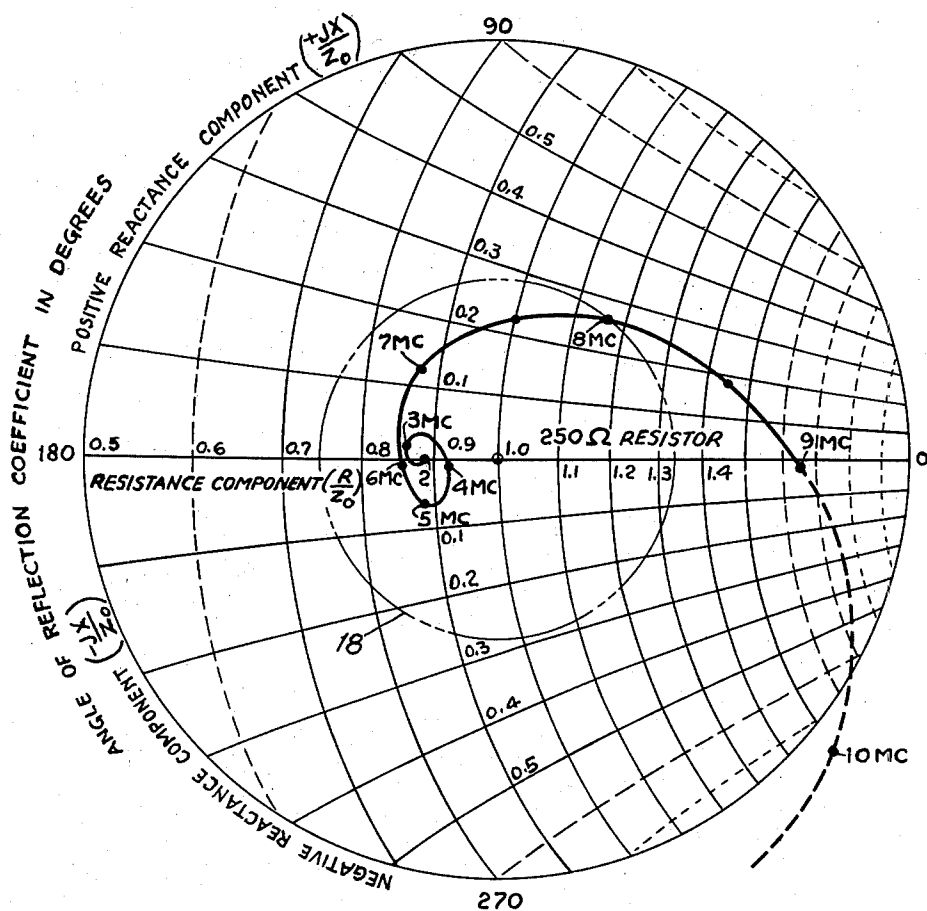
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Fig. 3



Inventors
VERNON F. CLIFFORD
SEYMOUR A. COTTLER
GEORGES A. DECHAMPS
By *Philip M. Bolton*
Attorney

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WIDEBAND FOLDED MONOPOLE ANTENNA

Vernon F. Clifford, Islet Terrace, Seymour A. Cottler, North Babylon, and Georges A. Deschamps, New York, N.Y., assignors to International Telephone and Telegraph Corporation, Nutley, N.J., a corporation of Maryland

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7 Claims. (Cl. 343-749)

This invention relates to a short-wave transmitting or receiving antenna and more particularly to a new antenna design of the folded monopole type possessing certain desirable characteristics due to the novel design of the antenna.

In a direction finder system consisting of a plurality of antennas, such as in an Adcock system, it is desirable that the impedance of each antenna match the characteristic impedance of its transmission line over a wide frequency range, as this results in a low standing wave voltage ratio and, thus, low losses in the transmission line over the wide frequency range. In such systems it is also desirable that each antenna be mechanically simple, essentially self-supporting and be of minimum height. In the past, antennas employed in direction finder systems having these desirable characteristics have consisted of adjustable elements or adjustable impedance matching devices or both. These adjustable elements or adjustable impedance matching devices were essential to tune the antenna over the desirable wide frequency range, yielding a low standing wave voltage ratio in the transmission line, by maintaining minimum antenna impedance variation over the wide frequency range.

It is the principal object of this invention to provide a mechanically simple antenna comprised of fixed components and having a limited variation of impedance over a wide frequency range, for example, over a 4 to 1 band of frequencies.

It is a further object of this invention to provide a mechanically simple, essentially self-supporting antenna requiring no adjustable elements or adjustable devices to tune it over a wide frequency range so that standing wave voltage ratio in the antenna transmission line remains low over the same wide frequency range.

It is a further object of this invention to provide a fixed vertical, essentially self-supporting antenna having low response to horizontally polarized radiation, and particularly having a maximum impedance variation ratio of 2 to 1 over the frequency range of 2 to 8 megacycles.

It is a preferred feature of our invention to provide an essentially self-supporting vertical antenna consisting of one member having a relatively large crosswise dimension and one or more parallel folded members, each having a relatively small crosswise dimension and each coupled at its one end to the top of said driven member and at its other end to a terminating impedance which is grounded.

In accordance with another preferred feature of this invention, the bottom end of said one member having a relatively large crosswise dimension is coupled directly to a transmission line and is insulated from the ground potential.

The above and other objects and features of our invention will best be understood by referring to the following detailed specification chosen by way of illumination and not limitation and by referring to the accompanying drawings, in which:

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Fig. 1 depicts a terminated folded monopole antenna for operation over a wide frequency range;

Fig. 2 depicts a terminated folded monopole antenna for use in a direction finder system over the frequency range 2 to 8 megacycles; and

Fig. 3 is the center section of a Smith impedance diagram for the antenna shown in Fig. 2.

Referring first to Fig. 1, there is shown a wideband terminated folded monopole antenna comprised of a relatively heavy driven member 1 and a relatively light parallel folded member 2 orientated parallel with and located a distance m from member 1. Folded member 2 is terminated at a grounded impedance 3. The base of driven member 1 is insulated from and physically raised above the ground plane 4 by insulator 5, which is mounted on supporting conductor post 6. Post 6 is grounded by ground plane 4. Driven member 1 is electrically coupled at its bottom end to one element of transmission line 7, which has a characteristic impedance of Z_0 . The other element of transmission line 7 is electrically coupled to supporting conductor post 6 and thus to ground. A signal detection network or frequency generator (depending on whether the antenna is employed to receive or transmit), denoted by 8, is electrically coupled to transmission line 7 so that line 7 can be matched if terminated by its characteristic impedance Z_0 .

The antenna shown in Fig. 1 may be employed to transmit or receive a wide band of selected frequencies. In order to achieve minimum antenna impedance change and a low standing wave voltage ratio over the selected band of frequencies, it is required that the length of member 1, denoted by the dimension k be slightly less than one-quarter wavelength of the highest frequency in the selected band of frequencies and that the cross-section dimensions of driven member 1 and parallel member 2 and the distance m between these members must be adjusted so that the resistive component of impedance of the complete antenna, in conjunction with its terminating impedance 3, is very nearly equal to the characteristic impedance, Z_0 of the transmission line when the antenna is energized by the middle frequency of the chosen frequency range. If these dimensions and terminating impedance 3 are properly chosen, there will be a minimum variation in the antenna impedance, and standing wave voltage ratio will remain low over the chosen frequency range.

Referring now to Fig. 2, there is shown a terminated folded monopole type antenna having two parallel members, each terminated by separate resistances of the same value. This antenna is designed for wideband operation and has an impedance variation of less than two to one over the frequency range 2 to 8 megacycles and has low response to horizontal polarization. It is comprised of a relatively heavy driven member 9 and two relatively light parallel folded members 10 and 11. Driven member 9 is preferably 27 feet long and 4 inches in cross-section diameter while parallel members 10 and 11, which are in the same vertical plane as member 9, are each preferably $\frac{1}{4}$ inch in cross-section diameter. Parallel members 10 and 11 are also parallel to member 9 and each is separated approximately 15 inches from member 9. Driven member 9 is energized by one element of transmission line 12, which has a characteristic impedance of 250 ohms and is electrically coupled to detector 13. The other element of transmission line 12 is coupled to supporting conductor post 14, which is grounded to ground plane 15. Each of parallel members 10 and 11 is coupled at its upper end directly to driven member 9 and its lower end to a separate terminating resistor which terminates the member to ground.

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Parallel member 10 is coupled to 400 ohms terminating resistor 16, and parallel member 11 is coupled to 400 ohms terminating resistor 17. Supporting conductor post 14 is of an appropriate length to physically raise the antenna to a desirable height which may be required by local conditions of terrain or the possibility of ground flooding.

In Fig. 3 there is shown the center section of a Smith antenna impedance chart on which are plotted the reactive and resistive components of impedance of the antenna shown in Fig. 2 when operated over the frequency range 2 to 8 megacycles and above 8 megacycles. Circle 18 originating from the point of perfect match between antenna impedance and transmission line encompasses all values of antenna impedance for which the standing wave voltage ratio in transmission line 12 will be no greater than 2. A derivation of the Smith impedance diagram and description of its use may be found in section 2.8, volume 12 (Microwave Antenna Theory and Design, by Silver) of the MIT Radiation Laboratory Series. As can be seen, the antenna impedance for all frequencies between 2 and 8 megacycles falls within this circle, indicating that the standing wave voltage ratio in transmission line 12 will not exceed the value 2 when the antenna is operated over this frequency range.

The antenna shown in Fig. 2 is particularly suited for use in an Adcock array consisting of a plurality of such antennas arranged symmetrically in a circle so that each of the two parallel members and the driven member of an antenna lie in one and the same vertical radial plane emanating from the center of the array. Application of this invention is also advantageous where a broadband antenna creating a low standing wave voltage ratio over its band of operating frequencies is desired.

While we have described one specific antenna structure by way of illustration, many variations in the details thereof may be had without departing from the scope of our invention. For instance, the number of parallel folded members, the distance between parallel folded members and the driven member, the relative cross-sectional dimensions of the driven member and the parallel folded members, and the value of each terminating impedance terminating each folded member to ground may be appropriately varied to achieve a desirable low standing wave voltage ratio when the antenna is operated over a chosen wide band of frequencies. The specific description shown here is by way of example and is not intended as a limitation of our invention as set forth in the objects thereof and in the accompanying claims.

We claim:

1. An antenna having at least two radiating elements the dimensions of which are suitably chosen for relatively wide frequency band operation, one only of said elements being substantially forty times thicker than the others and coupled directly at one end to a transmission line the remaining of said elements each being coupled to the other end of said one element and to a separate impedance which is grounded, the general arrangement, relative thickness of said elements and value of each of said impedances being such that an impedance match is provided between said antenna and said transmission line.

2. An antenna having at least two radiating elements the dimensions of which are suitably chosen for operation over a predetermined frequency band, one only of said elements being coupled directly to a transmission line the remaining of said elements being substantially one fortieth as thick as said one element and each coupled at its one end of said one element and at its other end to a different impedance, which is terminated to ground, the general arrangement and dimensions of said elements and the value of said impedance being such that the impedance of said antenna does not vary beyond predetermined limits when the antenna is energized within said predetermined frequency band.

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3. An antenna of the folded monopole type for use over a wide band of frequencies comprising a first member whose length is substantially one quarter wavelength of the highest frequency in said predetermined band and is coupled directly at its one end to a transmission line and at its other end to at least one folded member, each folded member having a cross-sectional area substantially one sixteen hundredth as great as said first member and of substantially the same length as said first member and being terminated to ground by an impedance, the general arrangement relative cross-sectional areas of said first member and said folded members and the value of each of said impedances being such that the impedance of said antenna does not vary beyond predetermined limits when said antenna is energized over said predetermined band of frequencies.

4. An antenna of the folded monopole type for use over a predetermined frequency band comprising a first member having a length essentially one quarter wavelength of the highest frequency in said predetermined frequency band coupled directly at its one end to a transmission line and at its other end to at least one folded member of essentially the same length as said first member and arranged parallel with said first member, the ratio of cross-sectional areas of said first member to each folded member being substantially sixteen hundred each of said folded members being terminated to ground by at least one impedance, the arrangement and size of said members, and said impedance comprising said antenna being such that the impedance of said transmission line is essentially matched by the impedance of said antenna when said antenna is energized over said predetermined wide band of frequencies.

5. An up-standing folded monopole type antenna for use over a wide frequency range having low response to horizontally polarized radiation and comprising a first up-standing member coupled at its one end to a transmission line having a fixed characteristic impedance and coupled at its other end to at least one folded member which is parallel to said first member and is terminated to ground by a suitably chosen impedance, said first member having a cross-sectional area hundreds of times greater than said folded members, the arrangement and size of said members and the value of said impedance being such that the impedance characteristics of said antenna essentially match the characteristic impedance of said transmission line when the antenna is energized by frequencies within said wide band of frequencies.

6. An up-standing folded monopole type antenna whose impedance does not vary beyond chosen limits when said antenna is energized by a signal whose frequency is varied over a chosen band of frequencies and which has low response to horizontally polarized radiation, comprising a driven member whose length is fixed and essentially equal to one quarter wavelength of the highest frequency in said chosen band of frequencies, at least one folded member orientated parallel to and separated considerably less than one quarter wavelength from said driven member, said driven member having a cross-sectional area approximately sixteen hundred times as great as each of said folded members, a different impedance terminating the bottom end of each folded member to ground and coupling means to couple the signal transmitting element of a transmission line to the bottom end of said driven member and wherein the size of said driven member, the size of each folded member, said chosen distance and the value of each impedance are chosen and fixed so that the impedance of said antenna matches the characteristic impedance of said transmission line within chosen limits when said antenna is energized by a signal whose frequency is varied over said chosen band of frequencies.

7. A terminated folded monopole antenna for use over a band of frequencies whose extreme values are in the ratio of four to one having an impedance at each of said

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frequency extremes in a ratio of no more than two to one comprising an up-standing cylindrical driven member having a length to diameter ratio of approximately seventy five and a length one quarter wavelength of the highest frequency in said band of frequencies, at least one folded member being of the same length and one-fortieth the diameter of said driven member and having one part oriented parallel to and another part coupled to the top of said driven member, said other part separated approximately one hundredth of a wavelength of said highest frequency from said driven member, a different impedance terminating the bottom end of each folded member to ground and coupling means coupling a transmission line to the bottom end of said driven member, the arrangement and size of said members and the value of said impedances being such that the imped-

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ance of said antenna at said frequency extremes are in a ratio of no more than two to one.

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