

June 14, 1960

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ANTENNA MOUNT

2,941,204

Filed June 16, 1955

2 Sheets-Sheet 1

FIG. 1.

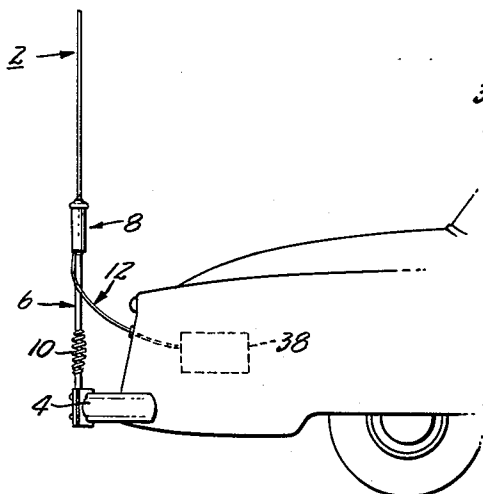


FIG. 2.

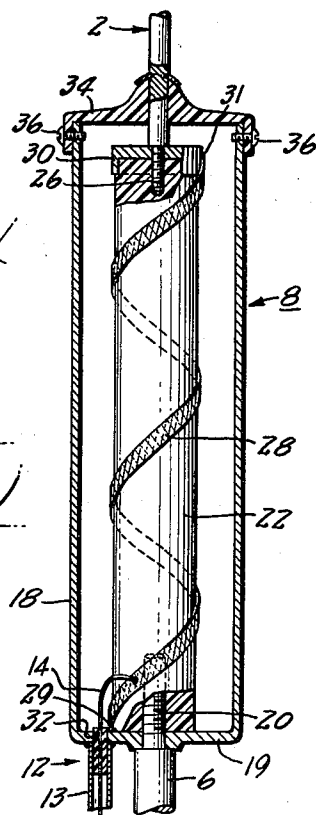


FIG. 4.

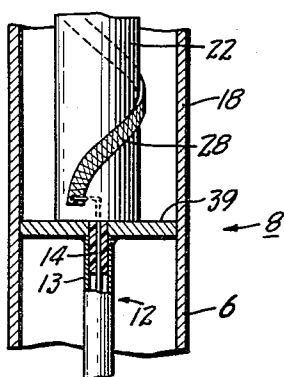


FIG. 5.

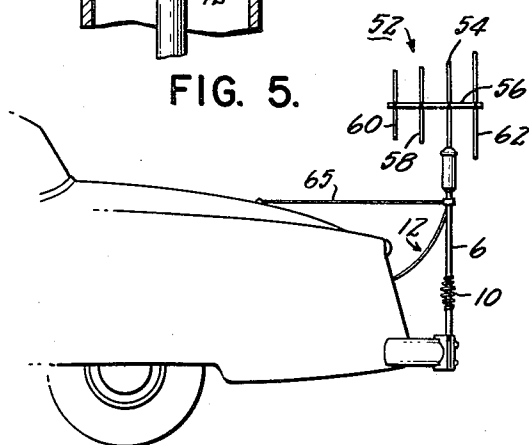
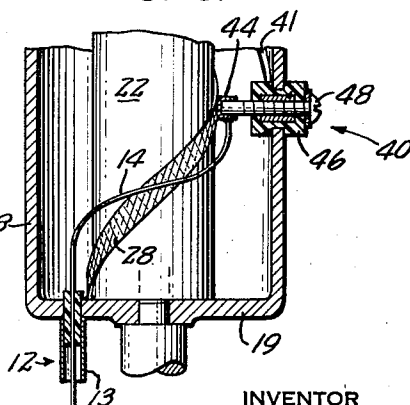


FIG. 3.



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FIG. 6.

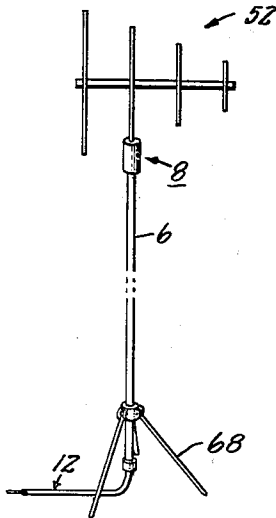


FIG. 7.

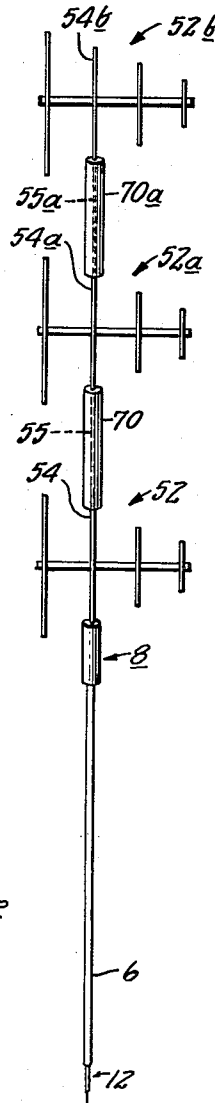


FIG. 9.

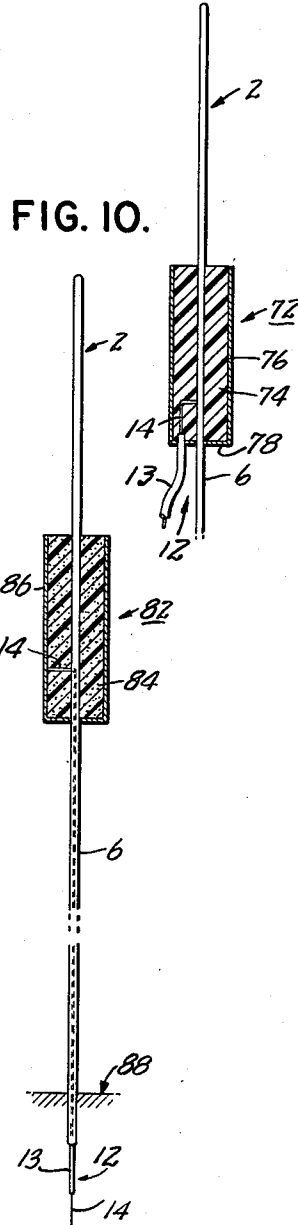


FIG. 10.

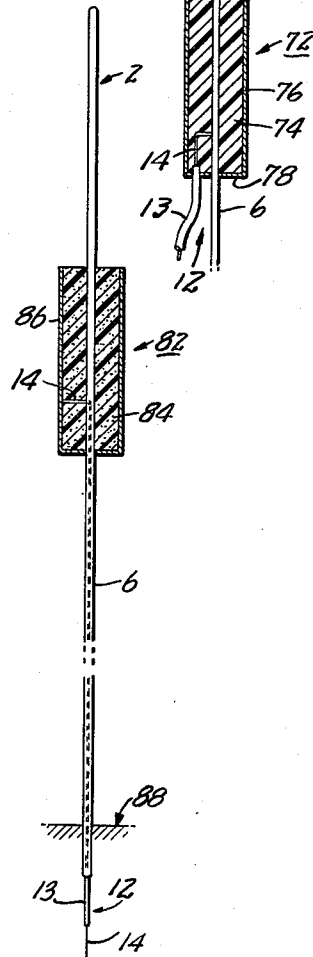


FIG. 8.

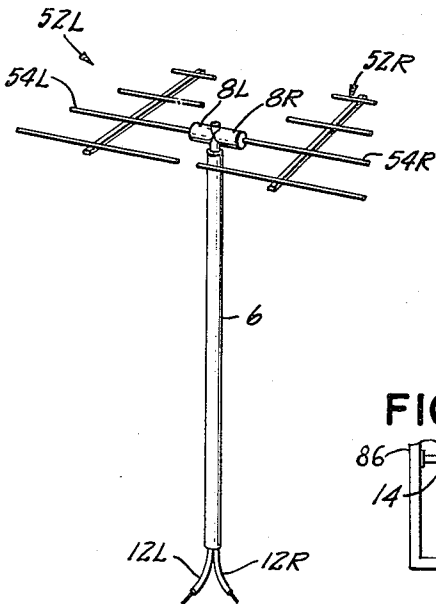
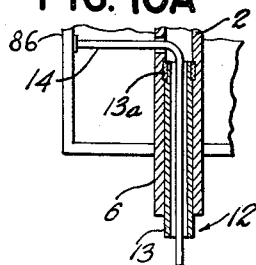


FIG. 10A



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Filed June 16, 1955, Ser. No. 515,805

3 Claims. (Cl. 343—713)

This invention relates to an improved antenna mount and particularly of a type for supporting and feeding end-supported and voltage-fed vertical antennas intended for mobile service, such as on automobiles or boats.

The mounting of an antenna on an automobile for mobile radio transmitting and/or receiving presents a number of difficult problems. To begin with, the antenna and its support must be able to withstand severe bending and vibration forces such as the wind or high speed movement of the automobile. If the diameter of the antenna, for example, is at all substantial, the force of the wind blowing against it may be enough to break it loose from its supporting structure, or at least to set up dangerous whipping and lashing back and forth.

A mobile transmitter has need for an antenna which is not only strong but which is able to radiate a signal to a given destination dependably even though the antenna is frequently being moved by the vehicle upon which it is mounted to different environments. Each move to a new place, of course, affects the radiation characteristics of the antenna. A half-wave antenna supported a suitable distance above the ground plane has been found to be noticeably better for this purpose than a quarter-wave antenna. The better performance of the former over the latter for such application makes it desirable to find some efficient means not heretofore available for mounting it and coupling it to the radio equipment.

It is conventional to mount a quarter-wave antenna projecting upward from the roof of an automobile, provided of course that the roof is metal. Though a half-wave antenna could be similarly mounted, it becomes difficult to avoid excessive base capacity effects which lead to low electrical efficiency. Furthermore, such an antenna cannot be directly connected to conventional transmission lines. This is particularly true of a half-wave antenna intended for operation at a frequency of 100 megacycles or higher.

A big drawback with mounting a vertical half-wave antenna directly on the bumper of a car is the distortion in the antenna radiation pattern caused by the nearby metal surfaces of the car. Added to this is the fact that when the bottom end of the antenna is mounted level with the bumper, nearby objects, such as other cars or fire plugs, mail boxes and the like have more effect on the radiation pattern than if the antenna were mounted with its bottom end somewhat above the bumper level.

The only half-wave antenna, so far as is known, which performs well electrically when mounted on a short post or the like extending up from and elevating the antenna above a car bumper or other similar "ground plane," is that shown in U.S. Patent No. 2,184,729. This antenna, commonly known as a coaxial antenna, is one-half wavelength long and can be mounted on a post-like support a short distance above a ground plane without adversely affecting the radiation pattern of the antenna. The post-like support, if properly dimensioned will not radiate. However, although this type of antenna is electrically suitable for use with mobile equipment, in forms as described

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and shown in said patent it is physically unsuitable for that purpose because of the large diameter of the sleeve which extends over the lower half of its active length. Such a sleeve, as mentioned previously, is greatly affected by wind and vibration and is therefore not practical for use on a mobile base, as an automobile or small boat.

Accordingly, an object of this invention is to improve the radiation characteristics of half-wave, end-fed, vertical dipole antennas supported above structures on which they are mounted;

to provide a strong, compact, and very efficient coupling arrangement to match such antennas to low impedance lines; and

to provide an efficient coupling arrangement which is small, compact and rugged enough for mounting vertical half-wave antennas on automobiles and the like.

The present invention provides a new structure for supporting and feeding a half-wave antenna of small outside uniform diameter so that it can be mounted easily and securely in the most advantageous position above a car bumper, or the like, and so that the half wave antenna will not be adversely affected by the support and will thereby radiate and receive efficiently. In accordance with one aspect of the invention, a mount for this purpose includes a coupling element or unit for end-feeding a thin rod-like half-wave antenna. This unit which is also of small size is connected electrically so as to provide optimum matching between the relatively high impedance of the antenna and the low impedance of the usual transmission line. Thus, the antenna can be mounted on said unit at certain elevated positions above the ground plane without there being radiation from the support which holds the antenna provided that the support is of suitable dimensions. Since the antenna itself is of the utmost simplicity and very small in diameter along its entire length, and since the coupling unit is small and of light weight, they are physically well suited for mobile use. In addition, the electrical performance of this light and easily transportable equipment, as employed with automobiles and boats, for example, exceeds that of conventional types of substantially heavier, more complex and cumbersome coaxial antennas.

A fuller understanding of the invention and its advantages and uses will be gained from the following description of embodiments thereof illustrated in the accompanying drawings in which:

Figure 1 is a view in elevation of an antenna system embodying the invention in a form suitable for being mounted on an automobile;

Figure 2 is a central vertical section on enlarged scale through one form of inductive loading coupling unit that connects the radiating portion of the antenna to the supporting base as shown in Figure 1;

Figure 3 is a fragmentary view in elevation on enlarged scale showing a form of coupling unit including means for adjusting its impedance transformation characteristics;

Figure 4 is a fragmentary view partly in central longitudinal section of a coupling unit similar to that of Figure 2 and showing a modification in the base connections to and support for the coupling unit;

Figure 5 is a view in elevation of a modification in which the antenna is a multi-element Yagi type;

Figure 6 shows a Yagi antenna similar to that of Figure 5 except that the supporting post therefor is hollow and encloses a portion of the coaxial feed line;

Figure 7 shows a plurality of co-operating Yagi antennas arranged with one superimposed on another and adjustable into and out of a common vertical plane;

Figure 8 shows a modification wherein two horizontally polarized Yagi antennas are mounted on a single post;

Figure 9 is a fragmentary view, partly in central longitudinal section of a coupling unit similar to that of Figure 2 and showing a modification in the base connections to and support for the coupling unit.

tudinal section, of a modified form of coupling unit wherein the loading is dielectric;

Figure 10 is a similar view of a portion of an antenna structure embodying a coupling unit wherein the loading is magnetic and the supporting post serves also as part of a coaxial feed line; and

Figure 10A is a fragmentary view on enlarged scale showing details of construction of the device of Figure 10, more particularly the solder connection between an upper end portion of the outer element of the feed line and the inner surface of the supporting post.

Referring to Figure 1, the radio-energy radiating and receiving portion or antenna of the antenna assembly is shown as a vertical metal rod or tube 2 of such length as to provide the desired characteristics and pattern of radiation, in this example, approximately one-half wave-length long at the frequency of operation. Rod 2 can be aluminum or other suitable material of small diameter along its length.

The automobile bumper 4 acts as the ground point for the conductive supporting structure of the antenna 2 which for reasons stated previously, is supported in operative position a short distance above bumper 4. This antenna supporting structure includes a post 6 and a coupling unit 8 mounted thereon. Post 6 includes a spring-type or other resilient connection 10 with an internal shorting strap for eliminating the inductive effect of the spring. Spring 10 is conveniently positioned to absorb shock and to permit yielding resistance to forces applied laterally to the antenna or to portions of the mount located above connection 10.

The coupling unit 8 provides both a secure mechanical support for the antenna rod 2 and also an effective impedance matching element to couple energy between said rod 2 and the low impedance feed supply line, as the coaxial cable 12.

As seen in Figure 2, unit 8 includes an outer shield or shell conveniently in the form of a metal tube or sleeve 18 having one end closed by a metal wall 19. Unit 8 is secured to the upper end of post 6 by a screw 20 extending through an opening in bottom wall 19 and threaded into a cylindrical core 22 within tube 18, the latter, for example, being made of copper. The core 22 may be formed of phenolic base plastic, high-strength polystyrene, fibre, impregnated wood, or other material that will not absorb excessive moisture and will not introduce excessive losses at the frequency of operation. Said core 22 is arranged in tube 18 with its upper end supporting the lower end portion of rod 2 which is secured in the upper end of core 22 by means of the screw 26.

Unit 8 also serves to couple energy between coaxial cable 12 and rod 2. Where the loading is of the induction type, a coil, as a strip of sheet or braided copper, or other suitable material, is extended in a helical coil 28 conveniently of three to six turns around core 22 from one end to the other. The upper end of coil 28 is connected conductively to the lower end of rod 2 through, for example, a circular metal bushing 30 between the upper end of core 22 and the lower end of rod 2 and to which the upper end of coil 28 is soldered at point 31. This arrangement also provides a capacitance connection between said coil 28 and rod 2 which results automatically by reason of what is known in the art as "stray capacity" supplied by and implicit in the relative positions and conditions of said coil and rod in operation.

The upper end of the conductive outside sheath 13 of the coaxial cable 12 is soldered to bottom wall 19 at 29. The inner conductor 14 of said cable passes through an opening 32 in wall 19 and is connected to coil 28 a suitable distance above point 29. The exact place of connection between the upper end of conductor 14 and coil 28 is selected to provide the best match between the impedance of cable 12 and that of antenna rod 2. Coaxial cable 12 is connected at its lower end (not shown) to a radio transmitter 38 (shown in dotted outline in Figure 1) or to another source of radio frequency energy, or to

a receiver, the same antenna structure being usable both for receiving and for transmitting.

The upper or open end of tube 18 is protected by a cap 34 of a suitable weatherproof insulating material which serves also to hold the lower end of rod 2 and core 22 in a proper or predetermined relation to the tube. Cap 34 can be permanently fixed around rod 2 and removably fastened to the tube by screws 36 or alternatively cap 34 may provide a tight resilient weatherproof fit for rod 2 and yet allow rod 2 to be removed through it when desired. Such construction permits rod 2 to be removed easily and quickly from unit 8 so that if desired a different antenna can be inserted therein as will be explained hereinafter.

Unit 8 is in effect a transformer either self-resonant by itself or resonant in conjunction with the antenna at the selected frequency of operation. A coupling or transformer of this short length is made possible by the electrical loading, as for example the inductive type using the coiled strip 28 within tube 18, or other suitable types later referred to. Where the electrical length of unit 8 together with its support 6, grounded at its lower end as shown, is less than a quarter wave-length, for example $\frac{3}{16}$ wave-length or less, their aggregate outside surface will not support a substantial amount of radiation at the frequency of operation. Accordingly, since unit 8 and post 6 can be made effectively non-radiating by maintaining their aggregate outside surface at optimum value, the bottom of antenna 2, Figure 1, or the antenna 52, Figure 6, for example, can be supported above the ground point or plane as bumper 4, without adversely affecting the pattern of radiation or reception. If a greater height above the ground plane is desired or necessary, support 6 can be lengthened, without impairing the radiation characteristics of the assembly as a whole, by an integral multiple of a half wave-length, thus producing a total physical length of unit 8 and support 6 within substantially $\frac{3}{16} L$ of the length according to the formula: $L = \lambda/2(N)$ where λ is an electrical wave-length measured on the outside surfaces of unit 8 and post 6 and N is an integer. The coupling unit shown in Figure 2 does not provide for adjustment of the transformation ratio once set. However, in case it is desired to replace antenna 2 with one having a substantially different impedance, it is advantageous to have some means of adjusting unit 8 to match the new impedance.

Figure 3 shows a modification of unit 8 wherein the point of connection of conductor 14 to coil 28 can be varied. Here, the top end of conductor 14 is connected to a conductive portion of a sliding brush assembly 40 which can be pushed along the helical slot 41 cut through the wall of tube 18 along a line coincident in level with at least a part of the turns of coil 28. An inner contact 44 carried by assembly 40 presses against coil 28 and connects conductor 14 to it at a point determined by the position of assembly 40 along slot 41. Assembly 40 includes an insulating bushing 46 having shoulders mating with the walls of slot 41 and which can be tightened thereagainst as desired by means of the screw 48.

Figure 4 shows a modification of the structure shown in Figure 2. Here, supporting post 6 is made integral with the resonance chamber or tube 18; and the bottom wall of this tube, equivalent to wall 19, is provided by an annular washer 39 fitted transversely within said tube at the bottom end of core 22. Thus, washer 39 supports core 22. Positioned coaxially within support 6, is cable 12, whose outer conductor 13 is soldered at its top end to the bottom side of washer 39 and whose inside conductor 14 passes through the central opening in this washer upward through the lower end of core 22 and is electrically connected to coil 28 at its lower end. The characteristic impedance of unit 8 is made the geometric mean of the impedance of line 12 and the antenna rod 2.

Figure 5 shows a vertically polarized Yagi antenna

52 supported by a base structure similar to that above described. The coupling unit coil, as 28 in Figure 2, is connected to radiating element 54 of the Yagi assembly which includes a cross bar 56, preferably of insulating material. Two director elements 58 and 60, shorter than the radiating element 54, are supported by cross bar 56 at one side of the radiating element; and a reflector element 62, slightly longer than the radiating element 52, is carried by the cross bar 56 a short distance from and at the opposite side of the radiating element. The dimensions of the directors 58 and 60 and the reflector 62 are selected in accordance with usual design practice for Yagi antennas. In the illustrated embodiment, radiating element 54 is electrically one-half wave-length long at the mid-portion of the operative frequency band for the installation. The support for this antenna is similar to that previously described, except that an additional mechanical brace 65, suitably insulated from the antenna, extends between post 6 and the body of the automobile.

At times it may be desirable to substitute a directional antenna, as a rotatably mounted Yagi antenna 52, for a non-directional one, as antenna rod 2, or vice versa, and an advantage of the present invention is that this may readily be done. In the event, for example, that the antenna rod 2 and Yagi 52 have the same or substantially the same frequency of operation, the two can be interchanged. These can be interchanged without adjustment of the transformer characteristics of unit 8 in the event the antenna impedances are equal or approximately equal. Rod 2 is removed simply by unscrewing the screws 36 and the end of rod 2 from core 22, and Yagi 52, with a cap 34 attached to the lower end of radiation element 54 thereof, is mounted on unit 8 by securing the inner end of said element in the upper end of core 22 and tightening the screws 36 of cap 34 or alternatively, removing antenna 2 alone by unscrewing at thread 26, and screwing in Yagi 52.

Figure 6 shows another arrangement for supporting and feeding a Yagi antenna similar to that shown in Figure 5. In this example, the antenna is supported on a hollow post or pipe 6, which is in turn mounted on a suitable base, as a tripod 68, thus permitting the coaxial cable 12 to enter pipe 6 at its bottom open end so that the presence of the cable thus shielded does not interfere with the radiation characteristics of antenna 52. The coupling unit 8 may be one of any of the types herein described.

Figure 7 shows an assembly of three Yagi antennas, 52, 52a and 52b, arranged one above another and energized by a coaxial cable 12 extending through tubular post 6, as in Figure 6, to a coupling unit 8. A single vertical rod mounted in the end of coupling unit 8 provides the radiating or driven elements 54, 54a and 54b of the antennas 52, 52a and 52b respectively, and also the connecting conductor portions, as 55, between elements 54 and 54a, and 55a between elements 54a and 54b. Each of conductor portions 55 and 55a is one-half wave-length (or any odd multiple thereof) long and each has a tubular shielding sleeve, as 70, which coaxially encloses conductor portion 55 in spaced relation thereto, and 70a which similarly encloses conductor portion 55a. Antennas 52, 52a and 52b can be oriented in the same vertical plane if maximum directivity and gain is desired. Alternatively, each can be oriented in a different vertical plane if wider or specialized directivity is preferred. The impedance of these three antennas together is one-third that of each. Thus by stacking an appropriate number of such antennas in the way shown, it is possible to obtain a composite antenna having a relatively low impedance.

An advantage of supporting and end-feeding the radiating element of Yagi antennas is that the arrangement of feed line 12, coupling unit 8 and support 6, as in Fig-

ures 5 through 7 for example, when the combined length of said support and unit is determined according to the previously given formula, does not adversely affect the radiation patterns of these antennas. However, where the radiating element corresponding to element 54 of a vertical Yagi antenna is center fed, as in conventional arrangements, the unavoidable presence of the vertical portion of the feed line and its supporting pole in that relation to the antenna assembly causes disturbance in the radiation pattern.

Figure 8 shows a system for separately end-feeding two horizontally polarized radiating elements of Yagi antennas 52L and 52R supported on a single mount. In this example, both of the coaxial cables 12L and 12R extend upwardly through the supporting pipe 6, one leading into coupling unit 8L and the other into the coupling unit 8R. These coupling units are mounted with their longitudinal axes positioned horizontally and extend outwardly from the supporting post 6 in opposite directions, each being connected at its inner end to one of the cables and at its outer end being connected to and supporting one of the elements 54L and 54R, respectively, of the antennas 52L and 52R.

Figure 9 shows a coupling unit 72 in which dielectric loading is used and which includes an insulating core 74 enclosed within a conducting shield 76. The shield 76, which like tube 18 is less than $\frac{1}{16}$ wave-length long, is supported on a post 6. A continuation of post 6 extends upward through core 74 and upon emerging therefrom becomes the antenna rod 2. Shield 76 has a bottom wall 78 which is electrically connected to post 6 and to which the outer conductor 13 of the cable 12 is connected. The inner conductor 14 of this cable passes through an opening in wall 78 and connects to the continuation of post 6 within core 74 at the appropriate point for impedance matching. Where antenna 2 is made integral with post 6, an exceptionally strong antenna assembly structure is obtained.

Figure 10 shows another antenna assembly structure including a coupling unit 82 similar in some respects to that shown in Figure 9, but with different base connections and wherein magnetic loading is used. In this example, the cable 12 extends upwardly within supporting pipe 6 a suitable distance into the core 84 and then the outer end of its inner conductor 14 turns through an opening in the continuation of post 6 and passes laterally through the core and into contact with the inside of the surrounding conductive sleeve 86. The location of this point of contact is selected to provide the desired impedance matching characteristics of the unit. The upper end of outer conductor 13 of cable 12 is soldered at 13a, Figure 10A inside post 6 near the opening through which conductor 14 passes. Core 84 is made of a suitable insulating material, such as polyethylene, through which is dispersed a finely divided magnetic material such as a normal ferrite core material. The over-all length of the coupling unit 82 is, as in the case of previously described couplers, less than $\frac{1}{16}$ wave-length. The radiating portion 2 of the antenna is one-half wave-length long; and the upper end of coupling unit 82 is positioned above the ground plane 88 according to the previously stated formula.

It is contemplated that various changes or modifications in the embodiments shown and above described can be made by those skilled in the art without departing from the spirit or scope of the invention as set forth.

I claim:

1. An arrangement for supporting and for end-feeding an antenna, said arrangement comprising an antenna element which is substantially a half wave length long, means defining a ground plane, and coupling and supporting means for holding said element with its longitudinal axis generally perpendicular and with its lower end spaced from said plane, said coupling and supporting means including a resonant transformer coupled to the

lower end of said antenna element and adapted to apply voltage thereto at an impedance substantially matched to that of said element, the outside surface of said coupling and supporting means being conductive and having a length above said ground plane such that said surface is non-resonant at the frequency of operation whereby the radiation characteristic of said antenna is not adversely affected by the presence of said coupling and supporting means.

2. The combination of elements as in claim 1 in which said antenna is part of a vertically polarized Yagi antenna.

3. An antenna mount assembly comprising in combination a vertical half wave antenna element having an effective radiating extent of one half wave length at operating frequency, means defining a ground plane, a coaxial low impedance energy supply cable having a conductive sheath enclosing a conductor wire electrically connected to energize said antenna element, and a non-radiating means for supporting said antenna element including a tubular sleeve supported above the ground plane and having a conductive lateral wall and a conductive closing wall at its lower end and being open at its upper end and having an effective radiating extent of less than one quarter of a wave length at operating frequency, a conductor mounted coaxially within and spaced from lateral interior wall surfaces of said sleeve, one end of said conductor being electrically connected to said sleeve and its

other end being electrically connected with said antenna element, and said conductor also being electrically connected to said conductor wire of said coaxial cable, and said conductive walls of said sleeve being electrically connected to said conductive sheath of said coaxial cable, said sleeve and said conductor therein being arranged and adapted to provide a transformer coupling means between said cable and said antenna element, and said sleeve having an external conductive surface which is non-resonant at the operating frequency of the antenna element.

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