

Aug. 16, 1966

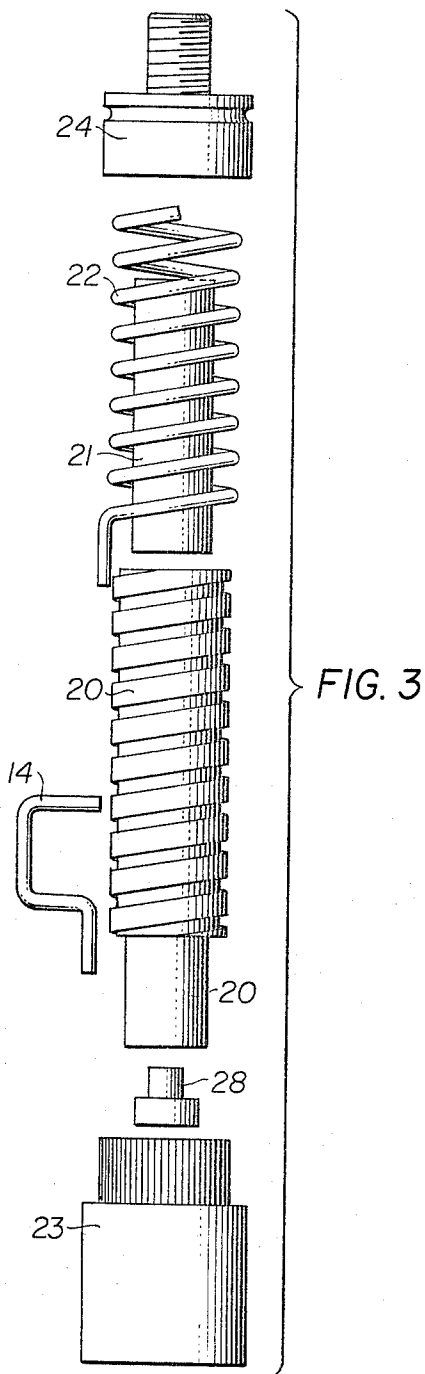
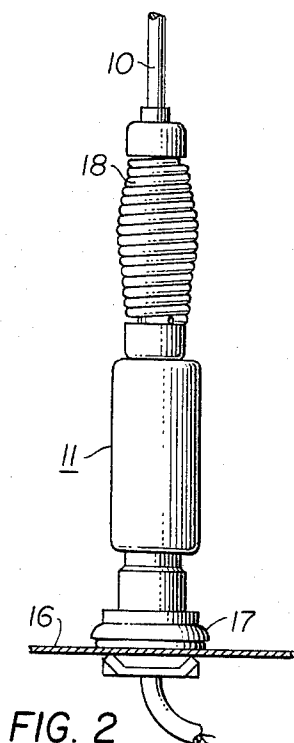
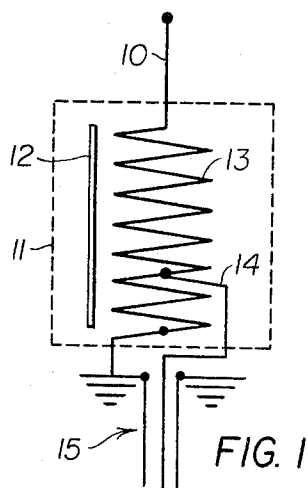
A. A. FINKE

3,267,476

VEHICLE-MOUNTED HALF WAVE ANTENNA WITH IMPEDANCE
MATCHING TRANSFORMER

Original Filed Sept. 18, 1959

3 Sheets-Sheet 1



INVENTOR.
ARTHUR N. FINKE
BY *Pyle & Gisher*
attys.

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A. A. FINKE

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3 Sheets-Sheet 2

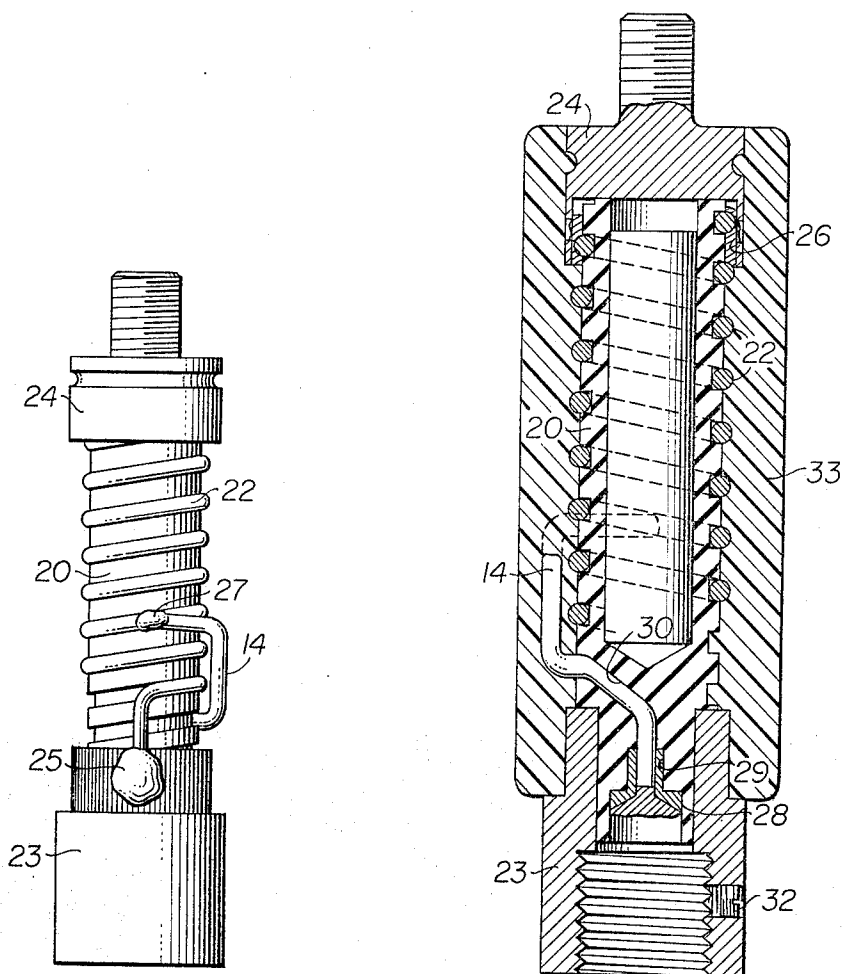


FIG. 4

FIG. 5

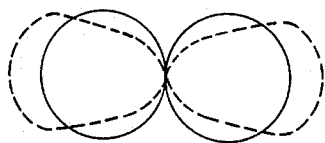


FIG. 6

INVENTOR.
ARTHUR N. FINKE
BY *Pyle & Fisher*
attys.

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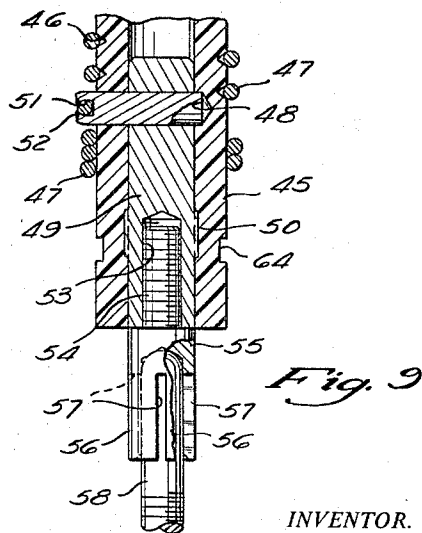
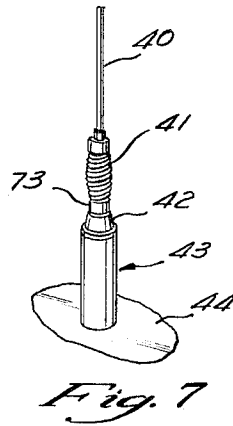
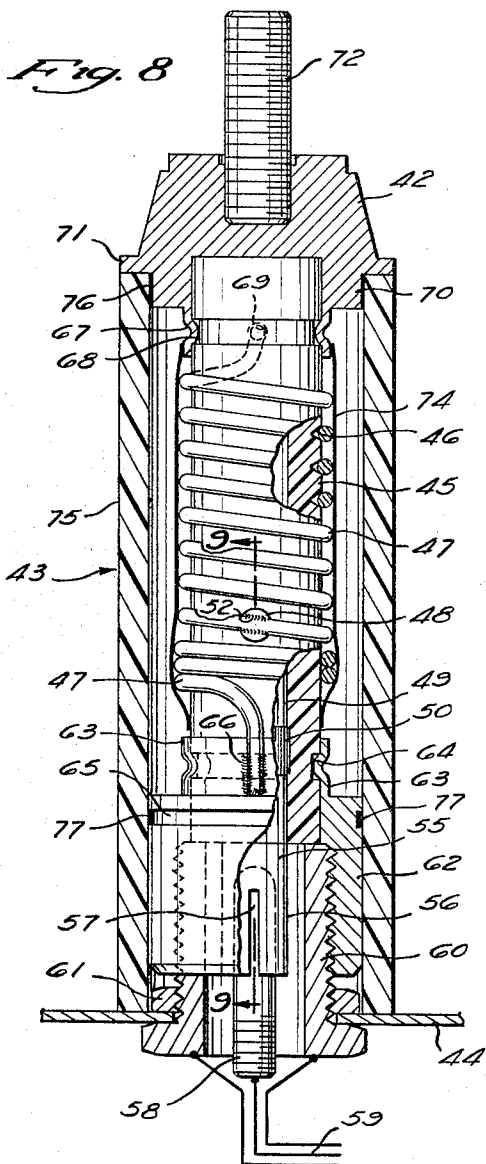
A. A. FINKE

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3 Sheets-Sheet 3



INVENTOR.
ARTHUR A. FINKE
BY
Ely, Holnick & Flynn
ATTORNEYS

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3,267,476
**VEHICLE-MOUNTED HALF WAVE ANTENNA
WITH IMPEDANCE MATCHING TRANS-
FORMER**

Arthur A. Finke, Newbury, Ohio, assignor to Antenna
Specialists Co., a corporation of Ohio
Continuation of application Ser. No. 842,969, Sept. 18,
1959. This application Feb. 17, 1965, Ser. No. 438,173
2 Claims. (Cl. 343-715)

This application is a continuation-in-part of my pending
application Serial No. 218,202, filed August 13, 1962,
now abandoned, which is a continuation of my earlier
application Serial No. 842,969, filed September 28, 1959,
now abandoned.

This invention relates to a vehicle-mounted com-
munications antenna system with a vertical antenna hav-
ing a physical length of substantially one-half wavelength.

Prior to the present invention it has been recognized
that a one-half wavelength vertical antenna positioned
just above the ground plane has a substantially higher
gain than a similarly mounted one-quarter wavelength
antenna. Quoting from the book, "Antennas: Theory
and Practice," by Schelkunoff and Fries (published 1952)
page 357:

"In 1933, W. M. Sharpless measured the power gain of
a $\frac{1}{2}$ wave vertical antenna (just above ground) with
reference to a $\frac{1}{4}$ wave vertical antenna at 18.3 mcs. He
found this gain to be 4 db. There would be some gain
even over a perfectly conducting ground, because of the
greater directivity of the $\frac{1}{2}$ wave antenna; but this gain
would only be 1.67 db. The difference of 2.33 db is due
to smaller ground currents in the case of the $\frac{1}{2}$ wave
antenna."

However, despite the recognized superiority of $\frac{1}{2}$ wave-
length antennas certain practical difficulties inhibited their
use on vehicles, such as automobiles, prior to the present
invention. A serious difficulty heretofore has been to
properly match the approximately 1200 ohm impedance
of the $\frac{1}{2}$ wavelength antenna to the 50 ohm impedance
of the communications equipment, usually a combination
receiver and transmitter.

In accordance with the present invention this difficulty
is overcome by connecting the lower end of the antenna
to an impedance-matching transformer coil having a novel
physical support that positively locates the turns of the
coil so that there is no significant variation in performance
between successive antennas provided with such coils and
manufactured on a mass production basis. In addition,
the present invention in its preferred embodiment has a
novel physical support arrangement for connecting the
transformer coil to the inner conductor of the coaxial
antenna lead-in cable and to the antenna itself.

It is a principal object of this invention to provide a
novel and improved vehicle-mounted half-wavelength
antenna system.

Another object of this invention is to provide such an
antenna system having a novel transformer unit arrange-
ment for matching the impedance of the antenna to the
much lower impedance of the communications equip-
ment on the vehicle.

Another object of this invention is to provide such an
antenna system having an impedance-matching trans-
former unit at the lower end of the antenna, including a
coil which is supported so that its successive turns are
positively located evenly spaced apart from each other.

Another object of this invention is to provide such an
antenna system having novel provision for physically
mounting the transformer unit and the antenna and for
providing the proper electrical connections between the
transformer coil and the antenna, the lead-in cable and
the vehicle body, respectively.

Further objects and advantages of this invention will be
apparent from the following detailed description of two
embodiments thereof which are illustrated in the accom-
panying drawings.

In the drawings:

FIGURE 1 is an electrical schematic illustration of a
first embodiment of the present antenna system with the
impedance-matching transformer enclosed in dotted out-
line;

FIGURE 2 is a side elevation of the antenna system of
FIG. 1 mounted on the body of a vehicle, such as an
automobile, which provides the ground plane;

FIGURE 3 is an exploded illustration of the impedance
matching transformer unit in the antenna invention of
FIGS. 1 and 2;

FIGURE 4 is a view of the parts of this transformer
unit assembled and soldered prior to encapsulating;

FIGURE 5 is a vertical section of this transformer unit
after encapsulating in a protective resin body;

FIGURE 6 is a diagrammatical illustration of a com-
parison of a conventional $\frac{1}{4}$ wavelength broadcast pattern
with the improved gain pattern produced by a $\frac{1}{2}$ wave-
length antenna system in accordance with the present
invention;

FIGURE 7 is a fragmentary perspective showing a
preferred second embodiment of the antenna system of
the present invention mounted on the body of a vehicle,
such as an automobile;

FIGURE 8 is a vertical section of the impedance-match-
ing transformer unit in this second embodiment of the
present invention; and

FIGURE 9 is a fragmentary vertical section taken along
the line 9-9 in FIG. 8.

FIGURE 1 presents a schematic electrical arrange-
ment of a first embodiment of the present improved
antenna system. Here, an antenna whip 10 of $\frac{1}{2}$ wave-
length is bottom end fed by a transformer 11 set apart in
the FIGURE 1 by a dotted outline. In accordance with
a first embodiment of this invention, the transformer con-
sists electrically of a high-permeability, high-Q magnetic
material core 12 wrapped by a coil 13. The lower end
of coil 13 is grounded, and the upper end is connected to
the whip 10. Between the ends of coil 13, a lead 14 is
tapped into the coil and leads through the inner con-
ductor of a coaxial lead-in cable 15 to a transmitter-
receiver. The outer conductor or sheath of cable 15 is
grounded to shield out interference signals.

In FIGURE 2 of the drawings, a side elevational view
of the entire antenna system is shown in order to better
understand the entire relationship of the parts, both elec-
trically and mechanically. The reference character 16
indicates a panel of a vehicle, such as an automobile, upon
which the antenna is mounted and to which it is grounded.
A stanchion assembly 17 is provided to grip the panel 16
physically and to provide a coaxial lead through the panel.
Connected above the stanchion 17 is the improved trans-
former 11 of FIG. 1 which in turn supports a metal barrel
spring 18 of conventional nature to absorb shock of
physical contact which might impinge against the bottom
end-supported antenna 10.

The transformer matches the approximately 1200 ohm
impedance of the $\frac{1}{2}$ wavelength antenna to the 50 ohm
impedance of the transmitter/receiver over a wide signal
frequency range without adjustment. In the FIGURE
3, the physical parts of this transformer assembly, except
the encapsulating case, are set forth in an exploded re-
lationship. The assembly includes a rigid coil support 20
of suitable insulation material surrounding a ferrite core
21. The transformer coil 22 is wound around the coil
support 20 from end to end, in the illustrated embodi-
ment for 7 full turns. As shown in FIGS. 3 and 5, the

coil support 20 has a continuous external helical groove whose successive turns are evenly spaced apart axially of the assembly. This groove positively locates the successive turns of coil 22, so that these turns are evenly spaced apart. This is extremely important to the successful practice of the present invention because the impedance matching action of the transformer would be variable and unpredictable in the absence of a positive control of the even spacing between its successive turns.

A metal mounting unit 23 is provided to hold the coil support 20, with the lower end of the coil support telescoped within the mounting unit, as shown in FIG. 5. A metal top end cap 24 is provided at the upper end of the coil support 20 to give support to the antenna shock mounting spring 18 (FIG. 2) and to complete the conductive path for a radio signal from the antenna 10 through spring 18 to the upper end of transformer coil 22.

In FIGURE 4 the parts are shown in their assembled relationship. The mounting nut 23 and the top end cap 24 are mounted on opposite ends of the coil support 20 and the coil 22 is wound around the coil support 20 from end to end. The lower end of coil 22 is soldered to the mounting nut 23 at a point indicated by the reference character 25, and extends up under the top end cap 24 and into a hole 26 in the cap 24. The upper end of the coil is soldered in the hole and thus provides good electrical connection thereto. Thus, the antenna whip 10 is electrically connected through the coil 22 to the mounting nut 23 which is in turn threadably mounted to the metallic grounded body of the stanchion assembly 17.

The lead 14 is a shunt lead and is electrically connected to the coil 13 intermediate the ends thereof. In this embodiment, as illustrated, the connection is a soldered connection at the point indicated by the reference character 27 (FIG. 4). Lead 14 is rigidly supported by the coil support 20 and extends from the soldered connection point 27 down to a contact 28 (FIG. 5) located in the lower end of the coil support 20. The contact 28 is a turned member fitted into a recess 29 provided for that purpose. A sliding passageway 30 extends from the exterior surface of coil support 20 to the top of the recess 29 and the lead extends through the passageway and into the contact 28. Solder, as illustrated, is floated into the end of contact 28 to join the members and provide retention of the members in the respective proper locations. Note that the contact 28 is located within the conducting mounting unit 23 but is insulated from nut 23. Hence, whenever the mounting nut 23 is threadably secured to the top of the stanchion assembly 17, a conductor contact (not shown) in the stanchion assembly 17 is brought into a physical pressure contact with the contact member 28. The mounting nut 23 is held against dislocation by means of a set screw 32 (FIG. 5).

Although the proper location of the soldered point 27 for correct impedance matching may be fairly closely established by calculation, the exact location in a particular complete antenna assembly is adjusted empirically.

As thus far described, it will be seen that the physical embodiment as shown in FIGURE 5 successfully carries out the electrical circuitry of FIGURE 1. The grounded coil 22 is characterized as having about a 1200 ohm impedance, but may be successfully fed by a 50 ohm transmitter-receiver through the shunt lead 14 which matches the impedance by entering at the second turn.

In order to protect and fully insulate the transformer 11, it is mounted in a suitable mold and encapsulated in a resin body 33 (FIG. 5). This encapsulating body 33 insulates the shunt lead 14 from contact with the coil 22 at any point other than the point 27 and also holds the lead 14 tightly in place to in turn hold the contact 28 in its proper location. This body 33 encloses the coil 22 and support core 20 from end to end and it

protects against weather and other deteriorating influences.

In the foregoing arrangement the transformer coil 22 is rigidly supported by the coil support 20 in a positive fashion, with its successive turns being located by the helical groove in the coil form precisely spaced apart evenly. Consequently, in mass production of these units there is no substantial variation in electrical characteristics from one antenna assembly to the next. The rigidly attached top end cap 24 and mounting nut 23 provide the proper electrical connections to the antenna and to the vehicle body, and the lead 14 provides the proper electrical connection between the coil 22 and the inner conductor of the antenna lead-in cable when the transformer unit is mounted on the stanchion 17.

As previously stated, it has long been known that a vertical $\frac{1}{2}$ wavelength antenna, end fed, will have a substantially higher gain than a vertical $\frac{1}{4}$ wavelength antenna. The gain shown by the $\frac{1}{2}$ wavelength antenna is believed to be caused by compression of the pattern of radiation and elimination of losses in the ground plane. A ground plane for a $\frac{1}{4}$ wavelength antenna requires some of the useful power fed into the antenna. In other words, more of the power generated by the radio equipment is put where it will do the most good. Prior to this invention, the drawback to the $\frac{1}{2}$ wavelength antenna has been that the $\frac{1}{2}$ wavelength antenna presents an impedance of approximately 1200 ohms at its feed point, whereas the $\frac{1}{4}$ wavelength antenna properly mounted on a ground plane presents an impedance of approximately 50 ohms. Since mobile communication receivers and transmitters are designed for 50 ohm input and output, the problem has been to design a low-loss transformer to change the impedance at the $\frac{1}{2}$ wavelength antenna feed point from 1200 ohms to 50 ohms and to make this transformer cover a wide frequency range in a single unit. Horizontally mounted $\frac{1}{2}$ wavelength antennas have been employed with the feed to the antenna being at the mid-point, but center feeding of a vertical antenna is impractical. This invention does provide a practical end feed for a $\frac{1}{2}$ wavelength antenna to produce the desired gain over a $\frac{1}{4}$ wavelength antenna.

FIGURE 6 is over-simplified in some respects, but illustrates very well what takes place in the transmission through the system of this invention as compared with transmission through a standard $\frac{1}{4}$ wavelength antenna. A simile is employed to explain this phenomenon by saying that the gain is like placing a book on a resilient doughnut and compressing the doughnut outwardly. In FIGURE 6, the shading from the true circular cross section illustrates the displacement and addition of the radiation pattern to produce the wider, successful communication range.

FIGURE 7 shows a preferred second embodiment of this invention in which the antenna 40 is mounted at its lower end on a barrel spring 41. The spring in turn is mounted on, and electrically connected to, the metal top end cap 42 of an impedance-matching transformer unit 43 mounted on the automobile body 44, which provides a ground plane for the antenna.

Referring to FIGURE 8, this transformer unit includes a rigid, hollow, insulation support core 45 formed with an external continuous helical groove 46 whose successive turns are evenly spaced apart along its length. This groove locates and receives the successive evenly spaced turns of a transformer coil 47. This helical groove 46 in the coil support 45 extends upwardly from a cross pin 48, to be described. Below this cross pin the lower turns of the coil 47 engage the smooth cylindrical periphery of the coil support and the spacing between successive turns of the coil here is not critical.

As shown in FIG. 9, the cross pin 48 has a press fit in the coil support 45 and in a longitudinal pin 49, which is tightly received in the lower end of the coil support 45. The exterior pin 49 is knurled at 50 to lock it in the coil

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support. The outer end of the cross pin 48 has a slot 51 which the adjacent turn of the transformer coil 47 is inserted, after which the outer end of the cross pin is crimped over the coil and is soldered to it at 52. This provides the intermediate tap connecting the inner conductor of the coaxial antenna lead-in cable to the transformer coil at a location spaced a few turns above its grounded lower end.

The longitudinal pin 49 has a screw-threaded recess 53 which is open at its lower end and which threadedly receives the screw-threaded shank 54 on a bushing 55. The latter has spring fingers 56 at its lower end separated by longitudinal slots 57. These spring fingers define a generally cylindrical recess for tightly receiving a contact pin 58, which is part of a rooftop mount on the vehicle. The contact pin is rigidly supported from the roof 44 in any suitable manner, the details of which are not part of the present invention and are omitted from the drawing for clarity. As shown in FIG. 8, this contact pin is connected to the schematically illustrated inner conductor 59 of the coaxial antenna lead-in cable which connects the antenna 40 to the receiver/transmitter in the vehicle. This connection may be by soldering or otherwise.

Bushing 55, longitudinal pin 49 and cross pin 48 are all of high electrical conductivity metal and are all tightly connected to each other to provide a low resistance electrical lead connecting the roof-mounted contact pin 58 and the inner conductor 59 of the antenna lead-in cable to the transformer coil 47 at its soldered connection 52 to the cross pin 48.

The rooftop mount on the vehicle also includes an upstanding, externally-threaded stud 60 (FIG. 8) which is attached to the vehicle roof 44 by a retainer nut 61. The stud surrounds, and is spaced from, the contact pin 58.

A mounting nut 62 in the transformer unit is threadedly mounted on the upper end of stud 60. This nut telescopically receives the lower end of the coil support core 45 and it presents an upstanding thin annular neck 63 which is crimped into an external circumferential groove 64 on the coil support core 45 to lock these parts together. The nut 62 itself has an external circumferential groove 65 for a purpose to be explained.

The transformer coil 47 has its lower end soldered at 66 (FIG. 8) to the neck 63 on the upper end of the mounting nut 62. The nut 62 and the stud 60 are both of high electrical conductivity metal and they effectively ground the lower end of the transformer coil 47 to the vehicle roof 44.

The metal top end cap 42 (FIG. 8) is telescoped over the upper end of the coil support core 45. This end cap has a depending thin annular neck 67 which is crimped into an external circumferential groove 68 on the coil support core 45 to lock these parts together. At this neck 67 the end cap 42 and the coil support core 45 have a radial opening 69 into which the upper end of the transformer coil 47 is inserted snugly. The transformer coil is soldered to the top end cap 42 at this location.

Above its depending neck 67 the top end cap 42 presents a cylindrical portion 70 and above that a radially outwardly projecting flange 71. A screw-threaded stud 72 is secured in the upper end of end cap 42 and projects upward therefrom to threadedly engage the complementary fitting 73 (FIG. 7) on the lower end of spring 41. The top end cap 42, stud 72, and the spring 41 are all of high electrical conductivity metal and they provide a low resistance path between the upper end of the transformer coil 47 and the lower end of antenna 40.

The complete assembly also includes electrical insulation tape 74 (FIG. 8) wrapped around the transformer coil 47 and a rigid insulation sleeve 75 extending between the vehicle roof 44 and the flange 71 on the top end cap 42. This sleeve has a sliding fit around the cylindrical portion 70 of the top end cap and preferably it is adhesively secured to the latter by epoxy resin adhesive at

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76. Also, the insulation sleeve has a sliding fit around the mounting nut 62 at the lower end of the assembly, and it is adhesively secured to the latter by epoxy resin adhesive 77 deposited in the groove 65 on this nut.

In the assembly of this system, the contact pin 58 and the stud 60 are attached first to the vehicle roof 44 to provide a mounting unit thereon. The fully assembled transformer unit, including the outer sleeve 75, is then inserted over this roof mounting unit, with the bushing 55 snugly receiving the contact pin 58 and with the nut 62 being screwed down onto the stud 60 until the lower end of the insulation sleeve 75 engages the roof. This sleeve and the top end cap 42 together provide a weather-proof housing for the transformer coil.

From the foregoing description it will be apparent that this transformer assembly may be quickly and easily attached to the vehicle body, as well as to the antenna, so as to provide a rigid physical mounting for the lower end of the antenna as well as proper electrical connections to the antenna, to the vehicle body and to the antenna lead-in cable for proper impedance matching of the antenna to the antenna lead-in cable and to the communications equipment on the vehicle. The transformer coil 47 is rigidly supported by the support core 45 with its turns properly spaced evenly to provide predetermined electrical performance characteristics and it is fully enclosed so as not to be subjected to displacement or damage by extraneous forces.

While two embodiments of the invention have been described in detail and illustrated in the accompanying drawings, it is to be understood that the invention is susceptible of other structural arrangements differing from the particular embodiments shown without departing from the spirit and scope of this invention.

I claim:

1. A vehicle-mounted communications antenna system for communications equipment having an impedance of substantially 50 ohms, said system comprising:

An upstanding half-wavelength antenna;
an antenna lead-in cable for connection to the communications equipment;

and an impedance-matching transformer unit at the lower end of the antenna comprising a rigid upstanding insulation support core having a continuous external helical groove thereon with the successive turns of the groove spaced apart evenly, a transformer coil having successive coil turns seated in said groove and evenly spaced apart thereby, conductive means at the upper end of said support core connecting the upper end of the coil to the lower end of the antenna, a conductive mounting nut telescopically engaging the lower end of said support core and attached to the lower end of the coil for grounding the latter to the vehicle body, and a conductive lead extending from the inner conductor of the antenna lead-in cable up through the support core and rigidly supported by the support core and connected to the coil at an intermediate point on the latter between its ends effective to match the impedance of the antenna to that of said communications equipment, said coil above said last-mentioned point presenting successive turns which are evenly spaced apart by the successive turns of said groove in the support core.

2. A vehicle-mounted communications antenna system for communications equipment having an impedance of substantially 50 ohms, said system comprising:

an upstanding half-wavelength antenna;
an antenna lead-in cable for connection to the communications equipment;

and an impedance-matching transformer unit comprising a rigid hollow upstanding insulation support core having a continuous external helical groove thereon with the successive turns of the groove spaced apart evenly, a transformer coil having successive coil turns seated in said groove and evenly spaced apart

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thereby, a conductive top end cap telescopically receiving the upper end of said support core and connected to the upper end of the coil, means conductively connecting said top end cap to the lower end of the antenna, a conductive mounting nut telescopically receiving the lower end of said support core and attached to the lower end of the coil for grounding the latter to the vehicle body, a conductive lead comprising a longitudinal pin snugly received in the lower end of the support core and extending upward therein and a cross pin extending from said longitudinal pin laterally outward through the support core and connected outside the support core to the coil at a point on the latter effective to match the impedance of the antenna to that of said communications equipment, said coil above said last-mentioned point presenting successive turns which are evenly spaced apart by the successive turns of said groove in the

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support core, insulation tape wrapped around said coil along its length, and a rigid insulation sleeve telescopically receiving said mounting nut and surrounding said support core and the coil along the length thereof up to said top end cap.

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HERMAN KARL SAALBACH, *Primary Examiner.*E. LIEBERMAN, *Assistant Examiner.*