

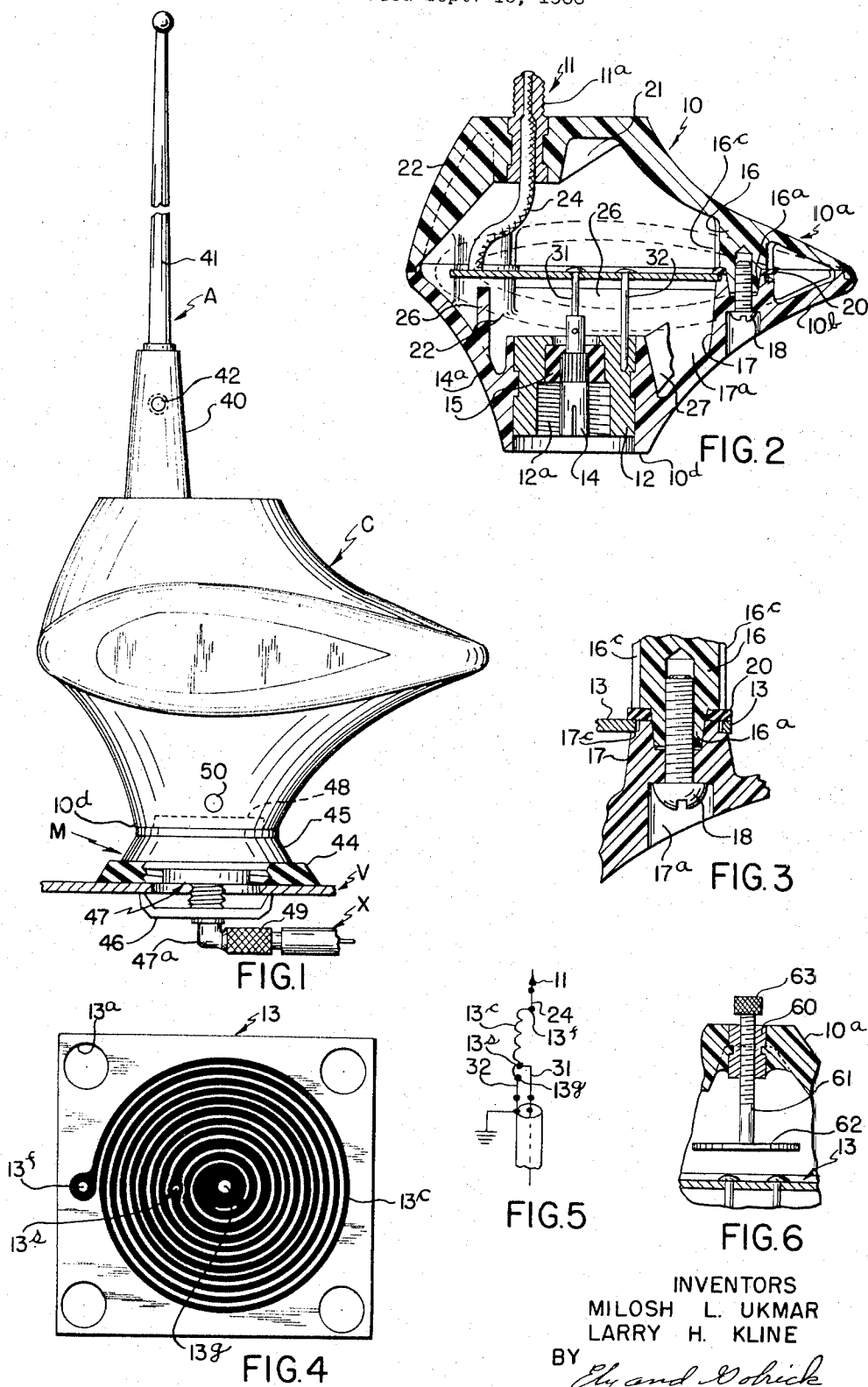
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MOBILE ANTENNA WITH FLAT SPIRAL LOADING AND MATCHING COIL

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INVENTORS
MILOSH L. UKMAR
LARRY H. KLINE
BY *Ely and Ostrick*
ATTORNEYS

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MOBILE ANTENNA WITH FLAT SPIRAL LOADING AND MATCHING COIL

Milosh L. Ukmar, Euclid, and Larry H. Kline, Beachwood, Ohio, assignors, by mesne assignments, to Allen Electric and Equipment Company, Chicago, Ill., a corporation of Michigan

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15 Claims

The present invention relates generally to an antenna and a mounting and coupling unit therefor, and more particularly to an antenna in combination with a mounting unit including a novel coupling or loading coil arrangement.

In the specific embodiment and combination hereinafter described the mounting unit includes a coil form providing in effect an impedance matching transformer and a loading coil for an end-fed antenna which is particularly adapted and useful for mobile communications equipment such as transceivers. Although the invention or various aspects thereof may have utility or advantages in other environments, it will be described herein relative to communications equipment operating on or in the so-called citizens-band frequencies, normally 27 mcs.

Transceivers or like mobile communications equipment generally have a transmitter output impedance of about 50 ohms for which standard coaxial cable is available, but the impedance of antennas of practical sizes differs markedly therefrom. Hence, a suitable coupling device or circuitry is required first to match the impedances in order to obtain acceptable energy transfer to the antenna. Moreover, for attainment of a desirably small yet relatively efficient antenna system, the coupling circuit desirably serves an antenna loading function, for increasing an antenna of acceptable physical length to an electrical length desirable for the contemplated operating frequency.

Thus for a bottom end fed and loaded antenna, the matching and loading functions in the prior art have been achieved by use of an auto-transformer type shunt fed loading coil in a mounting unit, with the metal body of the vehicle, such as an automobile, serving as the ground plane or counterpoise. Considerable effort and attention has been given in the prior art to provide a circuit and structure in such mounting and coupling units to achieve electrical and mechanical design permitting of mass production with little variation from unit to unit in the electrical characteristics, and also for maintaining precisely the originally established electrical characteristics during the lifetime of use.

However, such prior art devices have required the mechanical forming of the coils quite precisely with considerable care further being required in locating the points of connection to the transceiver equipment. Furthermore, to afford a physical structure which would not readily vary from its original disposition and electrical characteristics, hitherto it has been required that relatively rugged coil forms or support structure be used and, moreover, potted to insure invariable relation of the coil turns and associated parts.

By the present invention it is proposed to provide an auto-transformer coil of the coupling device as a printed circuit component, namely, a spiral coil on a flat insulation plate, so that the same may be produced with the points for attachment of input, output, and ground connections established in the printed circuit production, at speed, low-cost, precision and consistency now so well known for printed circuit techniques.

Further, there is provided a mounting for the component within a two-piece rugged enclosure which affords simplicity of fabrication and assembly, opportunity for

styling with considerable eye appeal, and absorbs many stresses upon the printed circuit component usually leading to deterioration and failure. The structure of the housing of the unit and the mounting is hereinafter more fully described.

Moreover, there is further provided a standard coupling unit adapted for use with a plurality of antenna forms and also with a variety of support structures whereby an auto rooftop, deck, fender, cowl or trunk lid mounted antenna installation is readily achieved, especially of an end-fed type.

It is the general object, then, of the present invention to provide an antenna particularly useful for mobile communication use, in combination with a unit mounting the antenna and further providing for impedance-matched coupling of the antenna through a standard impedance cable to the transmitter-receiver equipment proper.

Another object of the present invention is to provide an antenna mounting and coupling unit producible at relatively low cost by mass production operations with high precision and consistency from unit to unit. A still further object of the present invention is to provide for an end-fed antenna a mounting and coupling unit incorporating a printed circuit type impedance-matching or loading coil with a relatively simple and effective stress absorbing mounting for the printed circuit component within a requisite housing. A still further object of the invention is to provide for a mobile antenna, a mounting and coupling unit of the type described, which is adapted for use with a variety of supports whereby it may be readily attached at various locations on a vehicle.

Other objects and advantages will appear from the following description and the drawings wherein:

FIG. 1 is a side elevational view of an antenna mounting and coupling device, with attached end-fed vertical antenna and one manner of support on a vehicle, representing an antenna system embodying one form of the invention;

FIG. 2 is an irregular vertical section through the unit of FIG. 1;

FIG. 3 is a fragmentary sectional detail of the printed circuit board support arrangement in the housing;

FIG. 4 is a plan view of a printed circuit board component providing an auto-transformer type antenna loading and impedance-matching coupling coil;

FIG. 5 is a schematic diagram of the antenna-coupling unit circuitry; and

FIG. 6 is a fragmentary section showing a modification of the unit represented in FIG. 1.

In FIG. 1, a bottom end-fed antenna whip A is secured vertically on the top of the antenna mounting and coupling unit C, in turn at its bottom secured by a suitable support device M on a vehicle metal body portion V providing the ground plane for the antenna system connected by an energy transmission coaxial cable X or unbalanced lead means to the transceiver or other communications equipment served thereby.

It is here noted, however, that the particular ornamental design or styling of the housing herein disclosed for the unit C represents the design invention of another.

As principal components, the mounting and coupling unit C is comprised of a hollow housing 10 formed by top and bottom half-shell portions 10a, 10b of a suitable molded stable plastic or like insulating material and having respective molded-in metallic, preferably brass, inserts 11, 12 providing external connections for the antenna, for a coaxial cable lead to the transceiver or communications equipment and to the support device M; a flat printed circuit board plate component 13, providing an auto-transformer coil of the coupling unit; an insulated contact 14 supported by insulator bushing 15

concentrically in 12 for the inner conductor connection of the coaxial cable; and connecting means for the coil and mounting means as hereinafter described.

Since water or dust deposits on the coil or elements would change the electrical characteristics, these should be guarded against, through a hermetic sealing is not required. Hence the opposed lower peripheral edge of top shell 10a and upper peripheral edge of lower shell 10b are molded respectively with, in effect, an internally and externally rabbeted shape, i.e., with sections for an inter-fitting matching engagement, whereby a weather-proof, water-proof, dust-proof seal therebetween is readily effected. This seal may be made by application of a suitable solvent, for example, methyl ethyl ketone where ABS type molded plastic is used, applied at the time of assembly and effective to provide a so-called "chemical welding" or self-bonding of the parts upon evaporation of the solvent.

Further each half-shell has cooperatively opposed integrally molded upper posts 16 and lower posts 17, symmetrically located relative to the vertical longitudinal central plane of symmetry of the unit C and corresponding in center spacing to the corner apertures (see FIG. 4) of the printed circuit board 13, serving as further points of primary securement of the two housing halves to each other by self-tapping screws 18 passed upwardly through recesses 17a in the bottom posts and threaded into the center of the respective hollow top posts 16. (See also detail FIG. 3.)

Each post 17 in addition to the central screw-receiving bore is molded in effect with a larger counterbore or coaxial end recess receiving a corresponding reduced diameter end projection 16a of a length greater than the recess depth in 17 to provide a washer-capturing clearance spacing between the end of post 17 and the shoulder on the opposed top post where the reduced diameter of 16a begins. Each post 17, for a distance substantially equal to the thickness of the insulation board in 13, is reduced at its end to an outside diameter equal to that of the body of a corresponding post 16 to provide a flat shoulder 17c of external diameter greater than the board corner apertures 13a, whereby the board 13 is supported at each of its four corners by coplanar surfaces on the cooperating posts. The corner apertures of plate 13 have a diameter somewhat greater than the reduced end diameter portions of the posts 17, thereby providing circumferential clearance therewith; but respective resilient washers 20 of material such as rubber, shown fitted on projections 16a and each locally compressed by the bottom ends of a plurality of vertical longitudinal reinforcing ribs 16c running up from and having bottom ends as lateral extensions of the shoulder of each post 16, secure the board against rattling on the marginal periphery of each aperture 13a while permitting sufficient freedom for the board to shift relative to its corner supports under any subsequent tendency to warp and so absorbing the shape change to avoid related detrimental stresses in the board.

In accordance with known plastic structural design considerations, the inserts are externally grooved or otherwise contoured for firm retention in the plastic, appropriate plastic distribution and reinforcing ribs are provided as required, for example, in the top shell at 21, 22 running from the thickened inward cylindrical boss surrounding the circumferentially grooved portion of the bushing insert 11; and, on the bottom shell, ribbing 26, 27 between the bottom posts 16 and from the respective posts inwardly towards the generally cylindrical inward boss about the bushing insert 12.

The stud insert 11, having a projecting vertical portion 11a threaded to accommodate an adapter or bottom connector portion 40 of the antenna A, is seen to be in effect a sleeve or bushing adapted to receive therethrough, for an external end-soldered connection, the upper end of a slack flexible conductive braid lead 24 having its inner end

soldered in and to the apertured output point of the coil 13c.

To provide coupling means on the housing for mechanical attachment of the unit to supporting environment and a locus for termination of the lead means on the unit, in the insert 12, inward of an enlarged female threaded bore 12a, there is pressed into a reduced diameter portion an insulating collar 15 coaxially supporting a molded-in or pressed-in contact pin 14, having a split hollow cylindrical bottom portion thereby concentric with the threaded portion whereby a suitable connector attached to the environment of use and threaded into 12 may afford an external support of the unit as well as a means for an electrical connection, whereby the lead means is terminated in the unit. A short vertical copper connecting wire 31 projecting from the coaxially bored connector pin end 14a wherein it is soldered through a suitable lateral solder aperture, and a stiff brass solder pin 32 press-fitted into an eccentric bore in the top end of the insert 12, project through the board 13 to afford vertical connections top-soldered to the aperture shunt-feed and central ground connection points 13s and 13g respectively in the coil 13c on the top side of the board (coil not shown in FIG. 2, see FIG. 4). The wire 31 also may be a pin merely press-fitted into 14a.

FIG. 5 represents schematically the coil 13c in the antenna system wherein the turns between points 13g and 13s represent the primary and those between 13g and 13f the secondary of an auto-transformer for impedance-matching, and as well inductive antenna loading by some of the turns between 13f and 13s.

Although the housing could be in various ways formed of two drawn or cast metal half-shells rim sealed most conveniently by an adhesive, with suitable insulation of the stud 11 from a metallic top shell, and with a metal bottom shell machined to provide the internally bored and threaded structure presented by the insert 12, or a molded plastic top shell as in FIG. 2 with such a metal bottom shell, the molded plastic housing of the drawings is generally preferable from considerations of material costs.

The printed circuit coil board 13 comprises a nearly square, rectangular insulation plate, for example, a paper epoxy insulating board .062 inch thick originally with one ounce copper cladding as the stock for immersion plating to increase the conductive path of the finished spiral coil 13c, with the coil disposed on the top side. The coil of the pattern shown (see FIG. 4) has approximately $9\frac{1}{2}$ to $9\frac{3}{4}$ total flat spiral turns with ground feed point 13g at center, output or antenna feed point 13f at the outside, and the input or shunt feed point 13s at precisely the eighth turn inward from the output feed point 13f, or somewhat more than $1\frac{1}{2}$ turns from the effective ground center of the coil.

This printed coil structure affords an easy selection of precise coil length in a basic selected size or pattern achieved by merely providing or shifting the position of a bridge or shunt between the ground point and first turn on the stencil or photo transparency used in printed circuit production.

It is obvious that the board with the necessary turns, its appropriate corner apertures, and the drilled feed and soldering points may readily be produced precisely in consistent production by known printed circuit fabrication methods at relatively low cost.

Since the two halves 10a, 10b are fabricated with the posts 16 and 17 and their respective shoulders, apertures, ribs and inserts already provided in the molding operations the assembly proceeds quite simply. The insulator 15 with the connector pin 14 assembled therein is pressed into place in the insert 12, the short connecting wire 31 is pressed into and, if desired, soldered in the top of 14, and the pin 32 is press-fitted into 12. The board 13 with the flexible braid 24 already inserted in and soldered to the aperture antenna output or feed point 13f is placed

over the tops of and to rest on the shoulders of the posts 17, and the connectors 31 and 32 extending through the board apertured points 13s and 13g are then soldered thereto from the top; the free end of the braid 24 of measured length is then fed through the top shell insert 11 to project therefrom; and with washers 20 on 16a, the shells are then fitted together and the four self-tapping screws screwed into place, thereby clamping the board component with washers, between the shoulders on posts 17 and the shoulders provided by the bottom ends of ribs 16c. Thereafter the projecting end of the braid 24 is drawn out to a measured projection for the requisite slack between the insert 11 and the board 13; the projecting braid is trimmed off before or after soldering to the top end of 11, and the threads at 11a chased if necessary for clean up. Finally the solvent is applied to the external peripheral meeting line of the half-shells, whence by initial capillary action it is drawn between the interfitted surfaces to soften the same sufficiently to chemically weld together forming an effective seal after solvent evaporation.

The unit C itself is secured in the environment of use easily and quickly by any of a variety of devices now well known. For example, there is shown in FIG. 1 at M the general form of a securing and feed cable connector arrangement already in use for automotive vehicle roof installations including a flat annular rubber pad 44 centered about an aperture in a sheet metal vehicle roof V, and an ornamental collar 45 resting on the pad and having an apertured top inward flange on which the circular bottom edge 10d of the unit C rests; the mounting assembly M being secured on the roof by a toggle connection insertable from above comprising a toggle plate 46 threaded on the reduced lower end of a connector metal body 47 extending through the apertured top flange of 45 to receive in a bottom space of C, provided between bottom edge 10d and insert 12, a hidden nut 48 cooperating with toggle plate 46 to clamp the assembly M in position. The body 47 is male threaded over its upper main portion to mechanically engage and support the unit in the threaded insert 12 and, to provide a cooperating external connector as part of unbalanced lead means from the equipment, with body 47 serving as a portion of the grounded conductor, includes a coaxial insulated male pin element (not shown) receivable in the female pin 14 of unit C when the latter is screwed onto the projecting top end of body 47; and further is adapted to receive the cable X, e.g., a 50 ohm low loss coaxial cable, with its braided shield conductively secured by clamp sleeve 49 on the right angular bent metal tube 47a and an insulated length of its inner conductor extending up through the body to a point of conductive attachment of the inner conductor end to said male pin. Thus the structure embraced in the mechanical coupling insert 12 also provides locations where the conductors of the lead means terminate in the unit. The unit C, after being screwed in place on M and turned to desired final orientation, is secured by set screw 50 threaded through insert 12 to bear on 47a.

The ease of mounting the antenna is obvious, the internally threaded adapter connector sleeve 40 being merely screwed onto the projection 11a, the whip proper 41, e.g., of a nominal 36 inch length for citizens band frequency, being inserted in the adapter top bore and secured by a set screw 42, permitting a fine tuning or adjustment of the antenna length particularly by varying the degree of insertion of the whip in the adapter.

In FIG. 6, the unit is modified to include a simple further means in the system whereby a greater tuning ability is available by varying the inductance of the coil 13c, namely, a thin non-ferromagnetic metal plate shiftable toward and away from and in parallel disposition to the plane of the coil 13c. This function is provided by molding another sleeve insert 60 in the top half-shell

10a at the longitudinal center-plane and rearwardly of stud insert 11, female threaded to receive therethrough with axis perpendicular to the plane of coil 13c, a male threaded rod 61, bearing on its lower end a thin brass disc 62 shiftable toward and away from the coil upon rotation of the screw rod by a knurled knob 63 on its upper exterior end. A locking device to hold the adjusting screw element in selected position is provided, such as a set screw threaded through the wall of insert sleeve 60. This is particularly useful where it is contemplated that any of a variety of antenna rods or whips, varying somewhat in electrical length, may be used with one production unit.

By this invention, for example, an antenna system including a unit of the size represented in the drawings and a relatively short antenna whip of a nominal 36 inch length has been readily tuned to achieve a quite low voltage standing wave ratio of approximately 1.3 over the citizens band spectrum and better than 1.1 for resonance frequency. In this example, the antenna whip showed an impedance of about 15 to 20 ohms with a capacitive reactance component and the spiral coil 13c, of a pattern and size shown in FIG. 4 showed an inductance measured between 13g and 13f of 2.85 millihenries overall, and between 13s and 13g of 0.17 mh. at a 27 mc. test frequency, therefore, computed by difference, of 2.68 mh. between 13f and 13s.

What is claimed is:

1. For a mobile communication equipment antenna system, a mounting and coupling unit for supporting the antenna and connecting it through energy transmission lead means with the equipment comprising:

a flat spiral coil and insulation board supporting the coil and comprising therewith a printed circuit board component, said board component having coil connection points for an antenna connection and for a feed connection from said lead means,

a hollow housing enclosing and supporting said component,

a threaded stud fixed on said housing and adapted to threadedly engage and mount an antenna on the housing,

coupling means on the housing providing a region for mechanical attachment of the unit to supporting environment of use and a locus for termination of said lead means on the unit,

said stud and coupling means insulated from each other, and

first and second conductive means within the housing respectively connecting said stud to the antenna connection point and said coupling means to said feed connection.

2. A unit as described in claim 1 wherein said first conductive means is a flexible metal braid.

3. A unit as described in claim 1, wherein

said housing is comprised of two molded insulating plastic elements as half-shells having interengaging rim portions along which the shells are brought together to form a circumferentially continuous joint, and means for securing said shells together with said rim portions interengaging;

said stud being a metal insert molded in one half-shell, and

said coupling means being located on the other half-shell.

4. A unit as described in claim 3 wherein said coupling means includes a metal insert molded in place in said other half-shell, the last said insert having a threaded portion for engagement by means mounting the unit to the environment.

5. A unit as described in claim 4, wherein said coupling means includes a connecting pin coaxial with the threads of the last said insert, means insulating the pin from the last said insert, said pin having ends accessible respectively for engagement by a cooperation external electrical con-

necting element forming part of said lead means and internally for connection of one end of a said second conductive means in turn having its other end connected to said feed point.

6. A unit as described in claim 3 including board component mounting means comprising:

- a plurality of circularly apertured portions on the board external to the spiral coil;
- a like plurality of pairs of opposed post formations integrally molded on respective half-shells, the formations of each pair molded with endwise interengaging end portions extending through a respective circular aperture of the board;

all said post formations on one of said half-shells having respective external coplanar shoulders spaced from the ends thereof upon which the apertured portions of the board are respectively supported marginally circumferentially about the apertures thereof on one side of the board, each aperture providing circumferential clearance with the portion of a post formation extending therethrough;

respective resilient washers located on the other side of the board about a respective one of the post formations and opposite said shoulders,

all said post formations on the other half-shell having laterally extending formations cooperating with the shoulder formations and washers to support the board, while permitting a limited degree of shifting of the board to accommodate minor dimensional and shape changes of the board, particularly in the plane of the board.

7. A unit as described in claim 1 wherein said housing is comprised of two molded insulating plastic elements as half-shells having interengaging rim portions along which the shells are brought together to form a circumferentially continuous joint, and means for securing said shells together;

said first conductive means comprising a flexible metal braid with ends soldered to said stud and to the antenna connection point;

said half-shells having a plurality of pairs of opposed respectively integral post formations endwise telescopically engaging each other to form a board-supporting pillar extending through a respective board aperture with circumferential clearance of the aperture edge relative to the pillar, said posts of each pair including opposed shoulder surfaces on opposite sides of said board extending radially outward beyond the margins of the respective said aperture cooperating to locate the plane of said board;

said coupling means comprises a metal insert molded in place in said other half-shell and having a threaded portion for engagement by means mounting the unit to the environment, said coupling means including a connecting pin insulated from, and coaxial with the threads of, the last said insert, said pin having ends accessible respectively for engagement by a cooperating external electrical connecting element forming part of said lead means and internally for connection of one end of a said second conductive means in turn having its other end connected to said feed point.

8. A unit as described in claim 1 wherein said coil has further a point for a ground connection from said lead means at a location on the coil whereby said coil provides an auto-transformer for impedance matching between said antenna and said equipment; and including third conductive means within the housing connecting the last said connection point to a ground termination portion of said locus.

9. A unit as described in claim 8, wherein said first conductive means is a flexible metal braid.

10. A unit as described in claim 8, wherein said housing is comprised of two molded insulating plastic elements as half-shells having interengaging rim portions

along which the shells are brought together to form a circumferentially continuous joint, and means for securing said shells together with said rim portions interengaging;

said stud being a metal insert molded in one half-shell, and said coupling means being located on the other half-shell.

11. A unit as described in claim 10, wherein said coupling means includes a metal insert molded in place in said other half-shell, the last said insert having a threaded portion for engagement by means mounting the unit to the environment and forming a portion of a ground conductor of said lead means; said third conductive means connects the last said insert as said ground termination to said ground connection point of the coil.

12. A unit as described in claim 11, wherein said coupling means includes a connecting pin coaxial with the threads of the last said insert, means insulating the pin from the last said insert, said pin having ends accessible respectively for engagement by a cooperating external electrical connecting element forming part of said lead means and internally for connection of one end of a said second conductive means in turn having its other end connected to said feed point.

13. A unit as described in claim 10, including board component mounting means comprising:

- a plurality of circularly apertured portions on the board external to the spiral coil;
- a like plurality of pairs of opposed post formations integrally molded on respective half-shells, the formations of each pair molded with endwise interengaging end portions extending through a respective circular aperture of the board;

all said post formations on one of said half-shells having respective external coplanar shoulders spaced from the ends thereof upon which the apertured portions of the board are respectively supported marginally circumferentially about the apertures thereof on one side of the board, each aperture providing circumferential clearance with the portion of a post formation extending therethrough;

respective resilient washers located on the other side of the board about a respective one of the post formations and opposite said shoulders,

all said post formations on the other half-shell having laterally extending formations cooperating with the shoulder formations and washers to support the board, while permitting a limited degree of shifting of the board to accommodate minor dimensional and shape changes of the board, particularly in the plane of the board.

14. A unit as described in claim 8 wherein said housing is comprised of two molded insulating plastic elements as half-shells having interengaging rim portions along which the shells are brought together to form a circumferentially continuous joint, and means for securing said shells together; said first conductive means comprising a flexible metal braid with ends soldered to said stud and to the antenna connection point;

said half-shells having a plurality of pairs of opposed respectively integral post formations endwise engaging each other to form a board-supporting pillar extending through a respective board aperture with circumferential clearance of the aperture edge relative to the pillar, said posts of each pair including opposed shoulder surfaces on opposite sides of said board extending radially outward beyond the margins of the respective said aperture cooperating to locate the plane of said board;

said coupling means comprises a metal insert molded in place in said other half-shell and having a threaded portion for threaded engagement by support means both mounting the unit to the environment and providing an external electrical connector as

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part of an unbalanced type of said lead means, the portion of said support means achieving said threaded engagement being part of a ground conductor of the lead means;

said third conductive means connecting the last said insert as said ground termination to said connection point of the coil;

said coupling means including a connecting pin insulated from, and coaxial with the threads of, the last said insert, said pin having ends accessible respectively for engagement by a cooperating element of said external electrical connector element forming the ungrounded part of said lead means and internally for connection of one end of said second conductive means in turn having its other end connected to said feed point.

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15. A unit as described in claim 8, including a non-ferromagnetic metal plate mounted on the end of an externally accessible screw threadedly engaged in the housing for a coil inductance varying shift toward and away from and in parallelism to the plane of said coil.

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ELI LIEBERMAN, *Primary Examiner*.

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