United States Patent

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[54] MICROWAVE SPIRAL ANTENNA STRUCTURE

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[58] **Field of Search** 343/895, 908

[56] **References Cited**

UNITED STATES PATENTS

3,555,554 1/1971 Klo 343/895

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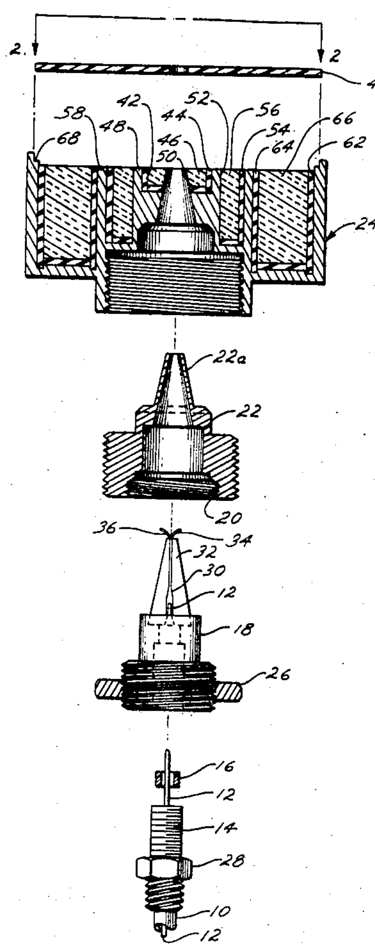
Attorney—Robert C. Smith and Plante, Hartz, Smith & Thompson

[57] **ABSTRACT**

A microwave antenna is described including a small diameter cylindrical aluminum housing which includes a plurality of concentric cavities tuned with resonant microwave material, the remaining volume of each being essentially filled with polyurethane foam material. A printed circuit spiral antenna structure overlies the cavities and is connected at its center through a microstrip balun to a coaxial conductor. A conical insert forming part of the connector overlies the microstrip balun and provides mechanical support thereto, and also prevents radiation from the balun from interfering with the operation of the cavities.

8 Claims, 2 Drawing Figures



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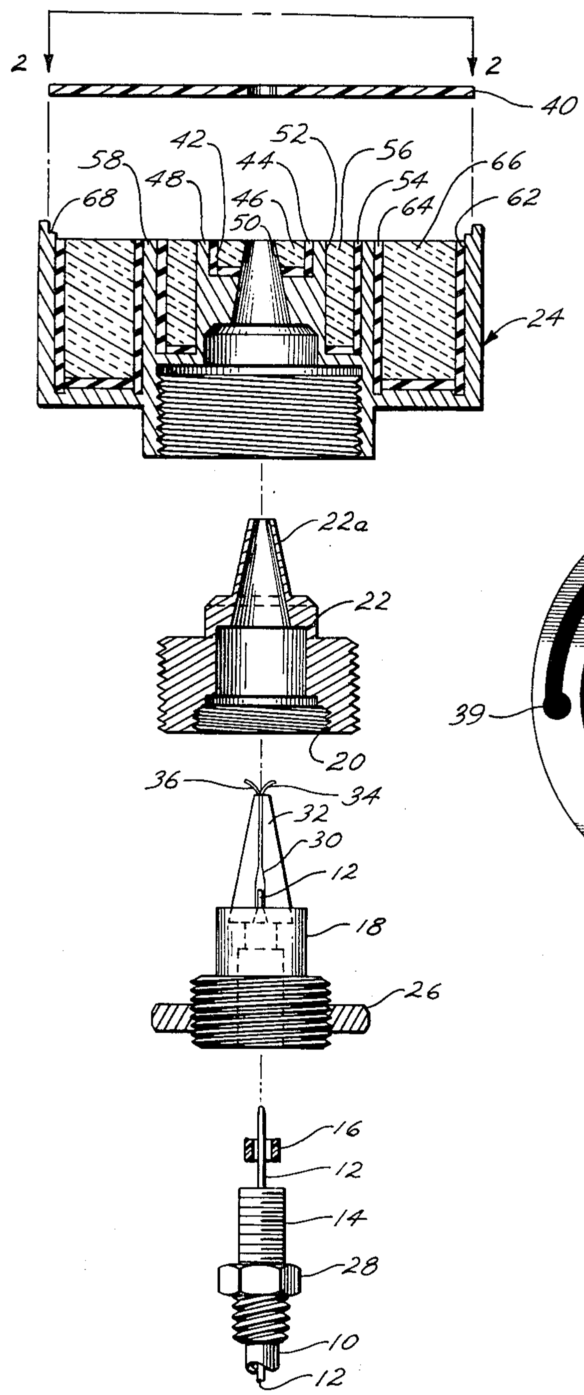

FIG_1

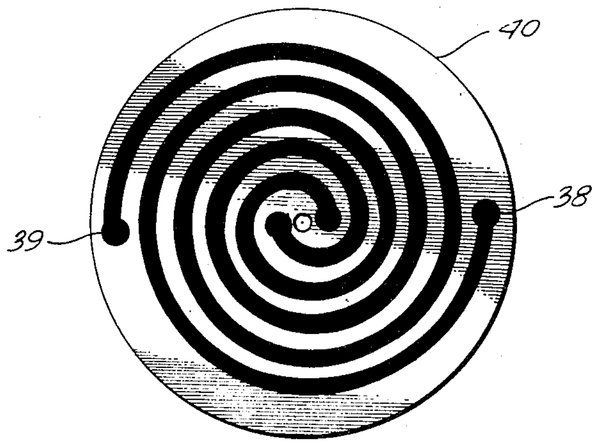

FIG_2

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MICROWAVE SPIRAL ANTENNA STRUCTURE

BACKGROUND OF THE INVENTION

The invention herein is a spiral microwave antenna having unusually broadband frequency characteristics. In U.S. Pat. No. 3,441,937 (common assignee), the applicants have disclosed a cavity backed spiral microwave antenna and feed structure of quite small dimensions in which the cavity is tuned by being lined with resonant microwave absorber material and dimensioned to minimize cancellations due to reflections from the bottom or back side of the cavity. This type of antenna has good bandpass characteristics, but when operated outside of its normal pass band as defined by its dimensions, unfavorable mode effects cause reduced gain and irregular patterns of reception for vertically, horizontally, or circularly polarized signals. There is, therefore, a need for a microwave antenna of size comparable to that discussed above which is capable of substantially broader frequency coverage without the undesirable performance limitations referred to above.

SUMMARY OF THE INVENTION

The present invention relates to a microwave antenna of small size with excellent broad band characteristics. This design extends the band width as compared with the design described in U.S. Pat. No. 3,441,937 by approximately 100 percent. This is accomplished by varying the resonating cavity construction such that, instead of a single cavity, a plurality of concentrically arranged cavities are used, each tuned and dimensioned as to diameter and depth, to optimize reception for a particular frequency band. Optimum reception characteristics, in this case, refers to essentially identical smooth curve patterns for both horizontal and vertically or circularly polarized input signals and to an absence of irregularity in the patterns caused by undesirable moding effects. Some small reduction in gain is experienced at the frequency boundaries between the bands, but the location of these boundaries may be controlled through design of the band widths of the individual cavities. The cavities are tuned, in large part, by lining them with resonant microwave absorber to avoid spurious reflections, and they may be filled with any suitable plastic foam material as an aid in retaining the absorber lining.

An antenna of this type is normally connected to a receiver through a coaxial cable and a balun or impedance matching transformer of the type shown in Gunshinan et al., U.S. Pat. No. 3,523,260 (common assignee). Although this balun is quite effective in minimizing spurious and undesirable radiation while effecting an impedance transformation, some such radiation does occur, and the antenna described herein includes a conical shield surrounding the balun to prevent such radiated energy from reaching the cavities and interfering with their operation.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded view, largely in section, of an antenna assembly made according to our invention.

FIG. 2 is a plan view of a printed circuit spiral antenna forming part of the assembly of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, a coaxial lead having an outer shield 10 and a center conductor 12 is constrained within a cylindrical threaded connector member 14 with the center conductor extending outwardly from member 14 on its inner end and surrounded by means of an annular insulator member 16. Member 14 is threadedly engaged with the interior of a mating connector member 18 which is threadedly engaged with threads 20 on the interior surface of a conical insert member 22. Member 22 is, in turn, threadedly engaged with the internal threads of the main antenna housing 24. A nut 26 carried on the exterior threads of connector 18 is tightened against the outside face of insert member 22 to secure connector 18 to member 22. Similarly, a nut 28 is tightened against the outside face of connector 18 to secure connector members 14 and 18 together. The inside end or upper end, as shown, of center conductor 12 is soldered to the wide end of the conductor track 30 on the balun 32. A similar, but differently tapered, conductor on the opposite side of balun 32 is soldered to the opposite side of the circuit as represented by the connector member 14. A pair of wires 34 and 36 provide connections between the balun conductor tracks and the spiral conductor tracks 38, 39 shown on the antenna board 40 (see FIG. 2).

As the connector member 18 is engaged with the conical insert member 22, the balun 32 will be drawn up into the conical sleeve portion 22*a* of member 22 such that the wires 34, 46 will protrude from sleeve 22*a*. When member 22 is fastened to housing 24, wires 34, 36 may be soldered to the tracks 38, 39 of antenna board 40. The conical sleeve 22*a* effectively shields undesirable radiation from the balun from reaching the cavity portions of housing 24 and also provides mechanical support for the balun.

The main housing member 24 includes a center cavity 42, an indeterminate cavity 52, and an outside cavity 62, each of which is essentially annular in configuration and of width and depth defined by the frequency range for which it is designed. Microwave resonant absorber 44 is retained on the wall of cavity 42 by means of a filling of plastic foam 46 of material such as polyurethane foam. Similarly, an absorber lining 54 appears on the sides and bottom of cavity 52, retained by a foam filling 56, and an absorber lining 64 in cavity 62 is retained by foam 66. The inner wall of intermediate cavity 52 was not lined with absorber because, in this particular case, it was found not to be required.

When the member 22 is threadedly engaged with housing 24, the conical shield 22*a* enters the tapered bore 50 and fits snugly such that its height is above that of the walls 48 and 58 between the cavities and essentially the same height as shoulder 68. The walls 48 and 58 are lower than the height of the shoulder 68 which supports the antenna board 40, and thus board 40 is separated from walls 48 and 58 by a significant space which may be air. Alternatively the height of the foam could be increased slightly to provide mechanical support for the antenna board 40, if desired. The height of walls 48 and 58 may vary and be quite critical in a given application since, if they are too close to board 40, they may interfere with operation of the antenna element. If they are too low, they will permit leakage from cavity to cavity, thus degrading performance. Those skilled in the art will recognize that the height of any given wall will depend somewhat upon the frequency crossover point between the cavities and will be able to choose a suitable height for any particular application for convenience in drawing since the actual antenna has many more convolutions of much narrower width than shown.

The diameter of the antenna and the number and spacing of the cavities is directly related to the frequency range which it is desired to cover, as will be appreciated by those skilled in the art. In general, the depth of each cavity will be slightly less than one-quarter wave length of the lowest frequency which it is expected to receive. An antenna which has been built is approximately two inches in diameter and provides excellent performance over the range of 2 – 20 GHz. Lower frequencies will require larger diameters and, if only higher frequencies are of interest, smaller diameters may be used. The dimensions of the individual cavities may be chosen with two principal factors in mind: first, the range over which optimum or near optimum performance is available, and second, the narrow frequency bands over which some loss in gain would be of least concern. The particular impedance matching balun shown is useful over the 2 — 20 GHz frequency range, but other arrangements such as that shown in the aforementioned Clasby et al., U.S. Pat. No. 3,441,937 may be preferred where the emphasis is on lower frequency ranges.

We claim:

1. A wide band width microwave antenna comprising:

a cylindrical housing of electrically conductive material whose height is substantially less than its radius,

a first cylindrical cavity in said housing centered on the axis thereof and having a depth substantially less than the height of said housing;

a second cavity in said housing concentric of said first cavity and spaced therefrom by means of a wall of electrically conducting material, said second cavity having greater depth than said first cavity;

a tapered bore and a threaded boss formed concentric with the axis of said housing;

a spiral antenna mounted on a substantially circular member of insulating material positioned on said housing such that its conductive pattern is to the outside and the opposite side of said member overlies said cavities, said member being spaced from said wall;

an insert member threadedly engaged with said boss, said insert member including a conical shield portion positioned in said conical bore and extending therethrough to the approximate height of said wall;

a waveguide device in said insert member having connections to said antenna conductive pattern; and means connecting a coaxial conductor to said waveguide.

2. A wide band width microwave antenna as set forth in claim 1 wherein at least one additional cavity is formed in said housing concentric with respect to said first and second cavities.

3. A wide band width microwave antenna as set forth in claim 2 wherein each of said additional cavities has greater depth than those closer to the axis of said housing.

4. A wide band width microwave antenna as set forth in claim 1 wherein said cavities are substantially tuned with liners of resonant microwave absorber material.

5. A wide band width microwave antenna as set forth in claim 3 wherein said cavities are substantially tuned with liners of resonant microwave absorber material.

6. A wide band width microwave antenna as set forth in claim 4 wherein said cavities contain a filler of polyurethane foam material.

7. A wide band width microwave antenna as set forth in claim 1 wherein a shoulder is formed on the outside edge of said housing for supporting said antenna at a height slightly above said wall.

8. A wide band width microwave antenna as set forth in claim 5 wherein the heights of the walls between said cavities are variable with the frequency ranges of the adjacent cavities.

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