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Lange

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[54] **MULTI-STAGED ANTENNA OPTIMIZED FOR RECEPTION WITHIN MULTIPLE FREQUENCY BANDS**

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[73] Assignee: **California Amplifier**, Camarillo, Calif.

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[51] **Int. Cl.**^{6} **H01Q 13/00**; H01Q 11/10

[52] **U.S. Cl.** .... **343/781 R**; 343/792.5; 343/840

[58] **Field of Search** .... 343/792.5, 795, 343/781 R, 840, 872

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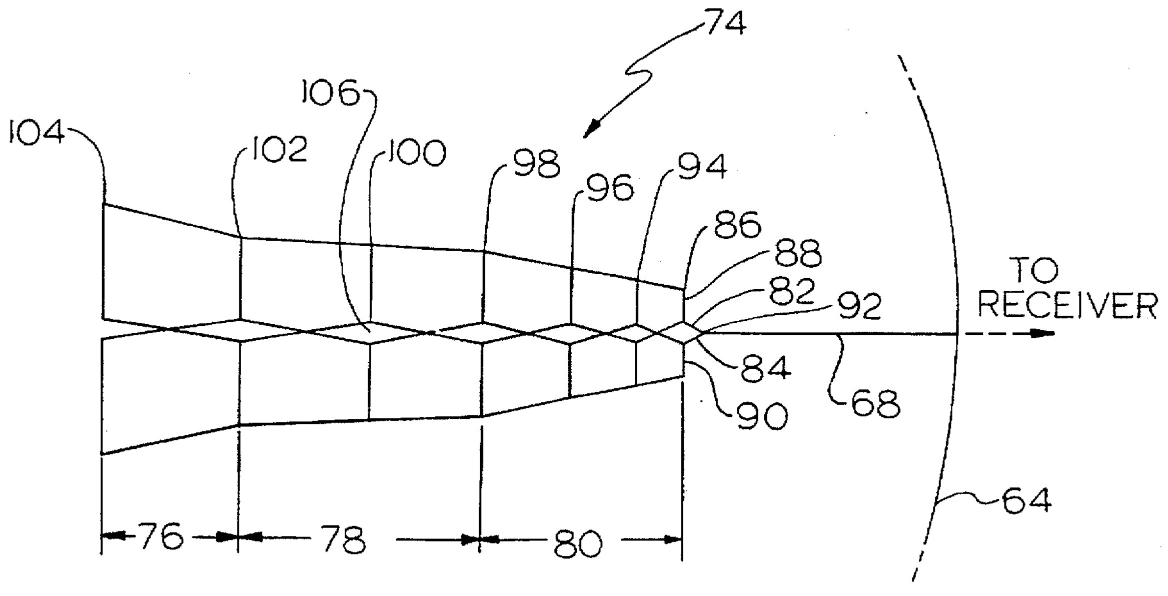
Assistant Examiner—Tan Ho
Attorney, Agent, or Firm—Freilich, Hornbaker, Rosen

[57] **ABSTRACT**

An antenna suitable for use at subscriber sites in a television distribution system having a high front-to-back ratio and optimized for reception within multiple frequency bands. The antenna is comprised of multiple tapered antenna stages including a primary antenna stage for receiving a primary frequency band and a coupling antenna stage for matching the impedance of the primary antenna stage to either a coaxial cable or downconverter electronics. The multiple antenna stages are alternatively formed from either a stamping of a metal sheet or a double sided printed circuit board.

14 Claims, 9 Drawing Sheets



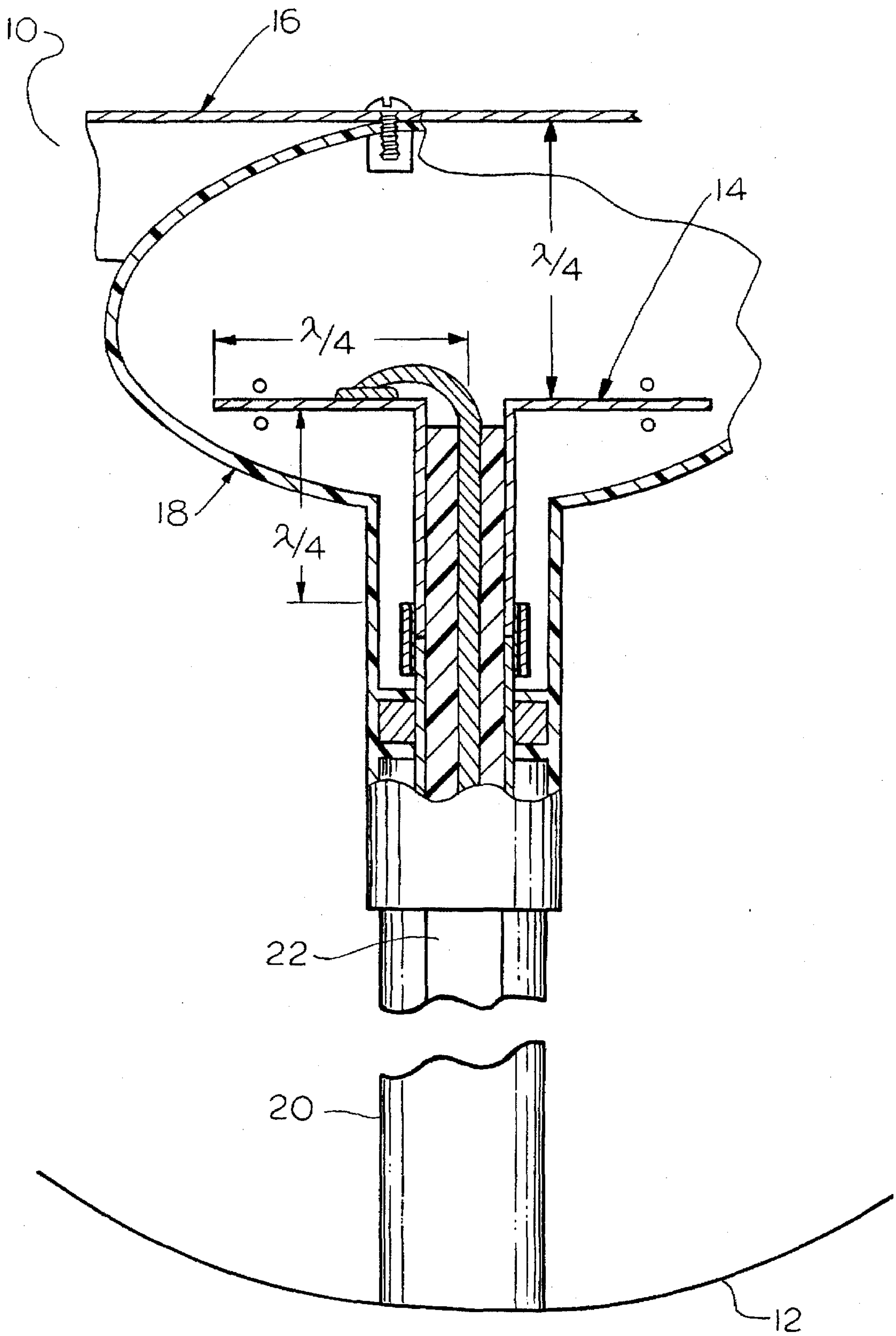


FIG. 1A (PRIOR ART)

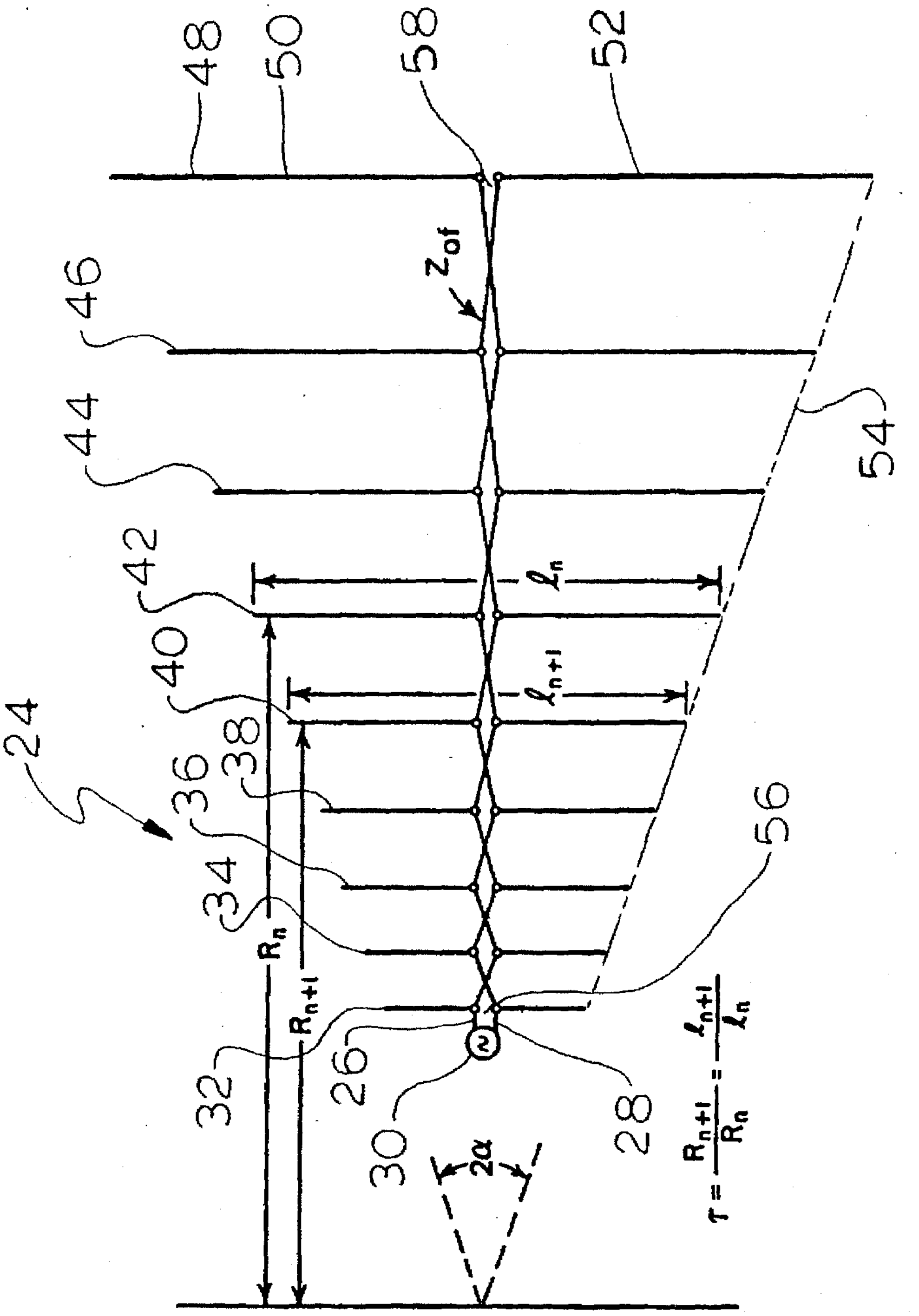


FIG. 1B (PRIOR ART)

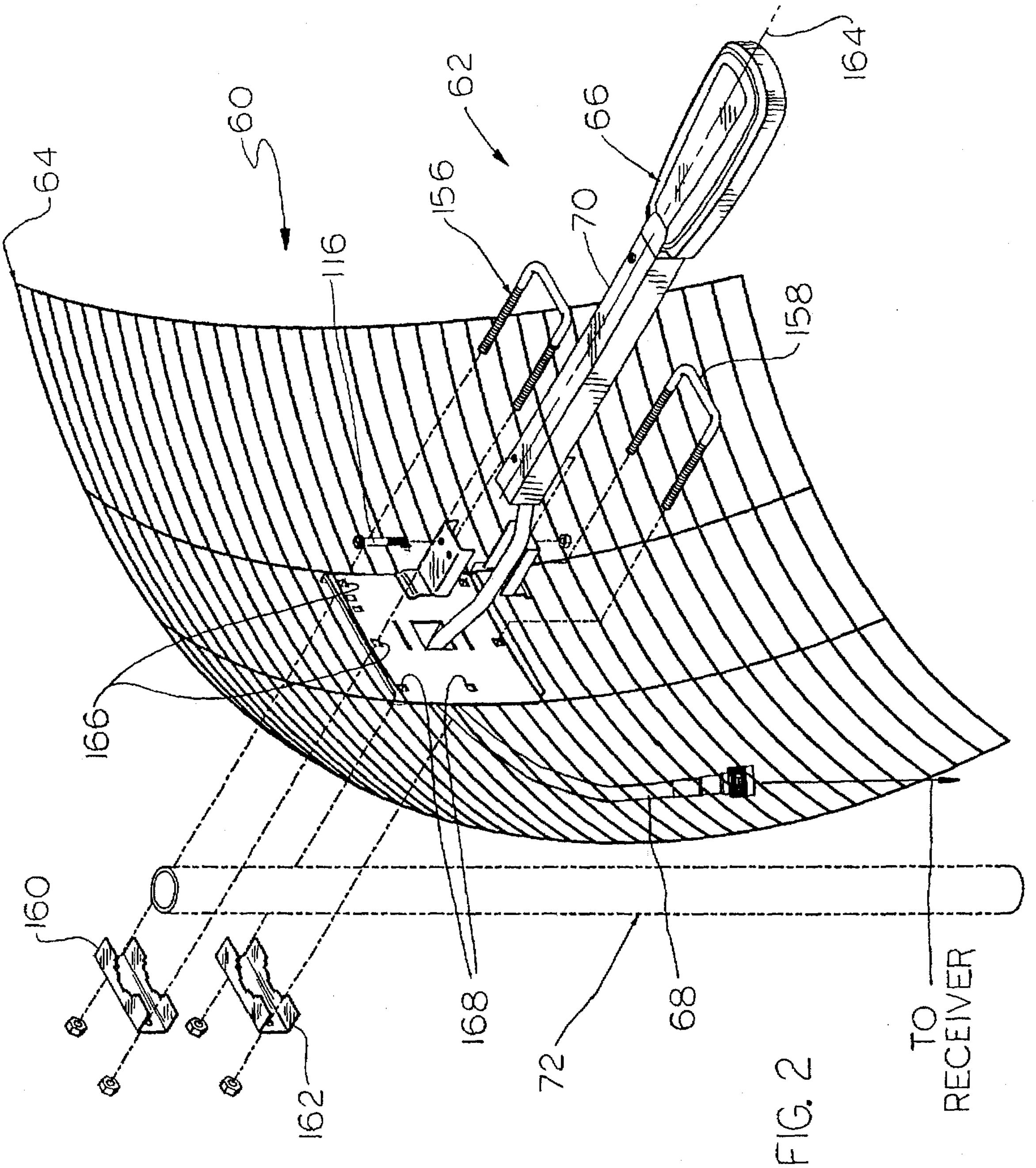


FIG. 2

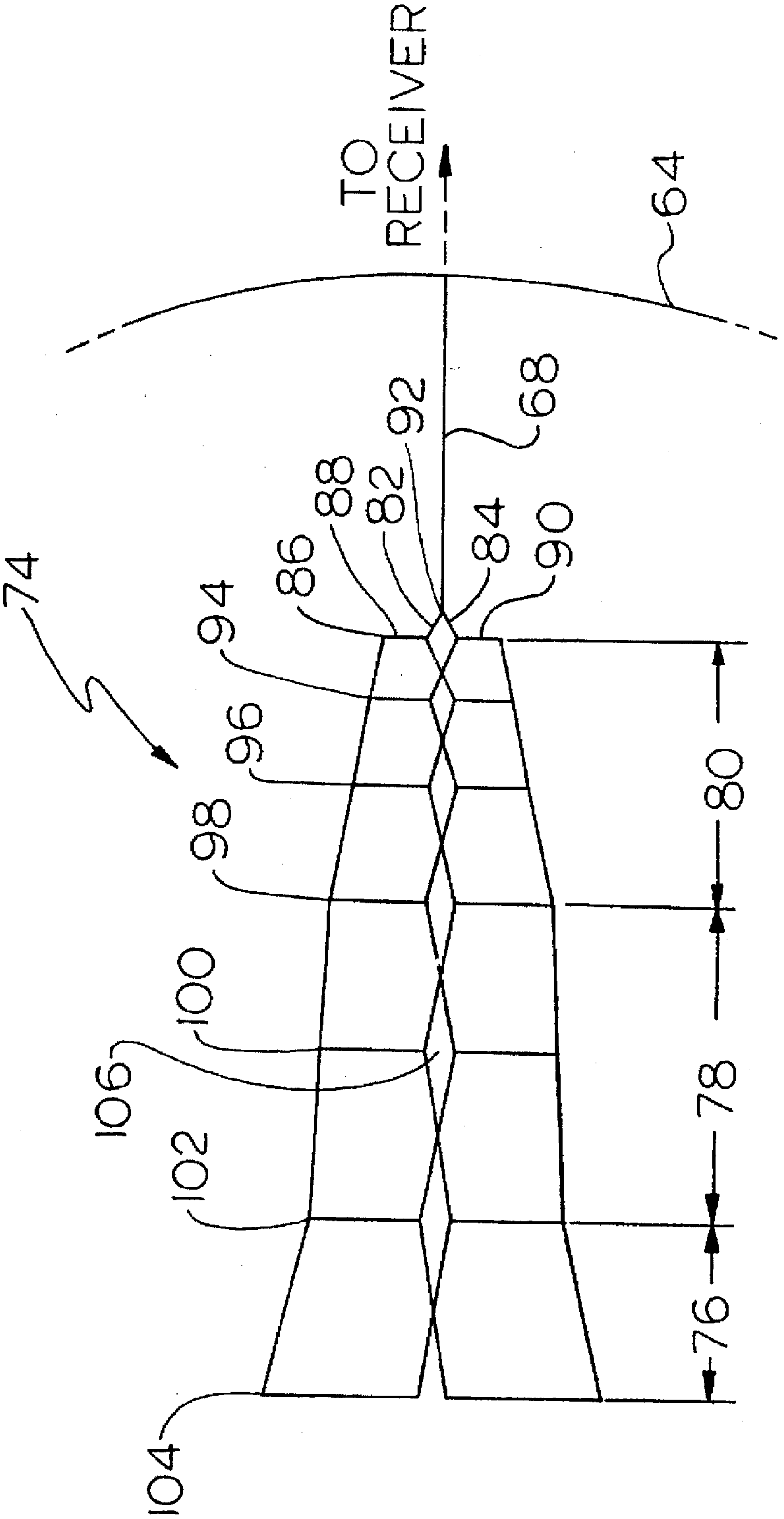

TO RECEIVER
64
68
92
88
82
86
84
90
74
94
96
98
100
106
102
104
80
78
76

FIG. 3

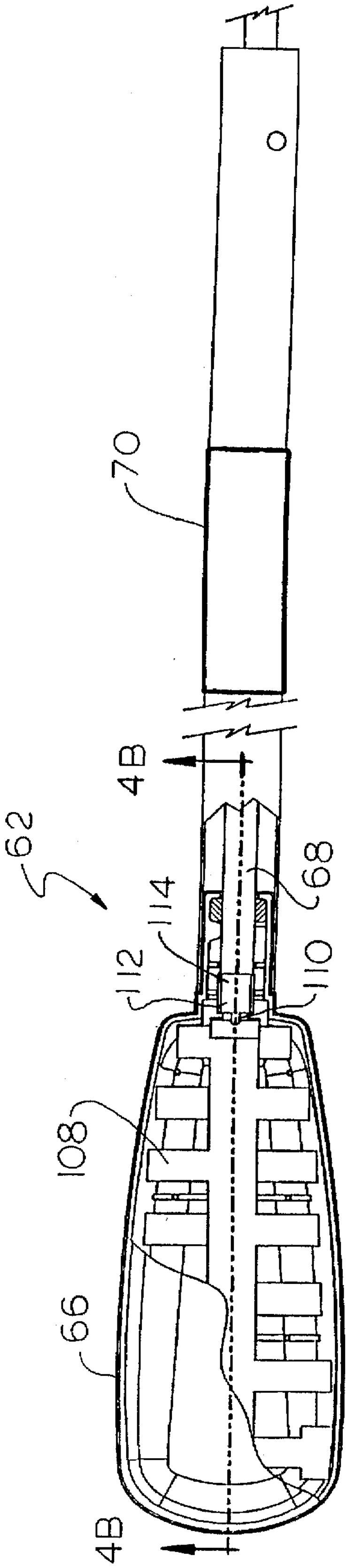


FIG. 4A

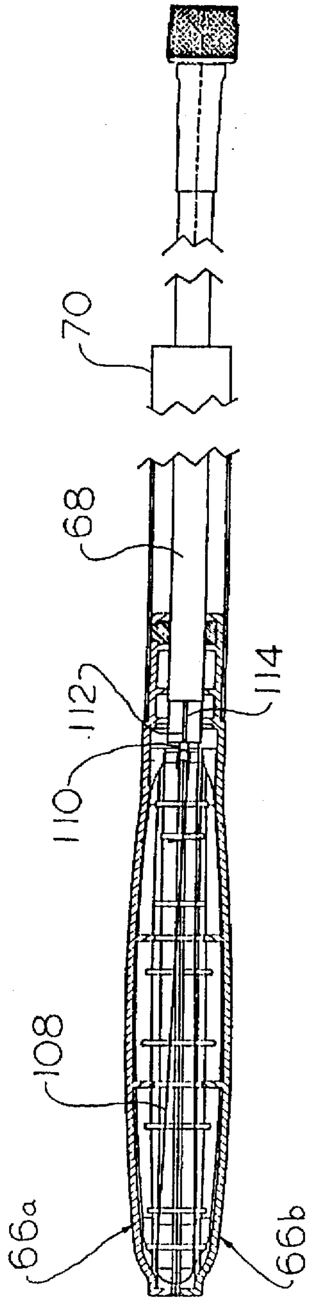


FIG. 4B

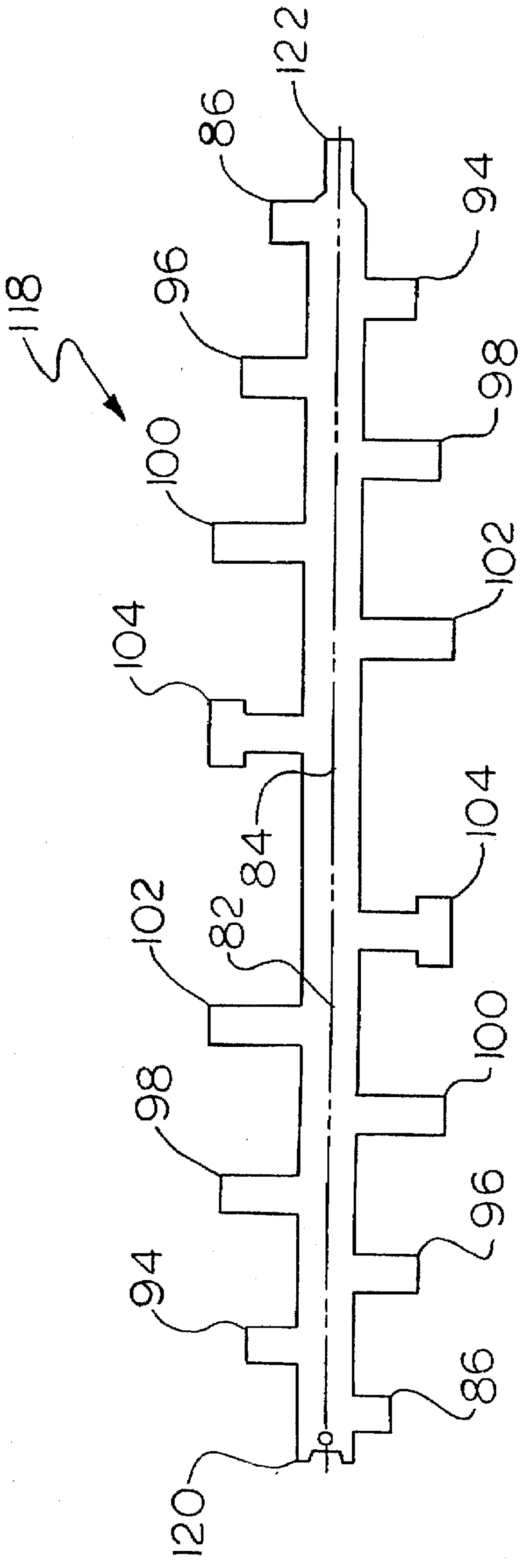


FIG. 5

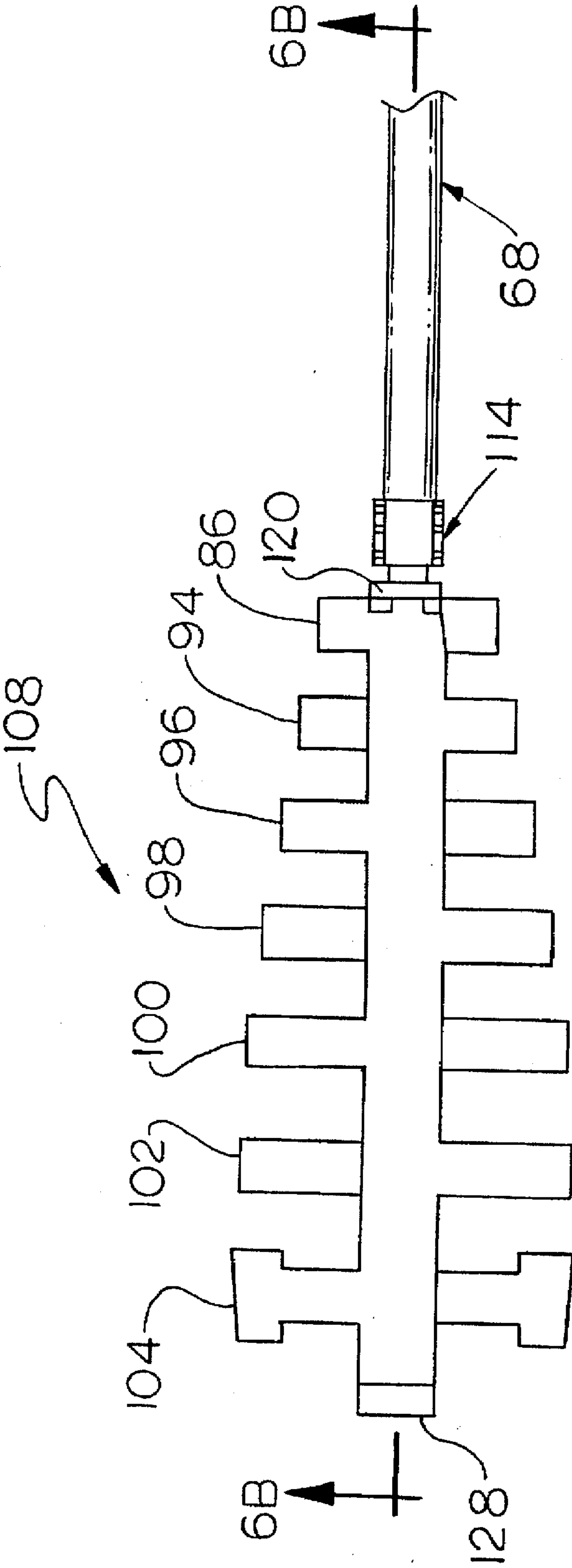

6B
68
114
120
86
94
108
96
98
100
102
104
128
6B

FIG. 6A

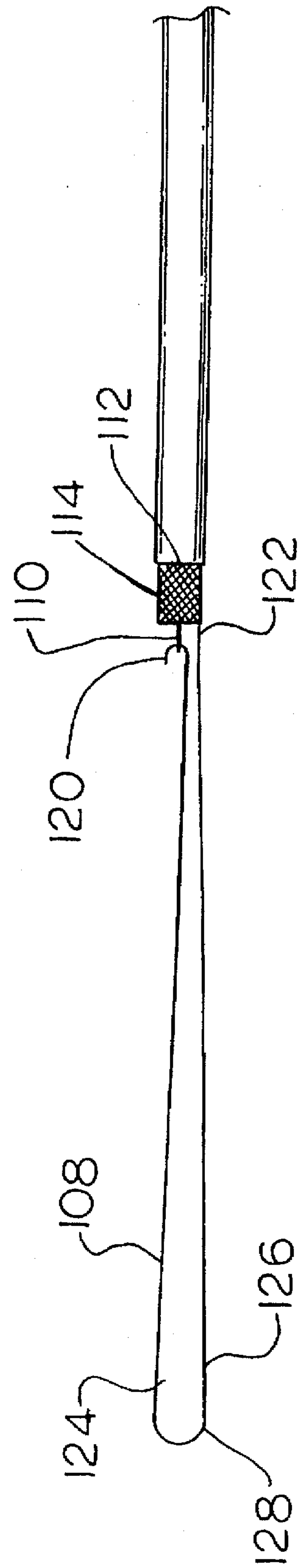

112
114
110
122
120
108
126
124
128

FIG. 6B

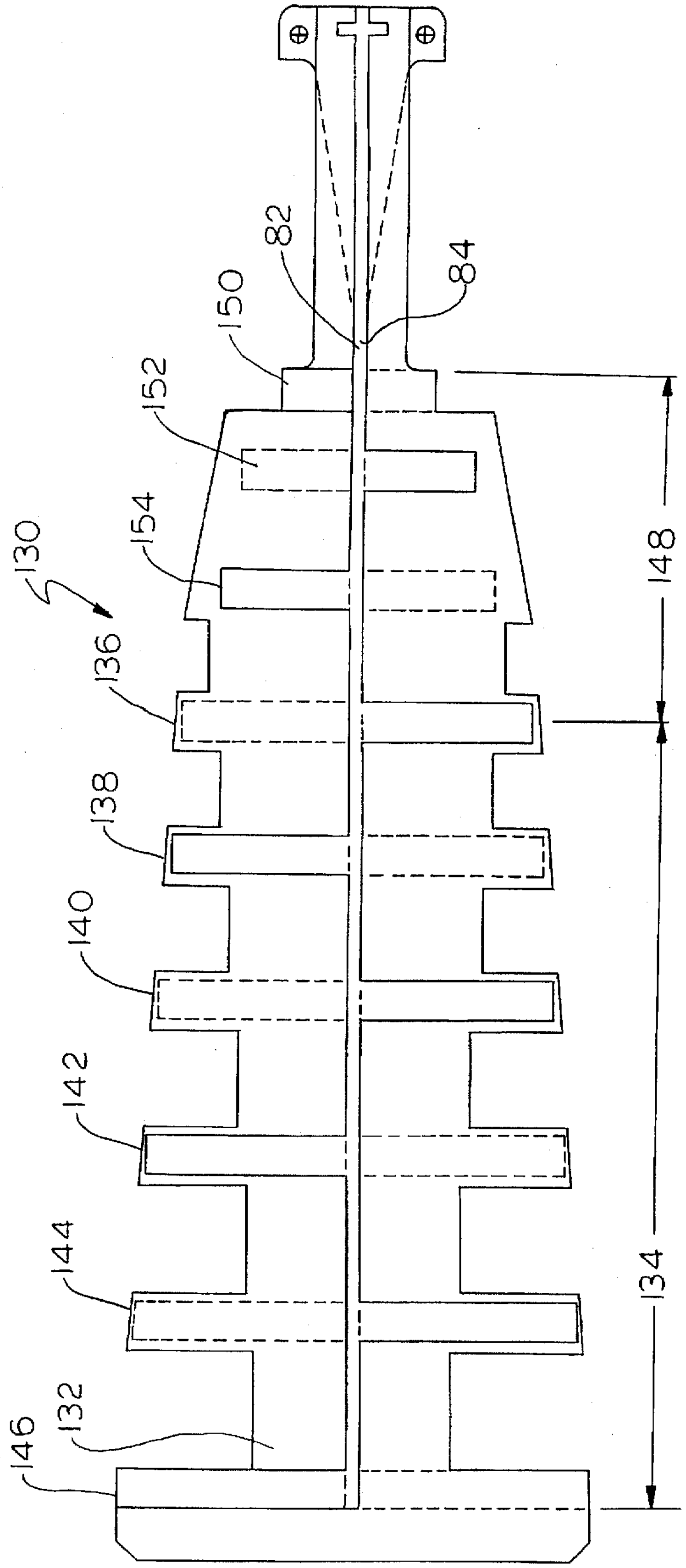


FIG. 7

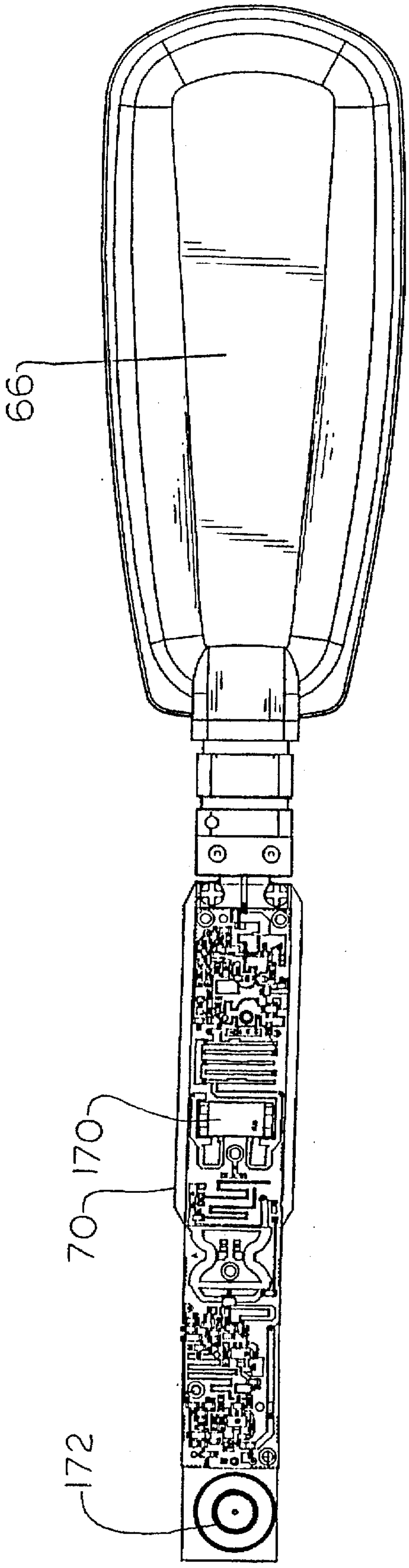


FIG. 8

MULTI-STAGED ANTENNA OPTIMIZED FOR RECEPTION WITHIN MULTIPLE FREQUENCY BANDS

BACKGROUND OF THE INVENTION

The present invention relates to antennas suitable for use at subscriber sites in a television distribution system for receiving microwave signals.

Subscription television service is typically provided either by hardwired cable systems or by "wireless cable" over-the-air systems. Wireless cable systems generally transmit within multiple bands of microwave frequencies, e.g., the 2.15 to 2.162 GHz Multipoint Distribution System (MDS) Band, the 2.4 to 2.4835 GHz Industrial Scientific Medical (ISM) Band and the 2.5 to 2.686 GHz Multichannel Multipoint Distribution System/Instructional Television Fixed Service (MMDS/ITFS) Band. All such microwave links are subject to the detrimental effects of multipath and competing source interference. In order to reduce the effects of interfering sources while obtaining a low cost to performance ratio, it is desirable to control antenna parameters such as the side lobe level, the front-to-back ratio, and the cross polarization level.

A typical prior art dipole feed antenna **10** used in a television distribution system (as shown in FIG. 1A) consists of a parabolic wire grid reflector **12** fed by a dipole **14** with a metal splash plate **16** placed approximately a quarter wavelength (relative to the center frequency of its desired frequency band) away from the dipole **14** on the opposite side from the reflector **12**. The dipole **14** is typically placed within a radome **18** and positioned in front of the reflector **12** with a hollow metal tube **20**. The tube **20** typically accommodates either a coaxial cable **22** or a downconverter. U.S. Design Pat. No. 269,009 and 268,343 respectively show typical examples of reflectors and radomes found in the prior art.

This use of the dipole **14** with the splash plate **16** typically presents some difficulties for feeding the reflector **12**. While the purpose of the splash plate **16** is to increase the sensitivity of the dipole **14** towards as compared to away from the reflector **12**, i.e., the front-to-back ratio, the measured radiation pattern shows that typical front-to-back ratio of this type of dipole represents an undesirable signal loss due to the lack of sensitivity of the dipole **14** in the direction of the reflector **12**. Another typical drawback to using the splash plate **16** near the dipole **14** is that it blocks a portion of the signal coming into the reflector **12**, reducing its effective area as well as forming a discontinuity in the electric field distribution impinging on the reflector surface.

Another class of prior art antennas includes log periodic (LP) antennas as described in Chapter 14 of the "ANTENNA ENGINEERING HANDBOOK Third Edition" by Richard C. Johnson, which is herein incorporated by reference. FIG. 1B, a reproduction of FIGS. 14–32 of the aforementioned reference, shows a schematic diagram of a typical LP antenna **24** comprised of first and second electrically conductive feed lines **26** and **28** driven by a signal source **30** and a plurality of dipoles **32**, **34**, **36**, **38**, **40**, **42**, **44**, **46** and **48** coupled to the feed lines **26** and **28**. Each dipole, e.g., dipole **48**, is formed from opposing dipole halves, e.g., dipole halves **50** and **52**, that are respectively coupled at right angles to the feed lines **26** and **28**. A significant feature of the LP antenna **24** is that a single line **54** connecting the end points of each of the dipoles defines a taper α which prescribes the performance of the LP antenna **24**. LP antennas are typically used to achieve broad bandwidths, e.g., on the order of several decades. However, the radiation characteristics of LP antennas are not well suited for use as feeds for reflectors since they typically have low gain, a low front-to-back ratio and unequal beamwidths in the two principal planes. While the beamwidths can be made nearly equal by spreading the two halves of the LP antenna apart (see FIGS. **14–30** of the aforementioned reference), this approach typically increases blockage and cross polarization. Additionally, the phase center location of LP antennas typically moves with frequency along the LP antenna, e.g., between a center point **56** of dipole **32** and a center point **58** of dipole **48**.

SUMMARY OF THE INVENTION

The present invention is directed to antennas exhibiting high front-to-back ratios and optimized for receiving signals in multiple microwave frequency bands, e.g., those frequency bands used by subscription television systems.

Embodiments of the present invention preferably comprise: 1) a reflector for focusing microwave signals to a focal point in front of said reflector, and 2) an array of dipoles having an essentially fixed phase center positioned essentially coincident with said focal point, wherein said dipole array is comprised of first and second feed lines respectively having diametrically opposed dipole halves coupled at essentially right angles to said feed lines. The dipole array is configured to define a primary stage comprised of a plurality of differently-sized primary dipoles arranged such that their ends define a first taper, and wherein each primary stage dipole is essentially a half wavelength long relative to the center frequency of a primary frequency band. The array further defines a coupling antenna stage comprised of a plurality of differently-sized secondary dipoles arranged such that their ends define a second taper greater than said first taper and wherein a common dipole is shared by said primary and coupling antenna stages.

Dipole array embodiments of the present invention are preferably formed either from stamped sheet metal, e.g., copper, or by conductive tracings on a printed circuit board. In the sheet metal embodiment, a sheet metal stamping is essentially folded back on itself to form the first and second feed lines. In the printed circuit board embodiment, the first and second feed lines are preferably formed by conductive tracings on opposite sides of the board.

Typically, adjacent subscription television systems use different polarization, i.e., vertical or horizontal. Therefore, preferred embodiments of the invention are preferably configured to exhibit low cross polarization levels for rejecting adjacent systems interfering signals.

The novel features of the invention are set forth with particularity in the appended claims. The invention will be best understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a cross sectional view of a typical prior art dipole feed antenna;

FIG. 1B is a schematic diagram of a typical prior art LP antenna comprised of first and second feed lines and a plurality of dipoles having a common taper;

FIG. 2 is a partially exploded view of an antenna assembly having a quasi log periodic (QLP) dipole array positioned at the focal point of a reflector;

FIG. 3 shows a schematic diagram of a preferred QLP dipole array comprised of three cooperative stages;

FIG. 4A shows a cutaway view of a preferred antenna feed subassembly using a QLP dipole array implemented with a sheet metal stamping and showing the QLP dipole array within a radome;

FIG. 4B shows a cross sectional view substantially along the plane 4B—4B of the preferred antenna feed subassembly of FIG. 4A showing the placement of the QLP dipole array within the radome;

FIG. 5 shows a top view of a preferred stamping used to implement the QLP dipole array;

FIG. 6A shows a top view of the QLP dipole array formed by folding the stamping of FIG. 5;

FIG. 6B is a side view of the QLP dipole array of FIG. 6A shown substantially along the plane 6B—6B;

FIG. 7 shows a printed circuit implementation of the QLP antenna; and

FIG. 8 shows a partially cutaway top view of a antenna feed subassembly implemented with a printed circuit dipole array showing its direct connection with a printed circuit board implementation of a downconverter.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is directed to antennas optimized for use within multiple frequency bands and exhibiting high front-to-back ratios, low cross polarization levels, and an essentially fixed phase center. In a preferred application, an embodiment of the present invention can be configured for use by subscription television subscribers to efficiently receive microwave signals in the 2.15 to 2.162 GHz Multipoint Distribution System (MDS) Band, the 2.4 to 2.4835 GHz Industrial Scientific Medical (ISM) Band and the 2.5 to 2.686 GHz Multichannel Multipoint Distribution System/Instructional Television Fixed Service (MMDS/ITFS) Band with performance exceeding that of currently available products at a comparable cost. Embodiments of the present invention are configured in multiple stages corresponding to the previously described frequency bands and provide a unique antenna feed assembly which efficiently illuminates a reflector as a consequence of a high front-to-back ratio, e.g., greater than 20 db.

FIG. 2 shows a partially exploded view of an antenna assembly **60** primarily comprised of an antenna feed subassembly **62** positioned in front of a reflector **64**, preferably parabolic. The primary purpose of the reflector **64** is to focus signals to a fixed focal point located in front of the reflector **64** where it is then received by the antenna feed subassembly **62**. (Note, the transmissive properties, i.e., the ability to radiate, and the receptive properties, the ability to receive radiation, of antennas are reciprocal. Thus, while much of the following description refers to receptive properties of an antenna, the description applies equally to transmission.) The antenna feed subassembly **62** is primarily comprised of a dipole array (described further below) having an essentially fixed phase center, a radome **66** encasing the dipole array, a coaxial cable **68** or a downconverter for interfacing the dipole array to a receiver (not shown) and a mounting tube **70** which is used to position the phase center of the dipole array at the focal point of the reflector **64**. As will be discussed further below, the antenna assembly **60** is mounted to a mast **72** to aim the antenna assembly **60** to optimally select a desired source signal according to the signal's origin and polarization.

FIG. 3 shows a schematic diagram of a preferred dipole array **74**, referred to as a quasi log periodic (QLP) dipole array due to its similarity to log periodic (LP) antennas. The QLP dipole array **74** is preferably formed of three cooperative antenna stages: 1) a secondary antenna stage **76** which is optimized for a secondary frequency band, 2) a primary antenna stage **78** which is optimized for a primary frequency band, and 3) a coupling antenna stage **80** which is used to balance the currents and match the impedance of the QLP dipole array **74** to the coaxial cable **68** or downconverter. In an exemplary embodiment, the secondary frequency band is the 2.15 to 2.162 GHz MDS band and the primary frequency band is 2.4 to 2.686 GHZ which includes the 2.4 to 2.4835 GHz ISM and the 2.5 to 2.686 GHz MMDS/ITFS bands.

The QLP dipole array **74** is essentially an array of at least seven dipoles which are coupled to first and second feed lines **82** and **84**, which in turn are coupled to the coaxial cable **68**. Each dipole, e.g., dipole **86**, is formed from a pair of dipole halves, e.g., dipole halves **88** and **90**, that are respectively coupled at right angles to the opposing feed lines **82** or **84**. Each successive dipole is coupled to opposing feed lines to provide an additional 180° phase shift between dipoles for a total phase shift between dipoles of 270°. When the signal radiates toward the reflector **64**, an extra 90° is added to the phase shift between dipoles for a total phase shift of 360°. In this way the signals from each dipole add in phase towards a feed point **92** which is coupled via the coaxial cable **68** to a receiver (not shown). When the signal radiates into the dipoles from the direction opposite the feed point **92**, 90° of phase shift between dipole halves is subtracted for a total of 180° of phase shift between dipoles. Thus, the signals received in each dipole cancel with each other when coming from the direction opposite the feed point **92**. While more than seven dipoles can be used to further improve performance, it is difficult to achieve a good front-to-back ratio with less than seven dipoles.

The first four dipoles, i.e., the coupling dipoles, **86**, **94**, **96** and **98** in the QLP dipole array **74**, relative to the feed point **92** and comprising the coupling antenna stage **80**, are strongly tapered (as denoted by a dashed-line connecting the ends of each constituent dipole). Dipoles **86**, **94** and **96** do not significantly radiate since they are much shorter than a half wavelength relative to the primary frequency. However, dipoles **86**, **94** and **96** are required to produce a good impedance match across the desired frequency band, resulting in a high return loss, e.g., greater than 15 db. The shorter dipoles **86**, **94** and **96** additionally behave as directors, causing a slight phase delay in the radiated signal due to their capacitive nature.

The primary antenna stage **78** is preferably comprised of at least three dipoles **98**, **100** and **102**, i.e., primary dipoles, having lengths of approximately a half wavelength at the center frequency relative to the primary frequency band. To achieve a good impedance match between the primary antenna stage **78** and the coupling antenna stage **80** and consequently matching the primary antenna stage **78** to the coaxial cable **68**, dipole **98** is positioned and sized to be common to both the coupling and primary antenna stages **80** and **78**. Thus, the taper of the coupling antenna stage **80** is chosen accordingly. In order to spread the radiated power out among more than just the first of these dipoles, it is necessary to have at least one dipole slightly shorter than a half wavelength and at least one dipole slightly longer than a half wavelength. Thus, the dipoles exhibit only a slight taper (as denoted by a dashed-line connecting the ends of each of the constituent dipoles) from one end to the other, i.e., dipole **98** is shorter than dipole **100** and dipole **100** is shorter than dipole **102**. Since different length dipoles will radiate with slightly different phases due to their length (neglecting the phase shift caused by the line length between dipoles), it is also necessary to slightly vary the spacing between dipoles. Due to the minimal taper and close spacing of the dipoles, i.e., **98**, **100** and **102** which comprise the primary antenna stage **78**, the phase center **106** of the primary antenna stage **78** and the total QLP dipole array **74** remain essentially fixed near the center of dipole **100** throughout the primary frequency band. Thus, the QLP dipole array **74** is preferably positioned to place the phase center **106** at the focal point of the reflector **64**.

The secondary antenna stage **76** is primarily comprised of a secondary dipole **104** having a length of approximately a half wavelength corresponding to the second frequency band, e.g., 2.15 to 2.162 GHz, and dipole **102** which is shared with the primary antenna stage **78**. However, as will be discussed further below, dipole **104** may be end loaded, as discussed in U.S. Pat. No. 3,732,572, which is herein incorporated by reference. By end loading dipole **104**, its length may be reduced below a half wavelength while maintaining a similar frequency response and minimizing blockage of the reflector **64** that is positioned to focus received signals on the QLP dipole array **74**. Dipole **104** may be considered to operate cooperatively with dipole **102** in the primary antenna stage **78**. Dipole **102** is slightly tapered (as denoted by a dashed line connecting the ends of each of the constituent dipoles) from the dimension of dipole **104** and its commonality with the primary and secondary antenna stages **78** and **76** provides an impedance match between. As such dipole **102** can be considered to be a primary and/or a secondary dipole.

Each antenna stage is preferably configured according to design parameters corresponding to a log periodic (LP) antenna, as described in Chapter 14 of the "ANTENNA ENGINEERING HANDBOOK Third Edition" by Richard C. Johnson. As discussed in this reference in association with FIGS. **14–30**, the characteristics of an LP antenna can be described according to the equations, $\tau=R_{n+1}/R_n$ and $\epsilon=r_n/R_n$, where the ratios τ and ϵ generally correspond to the relative spacings and widths of each dipole, and an angle α which generally corresponds to the taper of each antenna stage. Embodiments of the present invention, preferably exhibit larger tapers α and smaller spacing ratios τ in the coupling antenna stage **80** as compared to the primary antenna stage **78**. Table I shows exemplary values for α and τ.

TABLE I

	Primary Antenna Stage	Coupling Antenna Stage
α	0–5°	20–40°
τ	.9–.95	.6–.7

In interpreting these values, it should be noted that as α increases, the amount of taper increases and as τ increases, the spacing between the dipoles increases.

FIG. **4A** shows a preferred antenna feed subassembly **62** where a QLP dipole array **108**, i.e., a stamped QLP dipole array, is implemented (as described below) from a stamping of a metal sheet, e.g., preferably copper. The QLP dipole array **108** is preferably connected to the coaxial cable **68** by soldering the center conductor **110** of the coaxial cable **68** to one end of the QLP dipole array **108** and crimping the outer shield **112** of the coaxial cable **68** to the other end with a metal, e.g., brass, ferrule **114**. As shown in FIG. **4B**, the QLP dipole array **108** is protected by and supported in place by the radome **66** which is preferably injection molded as two halves **66*a*** and **66*b***. The two halves **66*a***, **66*b*** of the radome **66** are preferably ultrasonically welded together with the QLP dipole array **108** and a portion of the coaxial cable **68** inside. The end where the coaxial cable **68** comes out of the radome **66** is preferably further sealed with a small amount of all-purpose silicone rubber. As shown in FIG. **2**, the phase center **106** of the QLP dipole array **108** is positioned at the focal point of the reflector **64** by the hollow mounting tube **70**. The mounting tube **70**, which can be either dielectric or metallic, is preferably secured to the radome **66** by a screw **116**.

FIG. **5** shows a top view of a metal stamping **118** used to form the QLP dipole array **108**. The stamping **118** is folded back on itself to bring its two ends **120** and **122** together as shown in top view FIG. **6A** and side view FIG. **6B**. The two ends **120** and **122** of the QLP dipole array **108** are then connected to the ends, i.e., the shield **112** and the center conductor **110**, of the coaxial cable **68** (shown in FIGS. **6A** and **6B**). For example, the shield **112** is connected to end **122** and the center conductor **110** is connected to end **120**. Once folded, the top **124** and bottom **126** halves of the QLP dipole array **108** form the two feed lines **82**, **84** with preferably seven dipoles **86**, **94**, **96**, **98**, **100**, **102**, and **104** spaced along the feed lines and extending outwardly at essentially right angles from the feed lines **82** and **84**. A folded end **128** forms a short circuit between the top **124** and bottom **126** halves (and feed lines **82**, **84**) of the QLP dipole array **108** positioned a quarter wavelength past the last dipole **104**. The use of the folded end **128** allows the top **124** and bottom **126** halves to be easily aligned with each other in both axial and transverse directions as well as defining the spacing between the two halves. In addition to the spacing, the short circuit at the folded end **128** one quarter wavelength past the last dipole improves the directivity of the QLP dipole array **108** at the lower end of its frequency band.

As previously discussed, the first few dipoles **86**, **94** and **96** of the QLP dipole array **108** are less than half a wavelength of the primary frequency band and are tapered into a length corresponding to the primary frequency band. However, these dipoles improve the return loss of the QLP dipole array **108** and behave as directors for the remaining dipoles. The last dipole **104** in the QLP dipole array **108** is preferably end loaded as an alternative to having a longer dipole and allows the QLP dipole array **108** to fit into a smaller sized radome. End loading the last dipole results in a lower resonant frequency than a dipole of equal length that is not end loaded.

FIG. **7** shows an alternative embodiment of a QLP dipole array **130**, i.e., a printed circuit QLP dipole array, formed on a double sided printed circuit board **132** with the solid lines corresponding to etch on a first side of the printed circuit board **132** and the dashed lines corresponding to etch on its second side. Instead of placing a short circuit a quarter wavelength beyond the last dipole as with a stamped QLP dipole array **108**, the end of the QLP dipole array **130** is left open. This is done for two reasons. First, the dielectric substrate of the printed circuit board **132** fully structurally supports the top and bottom halves of the QLP dipole array **130** without any extra structural support. Second, the printed circuit board dielectric between the feed lines **82** and **84** increases the phase shift per unit length, allowing relatively more dipoles to be used within the same area than possible with the stamped QLP dipole array **108**. The greater number of dipoles helps to increase the directivity of the QLP dipole array **130** and essentially allows the currents to fully radiate before reaching the end of the QLP dipole array **130**. Therefore, a short circuit spaced a quarter wavelength away from the last dipole **146** would have little effect on the radiation pattern as it does with the QLP dipole array **108**. In this embodiment, a primary antenna stage **134** of the QLP dipole array **130** is preferably comprised of six dipoles, **136**, **138**, **140**, **142**, **144** and **146**, that form a slightly tapered LP antenna section corresponding to the desired primary frequency band, e.g., between 2.15 to 2.686 GHz. A coupling antenna stage **148** of the QLP dipole array **130** is preferably comprised of dipoles **150**, **152**, **154** and **136** and performs the equivalent impedance matching function to that previously described in reference to the coupling antenna stage **80** of the stamped QLP dipole array **108**. As previously described in reference to this prior embodiment, the tapers of the adjoining stages are chosen so that the common dipole, i.e., **136**, can be considered to be within either antenna stage, i.e., **134** or **148**.

The radome **66** which surrounds the QLP dipole array **108** or **130** is preferably formed from a low loss dielectric material which narrows the H-plane radiation pattern of the feed without significantly effecting the E-plane radiation pattern. This results from the fact that most of the dielectric is oriented parallel to the electric field in the H-plane and perpendicular to the electric field in the E-plane. Since the dielectric is close to the QLP dipole array **108** or **130** and oriented parallel to the direction of maximum radiation the radome **66** creates a phase delay along the axis of the QLP dipole array **108** or **130**. This results in a lensing effect of the H-plane pattern only. Embodiments of the present invention make use of a properly phased array and the lensing effect of the radome **66** to develop a primary radiation pattern ideally suited for use with the reflector **64**.

With reference again to FIG. **2**, there is shown a partially exploded view of an embodiment of the present invention used for either vertically or horizontally polarized signals. The antenna feed subassembly **62**, alternatively comprised of the stamped QLP dipole array **108** or the printed circuit QLP dipole array **130** within radome **66**, is mounted on the tube **70** coupled to the reflector **64** and used to position the phase center of the antenna feed subassembly **62** in front of the reflector **64** at its focal point. As shown in this figure, the reflector **64** is preferably attached to the vertically positioned mounting mast **72** using a pair of U-shaped brackets **156**, **158** and matching mating clamps **160**, **162** for fixedly coupling the antenna assembly **60** to the mounting mast **72**. By choosing its rotational position around the mounting mast **72**, the central axis **164** of the QLP antenna assembly **60** is aimed toward a microwave source. Additionally, by choosing between sets of mounting holes **166** and **168**, the antenna assembly **60** can be rotated 90° to adapt for either horizontally or vertically polarized signals.

Embodiments of QLP dipole arrays have been shown implemented in two different mediums. In one embodiment, the dipole array is formed from a stamping of a thin sheet of metal, e.g., copper. The connector is then attached to a separate downconverter (not shown). In the second implementation as shown in FIG. **8**, the QLP dipole array **130** is etched onto the printed circuit board which is contained within the radome **66** and connected directly to the printed circuit board of a downconverter **170** located within the hollow tube **70**. The downconverter is then coupled, preferably via a connector **172**, to a coaxial cable for delivery to a receiver. The performance of both implementations are nearly identical except that there is slightly less loss between the QLP dipole array **130** and the downconverter **170** in the printed circuit version without the coaxial cable. The stamped implementation has less loss up to the coaxial cable because it is suspended in free space while the printed circuit version is instead etched onto a dielectric sheet chosen for a particular frequency range.

While implementations of an antenna feed subassembly **62** have been described implemented with a stamped dipole array **108** as well as with a printed circuit board QLP dipole array **130** implementations, other equivalent implementations should be apparent to one of ordinary skill in the art. For example, each of the stages of the antenna could be separately fabricated and then mechanically and electrically coupled together to achieve similar results. Additionally, while a coaxial cable has been shown for coupling the output of the coupling antenna stage or the output of the downconverter to a receiver, other means known to one of ordinary skill in the art, e.g., a wireless transmitter, could be used to deliver the received microwave signals to a receiver.

Although the present invention has been described in detail with reference only to the presently-preferred embodiments, those of ordinary skill in the art will appreciate that various modifications can be made without departing from the spirit and the scope of the invention. For example, by scaling the size of the dipoles, it is possible to use embodiments of the present invention for point-to-point communication systems other than MMDS systems.

I claim:

1. A microwave antenna comprising:

first and second feed lines oriented essentially parallel to each other, each having a remote end and a feed end;

a primary antenna stage positioned proximate to said feed line remote ends for receiving microwave signals within a primary frequency band, said primary antenna stage comprised of a plurality of primary dipoles coupled along said feed lines and wherein each said dipole is comprised of a pair of dipole halves having inner and outer ends and wherein said inner end of a first dipole half is coupled essentially perpendicularly to said first feed line extending in a first direction therefrom and said inner end of a second dipole half is coupled essentially perpendicularly to said second feed line extending in a direction opposite to said first direction;

said plurality of primary dipoles including dipoles of different lengths each substantially equal to a half wavelength in said primary frequency band, said primary dipoles being arranged along said feed lines such that the outer ends thereof define a first taper angle;

a coupling antenna stage positioned proximate to said feed line feed ends comprised of a plurality of coupling dipoles coupled along said feed lines wherein each said dipole is comprised of a pair of dipole halves having inner and outer ends and wherein said inner end of a first dipole half is coupled essentially perpendicularly to said first feed line extending in a first direction therefrom and said inner end of a second dipole half is coupled essentially perpendicularly to said second feed line extending in a direction opposite to said first direction;

said plurality of coupling dipoles including dipoles of different lengths each shorter than a half wavelength in said primary frequency band, said coupling dipoles being arranged along said feed lines such that said outer ends define a second taper angle greater than said first taper angle;

a reflector for focusing microwave signals to a focal point in front of said reflector; and

wherein said primary antenna stage has an essentially fixed phase center positioned essentially coincident with said focal point.

2. The antenna of claim **1**, wherein said primary and coupling antenna stages share a common dipole.

3. The antenna of claim **1**, additionally comprising a coaxial cable coupled to said feed ends of said feed lines proximate to said coupling antenna stage for delivering received microwave signals.

4. The antenna of claim **3**, wherein said coaxial cable has a center conductor and a shield each respectively coupled to said feed ends of said first and second feed lines and said first and second feed lines are physically and electrically coupled at said remote ends of said feed lines.

5. The antenna of claim **1**, additionally comprising a tubular member for positioning said phase center of said primary and coupling antenna stages to be essentially coincident with said focal point.

6. The antenna of claim **1**, wherein said coupling antenna stage is comprised of at least four dipoles and said primary antenna stage is comprised of at least three dipoles with one dipole common to said coupling and primary antenna stages.

7. The antenna of claim **1**, wherein said microwave antenna additionally comprises a secondary antenna stage for receiving microwave signals comprised of a plurality of secondary dipoles coupled along said feed lines wherein each said dipole is comprised of a pair of dipole halves having inner and outer ends and wherein said inner end of a first dipole half is coupled essentially perpendicularly to said first feed line extending in a first direction therefrom and said inner end of a second dipole half is coupled essentially perpendicularly to said second feed line extending in a direction opposite to said first direction;

said plurality of secondary dipoles including dipoles of different length and arranged along said feed lines such that said outer ends define a third taper angle different from said first and second taper angles and wherein said secondary antenna stage shares a common dipole with said primary antenna stage.

8. The antenna of claim **7**, wherein said coupling antenna stage is comprised of at least four dipoles, said primary antenna stage is comprised of at least three dipoles and said secondary antenna stage is comprised of at least two dipoles and wherein said coupling and primary antenna stages have one dipole in common and said primary and second antenna stages have one dipole in common.

9. The antenna of claim **1**, wherein said feed lines and said coupling and primary antenna stages are formed from a stamping of a piece of metal which is then folded essentially in half.

10. The antenna of claim **1**, wherein said feed lines and said coupling and primary antenna stages are formed from a pattern etched onto both sides of a double sided printed circuit board.

11. A microwave antenna comprising:

first and second feed lines oriented essentially parallel to each other, each having a remote end and a feed end;

a primary antenna stage positioned proximate to said feed line remote ends for receiving microwave signals within a primary frequency band, said primary antenna stage comprised of a plurality of primary dipoles coupled along said feed lines and wherein each said primary dipole is comprised of a pair of dipole halves having inner and outer ends and wherein said inner end of a first dipole half is coupled essentially perpendicularly to said first feed line extending in a first direction therefrom and said inner end of a second dipole half is coupled essentially perpendicularly to said second feed line extending in a direction opposite to said first direction;

said plurality of primary dipoles including dipoles of different lengths each substantially equal to a half wavelength in said primary frequency band, said primary dipoles being arranged along said feed lines such that the outer ends thereof define a first taper angle;

a coupling antenna stage positioned proximate to said feed line feed ends comprised of a plurality of coupling dipoles coupled along said feed lines wherein each said dipole is comprised of a pair of dipole halves having inner and outer ends and wherein said inner end of a first dipole half is coupled essentially perpendicularly to said first feed line extending in a first direction therefrom and said inner end of a second dipole half is coupled essentially perpendicularly to said second feed line extending in a direction opposite to said first direction;

said plurality of coupling dipoles including dipoles of different lengths each shorter than a half wavelength in said primary frequency band, said coupling dipoles being arranged along said feed lines such that said outer ends define a second taper angle greater than said first taper angle;

wherein said primary antenna stage has an essentially fixed phase center;

a reflector for focusing microwave signals to a focal point in front of said reflector;

a tubular member for supporting said primary and coupling antenna stages in front of said reflector to position said phase center essentially coincident with said focal point; and

a downconverter for downconverting received microwave signal coupled to said second ends of said feed lines proximate to said coupling antenna stage; said downconverter located within said tubular member.

12. The antenna of claim **11**, wherein said coupling antenna stage is comprised of at least four dipoles and said primary antenna stage is comprised of at least six dipoles with one dipole common to said coupling and primary antenna stages.

13. The antenna of claim **11**, wherein said coupling and primary antenna stages are formed from a pattern etched on both sides of a double sided printed circuit board.

14. The antenna of claim **11**, additionally comprising a coaxial cable coupled to said downconverter for delivering said received signals.

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