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(54) **Cellular mobile communications antenna.**

(57) A mobile antenna system for use at frequencies in and above the 800 MHz band having a collinear radiator (10) mounted on one surface of a dielectric (14) such as the window of a vehicle and a tunable coupling circuit disposed internally of a conducted housing (22) mounted on the opposite surface of the dielectric (14) which acts as a counterpoise for coupling RF energy between the radiator (10) and a transmission line (42) connected to a suitable transceiver

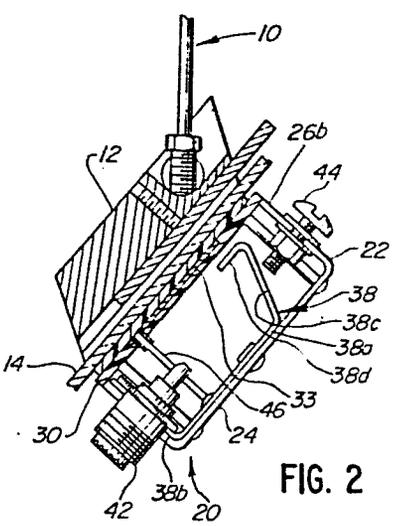


FIG. 2

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# CELLULAR MOBILE COMMUNICATIONS ANTENNA

## Field of the Invention

The present invention relates to communications antennas and more particularly to mobile communications antennas for frequencies in the area of the 800MHz frequency band of the type adapted to be mounted on a non-conductive surface such as a vehicle windshield.

## Background of the Invention

The recent introduction of cellular telephone service which utilize frequencies in the 800MHz frequency band and above, has increased interest in the efficient mobile antenna systems for those frequencies. Such services typically utilize a fairly wide band width. For example, existing and/or proposed systems operate over frequency bands of about 800-870 MHz, 820-900 MHz and 860-840 MHz. As can be seen by the above figures, the band width of such operating systems ranges from between about 60 to about 80 MHz. Thus, any antenna designed for use with such systems should provide efficient radiation characteristics and low VSWR over these band widths.

In addition, mobile antennas for such communications systems are designed to be mounted on vehicles. Some type of permanent installation is often necessary. For preferred locations, those which provide the most uniform radiation patterns, such as roof tops, this requires mounting to the vehicle such as automobiles by cutting holes into the body and permanently mounting the antennas in place. This is not always a satisfactory arrangement for vehicle owners.

Alternate mounting locations, such as fenders or trunk lids, which may allow for different mounting techniques, result in deterioration in the

desired uniformity in the radiation pattern. It would be desirable, therefore to have an antenna which could operate at these UHF frequencies and which at the same time could provide the desired operating characteristics without requiring the mounting arrangements that permanently mar a vehicle and require body repair when the antenna system is removed from the vehicle.

The mounting of a communications antenna on insulated surfaces such as the windshield of an automotive vehicle is known for much lower frequencies. One such an antenna system is disclosed in commonly assigned U.S. Patent No. 4,238,799 which issued on December 9, 1980, incorporated herein by reference.

The antenna system there specifically disclosed is particularly adapted for operation at frequencies well below the frequencies used for cellular phone communication systems. Thus, the antenna there disclosed was designed for operation in the CB and related bands of about 28-29 MHz.

Antennas similar to and adapted from the antenna disclosed in the aforesaid U.S. Patent No. 4,238,799 have been designed and operate at somewhat higher frequencies than those disclosed in that patent. However, although the electrical schematic representation of the circuit remains the same as that shown in Fig. 4 of that patent, as frequencies increase and reach the frequencies utilized in cellular phone systems, those at and above the 800 MHz band, the structure utilized for lower frequencies is no longer appropriate.

Furthermore, the antenna disclosed in the aforesaid patent is a relatively narrow band antenna which does not operate satisfactorily over the wide

frequency bands which are required for cellular phone systems.

Summary of the Invention

In accordance with the present invention, there is provided a communications antenna adapted to operate at and above the 800 MHz frequency band which is designed for mounting on an insulated surface such as the windshield of an automotive vehicle and which provides excellent efficiency and gain as well as the desirable band width to allow for efficient use at the cellular communications frequencies under consideration.

In accordance with the present invention, a vehicle window, e.g., the windshield is utilized to efficiently couple RF energy to a two-element collinear radiator mounted on the external surface of the windshield. In order to couple the RF energy between the antenna and a transceiver, a specially designed coupler configuration is mounted on the inner surface of the window in proximity to the antenna mount. The coupler reactively couples the radiator element to a transmission line while providing the desired 50 ohm input impedence.

The coupler in accordance with the present invention together with the radiator designed for use therewith provides desired VSWR characteristics over the operating band ranges of 60 to 80 MHz such as contemplated for use in cellular telephone systems.

In accordance with the present invention, specially designed tuning circuit elements are utilized and are disposed in a conductive coupler box which acts as a counterpoise for the antenna radiator. The window mounted antenna incorporating the present invention is capable of providing radiation characteristics comparable to antennas

mounted on the roof tops of vehicles, provides desired omni-directional coverage and satisfactory gain without the distortion which may arise from mounting antennas on trunk lids and other less satisfactory locations on a vehicle.

More specifically, the communications antenna system incorporatiog the present invention utilizes a collinear radiator having a 5/8 wave-length upper radiator and a lower radiator having an electrical length of between about 1/4 and 1/2 wave-length separated by an air-wound phasing coil.

One advantage of the glass mounted antenna system as set forth in the above-mentioned patent is the elimination of the ground plane and the resultant uniformity of radiation pattern independent of vehicle configuration. At the frequencies at which the assembly incorporating the present invention is used, however, one problem that arises is that the transmission line connecting the antenna assembly to the transceiver becomes "hot".

In order to eliminate this problem, the coupling or feed assembly is incorporated in a conductive housing which acts as a counterpoise. Disposed within the conductive housing are the components defining a coupling capacitor plate, and the tuned circuit utilized to tune the antenna and couple the radiator mounted on the external surface of the glass to the transmission line.

The configuration of the components disposed within the coupling or feed housing are significantly different than those that were suitable for use in the antenna disclosed in the aforesaid patent. Thus, the coupling capacitor plate forming a part of the feed housing is a printed circuit foil embedded in a

dielectric sheet forming one side of the housing. The plate of the coupling capacitor also acts as the plate of the adjustable tuning capacitor The other plate of the tuning capacitor is a generally U-shaped member. The base of the U is affixed to and in contact with the metallic housing forming the counterpoise. One leg of the U shaped plate, oriented at substantially 90° to the base, provides the ground or shield connection to a transmission line connector. The second leg forms the other plate of the tuning capacitor. The second leg extends at an obtuse angle to the base of the U and has a free end bent back to form a return oriented generally parallel to the base thereof. The return portion extends over at least a portion of the coupling plate or embedded foil element to define the adjustable coupling capacitor.

The adjustment of the capacitor is achieved by adjusting the position of the free end return and thereby adjusting the amount of overlap between that plate of the tuning capacitor and the foil coupling plate. The dielectric member in which the coupling plate is embedded forms the closure for the conductive housing or counterpoise.

The inductor is defined by a straight wire having a dimension suitable to the frequencies at which the antenna is to be tuned. The wire extends between and is electrically connected to the base of the generally U-shaped conductor and the foil coupling plate. The center conductor of the transmission line connector is electrically connected to the inductor at an appropriate tap point along its length whereby the impedence of the tuning circuit is matched to the 50 ohm impedence of the transmission line.

By utilizing a through-the-glass antenna assembly in accordance with the present invention, there is provided an antenna system capable of producing omni-directional radiation at and above the 800MHz band having a band width defined by a VSWR less than 1.5 over a range of about 60-80 MHz rendering the antenna suitable for use as a cellular phone system antenna providing desired gain and band width capabilities. At the same time, by use of the antenna system incorporating the present invention, the transmission line connecting the antenna to the transistor is not hot, thereby eliminating one safety concern.

Numerous other advantages and features of the present invention will become readily apparent from the following detailed description of the invention and the embodiments thereof, from the claims and from the accompanying drawings in which the details of the invention are fully and completely disclosed as a part of this specification.

Brief Description of the Drawings

Fig. 1 is a perspective view showing installation of an antenna on a windshield;

Fig. 2 is an enlarged cross-section taken along lines 2-2 of Fig. 1;

Fig. 3 is a perspective view, partially broken away of a feed or coupling assembly in accordance with the present invention;

Fig. 4 is an elevation of the coupling housing;

Fig. 5 is an elevation showing a suitable antenna radiator; and

Figs. 6 and 7 are VSWR plots for the antenna incorporating the present invention.

Detailed Description of a Preferred Embodiment

From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the true spirit and scope of the novel concept of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred. It is, of course, intended to cover by the appended claims all such modifications as fall within the scope of the claims.

Referring to the drawings there is shown an antenna system incorporating the present invention. The antenna system includes an elongated collinear radiator 10 comprising an upper section 10a having an electrical length of approximately 5/8 wavelength, and lower section 10b having an electrical length in excess of 1/4 wavelength separated by an air wound phasing coil 10c having a length suitable for proper phasing at the frequency at which the antenna is to be used.

The radiator terminates in a base or foot 12 such as one shown in U.S. Patent No. 4,266,227 having a generally flat surface adapted to be suitably affixed to the outer surface of a dielectric member such as a windshield 14 of a vehicle 16. A coupling or feed assembly 20 is affixed to the inner surface of the windshield 14 juxtaposed to the antenna base member 12.

The feed assembly 20 includes a conductive housing 22 having a front wall 24 and four side walls 26 with an open back 28. The conductive housing acts as a counterpoise for the antenna system and thereby results in the feed or transmission line between the antenna system and the transceiver remaining "cold". The open back 28 is closed by a dielectric circuit

board 30 having formed therein a conductive foil plate 33 which defines the second plate of a coupling capacitor 34 on opposite sides of the windshield 14.

The inner coupling plate 33 also forms one plate of an adjustable tuning capacitor. The other plate of capacitor 34 is defined by a generally U-shaped bent member 38 having a generally planar base portion 38a lying along and affixed to the inner surface of front wall 24 of the conductive housing 22. A standard transmission line coaxial connector 42 is disposed in one side wall 26a of the housing 22. The shield connection of the connector 42 is electrically connected to the housing 22 and to one leg 38b of the second tuning capacitor plate or U-shaped member 38 disposed generally perpendicular to the base 38a of the capacitor plate.

The other free leg 38c of the bent member 38 extends at a generally obtuse angle from the base 38 with the free end bent back to form a return 38d which overlaps and is spaced from the foil coupling plate 33. Adjustment of the capacitor 36 is achieved by utilizing a non-conductive member 44 which passes through the side wall 26b and engages the free end or leg 38c of the tuning capacitor plate 38 to displace the leg 38c inwardly and outwardly. This adjusts the amount of overlap between the capacitor plate return 38d and the coupling plate 33 to adjust the amount of capacitance thereof as is well known.

An inductor 46 in the form of a straight wire having a diameter to produce an inductance appropriate to the frequency to which the system is to be tuned is electrically connected to the base 38a of the adjustable capacitor plate 38 and to the foil 33 formed in the PC board dielectric. The center

conductor 48 of the transmission line connector 42 is electrically connected to the inductor/wire 46 at a point between its ends to match the impedance of the transmission line itself of about 50 ohms.

A system so constructed is capable of providing significant band width over the desired range of at least about 60 to 80 MHz. For example, in one embodiment of the antenna system incorporating the present invention an antenna was tuned at 806 MHz and maintained a VSWR below 1.5 between frequencies of about 800 MHz and about 860 MHz as shown at A in Fig. 6. An antenna tuned to 820 MHz maintained VSWR equal or less than 1.5 between a frequency of about 802 MHz to excess of 865 MHz as shown in B in Fig. 6. Another antenna that was designed for use in the 821-896 MHz band maintained a VSWR at or below 1.5 between the frequencies of 820 MHz and 895 MHz, as shown in Fig. 7.

Such an antenna system was able to provide a uniform radiation pattern as a function of radiation angle with a uniformity substantially similar to a roof mounted antenna and substantially better than trunk and cowl mounted antennas. Such uniformity is especially important for cellular phone type systems since communications using such systems occur in all directions and any reduction of gain in any particular direction would adversely affect the quality and ability of the mobile system to maintain communications.

Thus there has been dislcosed a mobile communications antenna system capable of use in the 800 MHz frequency band and above which does not require affixing to the metallic or conductive surface of a vehicle with the resulting damage thereto, which provides desired uniformity of

transmission as a function of horizontal angle which provides satisfactory gain in all direction and which eliminates any concern or problem of having a hot cable disposed within the passenger compartment of such vehicles.

While this invention is susceptible of embodiment in many different forms, there is shown in the drawing and will be described herein in detail a specific embodiment thereof with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific embodiment illustrated.

WHAT IS CLAIMED IS:

1. A mobile communications antenna for use in UHF frequencies at least as high as 800 MHz comprising:

- an elongated radiating member (10) attached at one end to a conductive base member (12) affixed to the outer surface of a non-conductive base member (14) affixed to a non-conductive dielectric member (30) of said a vehicle (16); and
- a coupling system disposed on the inner surface of said dielectric member (30) and juxtaposed with said antenna base (12), said coupling system including a conductive housing (20) defining a counterpoise for said antenna system and a plate member (33) juxtaposed with said base (12) to define therewith a coupling capacitor (34) for RF energy, said plate member being electrically insulated from said conductive housing (22), a tuned circuit connected to said coupling member (33) and disposed within said counterpoise housing (22) for tuning said antenna system to a desired frequency within said 800 MHz band, and a connector member (42) for a coaxial transmission line electrically connected to said tuned circuit at a point at which the impedance of the transmission line connected to said connector (42) and said tuned circuit is substantially the same.

2. An antenna as claimed in claim 1 wherein said coupling plate (33) is a printed foil

circuit formed in a non-conductive member (30), said dielectric member (30) closing one side of said housing (22); and including means for affixing said non-conductive closing member (30) to the inner surface of said vehicle dielectric member (14) with the foil generally juxtaposed with said antenna base (12).

3. An antenna as claimed in claim 2 wherein said tuned circuit comprised an adjustable capacitor (36) and an inductor (46) connected in parallel therewith, said foil coupling plate (33) being one plate of said tuning capacitor (36), and the other plate comprising a generally U-shaped conductive plate (38) having a base portion (38a) affixed to a conductive wall (24) of said housing (22), a first leg (38b) connected to said connector (42) and a second adjustable leg (38c) having a free portion (38d) juxtaposed and spaced from said foil coupling plate (33).

4. An antenna as claimed in claim 3 including means (44) for adjusting the degree of juxtaposition between the plates (33, 38d) of said tuning capacitor (38).

5. An antenna as claimed in claim 4 wherein said inductor (46) is a straight wire extending between and connected to said foil plate (33) and the house of said U-shaped plate (38).

6. An antenna as claimed in claim 5 wherein said connector (42) is a coaxial connector

having a shield contact connected to said first leg (38b) and said conductive housing (22) and a center connector (48) connected to said inductor wire (46) intermediate its ends.

7. An antenna as claimed in claim 6 wherein said radiator is a collinear radiator (10) having a first portion (10a) having a length about equal to 3/4 wavelength, a second portion (10b) including said base having a length between about 1/4 and 1/2 wavelength, and a phasing coil (10c) therebetween.

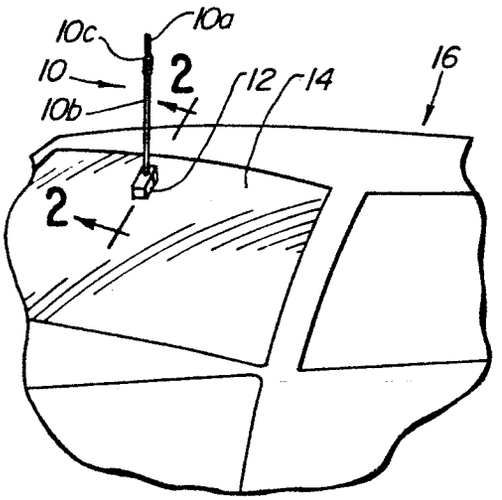



FIG. 1

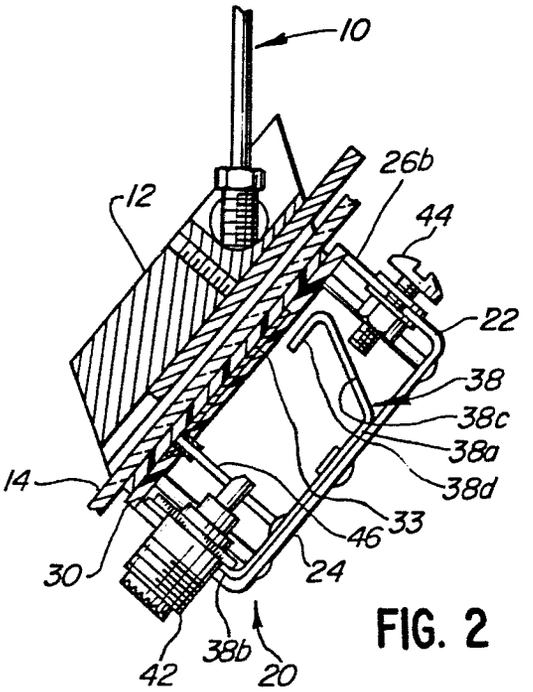



FIG. 2

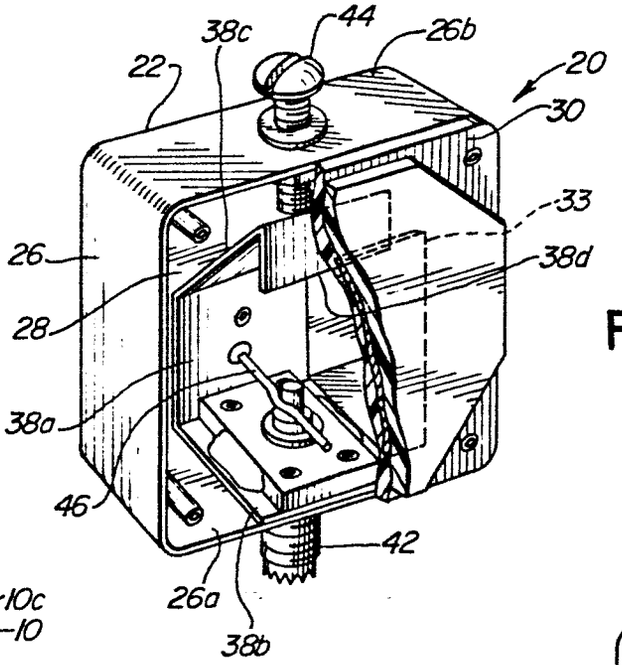



FIG. 3

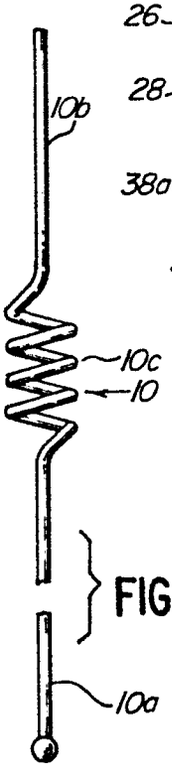



FIG. 5

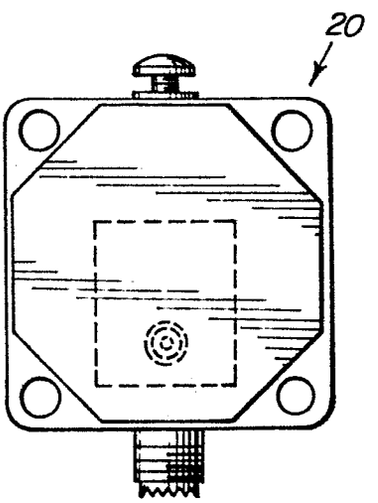
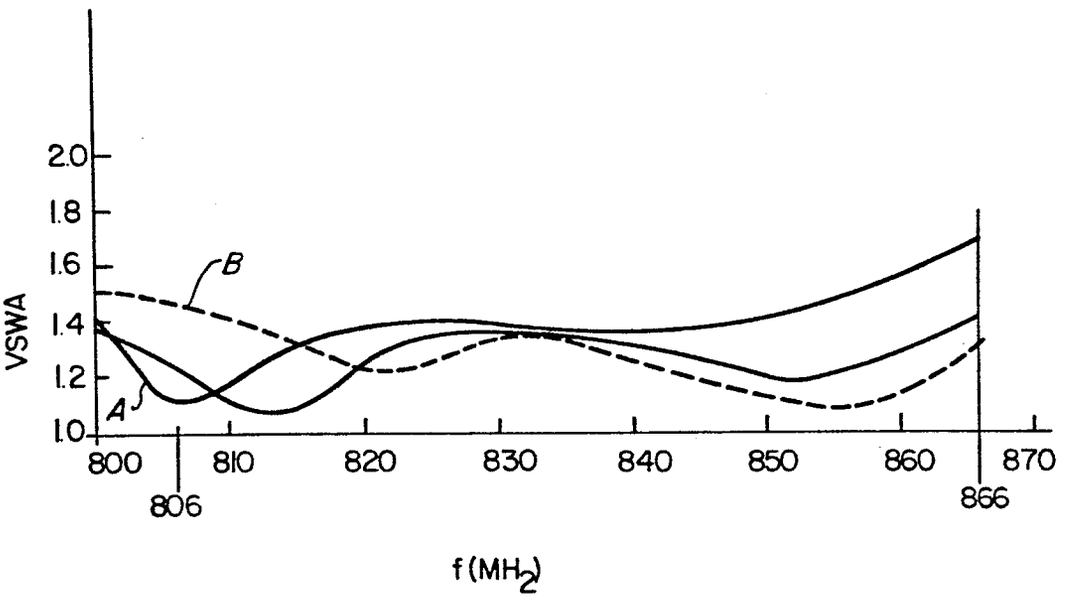



FIG. 4

FIG. 6


2.0
1.8
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1.2
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VSWA
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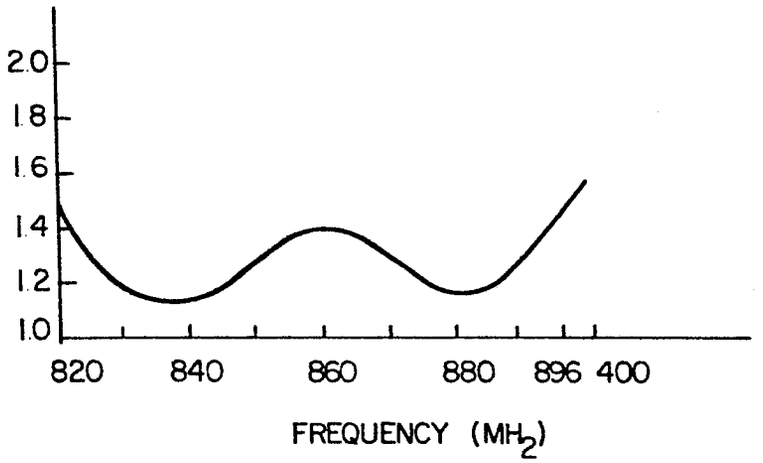
f(MH2)

FIG. 7


2.0
1.8
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896
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FREQUENCY (MH2)

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# EUROPEAN SEARCH REPORT

0137391
Application number

EP 84 11 1340

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl 4) |
|---|---|---|---|
| D,Y | US-A-4 238 799 (D.R. PARFITT)<br>* Figures 3,4; column 5, line 57 - column 6, line 10 * | 1 | H 01 Q 1/32<br>H 01 Q 1/12 |
| A | * Column 5, lines 33-45 * | 3,6 | |
| Y | US-A-4 089 817 (D. KIRKENDALL)<br>* Figure 3; column 5, line 34 - column 6, line 8 * | 1 | |
| D,A | US-A-4 266 227 (H.R. BLAESE)<br>* Figure 2; column 2, lines 62-68 * | 1 | |
| A | DE-A-2 257 352 (KATHREIN)<br>* Figure 1; page 2, lines 5-22 * | 7 | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| A | DE-A-2 543 973 (P.R.R. LAURENT)<br>* Figure 3; page 5, line 27 - page 6, line 8 * | | H 01 Q 1/08<br>H 01 Q 1/12<br>H 01 Q 1/32 |
| A | DE-A-2 130 888 (PHILIPS)<br>* Figure 2; column 3, line 59 - column 4, line 14 * | | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 26-11-1984 | BREUSING J |

CATEGORY OF CITED DOCUMENTS

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