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EP-A- 0 183 521
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(73)

Proprietor: **TOYOTA JIDOSHA KABUSHIKI KAISHA, 1,
Toyota-cho Toyota-shi, Aichi-ken 471(JP)**

(72)

Inventor: **Ohe, Junzo, Daini-Ekaku Apt 15303 2-56,
Ekakushin-machi, Toyota-shi Aichi(JP)**
Inventor: **Kondo, Hiroshi, 6-49, Nitamata Onishi-cho,
Okazaki-shi Aichi(JP)**

(74)

Representative: **Wood, Anthony Charles et al,
Urquhart-Dykes & Lord 91 Wimpole Street, London
W1M 8AH(GB)**

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Description

The present invention relates to automobile antenna systems for detecting broadcast radio frequency signals.

Antenna systems are essential to automobiles for receiving various broadcast wave signals, such as for radio, television and telephone, at the receivers located within the vehicle. Such antenna systems are also important for citizen band transceivers. Therefore, such antenna systems play an important role in the communication equipment which will be installed as a factory-installed item in the car of the future.

One of the conventional antenna systems is generally known as a pole antenna which projects outwardly from the vehicle body. Although such a pole antenna is superior in performance, it always remains a nuisance from the viewpoint of vehicle body design.

Furthermore, such a pole antenna is disadvantageous in that it is subject to damage, tampering or theft and also in that the antenna tends to generate noise during high-speed driving. For these reasons, there has heretofore been a strong desire to eliminate the need for such pole antennas.

With the increase in the number of frequency bands for broadcasting or communication wave signals to be received at automobiles, in recent years, a plurality of pole antennas have been required in accordance with the respective frequency bands. This brings about other problems; a plurality of pole antennas spoils the aesthetic appearance of the automobile, and the reception performance deteriorates greatly due to electrical interference between the antennas.

Various efforts have hitherto been made to eliminate the pole antenna or to conceal it from the exterior. One of such proposals has been to apply a small-gauge antenna wire on the rear windshield of an automobile, and this proposal has been put to practical use.

Another type of antenna system has been proposed which detects the surface currents induced on a vehicle body by broadcast waves. Although utilization of currents which flow on the vehicle may apparently be the most reliable and efficient means, experiments carried out heretofore have shown very unfavorable results.

One reason why the surface currents on an ordinary vehicle body cannot be effectively utilized is that the value of the surface currents has proved to be lower than expected so that it has not been possible to obtain a useful output from the surface currents on the roof panel of a vehicle body (the portion mainly used for detection) that is at a sufficiently high level.

Another reason is that surface currents often have noise mixed therein. This noise is mainly produced by the engine ignition system of the vehicle and its battery charging regulator system, and it leaks into the vehicle body during the operation of the engine. It is therefore impossible to realize reception of broadcast wave signals in a sufficiently

clear manner for this system to be put to practical use.

In spite of such an unfavorable situation, some proposals have hitherto been made to overcome the above problems. One of such proposals is disclosed in Japanese Patent Publication 22 418/1978. In this antenna system, an electrical insulator is provided at a portion of the vehicle body on which currents are concentrated, with the currents being detected directly by a sensor between the opposite ends of the insulator. Although such structure can detect utilizable signals which are superior in SN ratio, a pick-up used therein requires a particular cut-out in the vehicle body. This cannot be accepted in the mass-production of automobiles.

Another proposal is disclosed in Japanese Utility Model Publication No. 34 826/1978 in which an antenna including a pick-up coil is provided for detecting currents flowing in a pillar of the vehicle body. This system is advantageous in that the antenna can be disposed completely within a vehicle body. However it is not practical for the pick-up coil used therein to be located adjacent to the vehicle pillar in a direction perpendicular to the longitudinal axis of the pillar. Thus, it also appears that this arrangement cannot pick up any utilizable output of the antenna.

As has been described above, the conventional antenna system have not been successful in efficiently detecting currents induced on the vehicle body by broadcast wave signals. Furthermore, in the conventional antenna systems the receiving sensitivity is low and varies in accordance with the frequency band.

The conventional antenna system is mainly intended for reception of AM waves. However, the wavelength of such broadcast wave signals is too long for an antenna which detects the currents on a vehicle body, and good receiving characteristics cannot be obtained with respect thereto. The present inventors took notice of these frequency wavelength characteristics, and accordingly the present invention is aimed at handling broadcast wave signals at a frequency above 50 MHz., i.e. in the FM band. This approach has enabled very effective reception from the currents on a vehicle body to be obtainable, which has conventionally been considered to be impossible.

An object of the present invention is to provide an improved automobile antenna system whereby surface currents induced on the automobile body by broadcast radio frequency signals at a frequency above 50 MHz., e.g. the FM frequency band, can efficiently be detected.

Document DE-A 1 949 828 describes an automobile antenna system comprising a pick-up mounted adjacent a sheet metal member forming a portion of the automobile body to detect radio frequency surface currents induced in said sheet metal member by broadcast radio frequency signals; said pick-up comprising an elongate loop antenna.

The present invention is characterized in that: in order to be suitable for detecting such radio frequency surface currents at a frequency above 50 MHz, which surface currents have a concentrated

flow along a marginal edge portion of said sheet metal member;
 said pick-up is mounted to said automobile body portion with a longer side of said elongate loop antenna extending lengthwise of and closely adjacent to said marginal edge portion; and said longer side is in the form of a spiral coil having a plurality of turns bounded by a notional cylinder having its longitudinal axis parallel to said marginal edge portion, whereby the loop antenna exhibits a series resonance characteristic at frequencies in a frequency band dependent on the self inductance and on the parasitic capacitance presented by said spiral coil.

Our co-pending European patent applications under publications Nos. EP-A 183 521 and EP-A 181 200 are documents of the type mentioned in Article 54(3) of the European Patents Convention.

EP-A 183 521 describes an automobile antenna system wherein a pick-up comprises an elongate loop antenna extending around a core of material of high permeability. In one embodiment the loop antenna is a wound antenna of a plurality of turns extending around said core. The longer side thus consists of parallel runs of adjacent turns.

EP-A 181 200 describes various embodiments of an automobile antenna system in which a varactor diode is connected to the pick-up to adjust the resonance frequency characteristics of the antenna. In several embodiments the pick-up is a single turn loop antenna, but in the embodiments of Figures 6, 11 and 16 the loop antenna is replaced by a pick-up of another type, being an antenna coil wound around a ferrite core.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a plan view of an automobile antenna system in accordance with the present invention;

Fig. 2 is a perspective view of the pick-up of the system shown attached to the rear window frame of the roof panel of an automobile;

Fig. 3 is an external perspective view of the high-frequency pick-up;

Fig. 4 is a sectional view of the high-frequency pick-up shown in Fig. 3;

Fig. 5 is a schematic explanatory view of the high-frequency pick-up which is in close contact with the vehicle body;

Fig. 6 shows a relationship between the frequency band and the reception level in an automobile antenna system according to the present invention;

Fig. 7 is a schematic circuit diagram for the high-frequency pick-up;

Fig. 8 is a detailed circuit diagram for the high-frequency pick-up shown in Fig. 7;

Fig. 9 is an explanatory view of the surface currents I produced on the vehicle body B by external waves W ; and

Fig. 10 illustrates a probe for detecting the distribution of surface currents on the vehicle body and having the same construction as that of the high-frequency pick-up used in the present invention, and a circuit for processing signals from the probe.

Fig. 9 shows that when external electromagnetic waves W , such as broadcast waves, pass through the vehicle body B of conductive metal, surface currents I are induced at various vehicle locations at levels corresponding to the intensities of electromagnetic waves passing therethrough.

The present invention aims only at electromagnetic waves of relatively high frequency bands in excess of 50 MHz, such as FM broadcast waves and TV waves.

The distribution of the surface currents induced on the vehicle body by electromagnetic waves within the above-described particular wave band is measured so as to seek a location on the vehicle body which is higher in surface current density and lower in noise and at which a pick-up used in the present invention is located.

The distribution of surface currents is determined by simulation using a computer and also by measuring actual intensities of surface currents at various locations on a vehicle body. The measurement is carried out by the use of a probe which can operate in accordance with the same principle as that of a high-frequency pick-up actually located on the vehicle body at a desired location, as will be described later. Such a probe is moved on the vehicle body over the entire surface thereof to measure the level of surface currents at various locations of the vehicle body.

Fig. 10 shows an example of such a probe P which is constructed in accordance with substantially the same principle as that of the high-frequency pick-up described hereinafter. The probe P is composed of a casing 10 of an electrically conductive material for preventing any external electromagnetic wave from transmitting to the interior thereof and a loop coil 12 fixed within the casing 10. The casing 10 includes an opening 10a formed therein through which a portion of the loop coil 12 is externally exposed. The exposed portion of the loop coil 12 is located in close proximity to the surface of the vehicle body B to detect magnetic flux induced by surface currents on the vehicle body B . Another portion of the loop coil 12 is connected to the casing 10 through a short-circuiting line 14. The loop coil 12 further includes an output end 16 connected to a core 20 in a coaxial cable 18. Still another portion of the loop coil 12 includes a capacitor 22 for causing the frequency in the loop coil 12 to resonate relative to the desired frequency to be measured to increase the efficiency of the pick-up.

Thus, when the probe P is moved along the surface of the vehicle body B and also angularly rotated at various locations of measurement, the distribution and direction of surface currents can accurately be determined at each of the vehicle locations. In Fig. 10, the output of the probe P is amplified by a high-frequency voltage amplifying circuit 24 and the resulting output voltage is measured by a high-frequency voltmeter 26. This coil output voltage is read at the indicated value of the high-frequency voltmeter 26 and also is recorded by an XY recorder 28 to provide the distribution of surface currents at various vehicle locations. The input of the XY recorder 28 receives signals indica-

tive of various locations on the vehicle from a potentiometer 30 to recognize the value of high-frequency surface currents at the corresponding vehicle location.

Figs. 1 and 2 shown an embodiment of the present invention in which the high-frequency pick-up is disposed in close proximity to the rear peripheral edge of a roof panel.

In Fig. 2, a roof panel 32 is exposed or coated with a coating material and this metal roof panel 32 is connected to a rear window glass 36 with a rear window frame 34 as its peripheral end.

In this embodiment, a high-frequency pick-up 38 is provided on the rear window frame within the distance of $12 \times 10^{-3}\lambda$ (λ represents the wavelength of broadcast waves) from the outer peripheral edge of the vehicle body.

As shown in detail in Fig. 1, the high-frequency pick-up 38 includes a loop antenna 42 within a casing 40 and constitutes an electromagnetic coupling type pick-up having a similar structure to the probe including a loop coil which is used for detecting the distribution of the surface currents of a vehicle body. In accordance with the present invention a longer side of the loop antenna 42 extends lengthwise of and closely adjacent to a marginal edge portion of the sheet metal member, i.e. the edge of the opening in the frame 34 as shown in Figs. 1 and 2, the longer side being in the form of a spiral coil 42a having a plurality of turns bounded by a national cylinder having its longitudinal axis parallel to the marginal edge portion as shown in Fig. 1.

As shown in Figs. 3 and 4, the loop antenna 42 extends from a circuit in a housing 44 and includes the spiral coil portion 42a and a lead-out portion 42b. The signals detected are processed by an impedance matching circuit and an amplifying circuit provided in the circuit in housing 44. The high-frequency signals obtained in this way are fed outward by a coaxial cable 48 through a BNC connector 50 to be transmitted to various receivers such as a radio and a television installed in the vehicle.

The exterior of the circuit housing 44 is covered with a metal casing 40a which shields it from external electromagnetic waves, while the exterior of the lead-out portion 42b of the loop antenna 42 is covered with a resin casing 40b so that external magnetic flux is effectively detected. The resin casing 40b is provided with a holding arch 46 for holding the spiral coil portion 42a.

The coil 42a is covered with electrical insulation so that the loop antenna 42 is arranged in close contact with the rear window frame in an electrically insulated state therewith. The spiral coil portion 42a is slightly flexed such as to be pressed toward the rear window frame 34, whereby the flux caused by the surface currents is strongly interlinked with the loop antenna 42.

The described antenna system can resonate at frequencies in a desired frequency band dependent on the self inductance and the parasitic capacitance (capacitance generated between both ends of the loop), thereby enjoying highly sensitive reception. The diameter of the spiral coil of the loop anten-

na 42 is about 1 cm in this embodiment, and the number of turns can be determined in accordance with a desired frequency.

For example, as shown in Fig. 6 which shows the relationship between the frequency band and the reception level, if the first resonance is required at approximately 100 MHz, the spiral coil should have about 20 to 30 turns.

In this case, the length of the elongate loop antenna 42 is about 10 cm, and the resonant points in this embodiment appear at integral multiples of the frequency at the first resonant point. For example, if the first resonant point is set at the center of 70 to 110 MHz of the TV broadcasting VHF (Lo) band in Japan, namely, 90 MHz, then the second resonant point is at 180 MHz of the TV broadcasting VHF (Hi) band in Japan, wherein highly sensitive characteristic is obtained.

The broken line in Fig. 6 shows the parallel resonance type sensitivity characteristic of a single loop antenna.

As is obvious from the graph, the sensitivity characteristic in this embodiment is enhanced by about 5 to 10 dB in comparison with the single loop antenna.

Referring to Fig. 7, the casing 40 of the high-frequency pick-up 30 accommodates the impedance matching circuit 54 and the amplifying circuit 56 as the integral circuitry 44, and the output impedance of the amplifying circuit 56 and the characteristic impedance of the coaxial cable 48 match, thereby enabling very effective signal processing.

In Fig. 7, a capacitor 52 is connected to the loop antenna 42 in series, and the impedance of the signal detected by the loop antenna 42 is matched by the impedance matching circuit 54, is amplified at a high frequency by the amplifying circuit 56 in the next step, and is fed by the coaxial cable 48 to a receiver installed in the vehicle. If the capacitor 52 is a variable capacitor, fine adjustment of the resonance frequency is possible.

Fig. 8 shows a detailed circuit structure of the circuit shown in Fig. 7. Fig. 8 is similar to Fig. 5 in the above-mentioned EP-A 181 200. Both the connection of the circuits and the operation thereof will be explained at the same time in the following.

The impedance matching circuit 54 includes a band-pass filter 58 and a discharge tube 60, and the voltage of the loop antenna 42 detected by the capacitor 52 is fed to the band-pass filter 58. The output of the band-pass filter 58 is supplied to the parallel circuit of the discharge tube 60 and a capacitor C_3 .

The discharge tube 60 is provided for the purpose of protecting the antenna from electrostatic breakdown, and prevents the circuit from being broken by external static electricity, lightning or the like. The band-pass filter also matches the impedance of the loop antenna 42.

The detected signal which has been subjected to impedance matching in this way is fed to the high-frequency amplifying circuit 56 for high-frequency amplification.

The amplifying circuit 56 includes transistors Q_1 and Q_2 which are connected in two stages and the

output thereof is supplied from the coaxial cable 48 to the receiver.

In Fig. 8, the inductances L_1 , L_2 denote peaking coils, the resistors R_2 , R_3 resistors for stabilizing the action of the transistor Q_1 , the resistors R_5 , R_6 bias resistors, and the symbols C_3 , C_9 bypass capacitors.

The coating of a conductor material of the coaxial cable 48 is grounded and constitutes a ground lead of the impedance matching circuit 54 and the high-frequency amplifying circuit 56 provided in the casing.

The output impedance of the high-frequency amplifying circuit 56 and the characteristic impedance of the coaxial cable 48 are selected at approximately the same value, thereby maintaining good matching between the high-frequency amplifying circuit 56 and the coaxial cable 48.

As described above a desired impedance matching and high-frequency amplification of a feeble signal detected by the loop antenna 42 takes place within the casing 40 where the signal is detected, these circuits being small enough to be accommodated in the casing 40. The signal fed by the coaxial cable 48 is so stable that broad-band reception of FM or TV broadcast waves is enabled with efficiency and high sensitivity.

In this way, an automobile antenna system according to the present invention utilizes the high-frequency surface currents induced by broadcast wave signals in comparatively high-frequency bands, e.g., broadcast wave signals or more than 50 MHz, at specific portions of a vehicle body, particularly, at marginal portions of a vehicle body.

Claims

1. An automobile antenna system comprising a pick-up (38) mounted adjacent a sheet metal member (34) forming a portion of the automobile body to detect radio frequency surface currents induced in said sheet metal member by broadcast radio frequency signals; said pick-up (38) comprising an elongate loop antenna (42); characterized in that: in order to be suitable for detecting such radio frequency surface currents at a frequency above 50 MHz, which surface currents have a concentrated flow along a marginal edge portion of said sheet metal member (34); said pick-up (38) is mounted to said automobile body portion with a longer side (42a) of said elongate loop antenna (42) extending lengthwise of and closely adjacent to said marginal edge portion; and said longer side is in the form of a spiral coil (42a) having a plurality of turns bounded by a notional cylinder having its longitudinal axis parallel to said marginal edge portion, whereby the loop antenna (42) exhibits a series resonance characteristic at frequencies in a frequency band dependent on the self inductance and on the parasitic capacitance presented by said spiral coil (42a).

2. A system according to claim 1 characterized in that said spiral coil (42a) has a diameter of substantially one centimetre and between substantially 20

and 30 turns, and said notional cylinder has a length of substantially ten centimetres.

3. A system according to claim 1 or claim 2 characterized in that a variable capacitor (52) is connected in series with said spiral coil (42a) in the loop of said loop antenna (42) to permit adjustment of the series resonance characteristic of the loop antenna.

4. A system according to any one of claims 1 to 3 characterized in that said pick-up (38) includes a casing (40) mounted to said sheet metal member (34), said casing having an elongate exterior recess (46) which is curved in cross-section to hold said spiral coil (42a).

5. A system according to claim 4 characterized in that said casing houses an impedance matching circuit electrically connected to said loop antenna, and an amplifying circuit connected to amplify the output of said impedance matching circuit; and a coaxial cable is connected to supply the output of said amplifying circuit to a receiver in the automobile body.

6. A system according to any one of claims 1 to 5 characterized in that said pick-up (38) is mounted adjacent a marginal edge portion of the sheet metal member forming the roof panel (34) of the automobile.

Patentansprüche

1. Kraftfahrzeug-Antennenanlage mit einem benachbart zu einem ein Teil der Kraftfahrzeugkarosserie bildenden Blechbauteil (34) befestigten Empfänger (38), um in diesem Blechbauteil durch Rundfunk-Hochfrequenzsignale induzierte Hochfrequenz-Oberflächenströme zu erfassen; wobei der erwähnte Empfänger (38) eine längliche Rahmenantenne (42) umfaßt; dadurch gekennzeichnet, daß:

um zum Erfassen solcher Hochfrequenz-Oberflächenströme mit einer Frequenz über 50 MHz, welche Oberflächenströme einen konzentrierten Fluß längs eines Randkantenabschnitts des genannten Blechbauteils (34) haben, geeignet zu sein;

der erwähnte Empfänger (38) an dem besagten Kraftfahrzeug-Karosserieteil mit einer längeren Seite (42a) der genannten länglichen Rahmenantenne (42) in Längserstreckung sowie eng benachbart zu dem erwähnten Randkantenabschnitt befestigt ist; und

die besagte längere Seite in der Gestalt einer Spiralspule (42a) ausgebildet ist, die eine Mehrzahl von durch einen imaginären Zylinder, dessen Längsachse parallel zu dem erwähnten Randkantenabschnitt verläuft, begrenzte Windungen aufweist, wodurch die Rahmenantenne (42) eine Reihenresonanzcharakteristik bei Frequenzen in einem von der Selbstinduktivität und von der durch die genannte Spiralspule (42a) dargebotenen parasitären Kapazität abhängigen Frequenzband entfaltet.

2. Anlage nach Anspruch 1, dadurch gekennzeichnet, daß die genannte Spiralspule (42a) einen Durchmesser von im wesentlichen einem Zentimeter sowie zwischen im wesentlichen 20 und 30 Windungen hat und der besagte imaginäre Zylinder eine

Länge von im wesentlichen zehn Zentimetern aufweist.

3. Anlage nach Anspruch 1 oder Anspruch 2, dadurch gekennzeichnet, daß ein veränderlicher Kondensator (52) mit der genannten Spiralspule (42) im Rahmen der erwähnten Rahmenantenne (42) in Reihe geschaltet ist, um eine Justierung der Reihenresonanzcharakteristik der Rahmenantenne zu erlauben.

4. Anlage nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß der erwähnte Empfänger (38) ein an dem genannten Blechbauteil (34) befestigtes Gehäuse (40) umfaßt, wobei dieses Gehäuse eine längliche, außenliegende Vertiefung (46) hat, die im Querschnitt gekrümmt ist, um die genannte Spiralspule (42a) zu halten.

5. Anlage nach Anspruch 4, dadurch gekennzeichnet, daß das besagte Gehäuse eine Impedanz-Anpassungsschaltung, die elektrisch mit der genannten Rahmenantenne verbunden ist, und eine Verstärkerschaltung, die für eine Verstärkung des Ausgangs der erwähnten Impedanz-Anpassungsschaltung geschaltet ist, aufnimmt, und ein Koaxialkabel angeschlossen ist, um den Ausgang der besagten Verstärkerschaltung einem Empfänger in der Kraftfahrzeugkarosserie zuzuführen.

6. Anlage nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß der erwähnte Empfänger (38) angrenzend an einen Randkantenabschnitt des die Dachtafel (34) des Kraftfahrzeugs bildenden Blechbauteils befestigt ist.

Revendications

1. Un système d'antenne pour automobile comprenant un capteur (38) monté adjacent à un organe en tôle métallique (34) formant une partie de la carrosserie de l'automobile pour détecter des courants de surface à fréquence radio induits dans ledit organe métallique en tôle métallique par les signaux de fréquence radio de radiodiffusion; ledit capteur (38) comprenant une antenne en boucle allongée (42), caractérisé en ce qu'afin de pouvoir détecter ces courants de surface à fréquence radio à une fréquence supérieure à 50 MHz, ces courants de surface présentant un écoulement concentré le long d'une partie de bord marginal dudit organe en tôle métallique (34), ledit capteur (38) est monté sur ladite partie de carrosserie automobile avec une face plus longue (42a) de ladite antenne en boucle allongée (42) s'étendant le long de ladite partie de bord marginal et étroitement adjacent à cette partie de bord marginal; et en ce que ladite face plus longue présente la forme d'un bobinage spiral (42a) présentant une pluralité de tours délimités par un cylindre fictif dont l'axe longitudinal est parallèle à ladite partie de bord marginal, de manière que l'antenne en boucle (42) présente une caractéristique de résonance série à des fréquences situées dans une bande de fréquence fonction de la self-inductance et de la capacitance parasite présentée par ledit bobinage spiral (42a).

2. Un système selon la revendication 1, caractérisé en ce que ledit bobinage spiral (52a) présente un diamètre de sensiblement un centimètre et entre en-

viron 20 et 30 tours, et en ce que ledit cylindre fictif présente une longueur d'environ 10 cm.

3. Un système selon la revendication 1 ou 2, caractérisé en ce qu'un condensateur variable (52) est relié en série avec ledit bobinage spiral (42a) dans la boucle de ladite antenne en boucle (42) afin de permettre le réglage de la caractéristique de résonance série de l'antenne en boucle.

4. Un système selon l'une quelconque des revendications 1 à 3, caractérisé en ce que ledit capteur (38) comporte un carter (40) monté sur ledit organe en tôle métallique (34), ledit carter présentant une cavité extérieure allongée (46) qui est incurvée en section transversale afin de maintenir ledit bobinage spiral (42a).

5. Un système selon la revendication 4, caractérisé en ce que ledit carter loge un circuit d'accord d'impédance électriquement relié à ladite antenne en boucle et un circuit d'amplification relié de façon à amplifier la sortie dudit circuit d'accord d'impédance, et en ce qu'un câble coaxial est relié de manière à adresser la sortie dudit circuit d'amplification à un récepteur dans la carrosserie de l'automobile.

6. Un système selon l'une quelconque des revendications 1 à 5, caractérisé en ce que ledit capteur (38) est monté adjacent à une partie de bord marginal de l'organe en tôle métallique formant le panneau de toit (34) de l'automobile.

FIG. 1

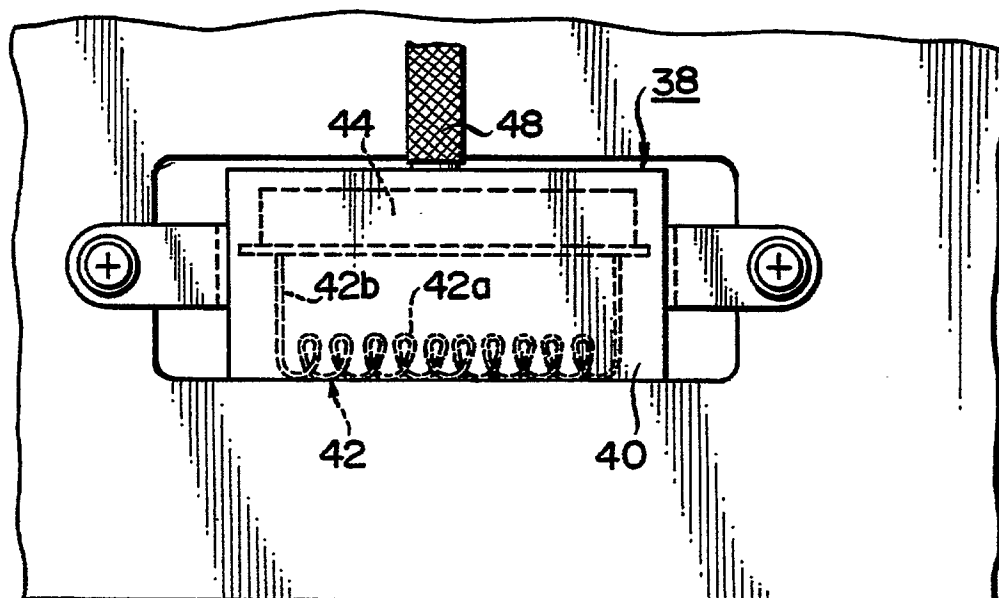


FIG. 2

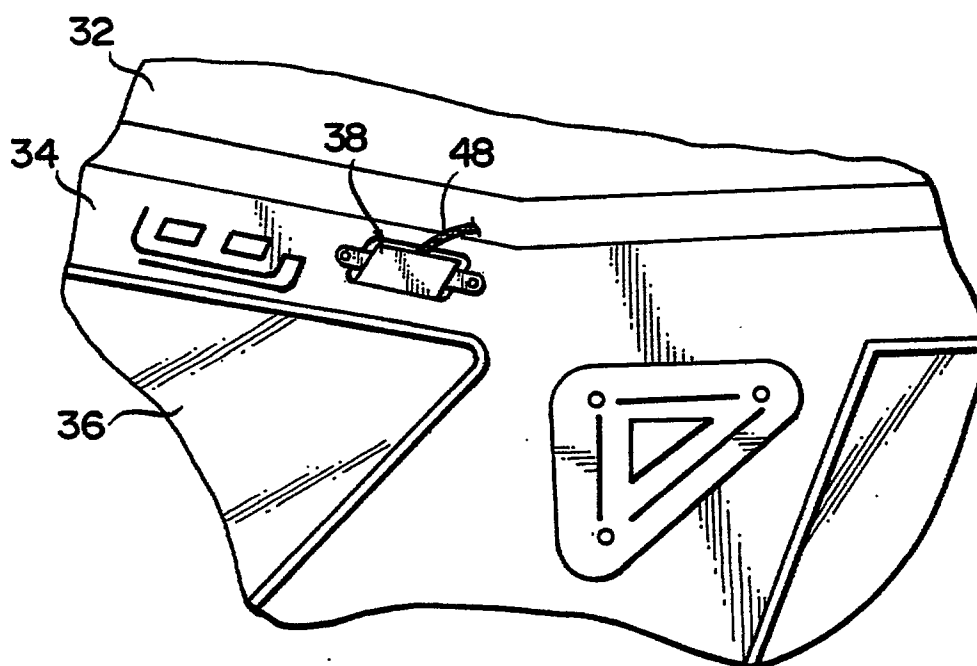


FIG. 3

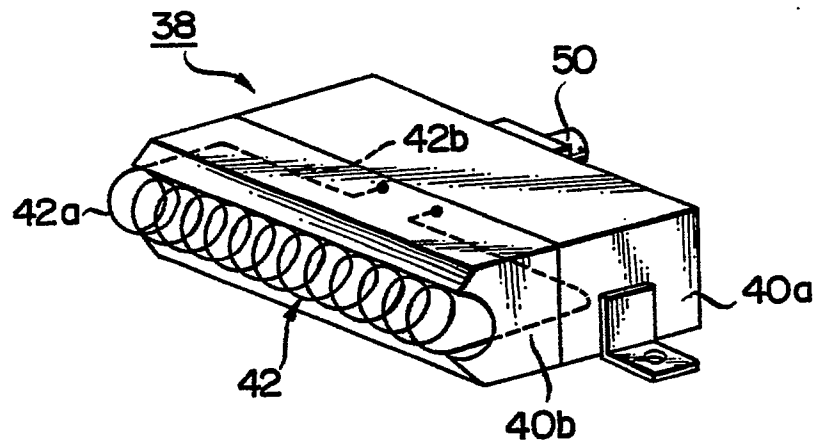


FIG. 4

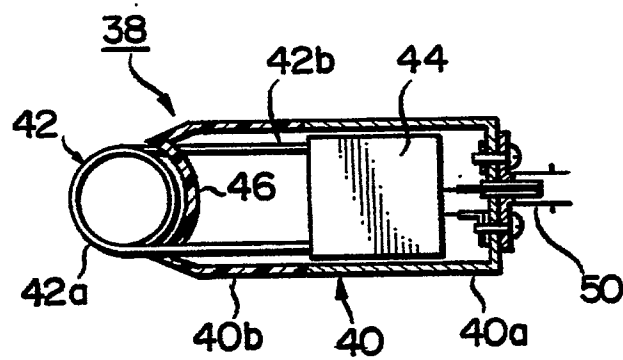


FIG. 5

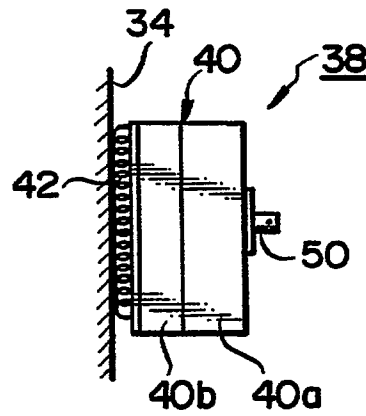


FIG. 6

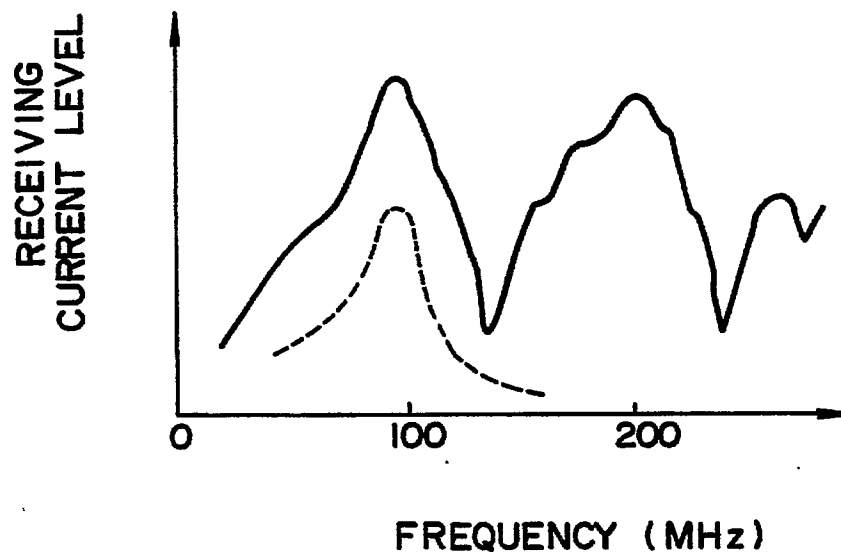


FIG. 7

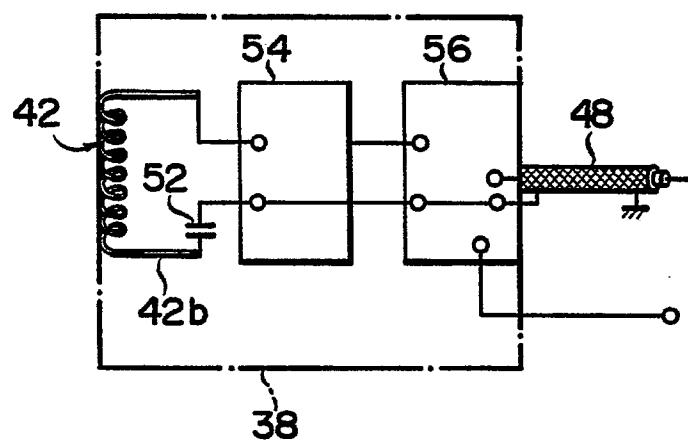


FIG. 8

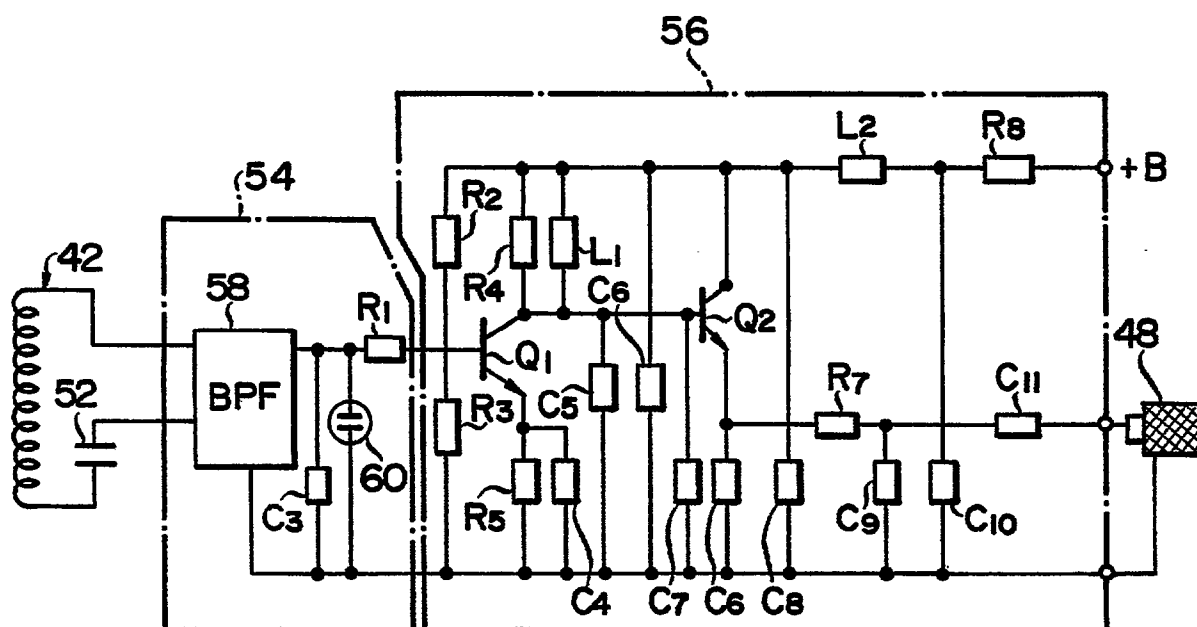


FIG. 9

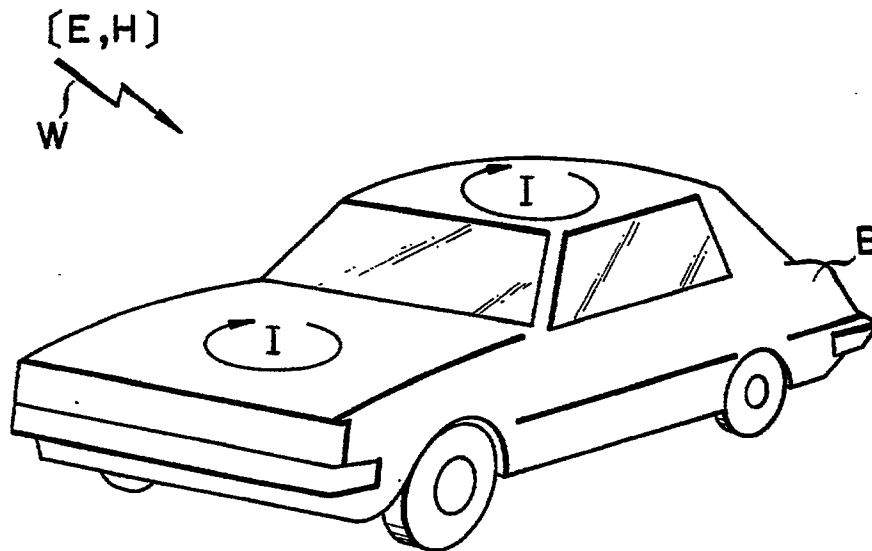


FIG. 10

