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ANTENNA SYSTEM HAVING PLURAL ANTENNA PORTIONS

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(56) Prior Art Documents
US 5204687
US 5343213
US 5317325

(57) Claim

1 An antenna system comprising a casing, and an antenna element being movable relative to said casing and usable in states of being extended from and partially housed within said casing, wherein

said antenna element includes:

a first antenna portion acting as an antenna when said antenna element is partially housed within said casing; and

a second antenna portion having all electrically conducting portions thereof electrically insulated from and spaced apart from and positioned with respect to all electrically conducting portions of said first antenna portion such that electromagnetic coupling between said second antenna portion and said first antenna portion becomes negligible, said second antenna portion acting as an antenna when said antenna element is extended from said casing;

said casing including an antenna power-feeding section for electrically coupling a radio circuit to said first or second antenna portion;

said first antenna portion having a conductor with a predetermined length, which is held by said casing in such a manner that a majority of the conductor projects from the casing when the antenna element is partially housed within said casing;

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the conductor of the first antenna portion being electrically coupled to said antenna power-feeding section when the antenna element is partially housed within said casing;

said second antenna portion being mounted below said first antenna portion and having a conductor with a predetermined length;

the conductor of the second antenna portion being electrically coupled to said antenna power-feeding section when said antenna element is extended from the casing.

10. An antenna system comprising a casing, and an antenna element being movable relative to said casing and usable in states of being extended from and partially housed within said casing, wherein

said antenna element includes:

a first antenna portion acting as an antenna when said antenna element is partially housed within said casing; and

a second antenna portion having all electrically conducting portions thereof electrically insulated from and spaced apart from and positioned with respect to all electrically conducting portions of said first antenna portion such that electromagnetic coupling between said second antenna portion and said first antenna portion becomes negligible, said second antenna portion acting as an antenna when said antenna element is extended from said casing;

said casing including an antenna power-feeding section for electrically coupling a radio circuit to said first or second antenna portion;

said first antenna portion having a conductor with a predetermined length, which is held by said casing in such a manner that a majority of the conductor projects from the casing when the antenna element is partially housed within said casing;

the conductor of the first antenna portion being electrically coupled to said antenna power-feeding section when the antenna element is partially housed within said casing, said conductor of said first antenna portion and said antenna power-feeding section being spaced apart from said first antenna portion when said antenna element is partially housed within said casing such that electromagnetic coupling between said second antenna portion and said conductor of said first antenna portion, said antenna power-feeding section and said first antenna portion becomes negligible and power-feeding loss between said first and second antenna portions is thereby substantially eliminated when said antenna element is partially housed within said casing;

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said second antenna portion being mounted below said first antenna portion and having a conductor with a predetermined length;

the conductor of the second antenna portion being electrically coupled to said antenna power-feeding section when said antenna element is extended from the casing.

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ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT

Invention Title:

"Antenna system having plural antenna portions"

The following statement is a full description of this invention including the best method of performing it known to us:-

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to an antenna system suitable for a radio communication device, particularly for a portable radio communication device.

2 Description of the Related Art:

There has recently been known an antenna system, for a portable radio communication device, such as a portable radiophone, which can be housed within a phone body for carrying convenience. In this type of antenna system, an antenna element is designed to be extendible from a radiophone casing, even when housed within the phone body to enable transmission and reception.

A structure of such a conventional antenna system will now be described with reference to FIGS. 1 - 7.

FIGS. 1 and 2 are perspective views showing an outline of a portable radiophone. FIG. 1 and 2 show extended and retracted states of an antenna element 2, respectively. As can be seen, a distal end 3 of the antenna element 2 projects from the casing 1 when the antenna element is housed within the casing 1.

FIGS. 3 and 4 are partial cross-sectional views of the extended and retracted antenna element shown in FIGS. 1 and 2 respectively. As shown in these FIGS., a printed circuit

board 4, having a variety of high-frequency components mounted thereon, is contained within the casing 1. The printed circuit board 4 has a shared element (not shown) connected to a transmitting/receiving section, the shared element being coupled to an antenna power-feeding section 5. Further, the casing 1 is provided with a metallic mounting ring 6. A female screw thread is formed on the inner periphery of the ring 6, while a male screw thread is formed on the outer periphery of the casing connecting portion 7, so that the two can be mutually screwed together. The casing connecting portion 7 is also metallic and has a tongue piece 7a extending downwardly for supporting the antenna element 2. Namely, the casing connecting portion 7 has a through hole at its center, through which the antenna element 2 is inserted so as to be then supported by the tongue piece 7a.

FIG. 5 shows a detailed structure of the antenna element 2. The total length of the antenna element 2 is set to be approximately 1/4 - 1/2 of the central wavelength of the transmission radio wave . At the basic end portion (the end portion located within the casing 1) a metallic stopper 8, being in conductive contact with an antenna core line 9 is provided. At the distal end of the antenna element 2, a button 10 made of resin or the like is provided around the antenna core line 9, so that the antenna element 2 partly projects from the casing 1 at the time of retraction. Further, at the lower portion of the button 10, a lock pin 11 is insert-shaped for fixing the antenna core line 9. A metallic

power-feeding terminal 12 is provided around the lock pin 11 forming a power-feeding position at the time of retraction. The surface of the antenna core line 9a at the intermediate portion of the antenna element is covered with an insulating material.

A power-feeding operation at the time of extension and retraction of the antenna element 2 will now be described.

When the antenna element 2 is extended as shown in FIG. 3, the stopper 8 at the lower end of the antenna element 2 is held by the tongue piece 7a at the position in contact therewith at its distal end. As a result, the antenna power-feeding section 5 and the antenna element 2 are electrically connected so as to feed power to the antenna element 2. On the other hand, when the antenna element 2 is retracted, the power-feeding terminal 12 is held by the tongue piece 7a as shown in FIG. 4, and the antenna power-feeding section 5 supplies power to the distal end of the antenna 2 through the power-feeding terminal 12 and the lock pin 11 shown in FIG. 5. Thus, at the time of extension, the transmitting and receiving operations are carried out using the entire antenna element 2.

Meanwhile, when the antenna element 2 is retracted, only the distal end 3 projecting from the casing 1 functions as the antenna. Namely, only the portion positioned within the distal end 3 of the antenna core line 9 acts as the antenna.

Further as shown in FIG. 6, there is provided an antenna matching circuit 14 between the antenna power-feeding section 5 and the shared element 13 for conducting impedance matching

between the antenna 2 and the internal circuits at the time of extension and retraction. Such a type of antenna, however, has a disadvantage that the antenna gain is low because of its short projected portion at the time of retraction.

To cope with such a disadvantage, there has been proposed an improved antenna element 17 as shown in FIG. 7. This antenna element 17 comprises a loading coil 15 provided at the distal end 3 and having 1/4 wavelength, and a stick-shaped antenna 16 connected to the lower portion thereof and also having 1/4 wavelength. This antenna element 17 connects the loading coil 15 to the stick-type antenna 16 through the lock nut 11 for improving the conductivity. Therefore, when the antenna 17 is extended, the loading coil 15 of 1/4 wavelength and the stick-shaped antenna 16 of 1/4 wavelength will act as an antenna equivalent to a stick-shaped antenna having 1/2 wavelength. Meanwhile, at the time of retraction, the loading coil of 1/4 wavelength of the distal end 3 will act as an antenna.

As mentioned above, in the conventional retractable antenna system, the portions of the antenna element of the projected portion and the stored portion are conducting when in the retracted state. Therefore, the power is supplied not only to the projected portion but also partly to the stored portion, so as to cause power-feeding loss. In addition, a radio wave will be radiated from the stored portion to the inside of the casing, so as to undesirably affect the other electric components.

On the other hand, there has also been known a method in which a built-in antenna is separately provided, and this built-in antenna is switched to at the time of retraction. This type of antenna, however, requires a means for switching to the built-in antenna in association with the antenna retracting operation, and has such disadvantages as the casing necessarily being larger in order to contain the built-in antenna, and a reduced locating freedom of other mounting parts due to the limitation of the locating positions.

SUMMARY OF THE INVENTION

It is a desirable feature ~~therefore an object~~ of this invention to provide an antenna system which can suppress the undesirable effect of radio waves being coupled from the housed portion of the antenna element to the electric components inside the casing, can provide high antenna gain by improving the power-feeding loss generated at the housed portion, and is convenient in terms of portability due to its small size, without the need to provide any built-in antenna.

According to the present invention, there is provided an antenna system comprising a casing and an antenna element movable relative to the casing, the antenna element being usable in both an extended and retracted state. The antenna element includes a first antenna portion in which the antenna element is used in a state of being housed within the casing, and a second antenna portion which is insulated from the first antenna portion and in which the antenna element is used in a state of being extended from the

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casing.

The casing is provided with an antenna power-feeding section for electrically connecting a radio circuit mounted in the casing to the first antenna portion or the second antenna portion, the first antenna portion having a conductor of a predetermined length which is held by said casing in such a manner that a majority of the antenna element projects from the casing in the retracted state, with the conductor being electrically connected to the antenna power-feeding section. The second antenna portion is preferably mounted below ~~provided at the lower portion of~~ the first antenna portion and has a conductor of a predetermined length, the conductor being electrically connected to the antenna power-feeding section at the time of extension.

With the aforementioned structure, according to the antenna system of this invention, the antenna power-feeding section is connected only to the second antenna portion at the time of extension, so that the second antenna portion solely acts as an antenna. Meanwhile, when the antenna is retracted, the first antenna portion solely acts as antenna.

Since the antenna automatically switches at the time of extension and retraction, it is not necessary to provide any individual matching circuit for the antenna portions, so that a common matching circuit can readily carry out matching of the antenna element.

Further, since no power is fed to the second antenna portion which is accommodated within the casing in the retracted state, the electronic components such as radio cir-

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cuits within the casing would not be affected by the radiation of the radio waves from the second antenna portion.

Moreover, according to the antenna system of this invention, at the lower side of the first antenna portion, there is provided a first power-feeding terminal connected to the antenna power-feeding section of the casing so as to electrically couple the first antenna portion to the antenna power-feeding section. On the other hand, at the lower side of the second antenna portion, there is provided a second power-feeding terminal connected to the antenna power-feeding section of the casing so as to electrically couple the second antenna portion to the antenna power-feeding section.

Further, the conductor of the first antenna portion is composed of a coil-shaped conductor, while the conductor of the second antenna portion is composed of a ~~stick~~ rod-shaped conductor acting as an antenna core.

The first and the second antenna portions consist of dielectric substrates having strip conductors formed thereon, the conductor of the first antenna portion being composed of a strip conductor that has been patterned as the result of several folding operations on the dielectric substrate, while the conductor of the second antenna portion is composed of a strip conductor almost linearly patterned on the dielectric substrate.

The first antenna portion has a coil-shaped conductor, while the second antenna portion is composed of a dielectric substrate being connected to the first antenna portion and

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having a strip conductor that is almost linearly patterned.

The first antenna portion is composed of a dielectric substrate having a strip conductor that is patterned as a result of several folding operations thereon, while the second antenna portion is connected to the dielectric substrate of the first antenna portion, and the conductor of the second antenna portion is a rod-shaped conductor acting as an antenna core.

The second antenna portion is preferably composed of a rod-shaped element or a plurality of such elements mounted so as to be mutually slidable and also being extendible.

~~having a strip conductor that is almost linearly patterned.~~

The first antenna portion is composed of a dielectric substrate having a strip conductor that is patterned as a result of several folding operations thereon, while the second antenna portion is connected to the dielectric substrate of the first antenna portion, and the conductor of the second antenna portion is a stick-shaped conductor acting as an antenna core.

The second antenna portion is composed of a plurality of stick-shaped elements mounted so as to be mutually slidable ~~and also being extendible.~~

The antenna is mounted movably in the antenna receiving portion provided outside the casing.

The antenna power-feeding section has a power-feeding coil through which the antenna is inserted. A first power-feeding terminal is provided at the lower side of the first antenna portion for electromagnetically connecting to the power-feeding coil and for electrically coupling the first antenna portion to the antenna power-feeding section at the time of retraction. A second power-feeding terminal is provided at the lower side of the second antenna portion for electromagnetically connecting to the power-feeding coil and for electrically coupling the second antenna portion to the antenna power-feeding section at the time of extension.

In this manner, by composing the conductor of the first antenna portion as a coil or a conductor that has been patterned by folding operations on the dielectric substrate, it

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is possible to shorten the portion projecting from the casing at the time of retraction and to keep the whole system in a compact form suitable for carrying.

The above and other ~~objects~~, features and advantages of the present invention will become clear from the following description of the preferred embodiment thereof, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an antenna element of a conventional radio communication device at the time of extension;

FIG. 2 is a perspective view showing an antenna element of a conventional radio communication device at the time of retraction;

FIG. 3 is a cross-sectional view of a conventional antenna element at the time of extension;

FIG. 4 is a cross-sectional view of a conventional antenna element at the time of retraction;

FIG. 5 is a cross-sectional view of a structure of a conventional antenna element;

FIG. 6 is a circuit diagram showing an antenna portion in a conventional example;

FIG. 7 is a cross-sectional view showing a structure of an antenna element in a conventional example;

FIG. 8 is a cross-sectional view showing a structure of an antenna element according to a first embodiment of this invention;

FIG. 9 is a cross-sectional view showing an extended

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antenna element according to a first embodiment of this invention;

FIG. 10 is a cross-sectional view showing a retracted antenna element according to a first embodiment of this invention;

FIG. 11 is a detailed diagram of an antenna element according to a second embodiment of this invention;

FIG. 11A is a diagram showing an example in which conductors are formed at both sides of a substrate;

FIG. 12 is a perspective side view showing an antenna element according to a second embodiment of this invention;

FIG. 13 is a diagram showing a variation of antenna shape according to this invention;

FIG. 14 is a diagram showing a variation of antenna shape according to this invention;

FIG. 15 is a diagram showing a variation of antenna shape according to this invention;

FIG. 16 is a diagram showing an antenna guide provided outside the casing of this invention; and

FIG. 17 is a diagram showing a power-feeding coil according to this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first embodiment of the present invention will now be described with reference to FIGS. 8 - 10 of the accompanying drawings. The same components as in the aforementioned conventional example will be designated by the same numerals.

As shown in FIG. 8, an antenna 18 is composed of a first antenna portion 19 provided at the distal end of the antenna and a second antenna portion 20 connected thereto.

The first antenna portion 19 includes a button 10, a loading coil 21, a lock pin 11, and a power-feeding terminal 12. The button 10 is made of resin and contains the loading coil therein, which is made of a helically shaped piano wire. The lock pin 11 is made of metal such as brass, and is insert-shaped into the button 10 for fixing the lower end of the loading coil 21. The lock pin 11 is connected to the power-feeding terminal 12 and electrically coupled to the power-feeding terminal 12, the lock pin 11 and the loading coil 21. The power-feeding terminal 12 is to be located at an antenna power-feeding position at the time of retraction.

On the other hand, the second antenna portion 20 is composed of an antenna cylinder 22, an antenna core line 23 and a stopper 8. The antenna core line 23 is made of a flexible stainless wire and is pressingly inserted into the cylinder 22. The cylinder 22 is formed of a flexible insulator. A stopper 8 made of metal such as brass is pressed in through the base end side of the cylinder 22 for electrically connecting the stopper 8 and the antenna core line 23. A distal end 22a of the antenna cylinder 22 is fixed to the power-feeding terminal 12 for physically coupling the first antenna portion 19 to the second antenna portion 20. The lower end portion 12a of the power feeding terminal 12 is separated from that of the antenna core line 23 in the longitudinal direction

of the antenna, in such a manner that the electromagnetic coupling between the first antenna portion 19 and the second antenna portion 20 can be ignored. As a result, the first antenna portion 19 and the second antenna portion 20 are electrically insulated from each other.

The loading coil 21 is located at such a position that it is projected from the casing 1 at the time of retraction. The loading coil 21 is made of a helically shaped piano wire and has a length, from one end to another, of approximately 1/4 wavelength for shortening the projected portion of the antenna at the time of retraction. Accordingly, at the time of retraction, it will be equivalent to a state of being provided with a stick-shaped antenna having a length of 1/4 wavelength from the upper end surface of the casing.

The first antenna portion 19 and the second antenna portion 20 are electrically insulated from each other. At the time of extension, as shown in FIG. 9, power is supplied to the antenna core line 23 through the ring 6, the casing connecting portion 7 and the stopper 8 so that just the second antenna portion 20 acts as antenna. The length of the antenna core line 23 from its distal end to the basic end is set to a length of approximately 1/4 - 1/2 wavelength. The lengths of the loading coil 21 and the antenna core line 23 are finely adjusted by cut and try operations in accordance with the actual measured value.

At the time of retraction, the first antenna portion 19 acts as an antenna while the second antenna portion 20 is

housed within the casing. As shown in FIG. 10, the power is fed to the loading coil through the ring 6, the casing connecting portion 7, the power-feeding terminal 12 and the lock pin 11. Meanwhile, since the power-feeding terminal 12 is not coupled to the antenna core line 23, no power will be fed to the second antenna portion 20 at the time of retraction, so as to completely eliminate the feeding-power loss due to the accommodated portion and the undesirable affecting of the other electronic component inside the casing.

Thus, according to this embodiment, the antenna system is composed of the first antenna portion 19 having a loading coil 21 of 1/4 wavelength and the second antenna portion 20 fixed to the lower end of the first antenna portion 19 through the insulator and electrically insulated from the first antenna portion 19. Consequently, the first and the second antenna portions act as independent antennas at the time of extension and retraction respectively, so that the antenna matching can be readily achieved without providing any antenna matching circuit between the sharing element 13 and the antenna power-feeding section 5.

Second Embodiment

A second embodiment of this invention will now be described with reference to FIGS. 11 and 12. Besides the cylindrical form of the antenna element 18 described in the first embodiment, it can also be composed in plate form.

In this embodiment, the first antenna portion 19 and the

second antenna portion 20 are formed as strip conductors with a slight space therebetween on one surface of a dielectric substrate 25.

The first antenna portion 19 is arranged at the distal end portion of the dielectric substrate 25 with a strip conductor of approximately 1/4 wavelength being folded in a snaking form or the form of a letter U. An end of this folded conductor 26 is connected to a power-feeding point 27 at the time of retraction.

The second antenna portion 20, meanwhile, is slightly separated from the first antenna portion 19 and is composed of a strip conductor of approximately 1/4 wavelength - 1/2 wavelength linearly arranged on the dielectric substrate 25. An end of the linear conductor 28 which is located at the base end portion of the dielectric substrate 25 is then connected to the power-feeding point 29 at the time of extension. The actual length of the linear conductor 28 is decided by fine adjustment using cut and try operations.

As shown in FIG. 12, the periphery of the dielectric substrate 25, except at the antenna power-feeding points 27 and 29, is covered with resin, and a button 10 is provided around the first antenna portion 19 in the same manner as in the first embodiment. A stopper 30, made of resin or the like, is mounted at the base end portion. On the other hand, the periphery of the antenna power-feeding points 27 and 29 are covered with metal 31a and 32b so as to be easily contacted with the casing connecting portion 7.

Similarly to the antenna 18 in the first embodiment, since the antenna power-feeding portion 5 is electrically coupled to the metal 31b of the antenna base end portion, which is a power-feeding point at the time of extension, only the second antenna portion 20 will act as an antenna. At the time of retraction, the antenna power-feeding portion 5 is connected to the metal 31a, which is a power-feeding point at the time of retraction, so that the first antenna portion 19 is at a position projected from the casing 1 so as to enable transmission and reception. Further, since the first antenna portion 19 is formed by a folded conductor 26 of 1/4 wavelength, the portion projecting from the casing becomes short, even at the time of extension so as to be suitable for carrying. In addition, since the folded conductor 26 and the linear conductor 28 can be made at a higher dimensional accuracy by fine machining, such as etching processes, and at a higher speed than the first embodiment, it is possible to provide more stable characteristics.

While the folded conductor 26 is formed on one surface of the dielectric substrate 25 in the first antenna portion 19, if the coil-shaped folded conductors 26 are formed on both surfaces of the dielectric substrate 25 using a through hole 26a as shown in FIG. 11A, the projected portion can be shortened more than the case where only one surface is utilized. Moreover, by increasing the dielectric rate of the dielectric substrate 25, it is possible to reduce the space between the folded portions of the folded conductor 26, so

that the area of this shape can be further reduced.

Third Embodiment

A third embodiment of this invention will now be described with reference to FIGS. 13 - 15.

In the first and the second embodiments, the second antenna portion was formed by the linear antenna core line 23 and the linear conductor 28 respectively, but alternatively it is also possible to compose the first antenna portion 19 of a loading coil and a folded conductor respectively.

The basic requisite is that the first and the second antenna portions 19 and 20 should be electrically insulated from each other, and the second antenna portion 20 can be contained within the casing 1. If mechanically possible, the first and the second antenna portions can be formed by combination of a variety of antenna elements. It is possible, for example, to compose the first and the second antenna portions by any combination of a loading coil, strip conductor on the dielectric substrate, stick-shaped member, plate-shaped member, and volume ring etc. Examples are shown in FIGS. 13 - 15.

FIG. 13 shows an antenna element in which the first antenna portion 19 is composed of a loading coil 21, and the second antenna portion 20 is composed of a linear conductor 28 arranged on the dielectric substrate 25. FIG. 14 shows an antenna element in which the first antenna portion 19 is composed of a folded conductor 26 on the dielectric substrate

25, while the second antenna portion 20 is composed of a stick-shaped antenna core line 23. FIG. 15 shows an antenna element in which the first antenna portion 19 is composed of a loading coil 21, while the second antenna portion 20 is composed of an extendible element 32 made of a multi-stage metal rod, and the first and the second antenna portions are connected together. In this embodiment, the dielectric substrate 25 can be in cylindrically bent form, not in plate form.

Fourth Embodiment

A fourth embodiment of this invention will now be described with reference to FIG. 16.

In the last embodiment the antenna element was contained within the casing 1, but it is also possible to contain the antenna element within an antenna guide (accommodating portion) 34 provided outside the casing 1. In this embodiment, the same antenna element as in FIG. 11 is contained within the guide 34. The antenna power-feeding portion 5 is electrically coupled by not shown electric contacts to the antenna power-feeding points 27 and 29.

Fifth Embodiment

A fifth embodiment of this invention will now be described with reference to FIG. 17.

In the last embodiment, the power-feeding was carried out by electrically coupling the antenna and the power-feeding section 5, but alternatively it is also possible to perform

power-feeding by electromagnetic coupling by providing a power-feeding coil 35 connected to the power-feeding section 5 shown in FIG. 17. Namely, the currents from the antenna power-feeding section 5 flow into the power-feeding coil 35, and then through the electromagnetic coupling, to the first antenna portion 19 or the second antenna portion 20.

Sixth Embodiment

In the last embodiment, the first and the second antenna portions 19 and 20 were matched by cut and try operations, but alternatively it is also possible to provide an antenna matching circuit 14 between the common element 13 and the antenna power-feeding section 5 as shown in FIG. 6 to assure optimum matching conditions.

As mentioned above, according to this invention, since the first and the second antenna portions are electrically insulated from each other, no power will be fed to the second antenna portion, being a containing portion, at the time of retraction. As a result, undesirable effect of the radio wave radiation or the electronic components within the casing can be prevented.

Further, since the first and the second antenna portions are automatically switched for independent operation, the matching of the antenna can be readily provided.

In addition, since the part of the first antenna portion projecting from the casing at the time of retraction is composed of a loading coil or a folded conductor, it is possible

to minimize the length of the antenna portion projected from the casing at the time of retraction, and an antenna element which is capable of providing sufficient gain without being equipped with any built-in antenna can be realized.

Moreover, because a built-in antenna is not needed, there is also no need for a switching means with the built-in antenna, components, and locating spaces, so that the casing can be easily miniaturized.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1 An antenna system comprising a casing, and an antenna element being movable relative to said casing and usable in states of being extended from and partially housed within said casing, wherein

said antenna element includes:

a first antenna portion acting as an antenna when said antenna element is partially housed within said casing; and

a second antenna portion having all electrically conducting portions thereof electrically insulated from and spaced apart from and positioned with respect to all electrically conducting portions of said first antenna portion such that electromagnetic coupling between said second antenna portion and said first antenna portion becomes negligible, said second antenna portion acting as an antenna when said antenna element is extended from said casing;

said casing including an antenna power-feeding section for electrically coupling a radio circuit to said first or second antenna portion;

said first antenna portion having a conductor with a predetermined length, which is held by said casing in such a manner that a majority of the conductor projects from the casing when the antenna element is partially housed within said casing;

the conductor of the first antenna portion being electrically coupled to said antenna power-feeding section when the antenna element is partially housed within said casing;

said second antenna portion being mounted below said first antenna portion and having a conductor with a predetermined length;

the conductor of the second antenna portion being electrically coupled to said antenna power-feeding section when said antenna element is extended from the casing.

2. An antenna system according to claim 1, wherein:

said first antenna portion has a distal end and is provided, at an end opposite the distal end, with a first power-feeding terminal which is connected to said antenna power-feeding section of said casing, in order to electrically couple said first antenna portion to said antenna power-feeding section; and

said second antenna portion has a distal end and is provided, at an end opposite the distal end, with a second power-feeding terminal which is

connected to said antenna power-feeding section of said casing when the antenna is extended, in order to electrically couple said second antenna portion to said antenna power-feeding section.

3. An antenna system according to claim 2, wherein:

the conductor of said first antenna portion is composed of a coil-shaped conductor; and

the conductor of said second antenna portion is composed of a rod-shaped conductor acting as an antenna core.

4. An antenna system according to claim 2, wherein:

said first and second antenna portions are composed of a dielectric substrate having strip conductors being formed thereon;

the conductor of said first antenna portion is composed of a strip conductor being patterned in the form of a folded conductor on said dielectric substrate; and

the conductor of said second antenna portion is composed of a strip conductor being patterned in the form of a substantially linearly extending conductor on the dielectric substrate.

5. An antenna system according to claim 2, wherein:

said first antenna portion has a coil-shaped conductor; and

said second antenna portion is connected to said first antenna portion and is composed of a dielectric substrate having a strip conductor being patterned in the form of a substantially linearly extending conductor thereon

6. An antenna system according to claim 2, wherein:

said first antenna portion is composed of a dielectric substrate having a strip conductor being patterned by a plurality of folding operations thereon;

said second antenna portion is connected to said dielectric substrate of said first antenna portion; and

the conductor of said second antenna portion is a rod-shaped conductor acting as an antenna core.

7. An antenna system according to claim 2, wherein:

said second antenna portion is composed of a rod-shaped extendible element.

8. An antenna system according to claim 2, wherein:

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said antenna is mounted on and movable with respect to an antenna receiving section provided outside said casing.

9. An antenna system according to claim 1, wherein:

said antenna power-feeding section includes a power-feeding coil through which said second antenna portion is inserted;

said first antenna portion has a distal end and is provided, at an end opposite the distal end, with a first power-feeding terminal, which is electromagnetically connected to said power-feeding coil when the antenna element is partially housed within said casing, in order to couple said first antenna portion to said antenna power-feeding section; and

said second antenna portion has a distal end and is provided, at an end opposite the distal end, with a second power-feeding terminal, which is electromagnetically coupled to said power-feeding coil when the antenna is extended from said casing, in order to electrically couple said second antenna portion to said antenna power-feeding portion.

10. An antenna system comprising a casing, and an antenna element being movable relative to said casing and usable in states of being extended from and partially housed within said casing, wherein

said antenna element includes:

a first antenna portion acting as an antenna when said antenna element is partially housed within said casing; and

a second antenna portion having all electrically conducting portions thereof electrically insulated from and spaced apart from and positioned with respect to all electrically conducting portions of said first antenna portion such that electromagnetic coupling between said second antenna portion and said first antenna portion becomes negligible, said second antenna portion acting as an antenna when said antenna element is extended from said casing;

said casing including an antenna power-feeding section for electrically coupling a radio circuit to said first or second antenna portion;

said first antenna portion having a conductor with a predetermined length, which is held by said casing in such a manner that a majority of the conductor projects from the casing when the antenna element is partially housed within said casing;

the conductor of the first antenna portion being electrically coupled to said antenna power-feeding section when the antenna element is partially

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housed within said casing, said conductor of said first antenna portion and said antenna power-feeding section being spaced apart from said first antenna portion when said antenna element is partially housed within said casing such that electromagnetic coupling between said second antenna portion and said conductor of said first antenna portion, said antenna power-feeding section and said first antenna portion becomes negligible and power-feeding loss between said first and second antenna portions is thereby substantially eliminated when said antenna element is partially housed within said casing;

said second antenna portion being mounted below said first antenna portion and having a conductor with a predetermined length;

the conductor of the second antenna portion being electrically coupled to said antenna power-feeding section when said antenna element is extended from the casing.

11. An antenna system substantially as described with reference to Figures 8-17.

DATED this 12th day of December 1995

MITSUBISHI DENKI KABUSHIKI KAISHA
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ABSTRACT OF THE DISCLOSURE

An antenna system to be used for portable radio equipment is composed of first and second antenna portions. The first antenna portion has a loading section and is provided at a position projected from a casing even when being retracted and is also coupled to a power-feeding portion. The second antenna portion is connected to a lower end of the first antenna portion to be containable in the casing, and is coupled to the power-feeding portion at the base end portion when the antenna is extended. The second antenna portion is electrically insulated from the first antenna portion. Since the first and the second antenna portions are electrically insulated from each other, no power feeding to the contained portion will take place when the antenna is retracted. Further, since the first and the second antenna portions function independently, it is easy to obtain good matching of the antenna. Also, the length of the antenna element projecting from the casing when retracted becomes short, because of the first antenna portion having a loading portion, so that there will be no inconvenience in carrying of the radio equipment.

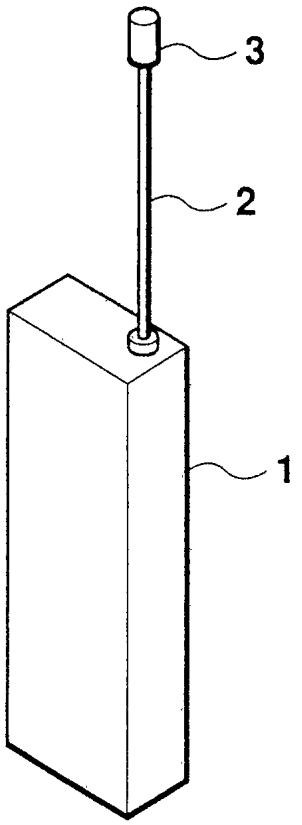


Fig. 1

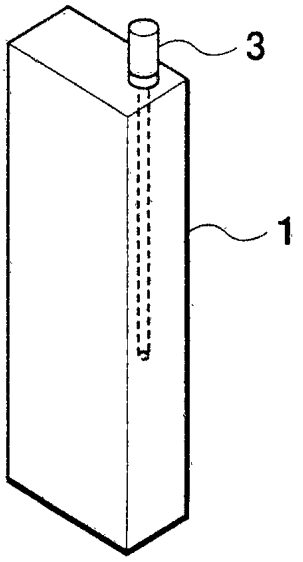


Fig. 2

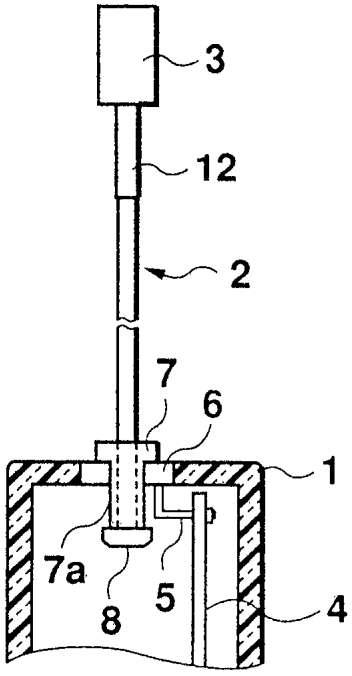


Fig. 3

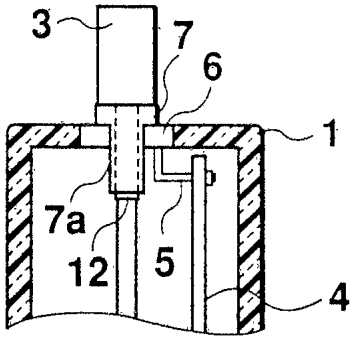


Fig. 4

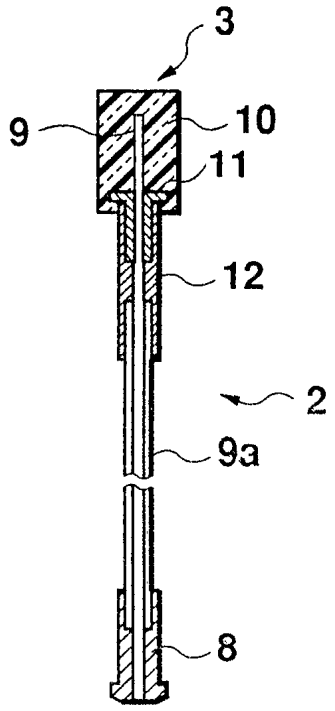


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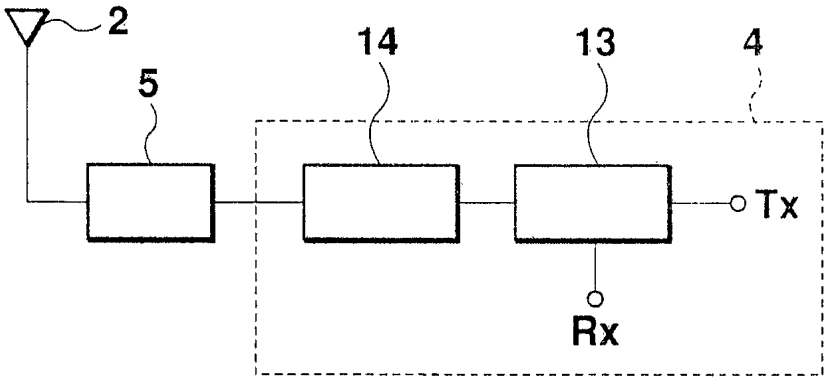


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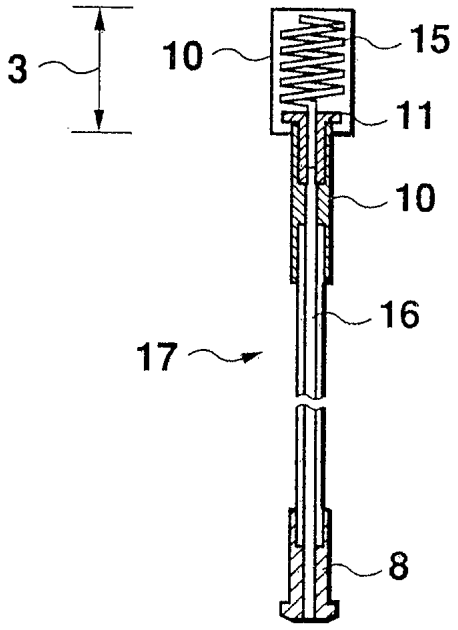


Fig. 7

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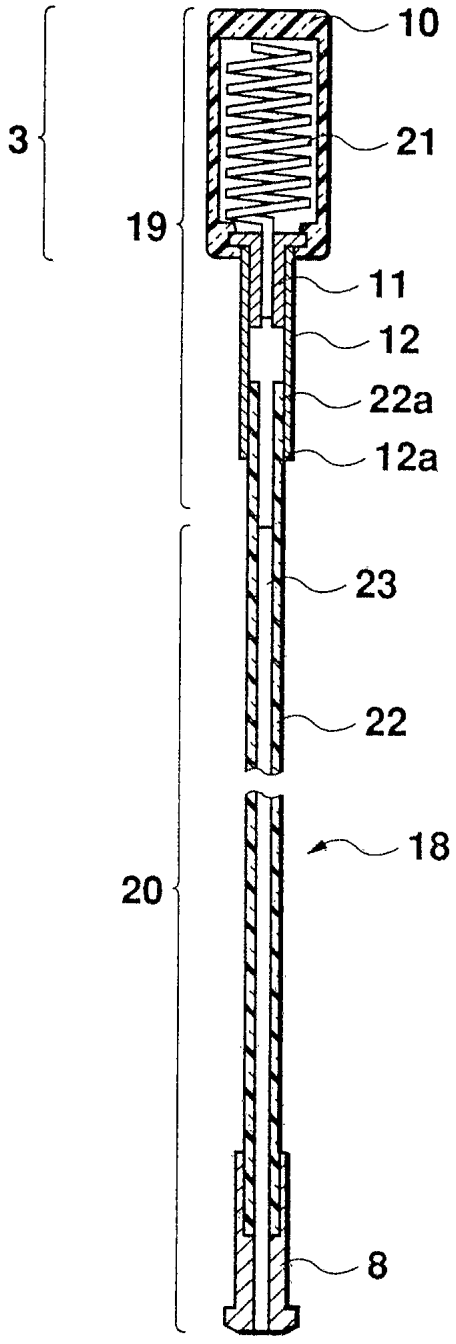


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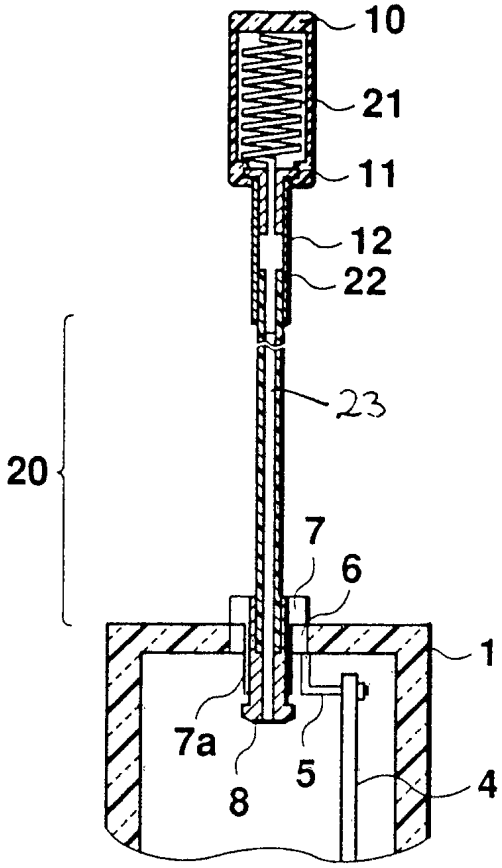


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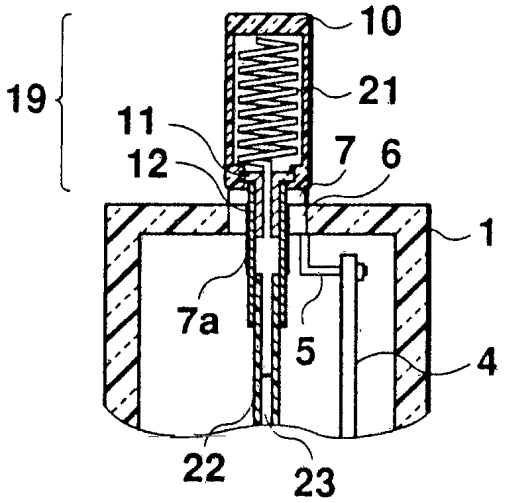


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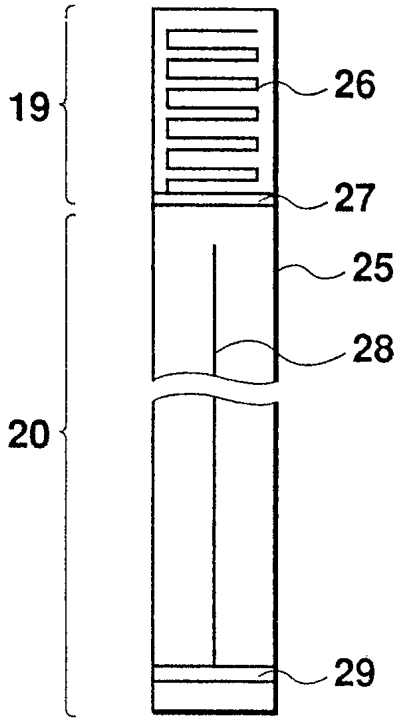


Fig. 11

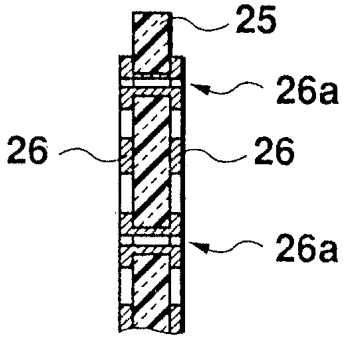


Fig. 11A

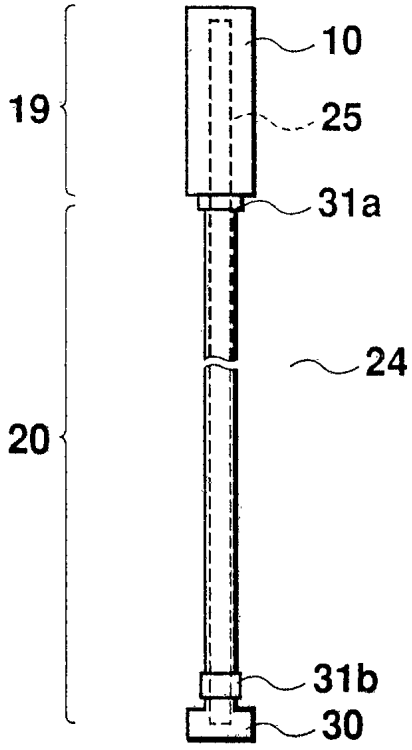


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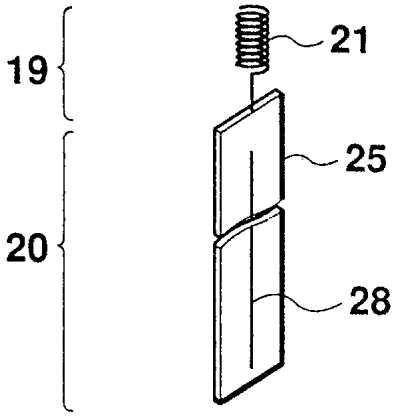


Fig. 13

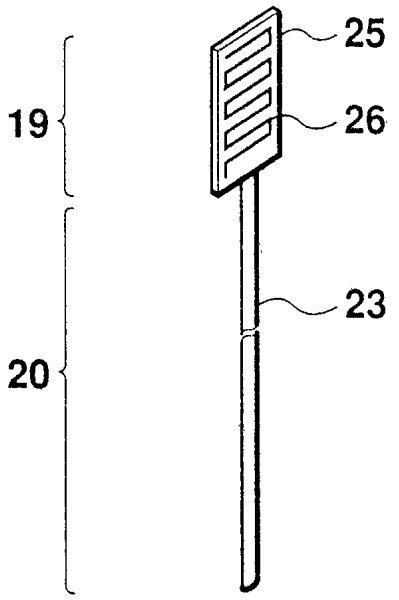


Fig. 14

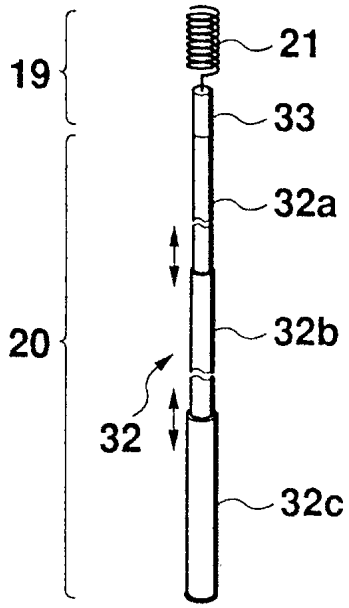


Fig. 15

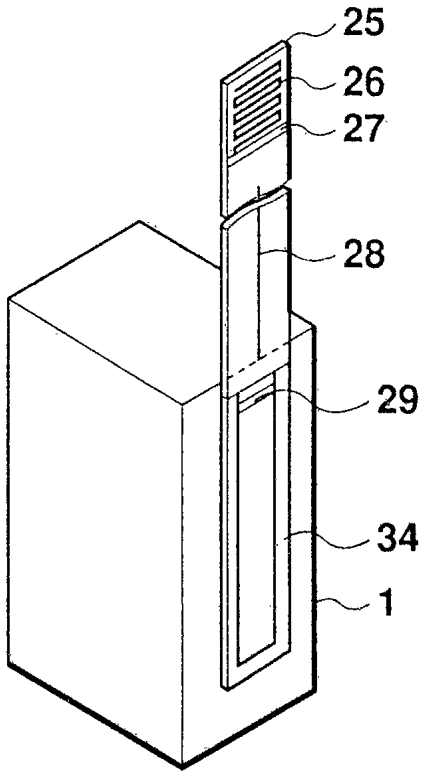


Fig. 16

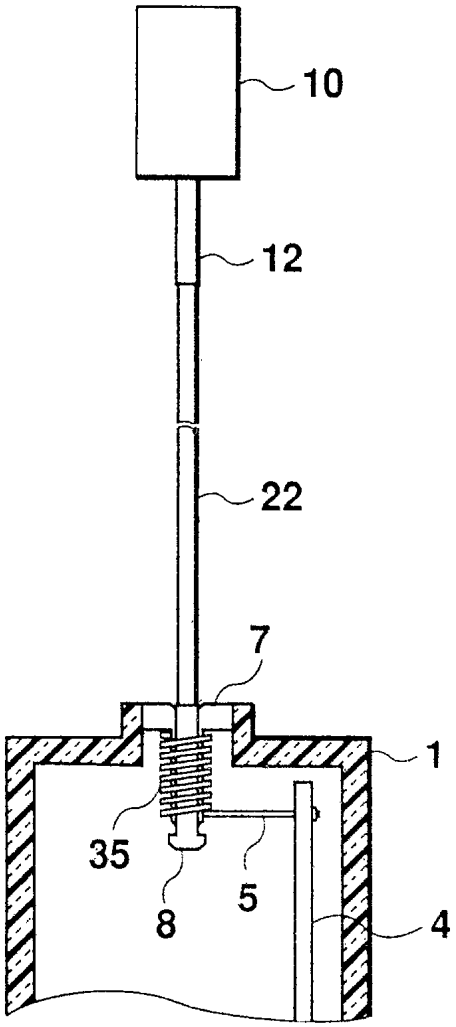


Fig. 17