

DESCRIPTION

WHIP ANTENNA AND METHOD OF PRODUCING THE SAME

Technical Field

This invention relates to a whip antenna equipped in a communication apparatus such as a mobile radio apparatus.

Background Art

Generally, mobile radio apparatuses are provided with antennas for transmission and reception of a radio wave. These antennas have a wide variety of shapes. Such tendency is remarkable in mobile telephone sets. Recently, in order to provide a mobile telephone set reduced in cost and improved in portability, a light-weight and economical antenna is desired. In most cases, use is made of a telescopic or extendable whip antenna which can be retreated or retracted in a housing of the mobile telephone set.

As illustrated in Fig. 1 or Fig. 2, a typical telescopic whip antenna comprises a first antenna portion 10 which can be retreated into a housing of a telephone set (not shown), and a second antenna portion 20 protruding outside of the housing of the telephone set even when the first antenna portion 10 is retreated.

Generally, the whip antenna is classified into one of an unseparate type and a separate type in which the first and the second antenna portions 10 and 20 are electrically

directly connected or electrically separated, respectively. In either type, each of the first and the second antenna portions 10 and 20 is covered with a face protection mold. For example, the first antenna portion 10 is covered by a tube made of insulating resin while the second antenna portion 20 is covered with an antenna top mold of insulating resin.

However, the tube and the antenna top mold as the face protection molds are formed in different manners by the use of different techniques. Therefore, a total number of steps is increased so that a high production cost is required. This results in an increase in product price.

In case where the face protection mold for the first antenna portion 20 of a long size is formed by the use of a die, it is highly possible that a molding material does not uniformly spread in every corner of the die. In this event, the face protection mold will suffer an uneven thickness or a local deficiency.

Disclosure of Invention

It is therefore an object of the present invention to provide a whip antenna which is easy in manufacture and low in cost.

It is another object of the present invention to provide a method adapted to production of the above-mentioned whip antenna.

Other objects of the present invention will become clear as the description proceeds.

According to the present invention, there is provided a whip antenna which comprises a first antenna portion and a second antenna portion coupled to the first antenna portion. The first antenna portion comprises a first antenna element and a coating portion covering the first antenna element. The second antenna portion comprises a conductive sleeve and a second antenna element arranged at one end of the sleeve and electrically connected to the sleeve. At least the one end of the sleeve and the second antenna element is enclosed in a mold of a resin material to form an antenna top portion. In the whip antenna, the coating portion is made of the same resin material as that of the mold covering at least the one end of the sleeve and the second antenna element and is integrally formed with the antenna top portion simultaneously when the mold is formed.

According to the present invention, there is provided a method of producing a whip antenna which comprises a first antenna portion and a second antenna portion combined with the first antenna portion. The first antenna portion comprises a first antenna element and a coating portion covering the first antenna element. The second antenna portion comprises a conductive sleeve and a second antenna element arranged at one end of the sleeve and electrically connected to the sleeve. At least the one end of the sleeve and the second antenna element being enclosed in a mold of a resin material to form an antenna top portion. The method comprises the steps of preparing a die having a

cavity for molding the coating portion and the antenna top portion, a plurality of gates communicating with the cavity to supply a molding material in a molten state to the cavity, and an air vent communicating with the cavity to evacuate the cavity, simultaneously molding the coating portion and the antenna top portion with the molding material by filling the molding material in a molten state into the cavity through the gates while the cavity is evacuated through the air vent.

Brief Description of Drawings

Fig. 1 is a half-sectional view of a conventional whip antenna of an unseparate type;

Fig. 2 is a half-sectional view of a conventional whip antenna of a separate type;

Fig. 3 is a half-sectional view of a whip antenna according to a first embodiment of this invention;

Fig. 4 is a perspective view of an opened state of a die used in production of the whip antenna illustrated in Fig. 3;

Fig. 5 is a perspective view of a closed state of the die illustrated in Fig. 4;

Fig. 6 is an enlarged perspective view of an example of a gate portion of the die illustrated in Fig. 4;

Fig. 7 is an enlarged perspective view of another example of the gate portion of the die illustrated in Fig. 4;

Fig. 8 is a half-sectional view of a whip antenna according to a second embodiment of this invention; and

Fig. 9 is a perspective view of a characteristic part of the whip antenna illustrated in Fig. 8.

Best Mode for Carrying Out the Invention

Referring to Fig. 3, description will be made about a whip antenna according to a first embodiment of this invention. Similar parts are designated by like reference numerals and will not be described any longer.

In the whip antenna, a first antenna portion 10 comprises a first antenna element 1, a coating portion 9 covering the first antenna element 1, and a conductive stopper 5 fixed to a bottom end of the first antenna element 1 and electrically connected to the first antenna element 1. The first antenna portion 10 is slidably inserted into a holder 4 which serves to attach the antenna to a housing (not shown) of a mobile telephone set. The holder 4 is fixedly attached to a top surface of the housing of the mobile telephone set.

A second antenna portion 20 comprises a conductive sleeve 6 fixed to a top end of the first antenna element 1 and electrically connected to the first antenna element 1, a second antenna element 2 which is a coil arranged on a top end of the sleeve 6, and a helical guide 7 fixed to the top end of the sleeve 6 to hold the second antenna element 2. Thus, in the whip antenna illustrated in Fig. 3, the second antenna portion 20 is a so-called helical antenna.

The sleeve 6, the second antenna element 2, and the helical guide 7 are enclosed in a mold of electrical insulating resin material to form an antenna top 11.

Simultaneously when the antenna top 11 is molded, the first antenna element 1 of the first antenna portion 10 is also enclosed in a similar mold of the insulating resin material to form the coating portion 9.

The stopper 5 formed at the bottom end of the first antenna portion 10 serves as a feeding portion for the whip antenna. When the first antenna element 1 is extended and retreated, the first antenna element 1 of the first antenna portion 10 and the second antenna element 2 of the second antenna portion 20 are energized or supplied with electric power through the stopper 5 to perform an antenna function, respectively.

In the whip antenna illustrated in Fig. 3, the first and the second antenna portions 10 and 20 are not separated both mechanically and electrically. Since the holder 4 fixedly attached to the housing of the mobile telephone set is not involved in energization or power supply, the holder 4 may be made of electrical insulating resin material. The first antenna portion 10 is slidably inserted into the holder 4.

Referring to Figs. 4 and 5 in addition to Fig. 3, description will be made about a method of producing the whip antenna illustrated in Fig. 3.

In this method, a die 30 is used. The die 30 comprises a lower split die 31 and an upper split die 32.

The lower split die 31 has a plurality of cavity portions 311, a liner portion 312, first and second gate portions 313 and 314, a coupling portion 315, an air vent 316, and a rubber packing 317. The cavity portions 311, four in number in the illustrated example, are formed on an upper surface of the lower split die 31 in parallel to one another. Each of the cavity portions 311 has an under part 311a of a linear shape and a top part 311b of a generally elliptical shape. The under part 311a serves to form the coating portion 9 of the whip antenna while the top part 311b serves to form the antenna top 11 of the whip antenna.

The liner portion 312 is formed on the top surface of the lower split die 31 and serves to introduce into each cavity portion 311 the insulating resin material as a molding material injected through an injection hole 321 of the upper split die 32 which will later be described. The liner portion 312 has one end 312a communicating with the injection hole 321 of the upper split die 32 and the other end divided into a plurality of branch portions 312b in one-to-one correspondence to the cavity portions 311. Each branch portion 312b extends along the top part 311b of a corresponding one of the cavity portions 311.

Each of the first gate portions 313 establishes communication between the branch portion 312b of the liner portion 312 and the top part 311b of the cavity portion 311 to introduce the insulating resin material in a molten state from the liner portion 312 into the top part 311b. As illustrated in Fig. 6, the first gate portion 313 has a

semiconical shape obtained by splitting a cone in a longitudinal direction.

Each of the second gate portions 314 establishes communication between the branch portion 312b of the liner portion 312 and the under part 311a of the cavity portion 311 to introduce the insulating resin material in a molten state from the liner portion 312 into the under part 311a. The second gate portion 314b has a semiconical shape similar to that of the first gate portion 313. Alternatively, each of the first and the second gate portions 313 and 314 may have a semiprismal shape obtained by splitting a prism in a longitudinal direction.

The coupling portion 315 has a trunk part 315a and four branch parts 315b extending from the trunk part 315a. The branch part 315b communicates with the cavity portions 311, respectively. Thus, the four cavity portions 311 are spatially combined by the coupling portion 315b.

The air vent 316 has one end communicating with the coupling portion 315 and the other end opened on a side surface of the lower split die 31.

The rubber packing 317 serves to seal a gap between the lower and the upper split dies 31 and 32 and is arranged at a peripheral zone of the upper surface of the lower split die 31 to surround the cavity portions 311, the liner portion 312, the first and the second gate portions 313 and 314, and the coupling portion 315.

Although not illustrated in the figure, the upper split 32 die is also provided on its lower surface with a

plurality of cavity portions, a liner portion, first and second gate portions, and a coupling portion in the manner similar to the lower split die 31. These portions are identical in shape with the cavity portion 311, the liner portion 312, the first and the second gate portions 313 and 314, and the coupling portion 315 of the lower split die 31. Therefore, when the upper split die 32 is bonded to the lower split die 31, the cavity portions of the upper and the lower split dies 31 and 32 form a plurality of hollow cavities each of which is for molding the coating portion 9 and the antenna top 11 of the whip antenna. Likewise, the liner portions of the upper and the lower split dies 31 and 32 form a pipe-like liner for introducing the insulating resin material in a molten state into the cavities. Likewise, the first and the second gate portions of the upper and the lower split dies 31 and 32 form first and second gates as holes for supplying the insulating resin material in a molten state from the liner into the cavities. Likewise, the coupling portions of the upper and the lower split dies 31 and 32 form a pipe-like communication hole for communication between the four cavities and the air vent 316. The upper split die 32 does not have the air vent 316 but has the injection hole 321 for injecting the insulating resin material in a molten state into the liner.

Description will be made about a process of producing the whip antenna by the use of the die 30.

At first, the second antenna element 2 wound around the helical guide 7 is fixed on the top end of the sleeve 6.

Simultaneously, the second antenna element 2 is electrically connected to the sleeve 6. To the bottom end of the sleeve 6, the top end of the first antenna element 1 is inserted to form an assembly.

The assembly is disposed in the cavity portion 311 of the lower split die 31. Specifically, the second antenna element 2, the helical guide 7, and the sleeve 6 are disposed in the top part 311b of the cavity portion 311 while the first antenna element 1 is disposed in the under part 311a of the cavity portion 311.

Then, the die 30 is closed as illustrated in Fig. 4.

In this state, the cavity is evacuated through the air vent 316 by the use of a vacuum device (not shown). Simultaneously, the insulating resin material in a molten state is filled into the cavity through the injection hole 321 of the upper split die 32 to wait solidification of the insulating resin material.

When the insulating resin material in the cavity is solidified, the die 30 is opened to remove a molded product from the die 30. By attaching the holder 4 and fixing the stopper 5 to the molded product, the whip antenna illustrated in Fig. 3 is completed. Herein, the stopper 5 can be fixed by preliminarily deforming the bottom end of the first antenna element 1 and press-fitting the bottom end to the stopper 5 or by inserting the bottom end of the first antenna element 1 into the stopper 5 and then caulking the stopper 5.

As the molding material, i.e., the insulating resin material, use is suitably made of nylon 11, nylon 66, ABS, polyolefin elastomer, polyurethane elastomer, or polyester resin. In case where one of these molding materials is used, the width of the gate is determined on the order of 0.3mm. In this event, it is easy to remove the product after the molding operation. It is preferable that the width of the gate is determined between 0.3mm and 0.6mm, taking into consideration the flowability of the insulating resin material.

In a general case where the first antenna element 1 has an outer diameter of 0.5-1.0mm, the coating portion 9 has a thickness of 0.4mm or more. It is preferable that each half side of the coating portion 9 is determined to have a thickness of 0.2mm, taking into consideration the strength and the design of the first antenna portion 10.

Next referring to Fig. 8, description will be made about a whip antenna according to a second embodiment of this invention. Similar parts are designated by like reference numerals.

In the whip antenna, the first antenna portion 10 and the sleeve 6 of the second antenna portion 20 are mechanically fixed to each other through an insulating resin portion 3. Simultaneously, the first and the second antenna portions 10 and 20 are electrically insulated from each other through the insulating resin portion 3. The bottom end of the sleeve 6 is exposed.

The whip antenna is a so-called separate antenna in which the antenna function is performed by different antenna elements in an extended state and a retreated state, respectively. In the extended state, the first antenna element 1 is energized through the stopper 5 formed at the bottom end of the first antenna element 1 of the first antenna portion 10. Thus, the first antenna element 1 performs the antenna function with the stopper 5 serving as a feeding portion. At this time, the second antenna element 2 of the second antenna portion 20 is not energized because of presence of the insulating resin portion 3 and does not perform the antenna function. In the retreated state, the second antenna element 2 is energized through the sleeve 6 as a feeding portion and performs the antenna function. At this time, the first antenna element 1 of the first antenna portion 10 is not energized because of presence of the insulating resin portion 3 and does not perform the antenna function.

Next, description will be made about a method of producing the whip antenna illustrated in Fig. 8.

A die (will hereafter be called a "second die") for producing the whip antenna in Fig. 8 is substantially similar to the die (will hereafter be called a "first die") for producing the whip antenna in Fig. 3 but is slightly different as will presently be described.

Specifically, in the first die, the top end of the under part 311a of the cavity portion 311 is formed so that it does not reach the sleeve 6 and is not brought into

contact with the first antenna element 1. On the other hand, in the second die, the top end of the under part of the cavity portion is formed so that it extends to the bottom end of the sleeve 6 and is brought into tight contact with the bottom end of the sleeve 6.

In addition, the first and the second dies are slightly different in position of the gates. In each of Figs. 3 and 8, the positions of the first and the second gates are depicted by G1 and G2, respectively. From comparison of Figs. 3 and 8, it is obvious that the first gates are located at the same position in the first and the second dies. On the other hand, the second gate in the second die is located at a level lower than that of the second gate in the first die because of the following reason. In the second die, the top end of the under part of the cavity portion is in tight contact with the bottom end of the sleeve 6. In order to avoid the second gate from being located there, the second gate is shifted downward.

The second die is different from the first die only in the above-mentioned respects. Therefore, upon describing the method of producing the whip antenna in Fig. 8, reference will be made to Fig. 4 as regards the die.

In order to produce the whip antenna in Fig. 8, the helical guide 7 with the second antenna element 2 preliminarily wound therearound is at first fixed to the sleeve 6 by press-fitting or screwing. The second antenna element 2 wound around the helical guide 7 is electrically

connected to the sleeve 6 to obtain the assembly. The assembly is disposed in the top part 311b of the cavity portion 311 formed in the lower split die 31. On the other hand, the first antenna element 1 is disposed in the under part 311a of the cavity portion 311. At this time, the top end of the first antenna element 1 is separated from the sleeve 6.

Subsequent steps are similar to those in the method of producing the whip antenna in Fig. 3. Specifically, the die 30 is closed and the cavity is evacuated through the air vent 316 by the use of the vacuum device (not shown). Simultaneously, the insulating resin material in a molten state is filled into the cavity through the injection hole 321 of the upper split die 32. At this time, as illustrated in Fig. 9, a hollow portion 8 having a diameter on the order of 1.9mm is formed at the center of the helical guide 7 and the sleeve 6. Therefore, the insulating resin material is supplied through the hollow portion 8 and the second gate portion 311b to the under part 311a. Thus, the antenna top 11, the insulating resin portion 3, and the coating portion 9 are simultaneously molded.

Then, when the insulating resin material is solidified, the die 30 is opened to remove the molded product from the die 30. The holder 4 is attached and the stopper 5 is fixed to the molded product. Thus, the whip antenna in Fig. 8 is completed.

Referring to Fig. 9 in addition, the description will be proceeded as regards the method of producing the whip antenna in Fig. 8. The helical guide 7 preliminarily formed by molding or the like is fixed to the sleeve 6 by press-fitting or screwing. Herein, the second antenna element 2 is wound around the helical guide 7 and electrically connected to the sleeve 6. At the center of the helical guide 7 and the sleeve 6, the hollow portion 8 having a diameter on the order of 1.9mm is formed to flow the insulating resin material. The helical guide 7 with the second antenna element 2 and the sleeve 6 are inserted into a molding die together with the first antenna element 1 to carry out molding of the antenna top 11. At this time, the insulating resin material flows through the hollow portion 8 to simultaneously form the insulating resin portion 3 and the coating portion 9 of the first antenna element 1.

The whip antenna in Fig. 3 can be produced through a method similar to the above-mentioned another method. It is noted here that, since the whip antenna in Fig. 3 does not have the insulating resin portion 3, the hollow portion 8 need not be formed in the sleeve 6 and the helical guide 7. In addition, in the whip antenna in Fig. 3, a part of the sleeve 6 need not be exposed. Therefore, the second antenna element 2, the helical guide 7, the sleeve 6, and the first antenna element 1 is integrally enclosed by a mold of the molding resin material A.

In each of the whip antennas illustrated in Figs. 3 and 8, both the antenna top 11 and the coating portion 9 (including the insulating resin portion 3 in case of the whip antenna in Fig. 8) of the first antenna element 1 are simultaneously molded. Thereafter, the holder 4 and the stopper 5 are attached to the first antenna portion 10. The stopper 5 is fixedly attached to the first antenna element 1 by deforming the bottom end of the first antenna element 1 and press-fitting the bottom end into the stopper 5. Alternatively, the stopper 5 may be fixed to the first antenna element 1 by caulking the stopper 5.

In each of the whip antennas illustrated in Figs. 3 and 8, the helical coil 2 independently formed is wound around the helical guide 7 separately formed. Alternatively, the coil may be formed by plating the helical guide to obtain a coil-like plating pattern which serves as a coil. Alternatively, as in a helical antenna disclosed by the present applicant in Japanese Patent Application No. 9-347912 (347912/1997) which is not yet published, a flexible substrate having a plurality of conductor patterns is rounded into a cylindrical shape so that the conductor patterns are connected in cascade to one another to form a coil. The coil on the flexible substrate is attached to the helical guide.

In Fig. 4, the gate of the die has a circular section in a direction perpendicular to a flowing direction of the insulating resin material. It is noted here that the gate may have an elliptical or a polygonal section without being

restricted to the circular section. Although the die illustrated in Fig. 4 is a split die, use may be made of a cylindrical die or a combination of a split die and a cylindrical die. In case where the cylindrical die is used, a parting line can be eliminated.



CLAIMS

1. A whip antenna comprising a first antenna portion and a second antenna portion coupled to said first antenna portion, said first antenna portion comprising a first antenna element and a coating portion covering said first antenna element, said second antenna portion comprising a conductive sleeve and a second antenna element arranged at one end of said sleeve and electrically connected to said sleeve, at least said one end of said sleeve and said second antenna element being enclosed in a mold of a resin material to form an antenna top portion, wherein said coating portion is made of the same resin material as that of said mold covering at least said one end of said sleeve and said second antenna element and is integrally formed with said antenna top portion simultaneously when said mold is formed.

2. A whip antenna as claimed in claim 1, wherein said first and said second antenna portions are electrically connected to each other.

3. A whip antenna as claimed in claim 2, wherein said second antenna portion is a helical antenna portion.

4. A whip antenna as claimed in claim 3, wherein said helical antenna portion comprises a coil as said second antenna element and a helical guide fixed to one end of said sleeve to prevent deformation of said coil.

5. A whip antenna as claimed in claim 4, wherein said coil is formed by a coil-like plating pattern formed



on said helical guide.

6. A whip antenna as claimed in claim 4, wherein said coil is formed by rounding a flexible substrate having a plurality of conductor patterns so that said conductor patterns are connected in cascade to one another.

7. A whip antenna as claimed in claim 1, wherein said mold is made of a molding material which is at least one of nylon 11, nylon 66, ABS, polyolefin elastomer, polyurethane elastomer, and polyester resin.

8. A whip antenna as claimed in claim 1, wherein said first and said second antenna portions are mechanically connected to each other and electrically insulated from each other by an insulating resin portion, said insulating resin portion is integrally formed together with said antenna top portion and said coating portion by the same resin material simultaneously when said mold is formed.

9. A whip antenna as claimed in claim 8, wherein said second antenna portion is a helical antenna portion.

10. A whip antenna as claimed in claim 9, wherein said helical antenna portion comprises a coil as said second antenna element and a helical guide fixed to one end of said sleeve to prevent deformation of said coil, said helical guide and said sleeve being provided with a hollow portion to flow the above-mentioned resin material therethrough when said mold is formed.

11. A whip antenna as claimed in claim 10, wherein said coil is formed by a coil-like plating pattern formed on said helical guide.



12. A whip antenna as claimed in claim 10, wherein said coil is formed by rounding a flexible substrate having a plurality of conductor patterns so that said conductor patterns are connected in cascade to one another.

13. A whip antenna as claimed in claim 8, wherein said mold is made of a molding material which is at least one of nylon 11, nylon 66, ABS, polyolefin elastomer, polyurethane elastomer, and polyester resin.

14. A method of producing a whip antenna claimed in claim 1, wherein said antenna top portion and said coating portion are simultaneously formed by a single molding step.

15. A method of producing a whip antenna claimed in claim 8, wherein said antenna top portion, said coating portion, and said insulating resin portion are simultaneously formed by a single molding step.

16. A method of producing a whip antenna comprising a first antenna portion and a second antenna portion combined with said first antenna portion, said first antenna portion comprising a first antenna element and a coating portion covering said first antenna element, said second antenna portion comprising a conductive sleeve and a second antenna element arranged at one end of said sleeve and electrically connected to said sleeve, at least said one end of said sleeve and said second antenna element being enclosed in a mold of a resin material to form an antenna top portion, said method comprising the steps of:

preparing a die having a cavity for molding said coating portion and said antenna top portion, a plurality



of gates communicating with said cavity to supply a molding material in a molten state to said cavity, and an air vent communicating with said cavity to evacuate said cavity; and

simultaneously molding said coating portion and said antenna top portion with said molding material by filling said molding material in a molten state into said cavity through said gates while said cavity is evacuated through said air vent.

17. A method as claimed in claim 16, wherein said whip antenna has an insulating resin portion formed between said first and said second antenna portions to mechanically connect and electrically insulate said first and said second antenna portions, said cavity being adapted to further mold said insulating resin portion so that said coating portion, said antenna top portion, and said insulating resin portion are simultaneously molded by said molding material.

18. A method as claimed in claim 16, wherein said die is a cylindrical die.

19. A method as claimed in claim 16, wherein said gate has a circular section, an elliptical section, or a polygonal section.

20. A method as claimed in claim 16, wherein said gate has a width of at least 0.3mm.

21. A method as claimed in claim 16, wherein said first antenna element has an outer diameter of 0.5-1.0mm while said coating portion has a thickness of 0.4mm.