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Nevermann et al.(10) **Pub. No.: US 2004/0051672 A1**(43) **Pub. Date: Mar. 18, 2004**(54) **MOBILE TELEPHONE COMPRISING A
MULTI-BAND ANTENNA****Publication Classification**(76) Inventors: **Peter Nevermann**, San Diego, CA
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(DE)(51) **Int. Cl.⁷** **H01Q 1/24; H01Q 1/36**(52) **U.S. Cl.** **343/702; 343/895**Correspondence Address:
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CHICAGO, IL 60690-1135 (US)(57) **ABSTRACT**(21) Appl. No.: **10/398,665**(22) PCT Filed: **Oct. 5, 2001**(86) PCT No.: **PCT/DE01/03832**(30) **Foreign Application Priority Data**

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An antenna means for a portable radio communication device, in particular a hand-portable mobile telephone, having at least one radiating element that has a meandering and cylindrical configuration. This structure is specifically advantageous in combination with an extendable and retractable whip antenna and, when having two or more meandering radiating elements, in multi-band radiating structures. The antenna device is suitable for manufacturing in large quantities, for example by a flexible printed circuit board technique.

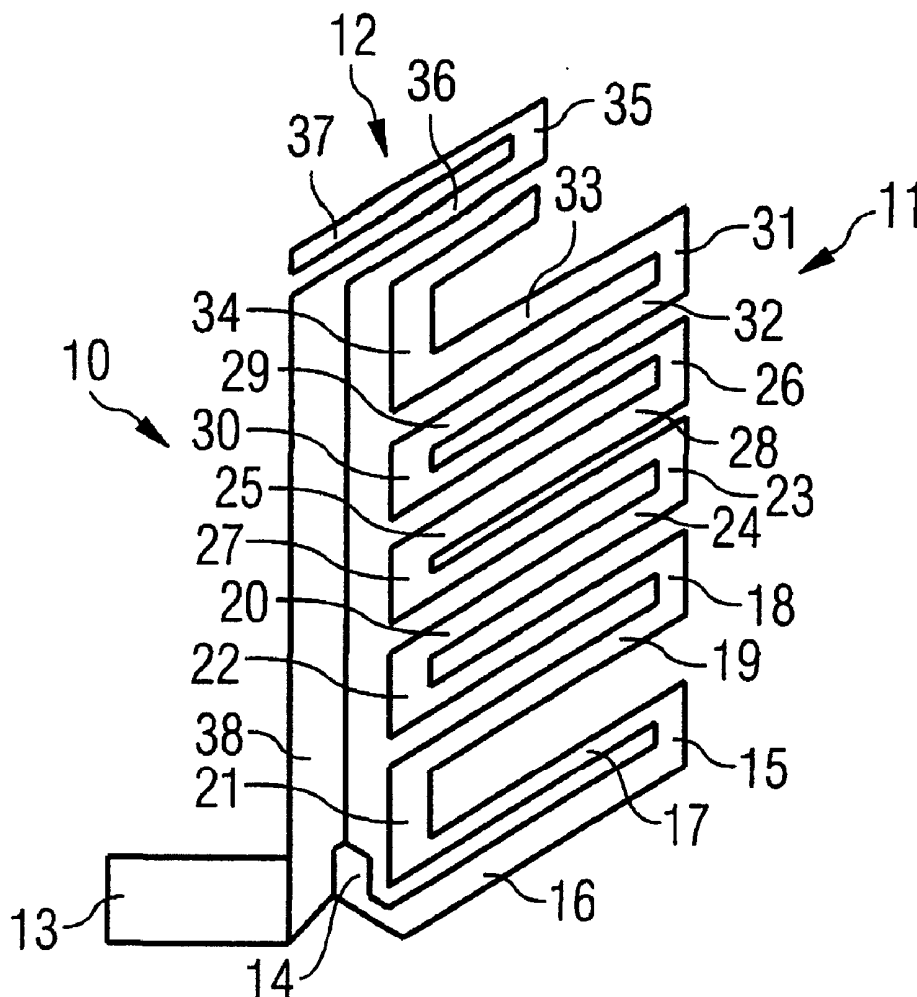


FIG 1

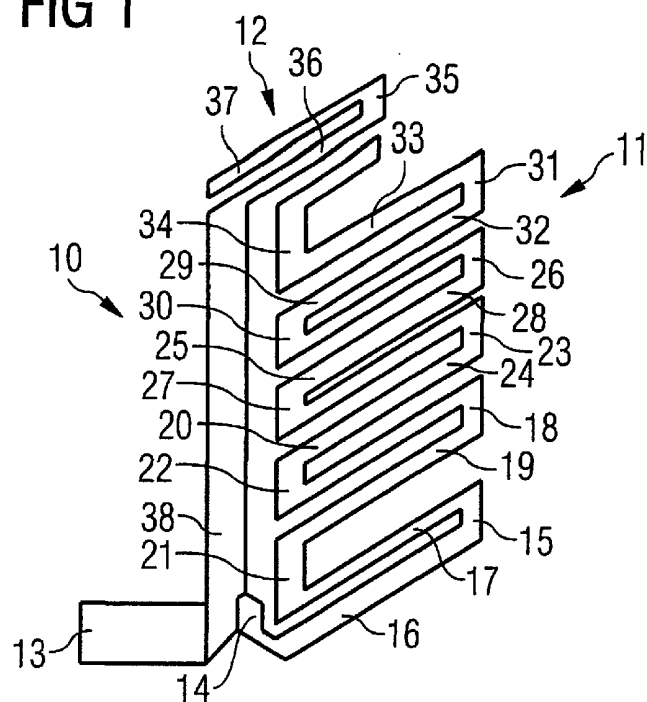


FIG 2

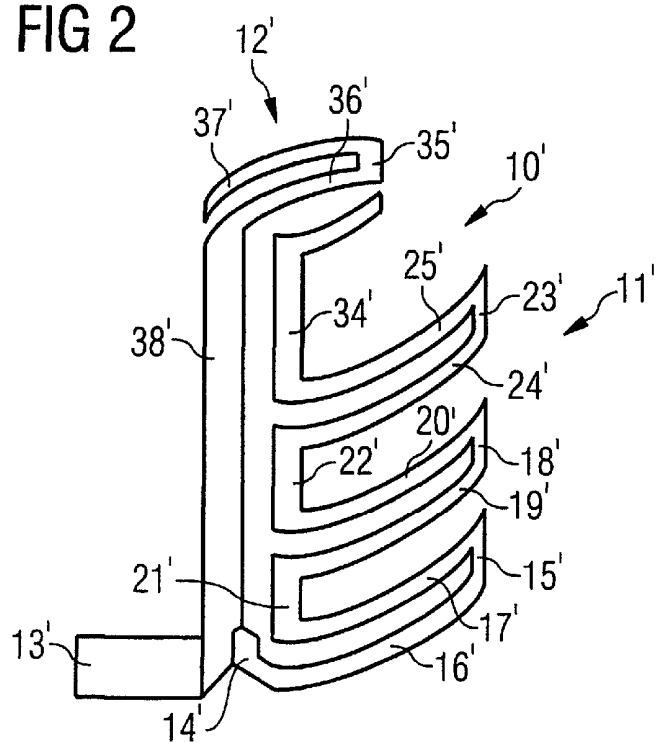
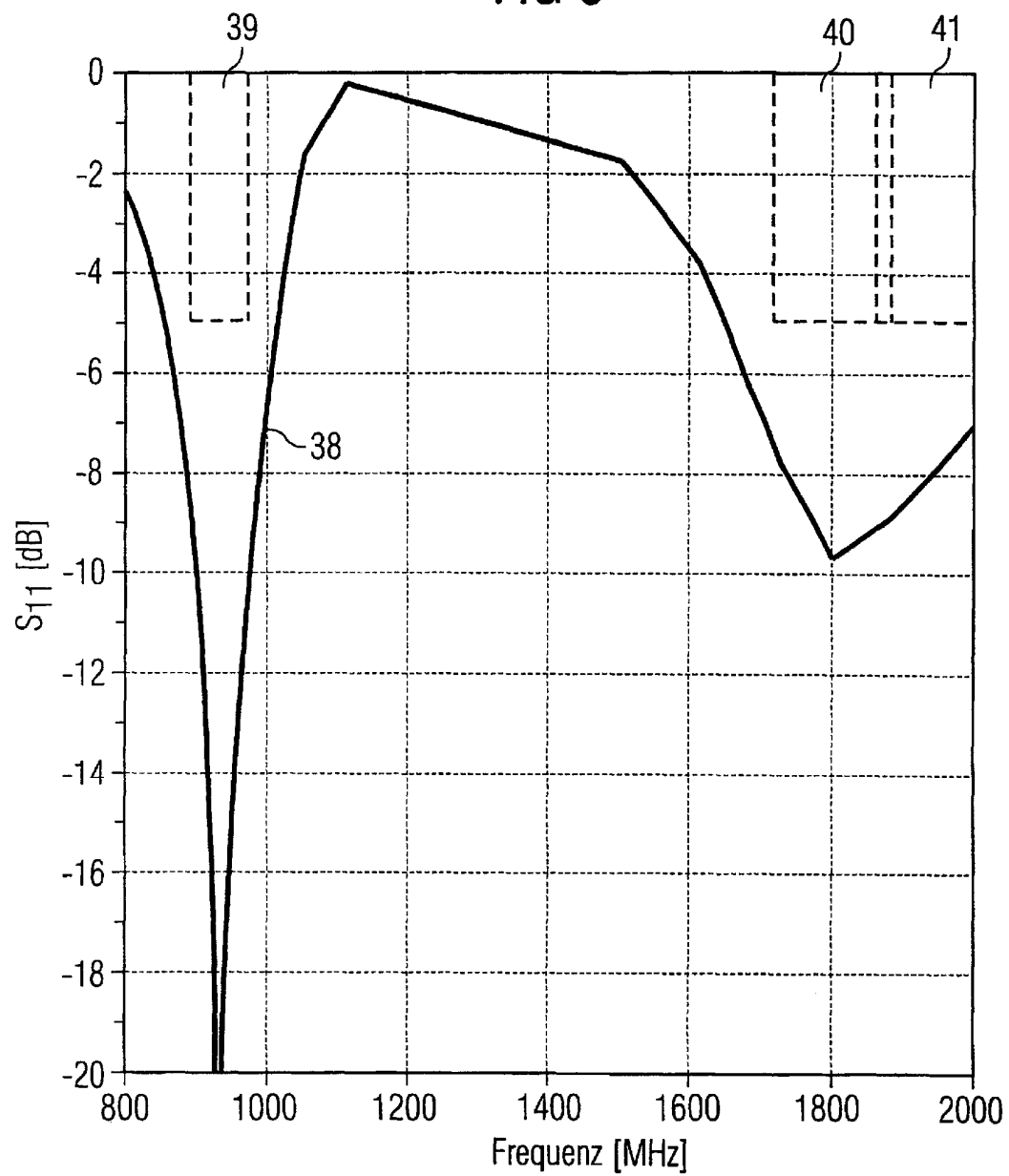


FIG 3



MOBILE TELEPHONE COMPRISING A MULTI-BAND ANTENNA

[0001] The present invention relates to a mobile radiotelephone comprising a multi-band antenna which has a meandering conductor structure and a contact spring for contacting the conductor structure to a transmitting-receiving electronics device.

[0002] A mobile radiotelephone of this type can be implemented as a mobile telephone, for example. The dimensions of the antenna of such a device, which antenna is nowadays integrated into the housing on a wide scale, are restricted for reasons of design. Furthermore, this mobile radiotelephone should also be increasingly capable of operating not only in a single network, corresponding to a single frequency range, but also in a plurality of networks, corresponding to a plurality of frequency ranges. An (integrated) antenna is therefore required which is capable of being used in two or more frequency ranges. In addition, there is a requirement that the mobile radiotelephone in question should be able to be implemented as cost-effectively as possible in respect of its performance capabilities and its design.

[0003] The multi-band antenna integrated into the housing of known mobile radiotelephones consists, for example, of a plurality of partial antennas. With regard to these partial antennas, these are either cylindrically symmetric helical wire structures or planar antennas which are preferably implemented on circuit boards. However, since their basic forms do not correspond to the shape of the housing which typically has a generally elliptical cross-section, such antennas require a relatively high amount of space in the housing. For this reason, the requirements relating to the design of the mobile radiotelephone cannot be complied with or can only be complied with inadequately, given the small dimensions.

[0004] A method is known from WO 99/22420 for implementing the multi-band antenna of the mobile radiotelephone in question by means of the application of meandering structures onto flexible printed circuit board material. A multi-band antenna of this type exhibits great flexibility as a result. The costs for the flexible base material and the requisite contacting to the flexible conductor material do however result in the fact that the costs for this antenna correspond to a multiple of the costs of the aforementioned nonflexible antenna.

[0005] One object of the present invention consists in creating a mobile radiotelephone of the type mentioned at the beginning whose multi-band antenna can be manufactured cost-effectively and guarantees freedom on the choice of design for the mobile radiotelephone. The object of the invention is achieved by the features described in claim 1. Advantageous developments of the invention are set down in the subclaims.

[0006] Since the meandering conductor structure and the contact spring of the antenna are formed according to the invention as a single part which is non-overlapping in its development, this antenna can be manufactured without any difficulties and cost-effectively by means of a single punching operation, which is then followed simply by an additional bending operation, if necessary. Since the single-piece punched and bent part according to the invention can be shaped as desired within broad limits, it can be adapted without any difficulties to the desired design of the mobile radiotelephone without attention needing to be paid to the structure of the antenna.

[0007] A further advantage of the antenna according to the invention consists in the fact that it can be produced with a high speed of manufacture and therefore with low manufacturing costs because it is possible to revert to using the standard punch and bend method. Since the multi-band antenna is designed as a single-piece punched and bent part, there is no need for separate manufacture and provision of the antenna spring.

[0008] By preference, the two meandering structures, of which there are at least two, of the multi-band antenna formed as a single-piece punched and bent part are connected in parallel and arranged so close to one another that a clear coupling is achieved, with the result that the overall volume of the multi-band antenna is kept to a minimum. In this situation, usage of the distributed partial inductances and capacitances of the meanders is optimized with the result that the antenna can be operated reliably in a plurality of frequency ranges. By means of optimization it is possible to deploy the multi-band antenna for example in the vicinity of its first resonant frequency for one of the target frequency bands, GSM for example, while close to its second resonant frequency it functions in such a broadband manner that this allows an application in the case of two further frequency bands, PCN and PCS for example.

[0009] A further advantage of the multi-band antenna formed as a single-piece punched and bent part consists in the fact that a rated impedance of 50 Ohm can be implemented without any difficulties, with the result that this antenna can be operated without an additional adapter network which is required on the basis of the prior art. This ensures that the antenna formed according to the invention can be operated without suffering those losses which are unavoidable as a result of adapter elements on the basis of the prior art.

[0010] The invention will be described in the following with reference to the drawings by way of example. In the drawings:

[0011] **FIG. 1** shows an embodiment of a multi-band antenna of the mobile radiotelephone according to the invention in side elevation view,

[0012] **FIG. 2** shows a second embodiment of a multi-band antenna of the mobile radiotelephone according to the invention in side elevation view, and

[0013] **FIG. 3** shows in diagrammatic form the reflection coefficient of the multi-band antenna shown in **FIG. 1**, whereby the frequency bands covered by the antenna are shown entered in dashed lines.

[0014] In **FIG. 1**, a multi-band antenna is denoted generally by the reference number **10**. With regard to the multi-band antenna **10**, this is a single-piece punched and bent part comprising a meandering conductor structure with a first meander **11** and a second meander **12** and a contact spring **13**. The two meanders **11**, **12** and the contact spring **13** are located relative to one another in such a way that there is no overlap in their development (in a developed state). The development of the first meander **11** is formed in planar fashion in the same way as the second meander **12**, and these two meanders are situated in two laterally displaced planes in their developed state and are connected with one another by way of a connecting piece **14** which is positioned at right angles to the meander planes. The contact spring **13** is

located in the area of the connecting piece **14** and represents an extension of this connecting piece.

[0015] The first meander **11** comprises a first meander section **15**, starting from the connecting piece **14**, with two arms **16** and **17** running parallel to one another. The first meander section **15** is followed by a second meander section **18** which comprises two arms **19** and **20** running parallel to one another and also parallel to the arms **16**, **17** of the first meander section **15**. The second meander section **18** is connected to the first meander section **17** by way of a crosspiece **21**. The second meander section is followed, connected by way of a crosspiece **22**, by a third meander section **23** which comprises two arms **24**, **25** running parallel to one another and also parallel to the aforementioned arms **16**, **17** and **19**, **20**. The third meander section **23** is followed by a fourth meander section **26** which is connected to the preceding meander section **23** by way of a crosspiece **27** and comprises two arms **28** and **29** which run parallel to one another and also to the aforementioned arms. The fourth meander section **26** is connected by way of a crosspiece **30** to a following fifth meander section **31** which like the preceding meander sections comprises two arms **32** and **33** in parallel alignment. The fifth meander section **31** runs into a terminating arm **34** extending in the meander direction and bent inwards by 90°.

[0016] The mutual spacing of the five meander sections **15**, **18**, **23**, **26** and **31** is chosen to be different in each case in the same way as is the relative spacing of their arms **16**, **17**, **19**, **20**, **24**, **25**, **28**, **29** and **32**, **33**. These spacings and their sequence are optimized in favor of the frequency range to be covered by the antenna.

[0017] The second meander **12** has a less complex structure than the first meander **11** and comprises a single meander section **35** which comes to be located at a distance above the terminating arm **34** of the first meander section **11** and has arms **36**, **37** running parallel to one another and also to the arms of the first meander **11**. The meander section **35** is connected by means of its lower arm **36** by way of a further, long connecting piece **38** to the contact spring **13** and the connecting piece **14**.

[0018] Three frequency ranges in total are defined as a result of the meandering conductor structure **11**, **12** of the multi-band antenna **10**. The pertinent reflection coefficient of the multi-band antenna **10** is shown in **FIG. 3** as a solid line and generally denoted by the reference number **38**. The three frequency ranges or bands of the multi-band antenna **10**, corresponding to the EGSM band, the PCN band and the PCS band, are shown in dashed lines and are denoted by the reference numbers **39**, **40** and **41**.

[0019] **FIG. 2** shows an alternative embodiment of the multi-band antenna **10** shown in **FIG. 1**. The multi-band antenna **10'** shown in **FIG. 2** essentially has the same basic structure as the multi-band antenna **10** shown in **FIG. 1** but with the difference that the development of the meanders comes to be located not in flat planes but on curved surfaces and with the difference that the first meander **11'** comprises not five but simply three meander sections. The second meander **12'** on the other hand is configured corresponding to the first meander **11**. The same elements of the antenna **10'** are denoted by the same reference numbers as for the antenna **10**, for which reason a detailed description of these elements is unnecessary. A further difference distinguishing

the antenna **10'** from the antenna **10** is the fact that the distances between their meander sections and also the distances between the arms of the meander sections are different, with the result that a different reflection coefficient is produced for the antenna **10'** than is the case with the antenna **10**.

[0020] The invention is not restricted to the two specific embodiments of a multi-band antenna described above. Rather, the invention can be embodied in any desired meander structures, including zigzag-shaped structures, as long as these structures can be implemented as a single-piece punched and bent part which is non-overlapping in its development.

1. Mobile radiotelephone comprising a multi-band antenna which has at least one meandering conductor structure (**11**, **12**; **11'**, **12'**), having a first (**11**; **11'**) and a second (**12**; **12'**) meander, and a contact spring (**13**; **13'**) for contacting the conductor structure (**11**, **12**; **11'**, **12'**) to a transmitting-receiving electronics device, characterized in that the meandering conductor structure (**11**, **12**, **11'**, **12'**) and the contact spring (**13**; **13'**) are formed as a single-piece punched and bent part which is non-overlapping in its development, whereby the first and the second meander (**11**, **12**) are located in two laterally displaced planes.

2. Mobile radiotelephone comprising a multi-band antenna which has at least one meandering conductor structure (**11**, **12**; **11'**, **12'**), having a first (**11**; **11'**) and a second (**12**; **12'**) meander, and a contact spring (**13**; **13'**) for contacting the conductor structure (**11**, **12**; **11'**, **12'**) to a transmitting-receiving electronics device, characterized in that the meandering conductor structure (**11**, **12**, **11'**, **12'**) and the contact spring (**13**; **13'**) are formed as a single-piece punched and bent part which is non-overlapping in its development, whereby the first meander (**11'**) is located on a first curved surface and the second meander (**12'**) is located on a second curved surface.

3. Mobile radiotelephone according to claim 1 or 2, characterized in that the meandering conductor structure (**11**, **12**) comprises meanders (**11** and **12**) of differing configuration in order to provide the multi-band functionality of the antenna.

4. Mobile radiotelephone according to one of the preceding claims, characterized in that the meanders (**11** and **12**) are located beside one another.

5. Mobile radiotelephone according to claim 4, characterized in that the meanders (**11** and **12**) comprise a different number and/or shape of meander sections (**15**, **18**, **23**, **26**, **31**).

6. Mobile radiotelephone according to one of claims 3 through 5, characterized in that the meanders (**11** and **12**) are connected to one another by way of a connecting piece (**14**) at an antenna signal infeed/outlet point.

7. Mobile radiotelephone comprising a triple-band antenna according to claim 6, characterized in that the second meander (**12**) joins up with the end of a first meander (**11**) furthest from the infeed/outlet point, and that a connecting piece (**38**) to the second meander (**12**) runs along a long side of the first meander (**11**).

8. Mobile radiotelephone comprising a triple-band antenna according to claim 7, characterized in that one of the two meanders (**11** and **12**) is tuned to a first resonant frequency while the other meander is tuned on a more broadband basis to a second and a third resonant frequency.

9. Mobile radiotelephone according to one of claims **1** through **8**, characterized in that the meandering conductor structure (**11, 12**) is essentially formed in a planar fashion in its development.

10. Mobile radiotelephone according to one of claims **1** through **9**, characterized in that the meandering conductor

structure (**11, 12**) is essentially formed in a curved fashion in its development.

11. Mobile radiotelephone according to one of claims **1** through **10**, characterized in that the meandering conductor structure (**11, 12**) has a rated impedance of 50 Ohm overall.

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