Title: HINGE FOR FOLDABLE TYPE ELECTRONIC APPARATUS AND THE FOLDABLE TYPE ELECTRONIC APPARATUS

Abstract: The invention provides a hinge for foldable type electronic apparatus comprising a first part, a second part and an intermediate part. The first part is rotatably connected to the intermediate part about a first axis via a first rotating mechanism and the second part is rotatably connected to the intermediate part a second rotating mechanism. The first rotating mechanism is constructed such that the first unit can be rotated between an opening position and a closing position. The second rotating mechanism is configured such that the second unit can be rotated and can be positioned at at least two rotation positions with respect to the intermediate unit. The present invention can set the first unit and the second unit at further different specific/predetermined open-angle positions except a closing position and a normal opening position.
HINGE FOR FOLDABLE TYPE ELECTRONIC APPARATUS AND
THE FOLDABLE TYPE ELECTRONIC APPARATUS

TECHNICAL FIELD

The present application generally relates to a hinge, and more specifically but not limited, to a hinge for foldable type electronic apparatus such as clamshell phone, notebook computer, PDA and so on.

BACKGROUND OF THE INVENTION

A hinge is typically used in foldable type electronic apparatus such as clamshell phone, which includes a first unit formed with a display means and a second unit formed with keyboard, electrical circuit, battery and so on. In a conventional clamshell phone, the first unit and the second unit are directly connected to a hinge so that the first unit can rotate with respect to the second unit between an open position (unfolded state) where the display means can be viewed and the keyboard can be operated and a closed position (folded state) where the display means and the keyboard are covered by each other. The conventional hinge has two parts (a first part for mounting the first unit and a second part for mounting the second unit) rotatably connected to each other and can thus rotate about a single-axis. Generally, due to the constraint of interaction between connecting portions of the first part and the second part as well as between the adjacent portions of the first unit and the second unit, the first unit can rotate from the folded state (namely, zero degree state) only by about 160 degrees so as to reach the unfolded state (namely, 160 degree state), and in any case it is impossible to rotate the first unit with respect to the second unit by 360 degree.

Recently, a hinge with double-axis has been developed. In the double-axis hinge construction, the first part and the second part are respectively rotatably connected to an intermediate part at different positions of the intermediate part, so that the first part and the second part can rotate with respect to the intermediate part about a first axis and a second axis respectively, wherein the first axis and the second axis are parallel to each other. The hinge with double-axis can achieve a 360-degree rotation of one part with respect to the other part.

An example of a double-axis hinge which is used for a foldable electronic device is disclosed in U.S. Patent Publication No. 2004/0266239 A1 by Kurokawa, wherein the double-axis hinge comprises two pivot shafts separately secured to two casings, two gears respectively formed on outer surfaces of the two pivot shafts and a bearing pivotally supports the first pivot shaft and the second pivot shaft. The two gears can mesh with each other.

In the hinge with double-axis of Kurokawa's, since the two pivot shafts are formed with gears so as to mesh, this structure inevitably causes a bulky hinge profile, which is contrary to the
requirement of being compact for a foldable electronic apparatus. In addition, additional mechanisms are needed to position the first part and the second part at a required rotating angle.

Another example of the double-axis hinge is disclosed in U.S. Patent Publication No. 2007/0151381 A1 by Pelkonen, wherein the double-axis hinge comprises two parallel shafts, each of which has a mounting section for connecting to a first unit or a second unit and has a coupling section. The two shafts are joined by a locking spring and a shaft shielding. The locking spring has two curved sections for connecting with the coupling sections of the two shafts respectively. A recess is formed on the circumferential part of the coupling section for each shaft. Each of the curved sections has an inwardly protruding portion to be engaged with a corresponding recess. When the protruding portion of one curved section is not engaged with the recess of a corresponding shaft, the curved section will be slightly enlarged by a force acting on the inwardly protruding portion by the peripheral surface of the coupling section on the shaft.

In the double-axis hinge disclosed in US 2007/0151381, like the hinge disclosed in US 2004/0266239 A1, the shafts, the locking spring and the shaft shielding occupy almost all space of the connecting section between the first part and the second part, thus it will be short of room to install other means such as a camera unit. In addition, since the positioning force for setting the first part and the second part at a specific rotating angle are generated by an elastic deformation along circumferential direction of the locking spring, and after a certain period of using, the elasticity of the locking spring will likely diminish or be smaller, and the opening position can not be stable. Thus the performance of the hinge will decrease. Furthermore, based on the construction that the locking action between the first curved section and the first shaft is stronger than the locking action between the second curved section and the second shaft, it can not stably set the first unit and the second unit at other specific open-angle positions than a closing position and a normal opening position.

**SUMMARY OF THE INVENTION**

One aspect of the present invention relates to a hinge with double-axis, which can set a first unit and a second unit at further different specific/predetermined open-angle positions in addition to a closing position and a normal opening position.

Another aspect relates to a hinge with double-axis, which can be compact and occupy less room of the section between the first part and the second part, so that more room will be left for disposing other means such as a camera unit.

Another aspect relates to a hinge with double-axis, which can set the first part and the second part at different open-angle positions with a stably force.

Another aspect relates to a foldable type electronic apparatus using the hinge with double-axis.

According to an aspect of the invention, a hinge for foldable type electronic apparatus comprises a first part for mounting on a first unit, a second part for mounting on a second unit and an
intermediate part for mounting on an intermediate unit. The first part is rotatably connected to the intermediate part about a first axis via a first rotating mechanism and the second part is rotatably connected to the intermediate part about a second axis parallel to the first axis via a second rotating mechanism. The first rotating mechanism is constructed such that without the rotation of the second rotating mechanism, the first unit can be rotated with respect to the second unit between an opening position where the electronic apparatus is in a normal opened state and a closing position where the first unit is folded on the second unit and the electronic apparatus is in a normal closed state. The second rotating mechanism is configured such that the second unit can be rotated and can be positioned at at least two rotation positions with respect to the intermediate unit.

Based on the structure of the hinge as described above, besides the normal opening rotation and closing rotation, the first part can further rotate and be positioned with respect to the second part at other different positions. As to the first unit and the second unit, any one of them can be disposed as comprising a display means. In an example, the first unit is disposed with a display means and the second unit is disposed with keyboard, electrical circuit, battery and so on.

As a development of the invention, the second rotating mechanism comprises a first rotary element associated with the second part and a second rotary element associated with the intermediate part, wherein the first rotary element and the second element are configured to be capable to engage with each other via their axial surfaces facing to each other so as to be positioned at at least two rotation positions.

As another development of the invention, the second rotating mechanism is configured to comprise a first rotary element connected to the second part and having a first axial surface, a second rotary element connected to the intermediate part, disposed coaxially with the first rotary element and having a second axial surface facing the first axial surface, and a coil spring for pressing axially one of the first rotary element and the second rotary element toward the other one of the first rotary element and the second rotary element. One of the first axial surface and the second axial surface is disposed circumferentially with at least two depressed portions at predetermined positions, and the other of the first axial surface and the second axial surface is disposed with a convex portion corresponding in shape to the depressed portions and capable of engaging sequentially with said depressed portions upon a relative rotation between the first rotary element and the second rotary element. The second rotating mechanism further has a releasing means for releasing the engagement of the convex portion with a corresponding depression portion by separating the first rotary element and the second rotary element axially against the force of the coil spring.

As one embodiment of the invention, in the hinge of the invention, the second rotating mechanism can be constructed such that the depressed portions are disposed as notches or slots and side walls in circumferential direction of the notches or slots are formed with steps or vertical surfaces with respect to the one of the first axial surface and the second axial surface having the depressed portions. The releasing means is disposed as an urging member operated from outside and capable of urging one of the first rotary element and the second rotary element pressed by the coil spring.
so as to axially separate the first rotary element and the second rotary element.

According to the embodiment described above, the second rotating mechanism can rotate by operating the urging member to disengage the engagement of the depressed portions with the convex portion. Furthermore, upon an alignment of the convex portion to a next predetermined depressed portion in rotating, the convex portion will be in engagement with the next predetermined depressed portion so as to position the first rotary element and the second rotary element at a next position. With this operation, the first unit and the second unit can be positioned at further predetermined positions.

As to another embodiment of the invention, in the hinge of the invention, the second rotating mechanism can be constructed such that the depressed portions are disposed as concave portions with side walls in circumferential direction thereof being formed as slopes with respect to the one of the first axial surface and the second axial surface having the depressed portions. The releasing means is formed by the slopes, and the slopes are adapted to guide the convex portion to move away in axial direction upon relative rotation between the first rotary element and the second rotary element so as to axially separate the first rotary element and the second rotary element.

According to another embodiment described above, the second rotating mechanism can rotate due to the guiding of the slopes to the convex portion so as to disengage the engagement of the concave portion and the convex portion, thus the first unit and the second unit can be positioned at further predetermined positions.

According to another aspect of the invention, it further provides a foldable type electronic apparatus. The foldable type electronic apparatus comprises a first unit, a second unit and an intermediate unit, wherein the first unit, the second unit and the intermediate unit are mounted on the hinge according the one aspect of the invention.

These and further features of the present invention will be apparent with reference to the following description and attached drawings. In the description and drawings, particular embodiments of the invention have been disclosed in detail as being indicative of some of the ways in which the principles of the invention may be employed, but it is understood that the invention is not limited correspondingly in scope. Rather, the invention includes all changes, modifications and equivalents coming within the spirit and terms of the claims appended thereto.

Features that are described and/or illustrated with respect to one embodiment may be used in the same way or in a similar way in one or more other embodiments and/or in combination with or instead of the features of the other embodiments.

It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.
Many aspects of the invention can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present invention. Likewise, elements and features depicted in one drawing or embodiment of the invention may be combined with elements and features depicted in one or more additional drawings or embodiments. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

As used herein, the term "electronic device", "wireless device", "portable communication device" includes portable radio communication equipment. The term "portable radio communication equipment," which may be referred to below as a mobile phone, a mobile device, a mobile radio terminal or a mobile terminal, includes all electronic equipment, including, but not limited to, mobile telephones, pagers, communicators, i.e., electronic organizers, smartphones, personal digital assistants (PDAs), or the like. While the present invention is being discussed with respect to portable communication devices, for example, it is to be appreciated that the invention is not intended to be limited to portable communication devices, and can be applied to any type of electronic equipment capable of being used for voice and/or data communication.

As will be appreciated, the invention may be used with mobile telephones, other telephones, personal digital assistants (PDA), other communication devices, computers, notebook computers, etc.; for brevity, the invention will be described by way of example with respect to mobile telephones, but it will be appreciated that the invention may be used with other communication devices.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more clear understanding of the present invention, the invention will now be described in details with reference to the accompanying drawings, which are not necessarily to scale; however, it should be understood that the description is only for the purpose of illustration, but not limitation to the invention.

Fig. 1 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the present invention, while the clamshell phone is in a folded state.

Fig. 2 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the present invention, while the clamshell phone is in a normal use state (160-degree rotation).

Fig. 3 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the present invention, while the clamshell phone is in a state rotating to a 300-degree opening.

Fig. 4 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the present invention, while the clamshell phone is in a state rotating to a 300-degree opening and standing on desk top.

Fig. 5 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the
present invention, while the clamshell phone is in a state rotating to a 360-degree opening.

Fig. 6 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the present invention, while the clamshell phone is in a state with the first unit rotating to a negative 180-degree opening for self picture shooting or video telephoning.

Fig. 7 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the present invention, while the clamshell phone is rotated in another way to the state for self picture shooting.

Fig. 8 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the present invention, while the clamshell phone is in a state rotating to a 180-degree opening for using a camera.

Fig. 9 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the present invention, while the camera unit is disposed in the second unit of the clamshell phone.

Fig. 10 is a schematic drawing that illustrates a clamshell phone applying the hinge according to the present invention, while the clamshell phone is in a state rotating to a negative 180-degree opening and hanging on a step member shown by dotted lines.

Fig. 11 is a perspective view illustrating the hinge in assembled state according to a first embodiment of the present invention.

Fig. 12 is another perspective view illustrating the hinge in assembled state according to the first embodiment of the present invention.

Fig. 13 is a further perspective view illustrating the hinge in assembled state according to the first embodiment of the present invention.

Fig. 14 is a side view illustrating the hinge in assembled state according to the first embodiment of the present invention.

Fig. 15 is a front view illustrating the hinge in assembled state according to the first embodiment of the present invention.

Fig. 16 is a front view illustrating the hinge in assembled state when the button is pressed according to the first embodiment of the present invention.

Fig. 17 is a rear view illustrating the hinge in assembled state according to the first embodiment of the present invention.

Fig. 18 is a perspective view illustrating the hinge with some elements in exploded state according to the first embodiment of the present invention.
Fig. 19 is another perspective view illustrating the hinge with some elements in exploded state according to the first embodiment of the present invention.

Fig. 20 is a perspective view illustrating the hinge with some elements in exploded state according to the first embodiment of the present invention.

Fig. 21 is another perspective view illustrating the hinge with some elements in exploded state according to the first embodiment of the present invention.

Fig. 22 is a perspective view illustrating the first part of the hinge according to the first embodiment of the present invention.

Fig. 23 is another perspective view illustrating the first part of the hinge according to the first embodiment of the present invention.

Fig. 24 is a perspective view illustrating the second rotary cam element of the hinge according to the first embodiment of the present invention.

Fig. 25 is another perspective view illustrating the second rotary cam element of the hinge according to the first embodiment of the present invention.

Fig. 26 is a perspective view illustrating the first guide pin of the hinge according to the first embodiment of the present invention.

Fig. 27 is another perspective view illustrating the first guide pin of the hinge according to the first embodiment of the present invention.

Fig. 28 is a perspective view illustrating the stopper of the hinge according to the first embodiment of the present invention.

Fig. 29 is another perspective view illustrating the stopper of the hinge according to the first embodiment of the present invention.

Fig. 30 is a perspective view illustrating the spring clamp ring of the hinge according to the first embodiment of the present invention.

Fig. 31 is a perspective view illustrating the second part of the hinge according to the first embodiment of the present invention.

Fig. 32 is another perspective view illustrating the second part of the hinge according to the first embodiment of the present invention.

Fig. 33 is a perspective view illustrating the second guide pin of the hinge according to the first
embodiment of the present invention.

Fig. 34 is another perspective view illustrating the second guide pin of the hinge according to the first embodiment of the present invention.

Fig. 35 is a perspective view illustrating the first rotary element of the hinge according to the first embodiment of the present invention.

Fig. 36 is a perspective view illustrating the button of the hinge according to the first embodiment of the present invention.

Fig. 37 is another perspective view illustrating the button of the hinge according to the first embodiment of the present invention.

Fig. 38 is a perspective view illustrating the intermediate part of the hinge according to the first embodiment of the present invention.

Fig. 39 is a perspective view illustrating the cable sleeve of the hinge according to the first embodiment of the present invention.

Fig. 40 is another perspective view illustrating the cable sleeve of the hinge according to the first embodiment of the present invention.

Fig. 41 is a perspective view illustrating the second intermediate part of the hinge according to the first embodiment of the present invention.

Fig. 42 is a sketch view illustrating the rotating action (original state) of the hinge according to the first embodiment of the present invention.

Fig. 43 is a perspective view illustrating the rotating action (original state) of the hinge according to the first embodiment of the present invention.

Fig. 44 is a sketch view illustrating the rotating action (160-degree rotation state) of the hinge according to the first embodiment of the present invention.

Fig. 45 is a perspective view illustrating the rotating action (160-degree rotation state) of the hinge according to the first embodiment of the present invention.

Fig. 46 is a sketch view illustrating the rotating action (300-degree rotation state) of the hinge according to the first embodiment of the present invention.

Fig. 47 is a perspective view illustrating the rotating action (300-degree rotation state) of the hinge according to the first embodiment of the present invention.
Fig. 48 is another perspective view illustrating the rotating action (300-degree rotation state) of the hinge according to the first embodiment of the present invention.

Fig. 49 is a sketch view illustrating the rotating action (360-degree rotation state) of the hinge according to the first embodiment of the present invention.

Fig. 50 is a perspective view illustrating the rotating action (360-degree rotation state) of the hinge according to the first embodiment of the present invention.

Fig. 51 is a sketch view illustrating the rotating action (negative 180-degree rotation state) of the hinge according to the first embodiment of the present invention.

Fig. 52 is a perspective view illustrating the rotating action (negative 180-degree rotation state) of the hinge according to the first embodiment of the present invention.

Fig. 53 is a perspective view illustrating the hinge in assembled state according to a second embodiment of the present invention.

Fig. 54 is a front view illustrating the hinge in assembled state according to the second embodiment of the present invention.

Fig. 55 is a perspective view illustrating the hinge with some elements in exploded state according to the second embodiment of the present invention.

Fig. 56 is another perspective view illustrating the hinge with some elements in exploded state according to the second embodiment of the present invention.

Fig. 57 is a perspective view illustrating the first rotary element of the hinge according to the second embodiment of the present invention.

Fig. 58 is another perspective view illustrating the first rotary element of the hinge according to the second embodiment of the present invention.

Fig. 59 is a perspective view illustrating the second rotary element of the hinge according to the second embodiment of the present invention.

Fig. 60 is another perspective view illustrating the second rotary element of the hinge according to the second embodiment of the present invention.

Fig. 61 illustrates a variation of the first rotary element with the first axial surface having a single circular section structure.

Fig. 62 illustrates a variation of the second rotary element with the second axial surface having a single circular section structure.
DETAILED DESCRIPTION OF THE INVENTION

Detailed description will be made by referring to the drawings, wherein the same or similar elements will be designated with the same or similar reference numerals throughout the drawings.

Certain terminology is used herein for convenience only and is not to be taken as a limitation on the invention. For example, words such as "upper," "lower," "left," "right," "horizontal," "vertical," "upward," and "downward" merely describe the configuration shown in the figures. Indeed, the components may be oriented in any direction. The terminology should therefore be understood as encompassing such variations unless specified otherwise.

As used herein, the term "keyboard" is used to mean any type of input device including one or more keys or touch sensitive area or areas, which may include predefined key positions or a gesture area. Further, the term "keyboard" is not intended to be limited to a keyboard based on contacting switch technology. Rather, "keyboard" as contemplated by this disclosure is intended to refer to any type of input technology that might be referred to as such, including a non-contacting type more typically referred to as a "touchpad" in which the proximity of conductive bodies is sensed.

Figs. 1-10 schematically show several different states of a clamshell phone using the hinge of the present invention.

A folded state of the clamshell phone is shown in Fig. 1. The clamshell phone includes a first unit (upper unit) 1, a second unit (lower unit) 2 and an intermediate unit 3 for connecting the first unit 1 and the second unit 2. The first unit 1 may be otherwise referred to as "cover" of the phone, and generally has a display means such as a display screen (LCD) on a side facing the second unit 2. Alternatively, in an example, the first unit 1 can have two display means on both sides facing and opposite to the second unit 2. The second unit 2 may be otherwise referred to as "main body" of the phone, and generally has a keyboard on a side facing to the first unit 1, a circuit board, a battery and so on disposed therein. The intermediate unit 3 may have a camera unit 4 (schematically shown by an arrow for indicating its picture shooting direction) disposed in its case.

By means of the hinge of the present invention, the first unit 1 is rotatably connected to the intermediate unit 3 and can rotate with respect to the intermediate unit 3 about a first axis, and the second unit 2 is rotatably connected to the intermediate unit 3 and can rotate with respect to the intermediate unit 3 about a second axis. Owing to the double-axis structure, the sum of a rotating angle of the first unit 1 capable of rotating with respect to the intermediate unit 3 and a rotating angle of the second unit 2 capable of rotating with respect to the intermediate unit 3 can reach 360 degrees.

A normal use state is shown in Fig. 2, wherein the first unit 1 is able to be rotated and is rotated to a 160-degree relation with respect to the second unit 2. In this state, the camera unit 4 as
represented schematically by the arrow shown in Fig. 2 is approximately towards front, that is, the facing direction of the lens of the camera unit is approximately towards front. The display means such as LCD disposed on the first unit will work as view finder for normal use.

Throughout Figs. 1-10, the direction of the arrow indicating the camera unit 4 indicates the facing direction of the lens of the camera unit 4.

Fig. 3 and Fig. 4 show a 300-degree rotation state of the clamshell phone, wherein Fig. 4 is an upset state (sometimes referred to as "upside down state") from Fig. 3 so that the clamshell phone can stand on desk top as a multimedia player.

Fig. 5 shows a 360-degree rotation state of the clamshell phone. In this state, the user can hold the phone horizontally as a digital camera.

Fig. 6 shows a negative 180-degree rotation state, which is developed from Fig. 5 by rotating the first unit 1 backward by 180 degree. In this state, both the camera unit 4 and the display means are towards the user for self picture shooting or video telephoning.

Fig. 7 also shows a negative 180-degree rotation state for self picture shooting or video telephoning, which is generally developed from Fig. 1 in another way by rotating the second unit 2 with respect to the intermediate unit 3 provided that the rotating resistance about the second axis is lower that that about the first axis so that the intermediate unit 3 will roughly keep still with respect to the first unit 1.

Fig. 8 shows a 180-degree rotation state developed from Fig. 2 by further rotating the first unit 1 with respect to the intermediate unit 3, so that the clamshell phone is in a state for using as a digital camera.

Fig. 9 shows an example of the clamshell phone that the camera unit 4 is disposed in the second unit 2 so that the clamshell phone can be used as a digital camera.

Fig. 10 shows a using state that the clamshell phone is in a state rotating to a negative 180-degree opening and hanging on a step member shown by dotted lines.

<First Embodiment

Figs. 11 to 41 show detailed structures of the hinge according to the first embodiment of the present invention.

The hinge includes a first part 10 for mounting on the first unit 1, a second part 30 for mounting on the second unit 2 and an intermediate part 20 for mounting on the intermediate unit 3.

The intermediate part 20 has a first end 201 rotatably connected to the first part 10 about a first axis via a first rotating mechanism 21 and a second end 202 rotatably connected to the second part
30 with respect to a second axis parallel to the first axis via a second rotating mechanism 22. The intermediate part 20 further has a mounting hole 203 formed on its body, so as to be mounted to the intermediate unit 3 via screw.

The first rotating mechanism 21 includes a first rotary cam element 11, a second rotary cam element 211 to be engaged with the first rotary cam element 11, a spring 212 for pressing the second rotary cam element 211 towards the first rotary cam element 11, a first guide pin 210 for penetrating the first rotary cam element 11 and the second rotary cam element 211 so as to guide their rotating about a first axis, and a stopper 12 for limiting a range of rotating angle between the first rotary cam element 11 and the second rotary cam element 211. Although the rotations of the first rotary cam element 11 and the second rotary cam element 211 are guided by the first guide pin 210, it could also be disposed as other structure, such as one of the first rotary cam element 11 and the second rotary cam element 211 is formed such that a portion thereof is in shaft shape, and the other of the first rotary cam element 11 and the second rotary cam element 211 is formed such that a portion thereof is in sleeve shape to be rotated about the shaft, so as to achieve the rotations of the first rotary cam element 11 and the second rotary cam element 211 about the first axis.

In the first rotating mechanism 21, the first rotary cam element 11 is associated in a manner of non-relatively rotating with the first part 10 so as to rotate together with the first part 10. As an example, as shown in the figures the first rotary cam element 11 can be formed integrally with the first part 10 so as to make the structure simple and compact. However, the skilled person in art can obtain other various structures of forming the first rotary cam element 11 separately from the first part 10 and mounting the first rotary cam element 11 on the first part 10 directly or by means of other member in a manner of keeping the first rotary cam element 11 rotating integrally with the first part 10.

In the first rotating mechanism 21, the second rotary cam element 211 is associated with the intermediate part 20 in a manner of non-relatively rotating and capable of moving axially with respect to the intermediate part 20, so as to rotate together with the intermediate part 20. As an example, as shown in the figures the second rotary cam element 211 is formed separately with the intermediate part 20. In this embodiment, the second rotary cam element 211 is mounted to the intermediate part 20 via the first guide pin 210, wherein both the second rotary cam element and the intermediate part are formed with non-circular holes (rectangle holes exactly), and the first guide pin 210 has a portion 2106 with corresponding non-circular cross-section. When the first guide pin 210 is inserted into the holes of the second rotary cam element and the intermediate part 20 with the portion 2106 of non-circular cross-section engaging with the holes, the second rotary cam element 211 can rotate integrally with the intermediate part 20 and a relative rotation between the second rotary cam element 211 and the intermediate part 20 is prohibited. Furthermore, the second rotary cam element 211 can slide on the first guide pin 210 so as to move respective to the first rotary cam element 11. The first guide pin 210 also has a circular portion 2107 corresponding to the hole of the first rotary cam element 11, so that the first guide pin 210 can rotate with respect to the first rotary cam element 11.

The first part 10 has a body 100, and the first rotary cam element 11 is formed at one end thereof,
as shown in Figs. 22 and 23. On the body 100, there are two holes 101 for receiving screws so as to be mounted on the first unit 1. At the other end of the first part 10, there is also disposed a connecting hole 102 for receiving a rotary member 214 so as to be rotatably connected to a second intermediate part 2001, which will described later.

The first rotary cam element 11 integrally formed with the first part 10 has a first cam surface 111 on an axial end. As clearly shown in Figs. 22 and 23. The first cam surface 111 is formed with two convex portions 1111 and two concave portions 1112. The convex portions 1111 and the concave portion 1112 are disposed circumferentially in sequence on the first rotary cam surface 111, wherein one convex portion is symmetric to the other convex portion about the rotating axis (i.e., the first axis) of the first rotary cam element 11, and one concave portion is symmetric to the other concave portion about the rotating axis.

The second cam element 211 has a second cam surface 2111, which is formed with two concave portions 2112 and two convex portions 2113. The concave portions 2112 and convex portions 2113 formed on the second surface 2111 are configured to match the concave portions 1112 and the convex portions 1111 formed on the first cam surface 111. When the concave portions 1112 and the convex portions 1111 formed on the first cam surface 111 match the convex portions 2113 and the concave portions 2112 formed on the second cam surface 2111 respectively, the first rotary cam element 11 and the second rotary cam element 211 will be positioned relatively.

The phases of the concave portions 2112 and 1112 and the convex portions 2113 and 1111 can be disposed such that a first matching position of the first cam surface 111 and the second cam surface 2111, which can position the first rotary cam element with respect to the second rotary cam element, corresponds to the normal opened state. Therefore, when the first unit is rotated, after a relative rotation between the first rotary cam element 11 and the second rotary cam element 211, the first unit 1 can be positioned at the opening position for normal use of the phone.

Furthermore, the opening angle of the first unit 1 with respect to the second unit 2 is generally about 160 degree to 170 degree, thus in the closed state of the phone, the concave portions 2112 and 1112 and the convex portions 2113 and 1111 are not in a fully engaged state, but in a partly engaged state, and have an tendency to move to the fully engaged state, as clearly shown in Fig. 17. Thus, in order to reach a second matching position (rotating by 180 degree from the first matching position) of the first cam surface 111 and the second cam surface 2111, the first unit 1 shall further rotate in the closing direction from the closed state. Therefore, in the closed state, due to the tendency of rotating from the partly engaged state to the fully engaged state, the first unit 1 will contact the second unit 2 under a pressure by the tendency (an engagement between slopes of corresponding concave portions of one of the first cam surface 111 and the second cam surface 2111 and corresponding convex portions of the other of the first cam surface 111 and the second cam surface 2111). That is, the second matching position of the first cam surface 111 and the second cam surface 2111 capable of positioning the first rotary cam element 11 and the second rotary cam element 211 is disposed at a closing side near a position corresponding to the closed state.
Although in this embodiment the two concave portions 1112 on the first cam surface 111 is symmetric to each other about the first axis so as to obtain a preload in closing direction to the first unit 1 at the closing position, however, the phase between the two concave portions 1112 can also be disposed at other positions, such as the phase of one concave portion is different by 160 degree or 170 degree from the phase of the other concave portion.

The first guide pin 210 has a head portion 2100 at one end thereof and a slot 2105 at the other 2104 end thereof for receiving and fixing a spring clamp ring 213. The head portion 2100 is larger than the hole of the first rotary cam element 11 and has a protrusion portion 2102 protruding radially from a base portion 2101. Two steps 2103 are formed between both sides of the protrusion portion 2102 and the base portion 2101. A stopper 12 is mounted (inserted into a mounting hole of the first part 10) on the first part 10 in a position capable of engaging with the steps 2103 of the first guide pin 210 so as to limit a rotating range of the first guide pin 210. The limited rotating range in this embodiment is 180 degree (larger than the normal opening angle). In addition, it is configured that when the first cam surface 111 and the second cam surface 2111 are in the first matching position (normal opening state), the stopper 12 is contacting one of the steps 2103 to stop a further rotation of the first guide pin 210.

When the first guide pin 210 is inserted into the first rotary cam element 11, the second rotary element 211, the coil spring 212 and the hole formed on the first end 201 of the intermediate part 20, the head portion 2100 of the first guide pin 210 contacts the first rotary cam element 11, and then the spring clamp ring 213 is fixed on the slot 2105, so that the first rotary element 11, the second rotary element 211 and the coil spring 212 are disposed between the head portion 2100 and the spring clamp ring 213.

According to the structure described above, in case of without the rotation of the second rotating mechanism 22, by means of the first rotating mechanism 21, the first unit 1 can be rotated with respect to the second unit 2 between the opening position (the normal opened state) and the closing position (the normal closed state), therefore, the clamshell phone can possess a normal function as a ordinary foldable phone with one unit is directly connected to the other unit via a rotating mechanism.

The second rotating mechanism 22 is configured to include a first rotary element 220, a second rotary element 221 and a coil spring 222, as shown in Fig. 18. The first rotary element 220 is associated in a manner of non-relatively rotating with the second part 30 and has a first axial surface 2201. The second rotary element 221 is associated with the intermediate part 20 in a manner of non-relatively rotating and capable of moving axially with respect to the intermediate part 20 (exactly with respect to the first rotary element 220), and is disposed coaxially with the first rotary element 220. In addition, the second rotary element 221 has a second axial surface 2210 facing the first axial surface 2201. The coil spring 222 is for pressing axially the second rotary element 221 (as one of the first rotary element 220 and the second rotary element 221) toward the first rotary element 220(as the other one of the first rotary element 220 and the second rotary element 221).
In the second rotating mechanism 22, the first rotary element 220 is formed integrally with the second part 30 as clearly shown in Figs. 31 and 32, so that their structure can be simple and compact. However, it is also possible to form the first rotary element 220 separately from the second part 30 and then to mount the first rotary element 220 on the second part 30 directly or by means of other member in a manner of keeping the first rotary element 220 rotating integrally with the second part 30.

The second rotary element 221 is formed separately from the intermediate part 20 in a manner of rotating together with the intermediate part 20. The second rotary element 221 has a hole at its central portion, and the intermediate part 20 also has a corresponding hole at its second end 202. A second guide pin 224 has an non-circular axial portion 2241 with corresponding cross-section shape to the holes, wherein the cross-section shape and the holes are in non-circular shape (such as roughly ellipse as shown in the figures), thus when the second guide pin 224 is inserted into the holes of the second rotary element 221 and the intermediate part 20, the second rotary element 221 can rotate integrally with the intermediate part 20. Furthermore, the second rotary element 221 is slidable on the second guide pin 224, thus the second rotary 221 can move axially with respect to the first rotary element 220.

Although the rotations of the first rotary element 220 and the second rotary element 221 are guided by the second guide pin 224, it could also be disposed as other structure, such as one of the first rotary element 220 and the second rotary element 221 is formed such that a portion thereof is in shaft shape, and the other of the first rotary element 220 and the second rotary element 221 is formed such that a portion thereof is in sleeve shape to be rotated about the shaft, so as to achieve the rotations of the first rotary element 220 and the second rotary element 221 about the second axis.

In this embodiment, although the second rotary element 221 is disposed to be movable axially with respect to the first rotary element 220, it can also be that the first rotary element 220 is disposed to be movable axially, as long as at least one of the first rotary element 220 and the second rotary element 221 is axially movable.

The first axial surface 2201 (as one of the first axial surface 2201 and the second axial surface 2210) is disposed circumferentially with at least two depressed portions (specifically a first depressed portion 2202, a second depressed portion 2203 and a third depressed portion 2204) at predetermined positions. The second axial surface 2210 (as other of the first axial surface 2201 and the second axial surface 2210) is disposed with a convex portion 2211 corresponding in shape to the depressed portions 2202, 2203, 2204 and capable of engaging sequentially with said depressed portions 2202, 2203, 2204 upon a relative rotation between the first rotary element 220 and the second rotary element 221.

The second rotating mechanism 22 further has a releasing means for releasing the engagement of the convex portion 2211 with a corresponding depression portion by separating the first rotary element 220 and the second rotary element 221 axially against the force of the coil spring 222.
The first depressed portion 2202 of the depressed portions is constructed such that when the first depressed portion 2202 is engaged with the convex portion 2211, the first unit 1 can be rotated with respect to the second unit 2 between the opening position and the closing position. The first depressed position 2202 can be called as an original position for the rotation of the second rotating mechanism 22.

The second depressed portion 2203 of the depressed portions is constructed such that the sum of a rotating angle of the first part 1 with respect to the intermediate part 3 and a rotating angle of the second part 2 with respect to the intermediate part 3 when the second depressed portion 2203 is engaged with the convex portion 2211 is 300 degrees.

The third depressed portion 2204 of the depressed portions is constructed such that the sum of a rotating angle of the first part 1 with respect to the intermediate part 3 and a rotating angle of the second part 2 with respect to the intermediate part 3 when the third depressed portion 2204 is engaged with the convex portion 2211 is 360 degrees.

Three depressed portions 2202, 2203, 2204 formed in shape of notches are formed on the first rotary element 220 along circumference of the first rotary element 220, as clearly shown in Fig. 31, that is, the depressed portions are formed without bottom portions so as to simplify the structure and make the first rotary element 220 compact. Alternatively, the depressed portions 2202, 2203 and 2204 can also be formed in shape of grooves (the depressed portions are formed with bottom portions).

The second rotary element 221, as shown clearly in Figs. 34 and 35, has the second axial surface 2210 facing the first rotary element 220. On the second axial surface 2210, it is formed with a convex portion 2211 protruding from the second axial surface 2210 to be engaged with one of the depressed portions 2202, 2203, 2204.

The second guide pin 224 has a circular portion 2242, which is inserted into a circular hole 2205 formed in the first rotary element 220, so that the second guide pin 224 can guide a relative rotation between the first rotary element 220 and the second rotary element 221. The second guide pin 224 further has a slot 2243 at an axial end thereof for receiving and fixing a second spring clamp ring 223. On the non-circular axial portion 2241, a step 2244 is formed to limit a movement of the second rotary element 221 in an axial direction towards the first rotary element 220 (left direction as shown in the Fig. 18). When the second guide pin 224 is inserted sequentially from one end into the hole of the second rotary element 221, the coil spring 222 and the hole formed on the second end 202 of the intermediate part 20 and the second spring clamp ring 223 is fixed in the slot 2243, the second rotary element 221 is pressed on one end by the spring force of the second coil spring 222 and is stopped on the other end by the step 2244. The circular portion 2242 is formed on the second guide pin 224 at a position contrary to the non-circular axial portion 2241 with respect to the step 2244. The circular portion 2242 is inserted into the hole 2205 of the first rotary element 220 with its axial end being mounted with a button 225 for operation outside. The button 225 is formed with a blind hole for receiving the axial end of the second guide pin 224.
When the second rotating mechanism is assembled, the convex portion 2211 of the second rotary element 221 is engaged into one of the depressed portions 2202, 2203, 2204. By urging the button 225 inwardly from outside, as shown in Figs. 15 and 16 (the arrow indicates a pressing force), the second guide pin 224 will move inwardly (right direction as shown in Fig. 18). By means of the step 2244 of the second guide pin 224, the second rotary element 221 will move with the second guide pin 224. Then, the first rotary element 220 and the second rotary element 221 are axially separated and the engagement of the convex portion 2211 with the depressed portions will be disengaged. In this embodiment, the second guide pin 224 with the button 225 is formed as a releasing means for releasing the engagement of the convex portion 2211 with a corresponding depression portion by separating the first rotary element 220 and the second rotary element 221 axially against the force of the second coil spring 222. By releasing the pressing force applied on the button 225, the second rotary element 221 will move back to its original position by the pressing force of the second coil spring 222. In the meantime, the second guide pin 224 will also move back.

At the stage that the first rotary element 220 and the second rotary element 221 are separated axially by pressing the button, if a rotating force is applied to the second rotating mechanism 22 (such as apply to the first unit 1 or the second unit 2), the first rotary element 220 and the second rotary element 221 will relatively rotate, then the convex portion 2211 of the second rotary element 221 will not correspond to the engaged concave portion. At this time, the pressing force to the button can be withdrawn, so that the second rotary element 221 will contact other portions (flat portion near the engaged concave portion of the first axial surface 2201 of the first axial surface 2201 by the returning force of the second coil spring 222. With further rotation, the convex portion 2211 of the second rotary element 221 will be engaged into a next concave portion of the first rotary element 220, so that the second rotating mechanism 22 is positioned in a further position.

By the same way, the second rotating mechanism 22 can be positioned in several predetermined positions. Therefore, further functions of the phone can be developed by the support of the positioning structure at several predetermined position of the second rotating mechanism. In addition, depends on different desired function, the predetermined position can be set accordingly.

Referring to Figs. 20, 21, 22 and 31, the second part 30 has a body 300, and the first rotary element 220 is formed at one end thereof. On the body 300 of the second part 30, it is disposed with two mounting holes 301 for mounting the second part 30 on the second unit 2 by such as screws. At the other end of the second part 30, there is also disposed a connecting hole 302 for receiving a rotary element 226 so as to be rotatably connected to the second intermediate part 2001.

The shape and structure of the second intermediate part 2001 are similar to those of the intermediate part 20. The second intermediate part 2001 has a mounting opening 2011 at one end thereof and another mounting opening 2012 at the other end thereof. The mounting openings 2011 has a slit 2014 on its periphery wall and the mounting opening 2012 also has a slit 2015 on its periphery wall. The second intermediate part 2001 further has a mounting hole 2016 formed on its body 2013, so as to be mounted to the intermediate unit 3 via screw.
The rotary element 214 is inserted into the mounting opening 2011 of the second intermediate part 2001 and the connecting hole 102 formed at the other end of the first part 10, then the first part 10 and the second intermediate part 2001 can be rotatable with each other about the first axis, that is, the rotary element 214, the mounting opening 2011 and the connecting hole 102 shall be co-axially disposed with the first rotating mechanism 21. With two rotating connections at both ends of the first part 10, the rotation of the first part 10 with respect to the intermediate part 20 and the second intermediate part 2001 could be very stable.

The rotary element 226 is inserted into the mounting opening 2012 of the second intermediate part 2001 and the connecting hole 302 formed at the other end of the second part 30, then the second part 30 and the second intermediate part 2001 can be rotatable with each other about the second axis, that is, the rotary element 226, the mounting opening 2012 and the connecting hole 302 shall be co-axially disposed with the second rotating mechanism 22. With two rotating connections at both ends of the second part 30, the rotation of the second part 30 with respect to the intermediate part 20 and the second intermediate part 2001 could be very stable.

Although the two rotating connections are disposed at both ends of the first part 10 and the two rotating connections are disposed at both ends of the second part 30, it could also be that only one rotating connection is dispose for the first part 10 and for the second part 30, such as, the first rotating mechanism 21 is disposed between a middle portion of the first part 10 and the intermediate part 20, thus a rotating connection with the second intermediate part 2001 can be omitted. Similarly, the second rotating mechanism 22 is disposed between a middle portion of the second part 30 and the intermediate part 20, thus a rotating connection with the second intermediate part 2001 can be omitted.

The structure of the rotary member 226 is similar to that of the rotary member 214, but with different orientation and size, thus the detailed description for the rotary member is omitted, but the person skilled in art can know its details on the basis of the description for the rotary member 214 and the drawings for the rotary member 214 and the rotary member 226. The rotary member 214 has a sleeve portion 2141 and a radial extension portion 2142 extending radially from the sleeve portion 2141. On the radial extension portion 2142, it is disposed a stop protrusion 2143 for engaging with a recess portion formed on the second intermediate part 2001 so as to rotate together with the second intermediate part 2001.

The sleeve portion 2141 has a circumferential wall 2146 extended axially from an axial surface 2145 of the sleeve portion 2141. The wall 2146 is disposed in a circular shape with a slit 2144 formed axially on the wall 2146. The slit 2144 corresponds to the slit 2104 of the second intermediate part 2001. The rotary member 214 has another axial surface 2147 opposite to the axial surface 2145. On the radial extension portion 2142, a groove 2148 for accommodating cables is disposed at the same side with the another axial surface 2147. The groove 2148 extends to an opening of the sleeve portion 2141. In assembly, the distal end surface of the radial extension portion 2142 of the rotary member 214 contacts with that of the rotary member 226, thus a passage for accommodating and guiding cables from the first unit 1 to the second unit 2 is established. As shown by a line with arrow in Fig. 20, the passage could be going from the space
accommodated by the first unit, passing the opening of the sleeve portion 2141 of the rotary
element 214 from one end thereof (outer side end) to the other end near the groove, and then
passing the groove 2148 to reach an end of the opening of the sleeve portion of the rotary element
226 near the groove, finally penetrating the opening of the sleeve portion of the rotary element 226
to go out from the other end of the opening of the sleeve portion of the rotary element 226 so as to
run into the space accommodated by the second unit 2. The cables guided by he passage can
connect a LCD module disposed in the first unit 1 and a PCB module disposed in the second unit
2.

By referring to Figs. 42-52, respective operations of the hinge according the first embodiment of
the invention will be described.

1. Original state (closed state)

Fig. 42 and Fig. 43 illustrate a first rotating action (original state) of the hinge according to the
first embodiment of the present invention.

In the original state, the clamshell phone is in a closed state, where the first unit 1 covers on the
second unit 2. As shown in the Fig. 42, the two lines with an angle therebetween mean a
differential angle between a specific position of the first rotating mechanism in the closed state
and a full engaged position of the first rotating mechanism. With the difference in angle, when the
first unit is in a closed state, the first unit will be further exerted a rotating force in the closing
direction so as to avoid a tolerance in the closed position of the first rotating mechanism. Specific
structure for generating the rotating force in the closed position can refer to the structure of the
first rotating mechanism described above.

In this state, the convex portion 2211 of the second rotary element 221 is engaged into the first
depressed portion 2202 of the first rotary element 220.

2. Normal opening state (160-degree rotation state)

Fig. 44 and Fig. 45 illustrate a second rotating action (160-degree rotation state) of the hinge
according to the first embodiment of the present invention.

When rotating the first unit 1 in the opening direction, the second rotating mechanism 22 is
positioned without operation to the releasing means (pressing the button 225) and only the first
rotating mechanism 21 is rotate. By means of the first rotating mechanism 21, the first unit 1 can
rotate with respect to the second unit 2. When the first part 11 rotates with respect to the
intermediate part 20 by about 160 degree (provided that the normal opening position is disposed at
160-degree rotation), the first rotating mechanism 21 is positioned, so that the clamshell phone is
in a normal opening state for use. Under this state, the second rotating mechanism 22 is positioned
and is prevented from rotating by the engagement of the convex portion 2211 of the second rotary
element 221 with the first depressed portion 2202 of the first rotary element 220.
3. a third rotating action (300-degree rotation state)

Figs. 46–48 illustrate a third rotating actions (300-degree rotation state) of the hinge according to the first embodiment of the present invention.

When the clamshell phone is in a normal opening state, by operating the releasing means (pressing the button 225) and further rotating the first unit 1 with respect to the second unit 2, since the first rotating mechanism is positioned and a further rotation of the first rotating mechanism is also prohibited by the engagement of the step 2103 of the head portion 2100 of the first guide pin 210 with the stopper 12, thus the second rotating mechanism 22 will rotate, namely the second part 30 will rotate with respect to the intermediate part 20. Once the second rotating mechanism 22 is rotating, the button 225 can be released, and then when the convex portion 2211 of the second rotary element 221 is engaged into a next depressed portion (the second depressed portion 2203), the first unit 1 is positioned in an angle of 300 degree with respect to the second unit 2. In this state, the clamshell phone can stand on desk top as a multimedia player.

4. a fourth rotating action (360-degree rotation state)

Fig. 49 and Fig. 50 illustrate a fourth rotating action (360-degree rotation state) of the hinge according to the first embodiment of the present invention.

From the third rotating action (300-degree rotation state), by pressing the button 225 and rotating the first unit 1, similar to the third rotating action, the convex portion 2211 of the second rotary element 221 is disengaged from the second depressed portion 2203 and going into an engagement with the third depressed portion 2204, so that the first unit 1 is positioned in an angle of 360 degree with respect to the second unit 2. In this state, when a camera unit 4 is disposed in the intermediate unit 3 as shown in Fig. 5, the user can hold the phone horizontally as a digital camera.

5. a fifth rotating action (negative 180-degree rotation state)

Fig. 51 and Fig. 52 illustrate a fifth rotating action (negative 180-degree rotation state) of the hinge according to the first embodiment of the present invention.

From the fourth rotating action (360-degree rotation state), by rotating the first unit 1 in a closing direction by 180 degree, the first rotating mechanism 21 will be positioned by an engagement between the first rotary cam element 11 and the second rotary cam element 211, then as shown in fig. 51, the first unit 1 will be positioned in a negative 180-degree rotation state with respect to the second unit 2, where the first unit 1 and the second unit 2 are extending contrarily (in opposite directions but not co-linear). In this state, as shown in Fig 6, both the camera unit 4 disposed in the intermediate unit 3 and the display means (LCD disposed in the first unit 1) are towards the user for self picture shooting or video telephoning.
<Second embodiment

Figs. 53 to 60 show detailed structure of the hinge according a second embodiment of the present invention.

The second embodiment is similar to the first embodiment with the difference on the structure of the second rotating mechanism, thus the detailed structure of the second embodiment except the second rotating mechanism can be clear by referring to the first embodiment and will not be described again in details for the purpose of simplicity and brevity. However, it should also be understood that any variations applied to the first embodiment can also be applied to the second embodiment unless specified otherwise or contrary to the specific structure of the second embodiment.

The second rotating mechanism 23 in the second embodiment includes: a first rotary element 231, a second rotary element 232 and a coil spring 233, as shown in Figs. 55 and 56. The first rotary element 231 is associated with the second part 30 in a manner of non-relatively rotating with the second part 30 and has a first axial surface 2310. The second rotary element 232 is associated with the intermediate part 20 in a manner of non-relatively rotating and capable of moving axially with respect to the intermediate part 20 (exactly sliding with respect to the first rotary element 231), and is disposed coaxially with the first rotary element 231. In addition, the second rotary element 232 has a second axial surface 2320 facing the first axial surface 2310. The coil spring 233 is for pressing axially the second rotary element 232 (as one of the first rotary element 231 and the second rotary element 232) toward the first rotary element 231 (as the other one of the first rotary element 231 and the second rotary element 232).

In the second rotating mechanism 23, the first rotary element 231 has a rectangle protrusion 2315 on a side surface opposite to the first axial surface 2310. The second part 30 has at one end 31 thereof a rectangle hole 310 for receiving the rectangle protrusion 2315, so that when the rectangle protrusion 2315 is engaged with the rectangle hole 310, the first rotary element 231 can rotate integrally with the second part 30. The protrusion 2315 and the hole 310 could be configured in other shapes, as long as their cross-sections are in non-circular shape, or at least shapes of a portion of the protrusion 2315 and a correspond portion of the hole 310 are in a non-circular shape, so that a relative rotation between the first rotary element 231 and the second part 30 is prohibited. In this embodiment, the first rotary element 231 and the second part 30 are formed separately, however, it could also be configured that the first rotary element 231 and the second part 30 are integrally formed, so that the structure can be simple and compact.

The first axial surface 2310 of the first rotary element 231 is circumferentially divided into two circular sections, that is an inner circular section 2311 and an outer circular section 2312. In the inner circular section 2311, it is disposed with a convex portion 2314, and in the outer circular section 2312 it is disposed with a convex portion 2313. The phase of the convex portion 2314 in the inner circular section 2311 is different by 180 degree from the phase of the convex portion 2313 in the outer circular section 2312, that is, the convex portion 2313 and the convex portion 2314 are disposed in the same diametrical line.
The second rotary element 232 is disposed separately from the intermediate part 20. The second axial surface 2320 of the second rotary element 232 is also divided into two circular sections, namely, an inner circular section 2321 and an outer circular section 2322. On the inner circular section 2321, it is disposed circumferentially three depressed portions, namely, a first depressed portion 2327, a second depressed portion 2328 and a third depressed portion 2329. On the outer circular section 2322, it is also disposed circumferentially three depressed portions, namely, a first depressed portion 2324, a second depressed portion 2325 and a third depressed portion 2326. The first depressed portion 2327, the second depressed portion 2328 and the third depressed portion 2329 of the inner circular section 2321 are respectively corresponding to the first depressed portion 2324, the second depressed portion 2325 and the third depressed portion 2326 of the outer circular section 2322, wherein the phases of the first depressed portion 2327, the second depressed portion 2328 and the third depressed portion 2329 of the inner circular section 2321 are different by 180 degree from the phases of the first depressed portion 2324, the second depressed portion 2325 and the third depressed portion 2326 of the outer circular section 2322. When the first axial surface 2310 is in engagement with the second axial surface 2320, the convex portion 2314 of the inner circular section 2311 will match with one of the first depressed portion 2327, the second depressed portion 2328 and the third depressed portion 2329 of the inner circular section 2321, and the convex portion 2313 of the outer circular section 2312 will match with one of the first depressed portion 2324, the second depressed portion 2325 and the third depressed portion 2326 of the outer circular section 2322. More specifically, the two convex portion 2313 and 2314 constitute a pair of convex portions, and the first depressed portions 2324 and 2327 constitute a first pair of depressed portions, the second depressed portions 2325 and 2328 constitute a second pair of depressed portions, the third depressed portions 2326 and 2329 constitute a third pair of depressed portions. In operation, the pair of convex portion is in engagement with one pair of the first pair, the second pair and the third pair of depressed portions.

In this embodiment, the depressed portions are disposed as concave portions with side walls in circumferential direction thereof being formed as slopes with respect to the second axial surface 2320. For example, the first depressed portion 2324 of the outer circular section 2322 is shaped as a concave portion and has two side walls 23241 and 23242 constructed as slopes at its both sides in circumferential direction. Similarly, the second depressed portion 2325 and the third depressed portion 2326 have respectively two side walls 23251 and 23252 and two side walls 23261 and 23262 shaped in slope. The depressed portions 2327, 2328, 2329 of the inner circular section 2321 have the same structure as the depressed portions of the outer circular section 2322 and also have slopes at its both sides in circumferential direction. For simplicity, the reference numerals are not provided, however, the person skilled in art, based on the teaching and description of this invention, will be clear to the structure of the depressed portions 2327, 2328, 2329 of the inner circular section 2321.

The structure of the slopes is used for guiding the convex portions to move away axially from the depressed portions when the first rotary element 231 rotates with respect to the second rotary element 232 from a state that the convex portions is in engagement with the depressed portions. Therefore, in this embodiment, the releasing means for releasing the engagement of the convex
portions with the depression portions is formed by the slopes, and the slopes are adapted to guide the convex portions to move away in axial direction upon relative rotation between the first rotary element and the second rotary element so as to axially separate the first rotary element 231 and the second rotary element 232.

5 The phases of the convex portions and the depressed portions can be dispose as follows:

1) The first pair of depressed portions 2324 and 2327 are constructed such that when the first pair of depressed portions 2324 and 2327 is engaged respectively with the convex portions 2313 and 2314, the first unit 1 can be rotated with respect to the second unit 2 between the opening position and the closing position. The first pair of depressed positions 2324 and 2327 can be called as an original position for the rotation of the second rotating mechanism 32.

2) The second pair of depressed portions 2325 and 2328 are constructed such that the sum of a rotating angle of the first part 1 with respect to the intermediate part 3 and a rotating angle of the second part 2 with respect to the intermediate part 3 when the second pair of depressed portions 2325 and 2328 is engaged with the convex portions 2313 and 2314 is 300 degrees.

3) The third pair of depressed portion 2326 and 2329 are constructed such that the sum of a rotating angle of the first part 1 with respect to the intermediate part 3 and a rotating angle of the second part 2 with respect to the intermediate part 3 when the third pair of depressed portion 2326 and 2329 is engaged with the convex portion 2313 and 2314 is 360 degrees.

A guide pin 235, which is similar to the first guide pin 210 in structure, has a head portion 2351 at its one end, and further has sequentially a round portion 2352, a non-circular portion 2353 with rectangle-section, and a slot portion 2355. The slot portion 2355 is disposed at the other end of the guide pin 235 and has a slot 2354 for receiving and fixing a spring clamp ring 234. The end 31 of the second part 30, the first rotary element 231, the second rotary element 232, a corresponding end of the intermediate part 20 have holes for the guide pin 235 to penetrate. The round portion 2352 corresponds to the end 31 of the second part 30 and the first rotary element 231, so that the second part 30 and the first rotary element 231 can rotate with respect to the guide pin 235. The non-circular portion 2353 corresponds in shape to the holes of the second rotary element 232 and the intermediate part 20, so that the second rotary element 232 can rotate with the intermediate part 20 and move axially with respect to the intermediate part 20. The shape of the holes of the second rotary element 232 and the intermediate part 20 as well as the section shape of the non-circular portion 2353 can also be disposed as other shapes, as long as they are in non-circular shapes, or at least the shapes of a portion of the section and a corresponding portion of the holes are in non-circular shapes. The head portion 2351 is larger than the hoe 310 of the end 31 of the second part 30. The head portion 2351 has a protrusion portion 23511 protruding radially from a base portion 23512. Two steps 23513 and 23514 are formed between both sides of the protrusion portion 23511 and the base portion 23512. A stopper 32 is mounted on the second part 30 in a position capable of engaging with the steps 23513 and 23514 of the guide pin 235 so as to limit a rotating range of the guide pin 235. The limited rotating range in this embodiment is at least 180 degrees (such as 200 degrees), but could be disposed as other ranges as desired.
Under an assembled state of the second rotating mechanism 23, when the convex portions 2313 and 2314 of the second rotary element 232 is engaged into one pair of the three pairs of depressed portions, if a rotation force is applied to the second rotating mechanism 23, the slope of the engaged depressed portions will guide the convex portions 2313 and 2314 to move away in axial direction against the pressing force of the spring 233, so as to disengage the engagement of the second rotary element 232 with the first rotary element 231. When the convex portions 2313 and 2314 is in alignment with a next pair of the depressed portions, the convex portion 2313 and 2314 will engage into the next pair of depressed portion by the pressing force of the spring 233, so that the second rotating mechanism 23 is positioned in a next position. The rotating action of the second embodiment is the same as the first embodiment in spite of a different structure, thus the detailed description of the rotating action of the second embodiment can be obtained by referring to figures 42-52 as well as corresponding descriptions.

In the second embodiment, although the first axial surface 2310 and the second axial surface 2320 are both disposed with two circular sections, the first axial surface 2310 and the second axial surface 2320 can also be disposed with only one circular section (a single circular section structure), as shown in Figs. 61 and 62. In Fig. 61, it illustrates the variation of the first rotary element with the first axial surface having a single circular section structure. The first axial surface 2310 of the first rotary element 231’ is disposed to the single circular section structure, and a convex portion 2313’ is formed on the first axial surface 2310’. In Fig. 62, it illustrates the variation of the second rotary element with the second axial surface having a single circular section structure. The second axial surface 2320 of the second rotary element 232’ is disposed to the single circular section structure, and three depressed portions 2324’, 2325’ and 2326’, namely, a first depressed portion 2324’, a second depressed portion 2325’ and a third depressed portion 2326’, are formed on the second axial surface 2320’. In this variation, similar to the structures in Figs. 59 and 60, these depressed portions are disposed as concave portions with side walls in circumferential direction thereof being formed as slopes with respect to the second axial surface 2320’. For example, the first depressed portion 2324’ is shaped as a concave portion and has two side walls 23241’ and 23242’ constructed as slopes at its both sides in circumferential direction. Similarly, the second depressed portions 2325’ and the third depressed portion 2326’ have respectively two side walls 23251’ and 23252’ and two side walls 23261’ and 23262’ shaped in slope.

However, with the single circular section structure, when the convex portion is disengaged from the depressed portion, the first rotary element 231 will be inclined to the second rotary element 232 in rotating. To solve this problem, it can also be disposed with a pair of convex portion in the single circular section structure with one convex portion being symmetric to the other convex portion about the rotating axis, however this structure limit a rotating range of no more than 180 degree. The structure of two circular sections can avoid the problem of incline of the first rotary element to the second rotary element in rotating, and also can set the rotating range to even 360 degrees. Anyway, as the second rotating mechanism, the structure of single circular section can also achieve the purpose of the invention and thus is also included in this invention.
The present invention may, of course, be carried out in other ways than those specifically set forth herein without departing from essential characteristics of the invention. The present embodiments are to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.
CLAIMS

1. A hinge for a foldable type electronic apparatus comprising:
   a first part for mounting on a first unit;
   a second part for mounting on a second unit; and
   an intermediate part for mounting on an intermediate unit;
   wherein the first part is rotatably connected to the intermediate part about a first axis via a first rotating mechanism and the second part is rotatably connected to the intermediate part about a second axis parallel to the first axis via a second rotating mechanism;
   the first rotating mechanism is constructed such that without the rotation of the second rotating mechanism, the first unit can be rotated with respect to the second unit between an opening position where the electronic apparatus is in a normal opened state and a closing position where the first unit is folded on the second unit and the electronic apparatus is in a normal closed state,
   the second rotating mechanism is configured such that the second unit can be rotated and can be positioned at at least two rotation positions with respect to the intermediate unit.

2. The hinge of claim 1, wherein the second rotating mechanism comprises a first rotary element associated with the second part and a second rotary element associated with the intermediate part, wherein the first rotary element and the second rotary element are configured to be capable to engage with each other via their axial surfaces facing to each other so as to have the second rotating mechanism be positioned at at least two rotation positions.

3. The hinge of claim 1, wherein the second rotating mechanism is configured to comprise a first rotary element associated in a manner of non-relatively rotating with the second part and having a first axial surface, a second rotary element associated in a manner of non-relatively rotating with the intermediate part, disposed coaxially with the first rotary element and having a second axial surface facing the first axial surface, and a coil spring for pressing axially one of the first rotary element and the second rotary element toward the other one of the first rotary element and the second rotary element, wherein at least one of the first rotary element and the second rotary element is axially movable,
   one of the first axial surface and the second axial surface is disposed circumferentially with at least two depressed portions at predetermined positions, and the other of the first axial surface and the second axial surface is disposed with a convex portion corresponding in shape to the depressed portions and capable of engaging sequentially with said depressed portions upon a relative rotation between the first rotary element and the second rotary element,
   the second rotating mechanism further has a releasing means for releasing the engagement of the convex portion with a corresponding depression portion by separating the first rotary element and the second rotary element axially against the force of the coil spring.

4. The hinge of claim 1, wherein the force required for rotating the first part with respect to the intermediate part is lower than the force required for rotating the second part with respect to the intermediate part.
5. The hinge of claim 3 or 4, wherein a first depressed portion of the depressed portions is constructed such that when the first depressed portion is engaged with the convex portion, the first unit can be rotated with respect to the second unit between the opening position and the closing position.

6. The hinge of claim 3 or 4, wherein a second depressed portion of the depressed portions is constructed such that the sum of a rotating angle of the first part with respect to the intermediate part and a rotating angle of the second part with respect to the intermediate part when the second depressed portion is engaged with the convex portion is 300 degrees.

7. The hinge of claim 3 or 4, wherein a third depressed portion of the depressed portions is constructed such that the sum of a rotating angle of the first part with respect to the intermediate part and a rotating angle of the second part with respect to the intermediate part when the third depressed portion is engaged with the convex portion is 360 degrees.

8. The hinge of claim 3, wherein the first rotary element is formed integrally with the second part.

9. The hinge of claim 3, wherein the first rotary element is formed separately with the second part and mounted to the second part in a manner of integrally rotating with the second part.

10. The hinge of claim 3, wherein the first rotary element and the second part are non-rotatably mounted on a guide pin and the first rotary element is slidable on the guide pin.

11. The hinge of claim 3, wherein the second rotary element is formed integrally with the intermediate part.

12. The hinge of claim 3, wherein the second rotary element is formed separately with the intermediate part and mounted to the intermediate part in a manner of integrally rotating with the intermediate part.

13. The hinge of claim 3, wherein the second rotary element and the intermediate part are non-rotatably mounted on a guide pin and the second rotary element is slidable on the guide pin.

14. The hinge of claim 3, wherein the depressed portions are disposed as notches or slots and side walls in circumferential direction of the notches or slots are formed with steps or vertical surfaces with respect to the one of the first axial surface and the second axial surface having the depressed portions, and the releasing means is disposed as an urging member operated from outside and capable of urging one of the first rotary element and the second rotary element pressed by the coil spring so as to axially separate the first rotary element and the second rotary element.

15. The hinge of claim 14, wherein the urging member is formed with a button portion at an outside end thereof to be pressed.

16. The hinge of claim 14, wherein a guide pin is disposed to penetrate holes disposed at a central
portion of the first rotary element and a central portion of the second rotary element respectively so as to guide the relative rotation between the first rotary element and the second rotary element.

17. The hinge of claim 16, wherein a step is disposed on the guide pin for urging one of the first rotary element and the second rotary element so as to separate the first rotary element and the second rotary element axially.

18. The hinge of claim 17, wherein one end of the guide pin extends outwardly to form an operating end, so that the guide pin is formed as the releasing means.

19. The hinge of claim 18, wherein the other end of the guide pin is formed with a slot for receiving and fixing a spring clamp ring.

20. The hinge of claim 3, wherein the depressed portions are disposed as concave portions with side walls in circumferential direction thereof being formed as slopes with respect to the one of the first axial surface and the second axial surface having the depressed portions;

the releasing means is formed by the slopes, and the slopes are adapted to guide the convex portion to move away in axial direction upon relative rotation between the first rotary element and the second rotary element so as to axially separate the first rotary element and the second rotary element.

21. The hinge of claim 20, wherein each of the first axial surface and the second axial surface is circumferentially divided into an inner annular section and an outer annular section,

each of the inner annular section and the outer annular section of one of the first axial surface and the second axial surface is disposed with said at least two depressed portions, wherein the phase of the depressed portions on the inner annular section is different by 180 degree from the phase of the depressed portions on the outer annular section,

each of the inner annular section and the outer annular section of the other of the first axial surface and the second axial surface is disposed with said convex portion, wherein the phase of the convex portion on the inner annular section is different by 180 degree from the phase of the convex portion on the outer annular section.

22. The hinge of claim 20, wherein a guide pin is disposed to penetrate holes disposed at a central portion of the first rotary element and a central portion of the second rotary element respectively so as to guide the relative rotation between the first rotary element and the second rotary element.

23. The hinge of claim 22, wherein the guide pin has a head portion at one end thereof and a slot at the other end thereof for receiving and fixing a spring clamp ring, and the first rotary element, the second rotary element and the coil spring are disposed between the head portion and the spring clamp ring.

24. The hinge of claim 23, wherein the guide pin is disposed to rotate with one of the first rotary element and the second rotary element, the head portion is disposed with steps for engaging with a stopper being disposed to rotate with the other of the first rotary element and the second rotary
element, so as to limit the relative rotation between the first rotary element and the second rotary element to a predetermined range.

25. The hinge of claim 1, wherein the first rotating mechanism comprises a first rotary cam element connected to the first part and having a first cam surface on an axial end, a second rotary cam element associated with the intermediate part in a manner of rotating with the intermediate part and being slidable axially with respect to the intermediate part, disposed coaxially with the first rotary cam element and having a second cam surface on an axial end facing and matching the first cam surface, and a second coil spring for pressing axially one of the first rotary cam element and the second rotary cam element toward the other one of the first rotary cam element and the second rotary cam element.

26. The hinge of claim 25, wherein a first matching position of the first cam surface and the second cam surface for positioning the first rotary cam element and the second rotary cam element is constructed to correspond to the normal opened state.

27. The hinge of claim 25 or 26, wherein a second matching position of the first cam surface and the second cam surface for positioning the first rotary cam element and the second rotary cam element is constructed at a closing side near a position corresponding to the normal closed state.

28. A foldable type electronic apparatus, comprising a first unit, a second unit and an intermediate unit, wherein the first unit, the second unit and the intermediate unit are mounted on a hinge of claim 1.

29. The foldable type electronic apparatus of claim 28, wherein the first rotating mechanism is disposed between one end of the first part and the intermediate part, and the second rotating mechanism is disposed between one end the second part and the intermediate part,

the other end of the first part is rotatably connected to a second intermediate part about the first axis, and the other end of the second part is rotatably connected to the second intermediate part about the second axis,

the second intermediate part is mounted on the intermediate unit.

30. The foldable type electronic apparatus of claim 28, wherein a camera unit is disposed in the intermediate unit.

31. The foldable type electronic apparatus of claim 30, wherein a facing direction of lens of the camera unit is disposed in a direction from the first rotating mechanism to the second rotating mechanism.

32. A method of use of a foldable type electronic apparatus comprising a first unit, a second unit and an intermediate unit, wherein the first unit, the second unit and the intermediate unit are mounted on a hinge of claim 1; wherein:
the first unit is rotated with respect to the second unit from a closed position to an open position where a display means disposed on the first unit can be viewed.
33. The method of claim 32, wherein a camera unit is disposed in the intermediate unit of the foldable type electronic apparatus and a facing direction of lens of the camera unit is disposed in a direction from the first rotating mechanism to the second rotating mechanism.

34. The method of claim 33, wherein said rotation of the first unit with respect to the second unit is carried out by rotating the first unit with respect to the intermediate unit.

35. The method of claim 34, wherein further rotating the intermediate unit with respect to the second unit so that the first unit and the second unit are positioned in a rotating angle of 300 degrees therebetween.

36. The method of claim 35, wherein further rotating the intermediate unit with respect to the second unit so that the first unit and the second unit are positioned in a rotating angle of 360 degrees therebetween, and the facing direction of lens of the camera unit is opposite to the facing direction of the display means disposed on the first unit such that the electronic apparatus can be used as a camera.

37. The method of claim 36, wherein further rotating the first unit in closing direction by 180 degrees so that the lens of the camera unit and the display means are facing the same direction.

38. The method of claim 37, wherein the first unit and the second unit are positioned with a rotating angle of 180 degrees therebetween and the intermediate unit is perpendicular to both the first unit and the second unit.