

VCM AND LENS BARREL INSERTION JIG

FIELD

[0001] An embodiment of the invention is directed to an assembly tool for assembling a camera module, more specifically, an assembly tool for connecting a VCM to a lens barrel to form a camera module. Other embodiments are also described and claimed.

BACKGROUND

[0002] Many portable electronic devices, such as mobile cellular telephones, include a digital camera. The lenses for such cameras must be compact to fit within the case of the portable electronic device. At the same time there is a desire to provide an increasingly high quality camera function in these devices. To provide a higher quality image, some cameras found in portable electronic devices include a camera module having an autofocus feature. Such camera modules typically have two major components, namely a lens barrel having a lens and a mechanism for moving the lens barrel (and the lens) along an optical axis to change the distance between the lens and an image sensor associated with the camera module. The mechanism for moving the lens barrel and associated lens may be, for example, a VCM (VCM). In particular, typically the lens barrel is inserted into the VCM and an image sensor is then assembled to the VCM to complete the camera module. The assembled camera module provides all the optical components in a single package that can be assembled into the portable electronic device.

[0003] Typically, the lens barrel is joined to the VCM by inserting the lens barrel within a lens holder formed within an opening of the VCM. In some cases, the lens holder and the lens barrel have complimentary screw threads that are used to join the lens barrel to the VCM. In such cases, the lens barrel is inserted into the lens holder through a bottom side of the VCM, and then rotated within the holder to join the two pieces together. Such method of inserting the lens barrel into the VCM, however, is difficult due to the threading and rotation of the lens barrel required to secure the barrel within the holder and ensure the lens is at the required “pre-focus” height. In particular, the “pre-focus” height is the height where the best image focus is achieved for the lens. The lens barrel is therefore rotated and adjusted until the “pre-focus” height is reached, and then glued to the lens holder to secure the height position.

[0004] To simplify the assembly process, some lens barrels do not have threading, and instead are designed to be secured to the VCM by a locking mechanism on the lens barrel. The locking position of the threadless lens barrel within the VCM is at a pre-calculated height which is equal to the desired “pre-focus” height of the lens, and therefore does not require a

precise rotation of the lens barrel within the lens holder of the VCM to achieve the desired “pre-focus” height.

SUMMARY

[0005] An embodiment of the invention is an assembly tool for assembling a camera module having a lens barrel and a VCM (VCM). More specifically, the assembly tool may be used to secure the lens barrel to the VCM. The assembly tool may include a base member having a lens barrel guide member that is operable to position a lens barrel on the base member. For example, the lens barrel guide member may include a pin member extending from the base member. The pin member may be dimensioned to fit within a recess formed in a base of the lens barrel so that the lens barrel position is fixed. In other words, the lens barrel does not rotate or otherwise change orientation with respect to the pin member. In some embodiments, a channel is formed through the pin and a suction force is applied through the channel to help hold the lens barrel to the pin. In some embodiments, the lens barrel guide member may be positioned within a cavity formed in the base member. The assembly tool may further include a VCM guide member positioned around the lens barrel guide member. The VCM guide member (which holds a VCM) may be positioned within the cavity formed in the base member and may rotate around the lens barrel guide member (e.g. around the pin) within the cavity. The VCM guide member may include a recessed region operable to receive and position a VCM around a lens barrel associated with the lens barrel guide member (e.g. positioned on the lens barrel guide member pin). In some embodiments, an opening, through which the lens barrel guide member is inserted, may be formed within the recessed region. The assembly tool may further include an actuator connected to the base member and the voice coil guide member. The actuator is operable to rotate the VCM guide member around the lens barrel guide member to secure a VCM received by the VCM guide member to a lens barrel associated with the lens barrel guide member. In some embodiments, the lens barrel remains in a fixed orientation when the VCM guide member is rotated around the lens barrel guide member.

[0006] Another embodiment of the invention is a tool for assembling a lens barrel to a VCM. The tool may include a base member having a lens barrel guide member and a VCM guide member cavity formed around the lens barrel guide member. In some embodiments, the lens barrel guide member is an extension member extending from a bottom of the VCM guide member cavity. The tool may further include a VCM guide member dimensioned to fit within the VCM guide member cavity and operable to rotate with respect to the lens barrel guide member. The voice coil guide member may have a recessed region dimensioned to receive a

VCM and an opening within the recessed region that is dimensioned to receive the lens barrel guide member. Rotation of the VCM guide member secures a VCM within the recessed region to a lens barrel positioned on the lens barrel guide member. The tool may further include an actuator connected to the VCM guide member to drive rotation of the VCM guide member. The actuator may include a slider bar that is rotatably connected to the VCM guide member and operable to slide with respect to the base member. In some embodiments, the tool may further include a locking member positioned within the recessed region of the VCM guide member to hold the VCM within the recessed region. In still further embodiments, the tool may include a cover member attached to the base member to enclose each of the tool components within the base member. The cover member may have an opening aligned with the lens barrel guide member and the VCM guide member to allow for access to the lens barrel guide member and the VCM guide member.

[0007] Another embodiment of the invention is a process for assembling a camera module. The process may include positioning a lens barrel on a base member that is operable to hold the lens barrel in a fixed position. The process may further include positioning a VCM within a guide member that is rotatably connected to the base member and positioned around the lens barrel. The guide member may have a recessed region within which the lens barrel and the VCM are positioned. The VCM may be rotated around the lens barrel by rotating the guide member with respect to the base member.

[0008] The above summary does not include an exhaustive list of all aspects of the present invention. It is contemplated that the invention includes all systems and methods that can be practiced from all suitable combinations of the various aspects summarized above, as well as those disclosed in the Detailed Description below and particularly pointed out in the claims filed with the application. Such combinations have particular advantages not specifically recited in the above summary.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" or "one" embodiment in this disclosure are not necessarily to the same embodiment, and they mean at least one.

[0010] **Fig. 1** illustrates an exploded perspective view of one embodiment of an assembly tool for assembling a camera module.

[0011] **Fig. 2** illustrates a perspective view of the assembled assembly tool of **Fig. 1**.

[0012] **Fig. 3A** illustrates a magnified perspective view of a VCM guide member and lens barrel guide member of the assembly tool of **Fig. 1**.

[0013] **Fig. 3B** illustrates a cross-sectional perspective view of the VCM guide member and lens barrel guide member along line 3B-3B' of **Fig. 3A**.

[0014] **Fig. 3C** illustrates a magnified perspective view of the VCM guide member and lens barrel guide member of **Fig. 3A** with a lens barrel attached to the lens barrel guide member.

[0015] **Fig. 3D** illustrates a perspective view of the VCM guide member and lens barrel guide member of **Fig. 3C** with a VCM positioned around the lens barrel.

[0016] **Fig. 4** illustrates a cross-sectional side view of the VCM guide member and lens barrel guide member along line 4-4' of **Fig. 3D**.

[0017] **Fig. 5A** illustrates a top view of one embodiment of the assembly tool of **Fig. 1** with the VCM guide members in an unlocked position.

[0018] **Fig. 5B** illustrates a top view of the assembly tool of **Fig. 1** with the VCM guide members in a locked position.

[0019] **Fig. 6** illustrates a top view of another embodiment of a VCM guide member for use within the assembly tool of **Fig. 1**.

[0020] **Fig. 7** is a block diagram illustrating a process of assembling a camera module.

DETAILED DESCRIPTION

[0021] In this section we shall explain several preferred embodiments of this invention with reference to the appended drawings. Whenever the shapes, relative positions and other aspects of the parts described in the embodiments are not clearly defined, the scope of the invention is not limited only to the parts shown, which are meant merely for the purpose of illustration. Also, while numerous details are set forth, it is understood that some embodiments of the invention may be practiced without these details. In other instances, well-known structures and techniques have not been shown in detail so as not to obscure the understanding of this description.

[0022] **Fig. 1** illustrates an exploded perspective view of one embodiment of an assembly tool for assembling a camera module. Assembly tool 100 may include a base member 102 designed to house the various components of the assembly tool 100. Representatively, base member 102 may be a jig having a top side 110 which provides an open framework for guiding the various components of the assembly tool 100 and a bottom side 112, which rests upon a support surface during assembly of the camera module. Representatively, in one embodiment, top side 110 may include one or more of cavity 104 formed therein and bottom side 112 may

be substantially flat. Cavity 104 may be of a size and shape suitable for having a lens barrel guide member 106 and voice coil motor (VCM) guide member 108 positioned therein. Lens barrel guide member 106 may be dimensioned to hold a lens barrel within cavity 104 and VCM guide member 108 may be dimensioned to hold a VCM and secure the VCM to the lens barrel.

[0023] Base member 102 may, in some embodiments, include more than one of cavity 104, lens barrel guide member 106 and VCM guide member 108 such that more than one camera module can be assembled simultaneously. Representatively, base member 102 may include cavities 104A, 104B, 104C, 104D, 104E and 104F, which are all of the same size and shape and arranged in rows along top side 110. Lens barrel guide members 106A, 106B, 106C, 106D, 106E and 106F and VCM guide members 108A, 108B, 108C, 108D, 108E and 108F are positioned within respective ones of cavities 104A-104F. In addition, one or more of actuators 114, 116 may be connected to each of VCM guide members 108A-108F to drive movement of each of VCM guide members 108A-108F with respect to base member 102. Movement of each of VCM guide members 108A-108F, in turn, rotates a VCM within each of VCM guide members 108A-108F around a lens barrel within each of lens barrel guide members 106A-106F to secure the VCM to the lens barrel. In this aspect, at least six camera modules may be assembled simultaneously using assembly tool 100. It is contemplated, however, that more or fewer camera modules may be assembled with the assembly tool 100, for example, as many as eight, ten or more camera modules may be assembled simultaneously using assembly tool 100.

[0024] Referring in more detail to lens barrel guide member 106, in one embodiment, lens barrel guide member 106 may have any shape and size suitable for holding a lens barrel at a desired position within cavity 104. Representatively, in one embodiment, lens barrel guide member 106 includes an extension member 118, which is a protrusion or pin like structure, that extends upwardly from a bottom of cavity 104. Extension member 118 provides a pedestal upon which a lens barrel may be positioned and held a desired distance from the bottom of cavity 104 so that the lens barrel is aligned with a VCM positioned in an associated VCM guide member 108. Extension member 118 may therefore have any size and shape suitable for holding a lens barrel as described herein. Extension member 118 may be centered within cavity 104 such that the lens barrel is positioned within a center of cavity 104. It should be understood that a size and shape of each of lens barrel guide members 106A-106F may be substantially the same, or different in cases where camera modules having different sized lens barrels are assembled within assembly tool 100. Additional features of lens barrel guide member 106 and its operation will be described in more detail in reference to **Fig. 3A-3D**.

[0025] VCM guide member 108 may have any size and shape suitable for holding and positioning a VCM around a lens barrel positioned on lens barrel guide member 106. In this aspect, VCM guide member 108 is of a size and shape that allows VCM guide member 108 to rotate, or pivot, around lens barrel guide member 106 and within cavity 104. Said another way, VCM guide member 108 is rotatably connected to base member 102 so that it can rotate with respect to the base member 102 and lens barrel guide member 106, to secure a VCM held by the VCM guide member 108 to a lens barrel on the lens barrel guide member 106.

[0026] Representatively, VCM guide member 108 may have a head portion 120 which holds a VCM and a tail portion 122 that is connected to one of actuators 114, 116. The head portion 120 may include a lens barrel guide member opening 126 through its center and a recessed region 124 positioned around opening 126. The opening 126 allows for VCM guide member 108 to be positioned within cavity 104 and around the extension member 118 of lens barrel guide member 106. In particular, extension member 118 extends through opening 126 when VCM guide member 108 is positioned within cavity 104. Recessed region 124 is dimensioned to hold a VCM within VCM guide member 108 in such an orientation that an opening of the VCM is aligned with opening 126. In this aspect, when a lens barrel is held on extension member 118, the VCM held by VCM guide member 108 is positioned around the lens barrel. Movement of one of actuators 114, 116 attached to tail portion 122 of VCM guide member 108 may then be used to rotate the head portion 120 of VCM guide member 108 around extension member 118 (which is within opening 126), and in turn, rotate the VCM around the lens barrel (which is on extension member 118) to secure the VCM to the lens barrel. It should be noted that in one embodiment, the lens barrel guide member 106 and lens barrel are at a fixed position and orientation on base member 102, therefore movement or rotation of the VCM guide member 108 or a VCM with respect to the lens barrel guide member 106 or lens barrel means the VCM guide member 108 or VCM moves while the lens barrel guide member 106 and lens barrel remain stationary and do not move. In addition, it should be understood that a size and shape of each of VCM guide members 108A-108F may be substantially the same, or in some cases, different, for example where camera modules having different sized VCMs and/or lens barrels are assembled within assembly tool 100. Additional features of VCM guide member 108 and its operation will be described in more detail in reference to **Fig. 3A-3D**.

[0027] Actuators 114, 116 may be of any size and shape suitable for driving movement of one or more of a VCM guide member 108. Representatively, in one embodiment, actuator 114 may include a slider bar 132 which slides along base member 102 and is rotatably connected to

each of VCM guide members 108A-108C by connectors 136. For example, in one embodiment, connectors 136 may be pins which are inserted into a connector opening 144 formed through the tail portion 122 of each of VCM guide members 108A-108C. Sliding of slider bar 132 across base member 102 using, for example, knob 134 extending from slider bar 132, rotates the associated VCM guide members 108A-108C in the desired direction (e.g. clockwise or counterclockwise). This, in turn, rotates a VCM within VCM guide members 108A-108C around an associated lens barrel positioned on the base member 102 to attach the two camera module components together.

[0028] Similarly, actuator 116 may include a slider bar 138 which slides along base member 102 and is rotatably connected to each of VCM guide members 108D-108F by connectors 142. For example, in one embodiment, connectors 142 may be pins which are inserted into a connector opening 144 formed through the tail portion 122 of each of VCM guide members 108D-108F. Sliding of slider bar 138 across base member 102 using, for example, knob 140 extending from slider bar 138, rotates the associated VCM guide members 108D-108F in the desired direction. This, in turn, rotates a VCM within VCM guide members 108D-108F around an associated lens barrel positioned on the base member 102 to attach the two camera module components together.

[0029] It should be understood that in one embodiment, actuator 114 and actuator 116 are two separate structures that are operated independent from one another. For example, actuator 114 may be used to drive movement of VCM guide members 108A-108C separate and independent from VCM guide members 108D-108F. In this aspect, VCM guide members 108A-108C and VCM guide members 108D-108F may be rotated in the same, or different, directions as desired. It is contemplated, however, that in other embodiments, actuator 114 and actuator 116 are connected, or formed as a single unit, such that they both slide simultaneously and therefore move all of VCM guide members 108A-108F together and in the same direction. In addition, although each of actuators 114, 116 are shown having a knob 134, 140, respectively, that can be used to slide them in the desired direction, it is contemplated that knobs 134, 140 may be optional and/or other mechanisms may be used to slide slider bars 132, 138, respectively. For example, in one embodiment, knobs 134, 140 are used to manually slide slider bars 132, 138 in the desired direction. In other embodiments, movement of VCM guide members 108A-108F is driven by a robotic machine, such as a pneumatic cylinder, or other mechanical device that operates automatically to drive movement of actuators 114, 116 and/or VCM guide members 108A-108F, with or without knobs 134, 140.

[0030] Assembly tool 100 may further include a cover member 128 which is attached to the top side 110 of base member 102 to enclose assembly tool 100. Cover member 128 may be a plate like structure having a similar footprint to that of base member 102 (e.g. a rectangular profile). Cover member 128 may include window 130, which aligns with the cavity 104 and lens barrel guide member 106 and VCM guide member 108 positioned therein, when cover member 128 is attached to base member 102. In embodiments where a number of cavities 104A-104F, lens barrel guide members 106A-106F and VCM guide member 108A-108F are provided, such as in the illustrated embodiment, a respective number of windows 130A, 130B, 130C, 130D, 130E and 130F are formed in cover member 128. Windows 130A-130F may have any size and shape suitable for allowing for insertion and/or removal of the camera module components (e.g. lens barrel and VCM) and assembled camera module within one or more of a cavity 104, lens barrel guide member 106 and VCM guide member 108 of base member 102. In addition, cover member 128 may include slots 146, 148, dimensioned to receive knobs 134, 140, respectively, to facilitate movement of slider bars 132, 138 using knobs 134, 140.

[0031] **Fig. 2** illustrates a perspective view of the assembled assembly tool of **Fig. 1**. Representatively, from this view, it can be seen that cover member 128 is attached to top side 110 of base member 102 to enclose assembly tool 100. Windows 130A-130F are aligned with each of a lens barrel guide member 106 and VCM guide member 108 positioned around the lens barrel guide member 106 such that the lens barrel and the VCM of the camera module 202 can be inserted and/or removed from assembly tool 100. In addition, it can be seen from this view that knobs 134, 140 used to drive movement of slider bars 132, 138 respectively, protrude through slots 146, 148, respectively, and are therefore accessible through cover member 128. Cover member 128 may be attached to base member 102 by any suitable mechanism, for example, a mechanical fastener such as a bolt, screw or the like, or a chemical fastener such as an adhesive or other chemical bonding agent. It is noted that the attachment of cover member 128 to base member 102 also helps to hold each of VCM guide members 108A-108F within their respective cavities 104A-104F formed in base member 102.

[0032] The operation of assembly tool 100 will now be described in more detail in reference to **Fig. 3A-Fig. 3D**. It should be understood that although a single cavity 104, lens barrel guide member 106 and VCM guide member 108, and assembly of a single camera module, are shown and described in **Fig. 3A-Fig. 3D**, the description applies to any one or more of cavities 104A-104F, lens barrel guide members 106A-106F and VCM guide members 108A-108F previously discussed in reference to assembly tool 100. In addition, cover member

128 is not shown in **Fig. 3A-Fig. 3D** so that additional aspects of the various assembly tool components can be shown in more detail.

[0033] Referring to **Fig. 3A**, **Fig. 3A** illustrates a magnified perspective view of a VCM guide member and lens barrel guide member of the assembly tool of **Fig. 1**. From this view, it can be seen that cavity 104 includes a pivot region 302 within which the head portion 120 of VCM guide member 108 is seated and a sliding region 304 within which the tail portion 122 is seated. The pivot region 302 and the sliding region 304 may have a depth substantially similar to a thickness of the VCM guide member 108 such that the VCM guide member 108 does not protrude above the top side 110 of base member 102. The pivot region 302 may have a cylindrical shape with a diameter only slightly larger than that of the head portion 120 such that the head portion 120 can rotate around the lens barrel guide member 106, more specifically extension member 118, within pivot region 302. The sliding region 304 may extend from the pivot region 302. The sliding region 304 may have a somewhat conical shape such that the tail portion 122 can slide from one side to the other of the pivot region 302 when the head portion 120 is rotated around the lens barrel guide member 106. The dimensions of the pivot region 302 may be used to control the angle of rotation of the VCM guide member 108, and in turn a rotation of a VCM around an associate lens barrel between a secure or locked position and an unlocked position, as will be described in more detail in reference to **Fig. 5A** and **Fig. 5B**.

[0034] It can further be seen from **Fig. 3A** that recessed region 124 is formed into a top side 306 of VCM guide member 108. Recessed region 124 may have a similar profile to that of a VCM such that a VCM can be held within recessed region 124 in a fixed orientation and position with respect to VCM guide member 108. In other words, the VCM, once positioned in recessed region 124, does not move with respect to VCM guide member 108. In this aspect, in some embodiments, recessed region 124 has a substantially square shaped profile and a depth similar to or less than a thickness of a VCM. In addition, in some embodiments, recessed region 124 may include one or more of perimeter cut-outs 308, 310, which are cut-outs formed within a side wall of the recessed region 124. The perimeter cut-outs 308, 310 may be of any size and shape suitable for forming a space between a sidewall of recessed region 124 and a VCM therein to facilitate removal of the VCM. Representatively, in one embodiment perimeter cut-out 308 is a circular cut-out from a corner of recessed region 124, which creates a gap between a corner of the recessed region 124 and a corner of a VCM positioned therein. In addition, perimeter cut-out 310 may be formed within a side wall of recessed region 124 such that a gap is formed between a side wall of recessed region 124 and a

side wall of a VCM positioned therein. A weight of the VCM helps to hold the VCM within VCM guide member 108.

[0035] It can further be seen from **Fig. 3A**, in combination with **Fig. 3B**, that the lens barrel guide member 106, more specifically extension member 118, extends through opening 126, which is formed within a center of recessed region 124 of VCM guide member 108. In this aspect, a lens barrel positioned on a top end of extension member 118 of lens barrel guide member 106 is, in turn, positioned within a center of recessed region 124. Further details of the relationship between the extension member 118 and VCM guide member 108 are shown in **Fig. 3B**.

[0036] In particular, **Fig. 3B** illustrates a cross-sectional perspective view of the VCM guide member and lens barrel guide member along line 3B-3B' of **Fig. 3A**. From this view, it can be seen that extension member 118 extends from a bottom 312 of cavity 104 and is positioned within opening 126 of VCM guide member 108. Extension member 118 has a height similar to, or slightly greater than, a thickness of the portion of VCM guide member 108 below the recessed region 124 such that a top end 314 of extension member 118 slightly protrudes into recessed region 124. In the illustrated embodiment, extension member 118 is shown having a substantially cylindrical shape, however, other sizes and shapes are contemplated, for example, extension member 118 may have a square or triangular cross-sectional shape.

[0037] Extension member 118 may also include a channel 316 running from the top end 314 to its bottom end 320. Said another way, extension member 118 may be hollow. In this aspect, a negative pressure or vacuum force, in other words a suction force, may, in some embodiments, be used to help hold the lens barrel on the extension member 118. Representatively, when a lens barrel is positioned on the top end 314 of extension member 118, a pump may be attached to the bottom end 320 of channel 316 to apply a suction force sufficient to hold the lens barrel to the top end 314. In this aspect, in some embodiments, a ring 318 may further be positioned on the top end 314 of extension member 118 to prevent vacuum leakage between the lens barrel and extension member 118. For example, in one embodiment, ring 318 may be a silicon ring attached to top end 314, such as by an adhesive of the like.

[0038] **Fig. 3C** illustrates a magnified perspective view of the VCM guide member and lens barrel guide member of **Fig. 3A** with a lens barrel attached to the lens barrel guide member. Representatively, a base 324 of lens barrel 322 is shown positioned on the top end 314 of extension member 118 of lens barrel guide member 106. Lens barrel 322 is therefore

positioned on extension member 118 and within recessed region 124 of VCM guide member 108. A suction force as previously discussed may be applied through extension member 118 to help hold lens barrel 322 in place.

[0039] **Fig. 3D** illustrates a perspective view of the VCM guide member and lens barrel guide member of **Fig. 3C** with a VCM positioned around the lens barrel. Representatively, VCM 326 is shown positioned around lens barrel 322, and within recessed region 124 of VCM guide member 108. VCM 326 may be positioned around lens barrel 322, such as by positioning a central opening of VCM 326 above lens barrel 322 and moving the VCM 326 down over the lens barrel 322 and into recessed region 124. Once in the recessed region 124, VCM 326 can then be rotated around lens barrel 322 to secure the two pieces together as will be described in more detail in reference to **Fig. 5A** and **Fig. 5B**.

[0040] **Fig. 4** illustrates a cross-sectional side view of the VCM guide member and lens barrel guide member along line 4-4' of **Fig. 3D**. From this view, the positioning of the VCM 326 with respect to the lens barrel 322 within assembly tool 100 can be seen. In particular, lens barrel 322 is shown resting on a top end 314 of extension member 118 of lens barrel guide member 106. In addition, in this view, it can be seen that in one embodiment, top end 314 of extension member 118 may have an orientation member 402 which fits within a complimentary shaped receiving area of the base 324 of lens barrel 322 such that lens barrel 322 is held in a desired orientation on extension member 118 and cannot rotate. For example, in one embodiment, orientation member 402 is a protrusion that fits within a recess formed in the base 324. A suction force in the direction of arrows 404 may further be applied to channel 316 to hold lens barrel 322 to extension member 118. VCM guide member 108 is further shown having VCM 326 within cavity 104, and positioned around lens barrel 322. In this aspect, when VCM guide member 108 is rotated around extension member 118, VCM 326 rotates around lens barrel 322 to secure the two pieces together. It is noted that orientation member 402 prevents lens barrel 322 from rotating during rotation of VCM 326. Once the VCM 326 is secured to lens barrel 322, the two pieces may be removed from the assembly tool 100 so that an image sensor and substrate (not shown) may be connected to the base of the lens barrel 322 and/or VCM 326 to complete the camera module.

[0041] **Fig. 5A** illustrates a top sectional view of one embodiment of the assembly tool of **Fig. 1** with the VCM guide members in an unlocked position. Representatively, in this view, a portion of base member 102 with cavities 104A-104C and VCM guide members 108A-108B is shown. It should be understood that although cavity 104C is shown, the associated VCM guide member 108C is removed so that further details of cavity 104C can be seen. In

particular, as illustrated by cavity 104C, each cavity may include a pivot region 302 within which the head portion 120 of VCM guide member 108 is seated and a sliding region 304 within which the tail portion 122 is seated. Sliding region 304 forms a substantially cone shaped cavity, the edges of which define an angle of rotation of the associated VCM guide member (e.g. VCM guide members 108A-108F). For example, in one embodiment, sliding region 304 may be dimensioned to allow the associated VCM guide member (e.g. VCM guide members 108A-108F) to have an angle of rotation α of less than 360 degrees.

Representatively, in one embodiment, the angle of rotation α may be less than 180 degrees, for example 90 degrees or less, more specifically, approximately 45 degrees or less, for example, from about 5 degrees to about 45 degrees, or from about 15 degrees to about 35 degrees or from 20 degrees to 30 degrees.

[0042] It should be understood that lens barrel 506 may be a “threadless” lens barrel, in other words, lens barrel 506 does not have external threading that is used to screw the lens barrel into the VCM. Lens barrel 506, therefore, does not require a full 360 degree rotation of the VCM 508 with respect to the lens barrel 506 to secure the two together, as may be the case with threaded barrel designs which may require multiple full rotations of the lens barrel with respect to the VCM. Therefore, an angle of rotation of less than 360 degrees is sufficient to secure VCM 508 to lens barrel 506.

[0043] Slider bar 132 of actuator 114 may drive rotation of VCM guide member 108A-108B (and 108C shown in Fig. 1) in either a clockwise or counter clockwise direction depending upon the direction slider bar 132 is advanced. Representatively, in **Fig. 5A**, slider bar 132 is initially positioned as close to side 514 of base member 102 as possible such that each of the associated VCM guide members 108A-108B are in a first position. The first position may be considered an “unlocked” position because in this position, a VCM 508 positioned within any one or more of VCM guide members 108A-108B is not secured, or otherwise locked, to a lens barrel 506 positioned on the associated lens barrel guide member of base member 102.

[0044] The locking system between the lens barrel 506 and VCM 508 can be seen more clearly in the magnified view shown in dashed lines. In particular, lens barrel 506 has a threadless design, in other words does not have threading around its outer surface, but instead includes radially protruding members 510A and 510B. In one embodiment, protruding members 510A and 510B are diametrically opposed to one another. VCM 508 further includes groove openings 512A, 512B which are connected to grooves 516A, 516B formed within the inner surface of VCM 508 and dimensioned to receive protruding members 510A, 510B. In

this aspect, to position VCM 508 around lens barrel 506, VCM 508 is inserted over lens barrel 506 such that protruding members 510A, 510B are positioned within groove openings 512A, 512B. VCM 508 may then be secured, or otherwise “locked,” to lens barrel 506 by advancing slider bar 132 in a direction of arrow 502, which in turn rotates VCM guide member 108A in a counter clockwise direction as illustrated by arrow 504. Rotation of VCM guide member 108A, in turn, rotates VCM 508 in a counter clockwise direction around lens barrel 506 so that protruding members 510A, 510B are positioned within the grooves 516A, 516B associated with groove openings 512A, 512B as shown in **Fig. 5B**.

[0045] In particular, **Fig. 5B** illustrates a top sectional view of the assembly tool of **Fig. 1** with the VCM guide members in a locked position. More specifically, VCM guide members 108A, 108B are rotated counter clockwise (in the direction of arrow 522) to a second position in this view, which in turn rotates the VCM 508 around lens barrel 506 to lock the two pieces together. In particular, as can be seen from the magnified view of VCM 508 and lens barrel 506, radially protruding members 510A and 510B are no longer aligned with groove openings 512A, 512B, and instead are now held within grooves 516A, 516B, and therefore VCM 508 is considered “locked”, or otherwise secured to, lens barrel 506.

[0046] In addition, it is noted that in some embodiments, base member 102 includes a track 518 for guiding a sliding movement of slider bar 132 along the top side of base member 102. In this aspect, track 518 may have any size, shape and depth suitable for guiding a sliding, or otherwise translational, movement of slider bar 132 along base member 102. For example, track 518 may have a similar width as slider bar 132 and a depth similar to a thickness of slider bar 132, but the length may be longer than slider bar 132 so that slider bar may slide a distance suitable for rotating each of the associated VCM guide members 108A-108F within a fixed angle of rotation α (e.g. from one side 514 to another side 520 of base member 102).

[0047] **Fig. 6** illustrates a top view of another embodiment of a VCM guide member for use within the assembly tool of **Fig. 1**. VCM guide member 600 is substantially similar to VCM guide member 108 described in reference to **Figs. 1-5B**, except in this embodiment, VCM guide member 600 includes a locking mechanism 608 which is used to lock a VCM 616 within the VCM guide member 600. In particular, similar to VCM guide member 108, VCM guide member 600 includes a head portion 602 and a tail portion 604. Head portion 602 includes recessed region 606 which is dimensioned to receive VCM 616. Locking mechanism 608 may be a plunger type mechanism which extends into recessed region 606 and imparts a radial force against a side of a VCM 616, which in turn, presses VCM 616 against the opposite wall of recessed region 606 to lock VCM 616 within VCM guide member 600.

[0048] Representatively, in one embodiment, locking mechanism 608 includes an end cap 612 which is connected to a resilient member 614. The end cap 612 is positioned within recessed region 606 and contacts the side of VCM 616 when it is positioned within recessed region 606. The resilient member 614 may extend in a lengthwise direction along the tail portion 604 of VCM guide member 600. The resilient member 614 may be, for example, a spring or other type of resilient member which is suitable for providing a resilient or elastic force in a direction of arrow 618. In one embodiment, locking mechanism 608 may be secured to VCM guide member 600 using a bracket 610. Bracket 610 may be, for example, a U shaped member which extends along tail portion 604. The end of resilient member 614 may be attached to the closed end of bracket 610 (i.e. the bottom of the U) such that the end cap 612 attached to the other end of resilient member 614 is free to spring in and out of bracket 610 in a direction of arrow 618.

[0049] To lock VCM 616 within recessed region 606, resilient member 614 may be compressed to provide more space within recessed region 606 for insertion of VCM 616. Once VCM 616 is within recessed region 606, resilient member 614 may be released such that it springs toward VCM 616 and end cap 612 presses VCM 616 against the wall of recessed region 606 to lock voice oil motor 616 within VCM guide member 600. VCM 616 may then be rotated around lens barrel 620 as previously discussed to secure the two pieces of the camera module together. The assembled camera module with VCM 616 secured to lens barrel 620 may, in turn, be removed from VCM guide member 600 by compressing resilient member 614 to create more space within recessed region 606 and, in turn, unlock VCM 616 from recessed region 606. Once unlocked, the assembled camera module may be removed from VCM guide member 600. It should be understood that VCM guide member 600 may be used in combination with, or in place of, any of the previously discussed VCM guide members 108.

[0050] **Fig. 7** is a block diagram illustrating a process of assembling a camera module. Representatively, in one embodiment, process 700 includes positioning a lens barrel on a base member (block 702). The base member may be, for example, base member 102 previously discussed in reference to **Fig. 1** which is a jig having a cavity and lens barrel guide member (e.g. an extension member) dimensioned to hold the lens barrel in a fixed position such that the lens barrel does not rotate on the base member. Process 700 may further include positioning a VCM within a guide member that is rotatably connected to the base member and positioned around the lens barrel (block 704). The guide member may be, for example, a VCM guide member 108 such as that previously described in reference to **Fig. 1**. In particular, the guide member may include a recessed region within which the lens barrel and the VCM are

positioned. To secure the VCM to the lens barrel, process 700 may further include rotating the VCM around the lens barrel by rotating the guide member with respect to the base member (block 706). The guide member may be rotated between a first position in which the VCM is not locked to the lens barrel and a second position in which the VCM is locked to the lens barrel. In some embodiments, the guide member may be rotated along an angle of rotation of forty-five degrees or less to lock the VCM to the lens barrel. In one embodiment, the guide member is rotatably connected to a slider bar and sliding the slider bar across the base member rotates the guide member. In still further embodiments, process 700 may further include applying a suction force to hold the lens barrel on the base member, as previously discussed in reference to **Fig. 4**.

[0051] While certain embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that the invention is not limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those of ordinary skill in the art. For example, in some embodiments, assembly of the camera module using the tool assembly may be automated by a robotic system which performs each of the previously discussed assembly operations. The description is thus to be regarded as illustrative instead of limiting.

CLAIMS

What is claimed is:

1. An assembly tool for assembling a camera module, the assembly tool comprising:
a base member having a lens barrel guide member, the lens barrel guide member operable to position a lens barrel on the base member;
a voice coil motor (VCM) guide member positioned around the lens barrel guide member, the VCM guide member having a recessed region operable to receive and position a VCM around a lens barrel associated with the lens barrel guide member; and
an actuator connected to the base member and the voice coil guide member, wherein the actuator is operable to rotate the VCM guide member around the lens barrel guide member so as to secure a VCM received by the VCM guide member to a lens barrel associated with the lens barrel guide member.
2. The assembly tool of claim 1 wherein the lens barrel guide member comprises a pin member extending from the base member.
3. The assembly tool of claim 2 wherein an end of the pin member is dimensioned to fit within a recess formed in a base of the lens barrel so that the lens barrel position is fixed.
4. The assembly tool of claim 2 wherein a channel is formed through the pin and a suction force is applied through the channel to hold the lens barrel to the pin.
5. The assembly tool of claim 1 wherein the lens barrel guide member is positioned within a cavity formed in the base member.
6. The assembly tool of claim 5 wherein the cavity is dimensioned to receive the VCM guide member and allow the VCM guide member to rotate around the lens barrel guide member.
7. The assembly tool of claim 1 wherein the lens barrel guide member is one of a plurality of lens barrel guide members and the VCM guide member is one of a plurality of VCM guide members such that the assembly tool is operable to secure a plurality of VCMs received by the

plurality of VCM guide members to a plurality of lens barrels associated with the plurality of lens barrel guide members.

8. The assembly tool of claim 1 wherein the VCM guide member comprises an opening within the recessed region and through which the lens barrel guide member is inserted.

9. The assembly tool of claim 1 wherein the lens barrel remains in a fixed orientation when the VCM guide member is rotated around the lens barrel guide member.

10. A tool for attaching a lens barrel to a voice coil motor (VCM), the tool comprising:
a base member, the base member having a lens barrel guide member and a voice coil motor (VCM) guide member cavity formed around the lens barrel guide member; and
a VCM guide member dimensioned to fit within the VCM guide member cavity and operable to rotate with respect to the lens barrel guide member, the voice coil guide member having a recessed region and an opening within the recessed region, the recessed region dimensioned to receive a VCM and the opening dimensioned to receive the lens barrel guide member and wherein a rotation of the voice coil guide member secures a VCM within the recessed region to a lens barrel positioned on the lens barrel guide member.

11. The tool of claim 10 wherein the lens barrel guide member is an extension member extending from a bottom of the VCM guide member cavity.

12. The tool of claim 10 further comprising an actuator connected to the VCM guide member to drive rotation of the VCM guide member.

13. The tool of claim 12 wherein the actuator is a slider bar that is rotatably connected to the VCM guide member and operable to slide with respect to the base member.

14. The tool of claim 10 further comprising a locking member positioned within the recessed region of the VCM guide member to hold the VCM within the recessed region.

15. The tool of claim 10 further comprising a cover member attached to the base member, the cover member having an opening aligned with the lens barrel guide member and the VCM guide member.

16. A method of assembling a camera module, the method comprising:
positioning a lens barrel on a base member, the base member operable to hold the lens barrel in a fixed position;
positioning a voice coil motor (VCM) within a guide member that is rotatably connected to the base member and positioned around the lens barrel, the guide member having a recessed region within which the lens barrel and the VCM are positioned; and
rotating the VCM around the lens barrel by rotating the guide member with respect to the base member.
17. The method of claim 16 wherein rotating the guide member comprises rotating the guide member between a first position and a second position, wherein in the first position, the VCM is locked to the lens barrel and, in the second position, the VCM is not locked to the lens barrel.
18. The method of claim 16 wherein rotating the guide member comprises rotating the guide member along an angle of rotation of forty-five degrees or less to lock the VCM to the lens barrel.
19. The method of claim 16 wherein rotating the guide member comprises sliding a slider bar rotatably attached to the guide member across the base member.
20. The method of claim 16 wherein a suction force is used to hold the lens barrel on the base member.