

Camera Assembly

FIELD OF INVENTION

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The invention relates broadly to a camera assembly.

BACKGROUND

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Pan and tilt assemblies have been employed to allow mounted cameras thereon to capture images around respective panning and tilting axes.

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Conventional pan and tilt assemblies, along with their mounted cameras, are typically housed in transparent hemispherical dome structures to protect the various components from surrounding weather conditions. However it will be appreciated that the hemispherical dome structure acts as an array of spherical lenses, in addition to the lens unit already present in the mounted cameras. This array of lenses will introduce associated image distortion phenomena such as spherical and chromatic aberrations, astigmatism, coma and collimation errors to the images captured by the mounted camera. The introduction of the hemispherical dome structure also increases the weight of the entire camera assembly, making the entire assembly unsuitable for vehicles that require a light load.

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Further, as the pan and tilt assemblies repeatedly rotate the mounted cameras, stress is introduced, especially at a terminal of a camera cable connecting the mounted camera to peripheral devices. The risk of breakage at the terminal thus increases.

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There is thus a need to have a pan and tilt assembly that addresses one or more of the above disadvantages.

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SUMMARY

According to a first aspect of the invention, there is provided a camera assembly comprising a camera; a tilting servomotor mechanically coupled to the camera for tilting the camera; a first support structure comprising a pan table for supporting the tilting servomotor and a camera converter board; a panning servomotor mechanically coupled to the pan table for panning the camera; a second support structure for supporting the panning servomotor; a first camera cable coupled between the camera and to the camera converter board on a side of the pan table facing the camera, and a second camera cable coupled to the camera converter board on an opposite side of the pan table facing the second support structure and extending through an opening in the second support structure.

The first cable may be secured at the camera converter board by a compression force exerted by a camera converter board casing mounted on the pan table for covering the camera converter board.

The second cable may be secured at the camera converter board by a first harness retainer element connected to the pan table.

The second cable may be secured at the second support structure by a second harness retainer element connected to the second support structure.

The first and second harness retainer elements may comprise securing plates for securing the second cable by a compressive force exerted by the securing plates.

The tilting servomotor may be coupled to the camera via a camera securing base; and the first cable may be secured to the camera securing base.

The first cable may be secured to the camera securing base via a clamp structure.

The first support structure may comprise at least one pylon mounted on the pan table, wherein the tilting servomotor may be mounted on one of the pylons.

The second support structure may comprise a pan table base adaptor for receiving and mounting the panning servomotor.

5 The second camera cable may be curled in a space defined between the pan table and the pan table base adaptor.

10 The camera assembly may further comprise a housing for housing the camera, the housing may be coupled to the tilting servomotor, wherein the first camera cable may be curled in a space defined between the housing and the pan table.

The housing may comprise a tilt drum.

15 The camera assembly may further comprising a protective lens, the protective lens may be held perpendicular to an optical axis of the camera through a protective lens mounting.

The protective lens may comprise a flat lens.

20 The flat lens may remain perpendicular to the optical axis as the camera rotates.

25 The camera assembly may further comprise a first servomotor cable coupled to the tilting servomotor, the first servomotor cable being secured to the opposite side of the pan table facing the second support structure and extending through the opening in the second support structure.

The camera assembly may further comprise a second servomotor cable coupled to the panning servomotor.

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BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

5 Figure 1 shows a perspective view of the various components that comprise a camera assembly built in accordance with one embodiment of the invention.

10 Figure 2 shows an exploded view of a tilting component of the camera assembly of Figure 1 disposed above an interface component of the camera assembly of Figure 1.

15 Figure 3 shows a perspective view of the components that comprise a panning component of the camera assembly of Figure 1.

20 Figure 4 shows a camera system.

25 Figure 5 shows the camera assembly of Figure 1 when the camera assembly is fully assembled.

DETAILED DESCRIPTION

30 Figure 1 shows a perspective view of the various components that comprise a camera assembly 100 built in accordance with one embodiment of the invention.

35 The camera assembly 100 includes a pan-tilt casing 102, a tilting component 104, an interface component 106 and a panning component 108.

40 The interface component 106 includes a pan table 110, a camera converter board 114, a board casing 112 and pylon fastening plates 116a and 116b. The pan table 110 includes a pan-tilt casing securing plate 124 having two fastening holes 124a and 124b disposed on two opposite ends of the plate 124. The board casing 112 has a fastening hole 112a on a protruding tip of the board casing 112. When the interface component 106 is assembled, the camera converter board 114 engages the pan table 110 through an opening 132, while the board casing 112 covers the camera converter board 114.

The panning component 108 includes a pan table adaptor 122, a bearing 142, a pan table base adaptor 144 and a panning servomotor section 146. The panning servomotor section 146 further includes a shaft 148, four servomotor spacers 150 and a panning servomotor 162.

When the panning component 108 is assembled, the panning servomotor section 146 is housed within the pan table base adaptor 144. Grooves (not shown) on opposite sides of the bearing 142 allow the shaft 148 to engage one side of the bearing 142 while the pan table adaptor 122 engages the opposite side of the bearing 142. The panning servomotor section 146 is fastened to the pan table base adaptor 144 via fastening means that engage the four servomotor spacers 150 through four correspondingly located bores 152.

When the camera assembly 100 is assembled, the tilting component 104 is fastened to one side of the pan table 110 using fastening means, e.g. in the form of screws (not shown) that engage the bases of a servo pylon 118 and a bearing pylon 120, the pan table 110 and the respective pylon fastening plates 116a and 116b. The panning component 108 is secured to the other side of the pan table 110 through the pan table adaptor 122 using, e.g. screws. The pan-tilt casing 102 is secured to the pan table 110 via the fastening holes 124a, 124b and 112a to house the components 104, 106 and 108.

When the panning servomotor 162 is activated, only the shaft 148 rotates. This causes the pan table adaptor 122, the interface component 106, the tilting component 104 and the pan-tilt casing 102 to correspondingly rotate, facilitated by the bearing 142, while the pan table base adaptor 144 remains stationary.

Figure 2 shows an exploded view of the tilting component 104 of the camera assembly 100 of Figure 1 disposed above the interface component 106.

The tilting component 104 includes a tilt drum 202, the tilt drum 202 comprising a cylindrical shaped camera drum casing 210 closed on respective ends by a driving disc 216 and an idling disc 218. The driving disc 216 and the idling disc 218 engage the

ends of the camera drum casing 210 through respective skirtings 212 and 214. The driving disc 216 is mechanically coupled through a circular servo control disc 206 to a tilting servomotor 204, while the tilting servomotor 204 is connected to the servo pylon 118. The idling disc 218 is mechanically coupled through a pinion 208 to the bearing pylon 120. The servo pylon 118 and the bearing pylon 120 support the tilt drum so that the tilt drum 202 is free to rotate 280 clockwise or anti-clockwise around a tilting axis 282 of the tilting servomotor 204.

The camera drum casing 210 houses a camera 220, a camera securing base 222, a shaft 234, a lens securing board 224, a protective lens 226 and a protective lens retainer 228.

The securing base 222 has a main body and two pairs of legs 222a and 222b. The securing base 222 further includes a cable securing plate 270 disposed between the pairs of legs 222a and 222b in the area adjacent to the rear of the camera 220. The cable securing plate 270 is secured to the securing base 222 by, for example, two M2 screws located at the two corners of the cable securing plate 270.

One pair of the legs 222b engages a surface of the driving disc 216 while the other pair of the legs 222a engages an opposing surface of the tilt drum 202. In this manner, the securing base 222 main body supports the camera 220. Similarly, one end of the beam 234 engages the same surface of the driving disc 216 while the other pair engages the same opposing surface of the tilt drum 202. Thus, the camera 220, the securing base 222 and the beam 234 will correspondingly rotate 280 when the tilt drum 202 is rotated 280 around the tilting axis 282, the rotation 280 of the tilt drum 202 being brought about when the tilting servomotor 204 is activated.

By employing a tilting servomotor 204, a wide rotation angle 280 around the tilting axis 282 is achievable. Specifically, the tilting servomotor 204 is capable of rotating the tilt drum 202 by about -45° to about $+135^{\circ}$ around a default starting position in which the camera 220 is in a horizontal position. It will be appreciated that a wider rotation range is achievable by using tilting servomotors that provide a larger rotating angle.

In contrast, conventional tilt camera assemblies employ stepper motors instead of servomotors. Tilting stepper motors typically only allow for a total rotation of about 70° around the tilting axis of the respective tilting stepper motor. Further, the degree of rotation afforded by the tilting stepper motors is restricted by the mechanical limit of the tilting stepper motors, and additional supports are required to accommodate a wider tilting rotating angle. This results in a heavier camera system and in turn requires a larger stepper motor to effect the larger rotation. Thus, the rotation afforded by the tilting servomotor 204 allows for a much wider and scalable tilting envelope.

A first camera cable 260 allows the camera 220 to be connected to peripheral devices. One end 260a of the first camera cable 260 is connected to the camera 220 while the other end 260b of the first camera cable 260 is connected to a cable connector 232 on the upper surface of the camera converter board 114. Thus, the first camera cable 260 is coupled between the camera 220 and the camera converter board 114 on a side of the pan table 110 facing the camera 232. The portion of the first cable 260 that is connected to the cable connector 232 is secured at the camera converter board 114 by a compression force exerted by the camera converter board casing 112 mounted on the pan table 110 for covering the camera converter board 114. In this manner, the camera converter board casing 112 and the pan table 110 act as a clamp structure.

An opening 236 on the camera drum casing 210 allows for the end 260a of the first camera cable 260 to enter the camera drum casing 210 and be electrically coupled to the camera 220. A portion of the first cable 260 is secured to the camera securing base 222 through a compressive force exerted by the cable securing plate 270 attached to the securing base 222. In this manner, the cable securing plate 270 and the securing base 222 acts as a clamp structure.

It will be appreciated that the clamping structures provided by the camera converter board casing 112 and the pan table 110, along with the cable securing plate 270 and the securing base 222, will cause the first cable 260 to have negligible movement at the first cable ends 260a and 260b as the tilt drum 202 rotates 280. This greatly reduces the risk of dislodgement of the first cable 260 from the camera 220 at the cable end 260a and dislodgement of the first cable 260 from the cable connector 232 at

the first cable end 260b. Thus, it will be appreciated that the clamping structures act as stress-relieving interfaces that alleviate dislodgement at the respective ends 260a and 260b of the first cable 260.

5 Sealant (not shown) seals the gap between the portion of the camera cable 260 adjacent to the opening 236. In this manner the assembled tilt drum 202 is kept sealed, eliminating the need for a protective camera dome to protect the camera 202 from surrounding weather conditions.

10 In conventional tilt camera assemblies that have their camera cable ends connected to terminal ends without a securing mechanisms such as the clamp mechanisms described above, the constant tilting angular movement of the assembly causes stress at their camera cable ends, thereby increasing the risk of dislodgement at their camera cable ends.

15 At an initial position of the tilt drum 202, the first camera cable 260 between the opening 236 and the camera converter board casing 112 is curled in the space defined between the pan table 110, the tilt drum 202 and the pylons 118 and 120. As the tilt drum 202 is rotated, the first camera cable 260 will roll around/unroll from the tilt drum
20 202 and re-curl/curl in the space defined between the pan table 110, the tilt drum 202 and the pylons 118 and 120. It will be appreciated that the curling and uncurling of the first camera cable 260 reduces breakage stress at the cable ends 260a and 260b. The rolling and unrolling of the first camera cable 260 around the tilt drum 202 advantageously assists in preventing the camera cable 260 from blocking the camera
25 220 during tilt drum 202 rotation.

 In this embodiment, the camera cable portion 260d between the opening 236 and the opening 132 is of sufficient length to allow the camera to rotate from about -45° to about $+135^{\circ}$ around the tilting axis 282 from the initial position in which the camera 220
30 is in a horizontal position.

 It will be appreciated that if the length of the first camera cable 260 is accordingly extended, the camera 220 will be able to rotate more than 180° around the tilting axis 282, such as one complete clockwise or one complete anticlockwise

revolution around the tilting axis 282. In such an embodiment, the tilting servomotor 204 allows the camera 220 to trace more than a substantially semicircular path about the tilting axis 282.

5 A servomotor cable 290 allows the tilting servomotor 204 to receive control signals from a motor controlling device (not shown) to operate the tilting servomotor 204. Only a portion of the servomotor cable 290 is illustrated in Figure 2. One end 290a of the servomotor cable 290 is connected to the tilting servomotor 204 while the portion 290b of the servomotor cable 290 exits the pan table 110 through the opening 132.
10 The portion 290b of the servomotor cable 290 is secured by a compression force exerted by the camera converter board casing 112 mounted on the pan table 110 for covering the camera converter board 114.

 In contrast to the first camera cable 260, the servomotor cable 290 remains
15 stationary as the tilt drum 202 rotates. To ensure that the servomotor cable 290 remains stationary, one possible approach is to have one portion 290c of the servomotor cable 290 secured along the pan table 110 using for example, clamps secured to the pan table 110 on a side of the pan table 110 facing the camera 232, and a remaining portion 290d of the servomotor cable 290 secured to the servo pylon 118 using for
20 example, clamps secured to the servo pylon 118.

 The camera converter board 114 acts as a wiring interface board to allow thinner and more flexible cables, such as ribbon cable, to be used for the first camera cable 260, instead of other cables such as coaxial cables, which are thicker and more inflexible.
25 This can further facilitate the tilting action. Ribbon cable can also be used for the servomotor cable 290.

 The lens securing board 224 has a circular opening that allows for snug engagement with the protective lens 226. Further, the lens securing board 224 is
30 disposed so that the plane of the protective lens 226 is substantially perpendicular to an optical axis of the camera 220 lens. The protective lens 226 is secured to the lens securing board 224 via the protective lens retainer 228, where a portion of the protective lens retainer 228 protrudes from the composite casing through an opening 230. The protective lens retainer 228, the protective lens 226 and the lens securing board 224 will

correspondingly rotate when the tilt drum 202 is rotated around the tilting axis 282 so that the plane of the protective lens 226 remains substantially perpendicular to the optical axis of the camera 220 lens as the tilt drum 202 rotates.

5 By positioning the plane of the protective lens 226 substantially perpendicular to the optical axis of the camera 220 lens, the protective lens 226 contributes negligible optical distortion phenomena to images captured by the camera 220 from light penetrating the protective lens 226. This can advantageously eliminate the need to use a special material that corrects such optical distortion phenomena, (such material
10 typically having to be used for the dome-shaped cover in existing systems) and allows the protective lens 226 to be an inexpensive flat lens.

The protective lens retainer 228 allows the use of a flat lens ensuring that images captured by the camera 220 have as little distortion as possible. Having the ability to
15 use a flat lens is e.g. advantageous when the camera 220 is an infra red camera, which typically requires a flat lens. Further, the protective lens retainer 228 allows for the protective lens 226 to be easily interchanged to different lenses.

In one embodiment, camera model FCB-780BPP from Sony is used for the
20 camera 220, where it is to be appreciated that other camera models can be used as well. The securing base 222 can be adapted to accommodate other cameras 220 by drilling bores through the securing base 222 that are aligned with the securing means disposed on such other cameras 220. In one embodiment, an acrylic plastic lens is used for the protective lens 226. In other embodiments, the flat lens can be made from glass
25 or comprise an infra red camera lens.

Figure 3 shows a perspective view of the components that comprise the panning component 108 of the camera assembly 100 of Figure 1.

30 From Figure 3, it can be observed that when the panning component 108 is assembled, the shaft 148 of the panning servomotor 162 engages the shaft member 322 of the pan table adaptor 122 through a hole 314 on the pan table base adaptor 144. The bearing 142 between the control arm 144 and the pan table adaptor 122 facilitates rotating of the pan table adaptor 122. Further, it will be appreciated that the pan table

adaptor 122 is mechanically coupled to the bottom of the pan table 110 (Figure 2) through e.g. screws that engage openings 318 on the pan table adaptor 122.

By employing a panning servomotor 162, a wide rotation angle 380 around a panning axis 382 is achievable. Specifically, the panning servomotor 162 is capable of rotating the tilting component 104 (Figure 2) by about $\pm 90^\circ$ clockwise or anti-clockwise from an initial position, in which the camera is in a default forward position, so that the tilting component 104 (Figure 2) can rotate a total angle of about 180° around the panning axis 382. In this manner, the panning servomotor 162 allows the camera 220 (Figure 2) to trace a substantially semicircular path about the panning axis 382. It will be appreciated that a wider panning angle can be achieved through the use of a suitable servomotor.

In contrast, conventional pan camera assemblies employ stepper motors instead of servomotors. Panning stepper motors typically allow for a total rotation of about 70° to 120° around the panning axis of the respective panning stepper motor. Thus, the rotation 280 afforded by the panning servomotor 162 allows for a much wider panning envelope than conventional pan camera assemblies.

One end 360a of a second camera cable 360 is coupled to the camera converter board 114 (Figure 2) through the opening 132 on the side of the pan table 110 that is facing the pan table base adaptor 144. The other end 360b of the second camera cable 360 extends through an opening 320 in the pan table base adaptor 144 to eventually terminate at a terminal 360t that allows the camera 220 (Figure 2) to be connected to peripheral devices. Such peripheral devices can include an external processing device 361 for the camera 220 (Figure 2) for control signals and data signals to and from the camera 220 (Figure 2).

A first cable harness retainer 370 is located adjacent to the opening 132 on the side of the pan table 110 that is facing the pan table base adaptor 144. The first cable harness retainer 370 secures a portion of the second camera cable 360, through a compressive force, to the pan table 110. In this manner, the second cable 360 is secured at the camera converter board 114 (Figure 2) by the first harness retainer element (not shown) connected to the pan table 110.

A second cable harness retainer 372 is located underneath the pan table base adaptor 144 adjacent to the opening 320. The second cable harness retainer 372 secures, using a compressive force, a portion of the second camera cable 360 to the
5 bottom of the pan table base adaptor 144.

The first and second cable harness retainers 370 and 372 are, for example, structures comprising rectangular delrin securing plates that are secured to the pan table 110 and the pan table base adaptor 144 using, for example, a pair of M3 screws
10 respectively. In this manner, the second cable 360 is secured at the camera converter board 114 (Figure 2) and at the pan table base adaptor 144 by compressive forces exerted by the respective rectangular delrin securing plates.

It will be appreciated that the first and second cable harness retainers 370, 372
15 act as securing structures that cause the second cable 360 to have negligible movement at the second cable ends 360a and 360b as the pan table 110 rotates 380. This reduces the risk of dislodgement of the second cable 360 from the camera converter board 114 (Figure 2) at the second cable end 360a and dislodgement of the second cable 360 from the terminal 360t at the second cable end 360b. Thus, it will be
20 appreciated that the harness retainers 370, 372 act as stress-relieving interfaces that alleviate dislodgement at the respective ends 360a and 360b of the second cable 360.

In conventional pan camera assemblies that have their camera cable ends connected to terminal ends without securing mechanisms such as the harness retainers
25 described above, the constant panning angular movement of the assembly causes stress at their camera cable ends thereby increasing the risk of dislodgement at their camera cable ends.

At an initial position of the pan table adaptor 122, the portion 360e of the second
30 camera cable 360 between the opening 320 and the opening 132 is curled in the space defined between the pan table base adaptor 144 and the pan table 110. As the panning servomotor 162 rotates 380 the pan table adaptor 122 around the panning axis 382, the curled cable portion 360e of the second camera cable 360 will uncurl to roll around the pan table base adaptor 144. As the pan table adaptor 122 returns to its initial starting

position, the camera cable portion 360e will unroll from the pan table base adaptor 144 and re-curl in the space defined between the pan table base adaptor 144 and the pan table 110. It will be appreciated that the curling and uncurling of the camera cable portion 260e reduces breakage stress at the cable ends 360a and 360b..

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In this embodiment, the second camera cable portion 360e between the opening 132 (Figure 2) and the opening 320 is of sufficient length to allow the camera 220 (Figure 2) to rotate 380 about 180° around the panning axis 382.

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It will be appreciated that if the length of the second camera cable 360 is accordingly extended, the camera 220 (Figure 2) will be able to rotate more than 180° around the panning axis 382, such as one complete clockwise or one complete anticlockwise revolution around the panning axis 382. In such an embodiment, the panning servomotor 162 allows the camera 220 (Figure 2) to trace more than a substantially semicircular path about the panning axis 382.

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The servomotor cable 290 extending from the opening 132 of the pan table 110 is also secured by the first and second harness retainers 370 and 372.. The other end 290e of the servomotor cable 290 extends through the opening 320 in the pan table base adaptor 144 to eventually terminate at a motor controlling device 302. The motor controlling device 302 is disposed beneath the panning servomotor 162.

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A substantial portion of the servomotor cable 290 is adjoined to a corresponding portion of the second camera cable 360, and it will be appreciated that the adjoined portion of the servomotor cable 290 rolls and unrolls around the pan table base adaptor 144 in the same manner as the second camera cable 360 as the panning servomotor 162 operates.

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The motor controlling device 302 is connected to the panning servomotor 162 through a second servomotor cable 390. It will be appreciated that the second servomotor cable 390 remains stationary as the panning servomotor 162 operates. Ribbon cable can be used for the second servomotor cable 390.

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Again, the camera converter board 114 (Figure 2) acts as a wiring interface board to allow thinner and more flexible cables, such as ribbon cable, to be used for the second camera cable 360, instead of other cables such as coaxial cables, which are thicker and more inflexible. This can further facilitate the panning action.

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Figure 4 shows a camera system 400.

The camera system 400 comprises the camera assembly 100 of Figure 1 and the motor controlling device 302 of Figure 3. The motor controlling device 302 is in electrical communication with the tilting servomotor 204 and the panning servomotor 162.

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The servomotors 204 and 162 are driven by appropriate pulse width modulation (PWM) signals from the motor controlling device 302. "Off-the-shelf" PWM signal generators 404 can be used in the motor controlling device 302 for directly controlling the servomotors 204 and 162. Thus, a form of electronic communication standardisation has been achieved between the motor controlling device 302 and the servomotors 204 and 162, producing the advantage of reducing the amount of signal processing.

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Similarly, as common "off-the-shelf" servomotors 204 and 162 are used in the camera assembly 100, access to the programming code corresponding to the servomotors driving signal characteristics are readily available.

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In contrast, stepper motors used in existing camera systems are not driven by PWM signals. Thus, the driving signals from an associated control processor have to be converted into suitable signals before they can operate the stepper motors. In addition, different programming codes have to be used for stepper motors manufactured from different suppliers. Thus, programming code standardisation is not achieved.

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Figure 5 shows the camera assembly 100 of Figure 1 when the camera assembly 100 is fully assembled.

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An example application of the camera assembly 100 is in an unmanned aerial vehicle (UAV, not shown) for surveillance purposes. In such an application, the camera assembly 100 can be mounted on the nose of the UAV. The camera assembly 100

can also be used on other vehicles, including unmanned balloons, remote controlled scouting vehicles and wind guided aerial vehicles.

Most components of the camera assembly 100 are manufactured using lightweight materials such as wood, derlin and/or carbon composite fibre fabric. Table 1 below summarises the weight of the components used to produce a prototype of the camera assembly 100, where most of the material used is wood. When wood is used for the camera assembly 100, the wood has to be first painted and subsequently sprayed with a few layers of clear epoxy finishing as a weather proofing agent. It will be appreciated that not all of the components listed in table 1 have been described above or shown in Figures 1 to 5.

Table 1: Summary of components used in camera assembly 100 prototype

Component	Weight(g)	Qty	Total Weight(g)
Driving Disc 216	28.86	1	28.86
Idling Disc 218	28.89	1	28.89
Lens Securing Board 224	5.61	1	5.61
Protective Lens Retainer 228	16.81	1	16.81
Protective Lens 226	3.62	1	3.62
Camera Securing Base 222	9.14	1	9.14
Camera Drum Casing 210	23.64	1	23.64
Camera Drum Pinion 208	1.96	1	1.96
Pinion Washer	0.32	1	0.32
M10 Thin Nut	1.204	1	1.204
Drum Bearing Spacer	0.08	1	0.08
Bearing Pylon 120	15.81	1	15.81
Servo Pylon 118	16.3	1	16.3
Pan Table 110	36.98	1	36.98
Camera Converter Board Casing 112	4.07	1	4.07
Harness Retainer	0.85	1	0.85
Pan Table Adaptor 122	7.74	1	7.74
Pylon Fastening Plate 116a, 116b	2.34	2	4.68
Servo Spacer	0.4	1	0.4
Servo Holder	1.17	1	1.17
Servo Holder Wire	2.7	1	2.7
Servo Control Arm XL Modified 148	4.15	1	4.15
Control Arm Adaptor	3.56	1	3.56
Pan table base Adaptor 144	56.86	1	56.86
Pan-tilt Casing 102	64.04	1	64.04
Camera 220	135.9	1	135.9
Converter Board 114	3	1	3
Servomotors 162, 204(JR DS3801)	30	2	60

Round Control Arm		1.72		1		1.72
Tilt Bearing		2.05		1		2.05
Pan Bearing 142		1.35		1		1.35
	Gross Weight					543.464
	Gross Weight less Camera					407.564

In the embodiment where carbon composite is used, the gross weight of the camera assembly 100 is around 350g. As carbon composite is inert to environmental conditions, it produces the advantage of not requiring protective treatment as opposed to using wood. Due to the advantages of achieving a light weight camera assembly 100 and requiring no further protective treatment, carbon composite is preferably used to manufacture the camera assembly 100.

Compared to conventional pan-and-tilt camera assemblies that typically weigh around 800g without their protective dome, the embodiments of the camera assembly 100 that use wood and carbon composite material are lighter in weight.

In contrast to conventional pan and tilt camera assemblies, the camera assembly 100 does not require a protective camera dome to protect the camera housed within the tilting component 104, as the camera is housed under air-tight conditions. Thus, a lighter camera assembly 100 is achieved, in addition to reducing the cost to manufacture the camera assembly 100.

Furthermore, in conventional pan and tilt camera assemblies that employ a transparent hemispherical dome structure to house and protect their pan and tilt assemblies and their camera mounted thereon, the hemispherical dome structure acts as an array of spherical lenses. This array of lenses will introduce associated image distortion phenomena such as spherical and chromatic aberrations, astigmatism, coma and collimation errors to the images captured by the mounted camera. Thus, eliminating such a protective camera dome provides the advantage of images captured by the camera being free from these associated image distortion phenomena.

Another advantage that the camera assembly 100 provides is having separate first and second camera cables 260 (Figure 2) and 360 (Figure 3) for the tilting and panning components 104 (Figure 2) and 108 (Figure 3) respectively as opposed to using

a single camera cable. Having separate cables for the tilting and the panning components 104 (Figure 2) and 108 (Figure 3) allows the stresses that arise from the tilting and the panning angular rotations to be confined within the respective cable disposed at the tilting and the panning components, rather than having the combined effect applied onto a single camera cable. This reduces the stress experienced at the camera cable ends.

It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. A camera assembly comprising

5 a camera;

a tilting servomotor mechanically coupled to the camera for tilting the camera;

a first support structure comprising a pan table for supporting the tilting servomotor and a camera converter board;

10 a panning servomotor mechanically coupled to the pan table for panning the camera;

a second support structure for supporting the panning servomotor;

a first camera cable coupled between the camera and to the camera converter board on a side of the pan table facing the camera, and

15 a second camera cable coupled to the camera converter board on an opposite side of the pan table facing the second support structure and extending through an opening in the second support structure.

2. The camera assembly according to claim 1, wherein the first cable is secured
20 at the camera converter board by a compression force exerted by a camera converter board casing mounted on the pan table for covering the camera converter board.

3. The camera assembly according to claims 1 or 2, wherein the second cable
25 is secured at the camera converter board by a first harness retainer element connected to the pan table.

4. The camera assembly according to any one of the preceding claims, wherein
the second cable is secured at the second support structure by a second harness
30 retainer element connected to the second support structure.

5. The camera assembly according to claims 3 or 4, wherein the first and
second harness retainer elements comprise securing plates for securing the second
cable by a compressive force exerted by the securing plates.

6. The camera assembly according to any one of the preceding claims, wherein the tilting servomotor is coupled to the camera via a camera securing base; and the first cable is secured to the camera securing base.

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7. The camera assembly according to claim 6, wherein the first cable is secured to the camera securing base via a clamp structure.

8. The camera assembly according to any one of the preceding claims, wherein the first support structure comprises at least one pylon mounted on the pan table, wherein the tilting servomotor is mounted on one of the pylons.

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9. The camera assembly according to any one of the preceding claims, wherein the second support structure comprises a pan table base adaptor for receiving and mounting the panning servomotor.

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10. The camera assembly according to claim 9, wherein the second camera cable is curled in a space defined between the pan table and the pan table base adaptor.

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11. The camera assembly according to any one of the preceding claims, further comprising a housing for housing the camera, the housing coupled to the tilting servomotor, wherein the first camera cable is curled in a space defined between the housing and the pan table.

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12. The camera assembly according to claim 11, wherein the housing comprises a tilt drum.

13. The camera assembly according to any one of the preceding claims, further comprising a protective lens, the protective lens held perpendicular to an optical axis of the camera through a protective lens mounting.

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14. The camera assembly according to claim 11, wherein the protective lens comprises a flat lens.

15. The camera assembly according to claim 14, wherein the flat lens remains perpendicular to the optical axis as the camera rotates.

5 16. The camera assembly according to any one of the preceding claims, further comprising a first servomotor cable coupled to the tilting servomotor, the first servomotor cable being secured to the opposite side of the pan table facing the second support structure and extending through the opening in the second support structure.

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17. The camera assembly according to any one of the preceding claims, further comprising a second servomotor cable coupled to the panning servomotor.