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(54) **UNMANNED AERIAL VEHICLE LAUNCH SYSTEM**

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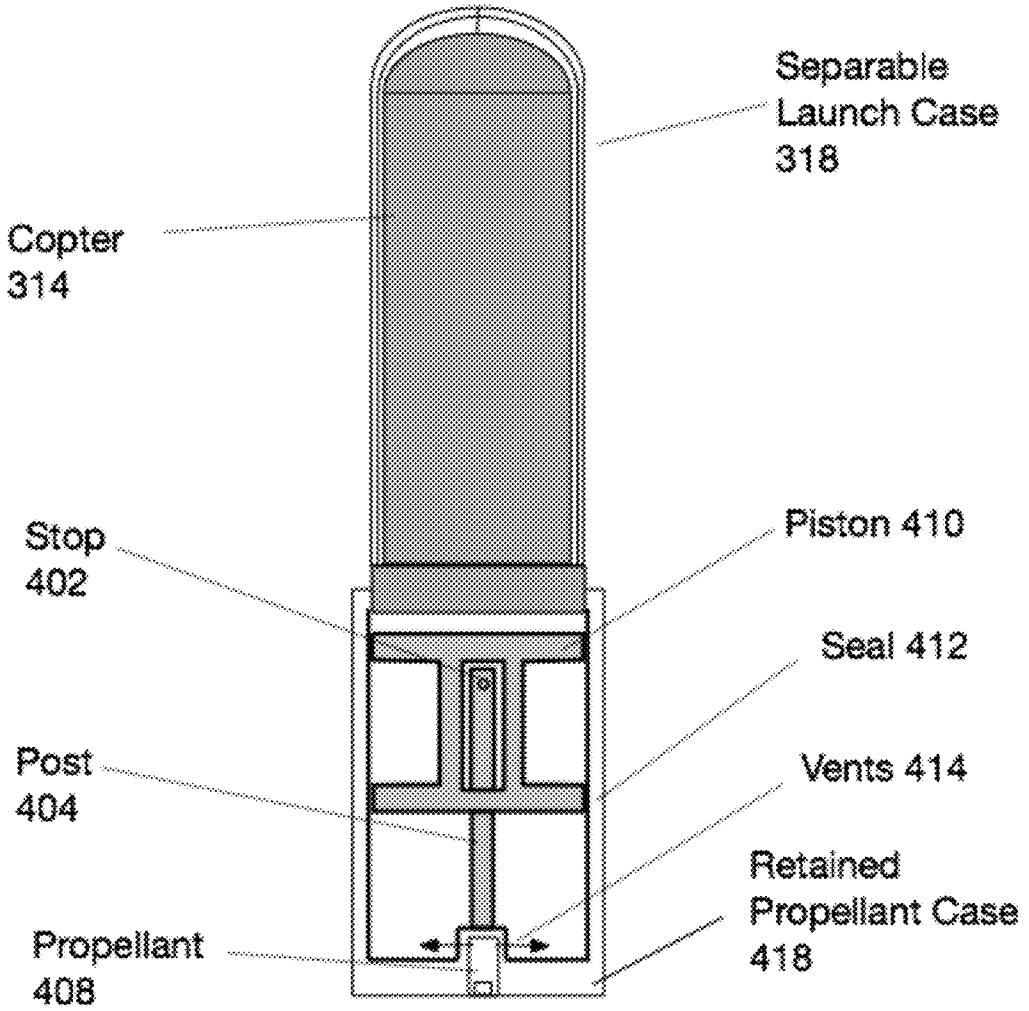
(57) **ABSTRACT**

Aspects of the present invention relate to unmanned aerial vehicle launch technologies.



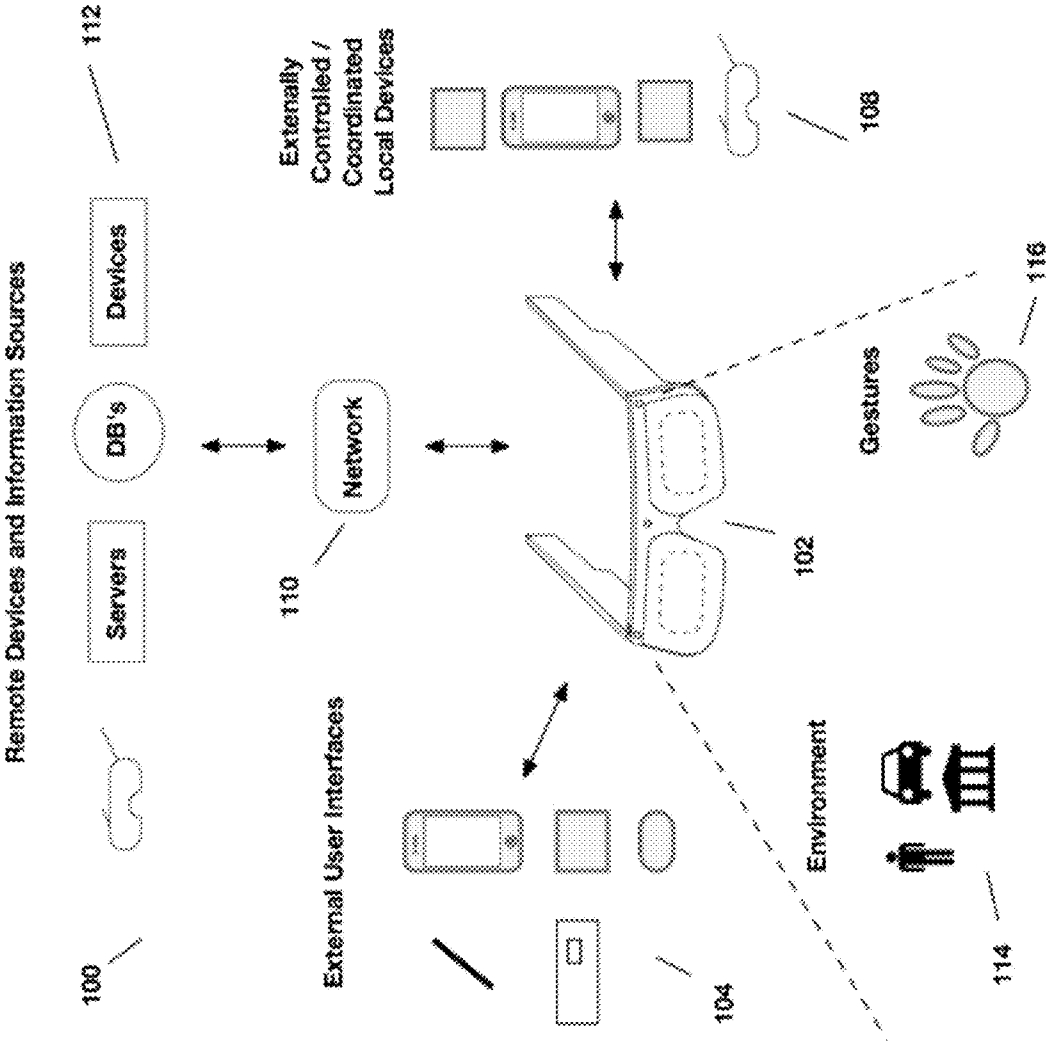

Remote Devices and Information Sources
100
Servers
DB's
Devices
112
110
Network
Externally Controlled / Coordinated Local Devices
108
External User Interfaces
104
102
Gestures
116
Environment
114

Figure 1

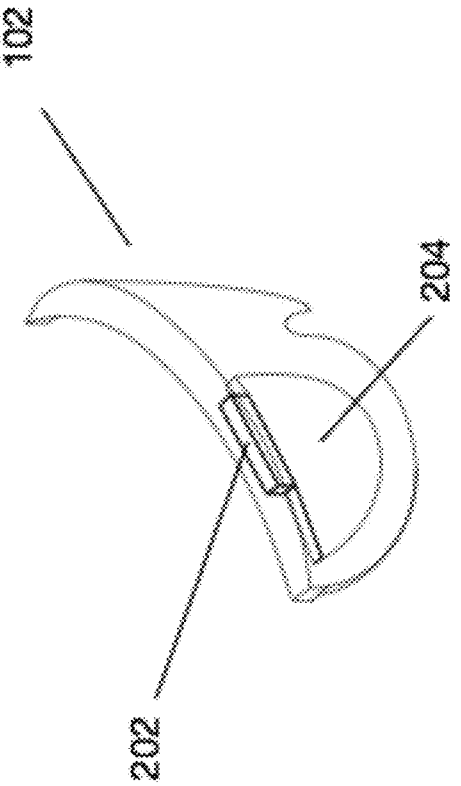


Figure 2

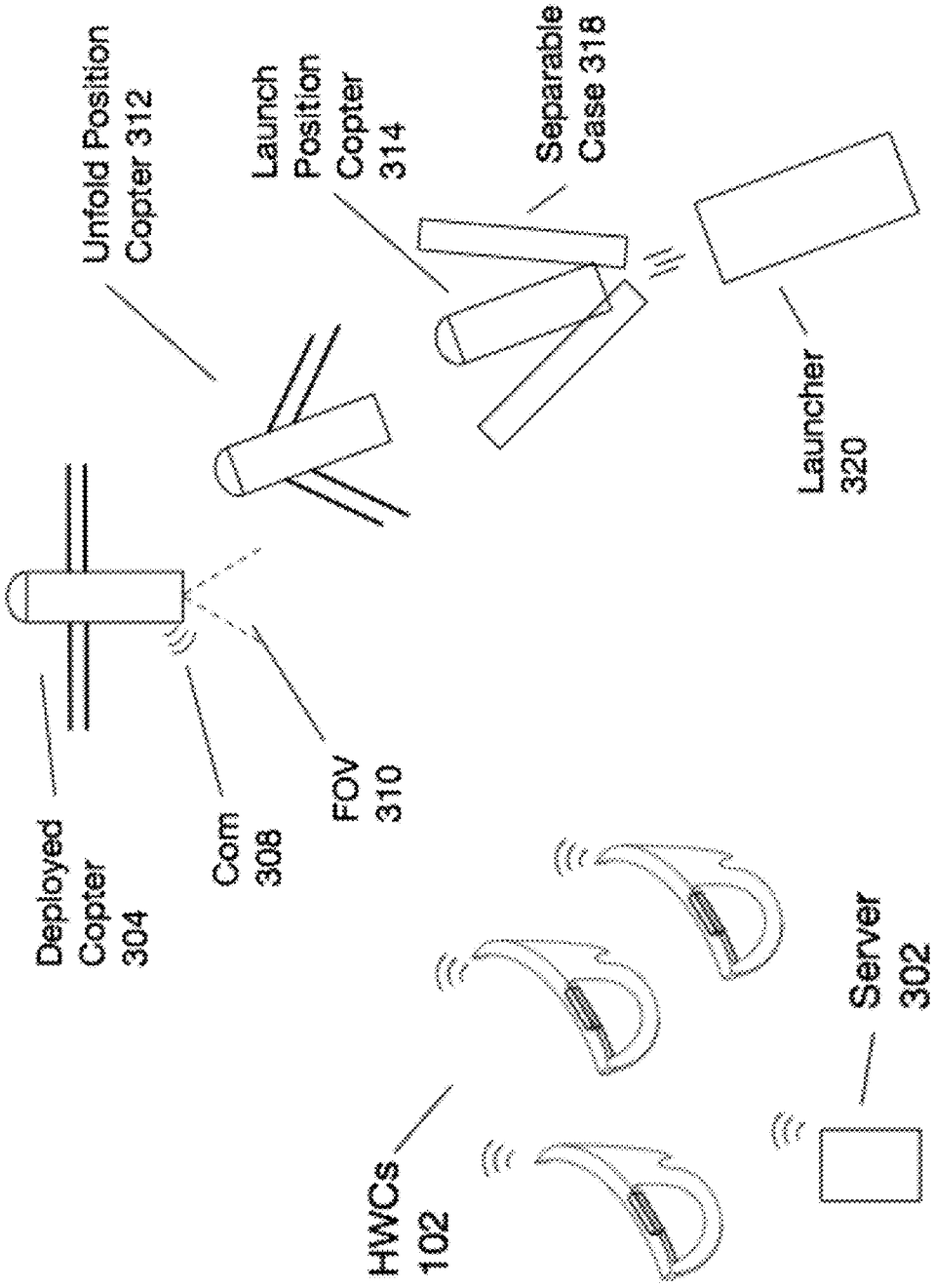

Unfold Position Copter 312
Launch Position Copter 314
Separable Case 318
Launcher 320
Deployed Copter 304
Com 308
FOV 310
HWCs 102
Server 302

Figure 3

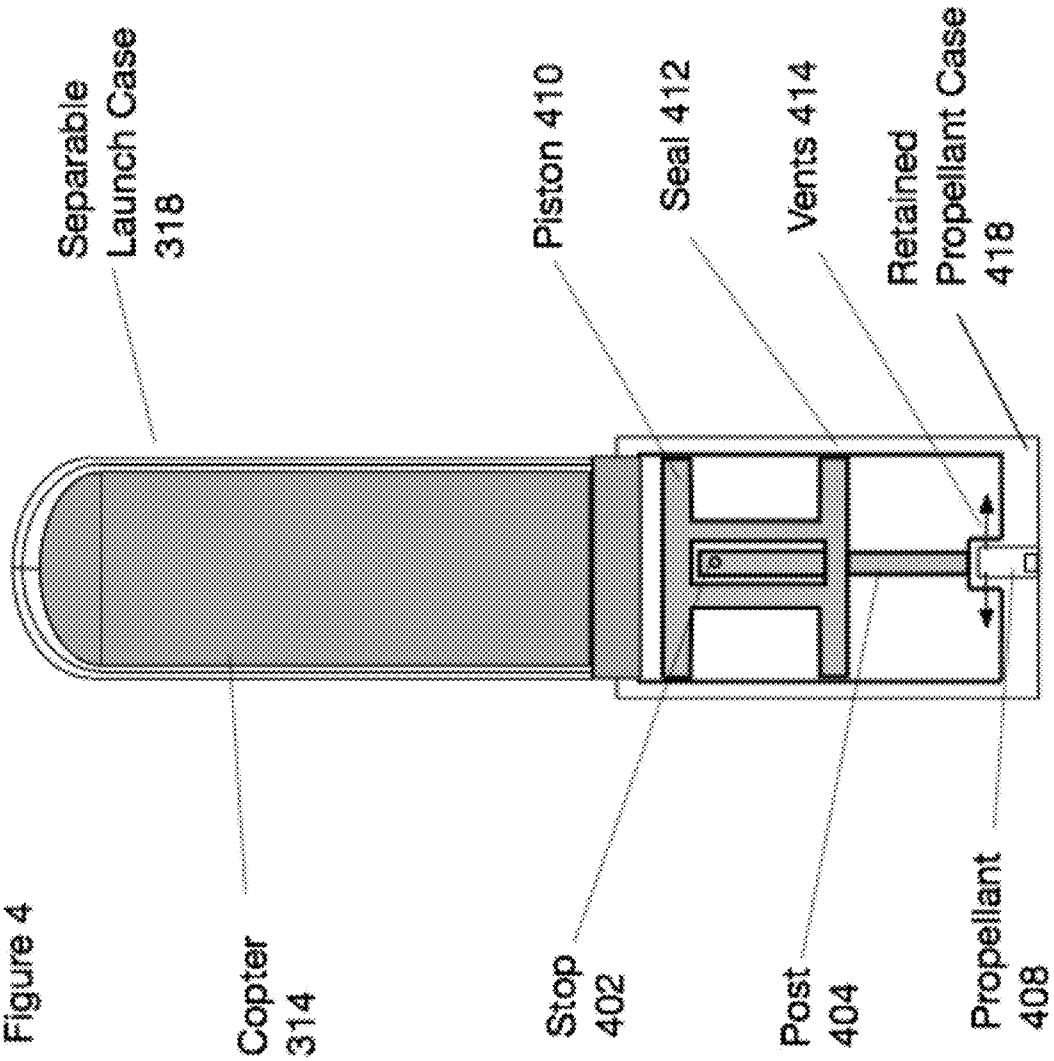

Separable Launch Case 318
Piston 410
Seal 412
Vents 414
Retained Propellant Case 418
Copter 314
Stop 402
Post 404
Propellant 408

Figure 4

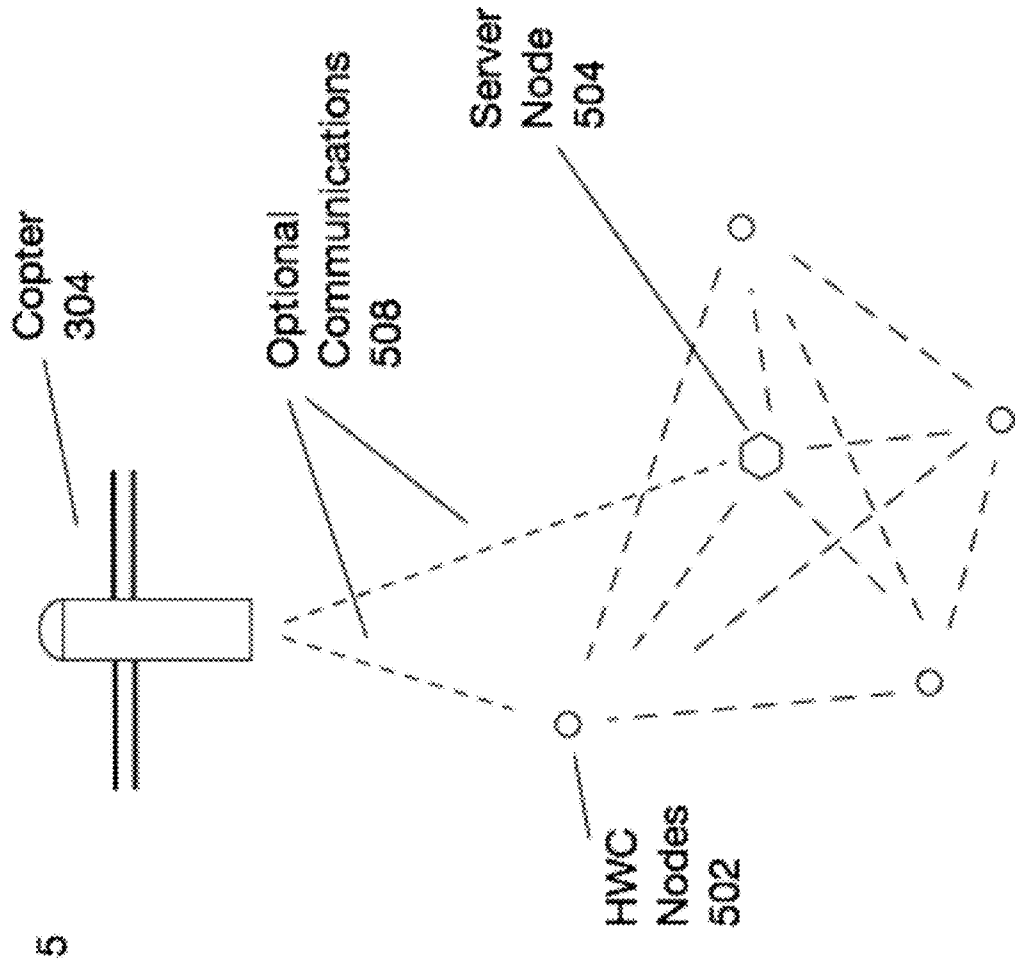

Copter
304
Optional
Communications
508
Server
Node
504
HWC
Nodes
502

Figure 5

UNMANNED AERIAL VEHICLE LAUNCH SYSTEM

BACKGROUND

[0001] 1. Field of the Invention

[0002] This invention relates unmanned aerial vehicle (UAV) systems. More particularly, this invention relates to UAV launch technologies.

[0003] 2. Description of Related Art

[0004] Unmanned aerial vehicles (UAVs) are used in connection with many different operations. UAVs come in many shapes and sizes. A need exists to improve UAVs and to improve UAV launch systems to make UAVs more useful and deployable.

SUMMARY

[0005] Aspects of the present invention relate to UAV launch technologies.

[0006] These and other systems, methods, objects, features, and advantages of the present invention will be apparent to those skilled in the art from the following detailed description of the preferred embodiment and the drawings. All documents mentioned herein are hereby incorporated in their entirety by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Embodiments are described with reference to the following Figures. The same numbers may be used throughout to reference like features and components that are shown in the Figures:

[0008] FIG. **1** illustrates a head worn computing system in accordance with the principles of the present invention.

[0009] FIG. **2** illustrates a head worn computing system with optical system in accordance with the principles of the present invention.

[0010] FIG. **3** illustrates a UAV launch and communication system in accordance with the principles of the present invention.

[0011] FIG. **4** illustrates a launch system in accordance with the principles of the present invention.

[0012] FIG. **5** illustrates a communication system in accordance with the principles of the present invention.

[0013] While the invention has been described in connection with certain preferred embodiments, other embodiments would be understood by one of ordinary skill in the art and are encompassed herein.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0014] Aspects of the present invention relate to head-worn computing ("HWC") systems. HWC involves, in some instances, a system that mimics the appearance of head-worn glasses or sunglasses. The glasses may be a fully developed computing platform, such as including computer displays presented in each of the lenses of the glasses to the eyes of the user. In embodiments, the lenses and displays may be configured to allow a person wearing the glasses to see the environment through the lenses while also seeing, simultaneously, digital imagery, which forms an overlaid image that is perceived by the person as a digitally augmented image of the environment, or augmented reality ("AR").

[0015] HWC involves more than just placing a computing system on a person's head. The system may need to be designed as a lightweight, compact and fully functional computer display, such as wherein the computer display includes a high resolution digital display that provides a high level of emersion comprised of the displayed digital content and the see-through view of the environmental surroundings. User interfaces and control systems suited to the HWC device may be required that are unlike those used for a more conventional computer such as a laptop. For the HWC and associated systems to be most effective, the glasses may be equipped with sensors to determine environmental conditions, geographic location, relative positioning to other points of interest, objects identified by imaging and movement by the user or other users in a connected group, and the like. The HWC may then change the mode of operation to match the conditions, location, positioning, movements, and the like, in a method generally referred to as a contextually aware HWC. The glasses also may need to be connected, wirelessly or otherwise, to other systems either locally or through a network. Controlling the glasses may be achieved through the use of an external device, automatically through contextually gathered information, through user gestures captured by the glasses sensors, and the like. Each technique may be further refined depending on the software application being used in the glasses. The glasses may further be used to control or coordinate with external devices that are associated with the glasses.

[0016] Referring to FIG. **1**, an overview of the HWC system **100** is presented. As shown, the HWC system **100** comprises a HWC **102**, which in this instance is configured as glasses to be worn on the head with sensors such that the HWC **102** is aware of the objects and conditions in the environment **114**. In this instance, the HWC **102** also receives and interprets control inputs such as gestures and movements **116**. The HWC **102** may communicate with external user interfaces **104**. The external user interfaces **104** may provide a physical user interface to take control instructions from a user of the HWC **102** and the external user interfaces **104** and the HWC **102** may communicate bi-directionally to affect the user's command and provide feedback to the external device **108**. The HWC **102** may also communicate bi-directionally with externally controlled or coordinated local devices **108**. For example, an external user interface **104** may be used in connection with the HWC **102** to control an externally controlled or coordinated local device **108**. The externally controlled or coordinated local device **108** may provide feedback to the HWC **102** and a customized GUI may be presented in the HWC **102** based on the type of device or specifically identified device **108**. The HWC **102** may also interact with remote devices and information sources **112** through a network connection **110**. Again, the external user interface **104** may be used in connection with the HWC **102** to control or otherwise interact with any of the remote devices **108** and information sources **112** in a similar way as when the external user interfaces **104** are used to control or otherwise interact with the externally controlled or coordinated local devices **108**. Similarly, HWC **102** may interpret gestures **116** (e.g captured from forward, downward, upward, rearward facing sensors such as camera(s), range finders, IR sensors, etc.) or environmental conditions sensed in the environment **114** to control either local or remote devices **108** or **112**.

[0017] We will now describe each of the main elements depicted on FIG. **1** in more detail; however, these descriptions are intended to provide general guidance and should not be

construed as limiting. Additional description of each element may also be further described herein.

[0018] The HWC **102** is a computing platform intended to be worn on a person's head. The HWC **102** may take many different forms to fit many different functional requirements. In some situations, the HWC **102** will be designed in the form of conventional glasses. The glasses may or may not have active computer graphics displays. In situations where the HWC **102** has integrated computer displays the displays may be configured as see-through displays such that the digital imagery can be overlaid with respect to the user's view of the environment **114**. There are a number of see-through optical designs that may be used, including ones that have a reflective display (e.g. LCoS, DLP), emissive displays (e.g. OLED, LED), hologram, TIR waveguides, and the like. In embodiments, lighting systems used in connection with the display optics may be solid state lighting systems, such as LED, OLED, quantum dot, quantum dot LED, etc. In addition, the optical configuration may be monocular or binocular. It may also include vision corrective optical components. In embodiments, the optics may be packaged as contact lenses. In other embodiments, the HWC **102** may be in the form of a helmet with a see-through shield, sunglasses, safety glasses, goggles, a mask, fire helmet with see-through shield, police helmet with see through shield, military helmet with see-through shield, utility form customized to a certain work task (e.g. inventory control, logistics, repair, maintenance, etc.), and the like.

[0019] The HWC **102** may also have a number of integrated computing facilities, such as an integrated processor, integrated power management, communication structures (e.g. cell net, WiFi, Bluetooth, local area connections, mesh connections, remote connections (e.g. client server, etc.)), and the like. The HWC **102** may also have a number of positional awareness sensors, such as GPS, electronic compass, altimeter, tilt sensor, IMU, and the like. It may also have other sensors such as a camera, rangefinder, hyper-spectral camera, Geiger counter, microphone, spectral illumination detector, temperature sensor, chemical sensor, biologic sensor, moisture sensor, ultrasonic sensor, and the like.

[0020] The HWC **102** may also have integrated control technologies. The integrated control technologies may be contextual based control, passive control, active control, user control, and the like. For example, the HWC **102** may have an integrated sensor (e.g. camera) that captures user hand or body gestures **116** such that the integrated processing system can interpret the gestures and generate control commands for the HWC **102**. In another example, the HWC **102** may have sensors that detect movement (e.g. a nod, head shake, and the like) including accelerometers, gyros and other inertial measurements, where the integrated processor may interpret the movement and generate a control command in response. The HWC **102** may also automatically control itself based on measured or perceived environmental conditions. For example, if it is bright in the environment the HWC **102** may increase the brightness or contrast of the displayed image. In embodiments, the integrated control technologies may be mounted on the HWC **102** such that a user can interact with it directly. For example, the HWC **102** may have a button(s), touch capacitive interface, and the like.

[0021] As described herein, the HWC **102** may be in communication with external user interfaces **104**. The external user interfaces may come in many different forms. For example, a cell phone screen may be adapted to take user input for control of an aspect of the HWC **102**. The external user interface may be a dedicated UI, such as a keyboard, touch surface, button(s), joy stick, and the like. In embodiments, the external controller may be integrated into another device such as a ring, watch, bike, car, and the like. In each case, the external user interface **104** may include sensors (e.g. IMU, accelerometers, compass, altimeter, and the like) to provide additional input for controlling the HWD **104**.

[0022] As described herein, the HWC **102** may control or coordinate with other local devices **108**. The external devices **108** may be an audio device, visual device, vehicle, cell phone, computer, and the like. For instance, the local external device **108** may be another HWC **102**, where information may then be exchanged between the separate HWCs **108**.

[0023] Similar to the way the HWC **102** may control or coordinate with local devices **106**, the HWC **102** may control or coordinate with remote devices **112**, such as the HWC **102** communicating with the remote devices **112** through a network **110**. Again, the form of the remote device **112** may have many forms. Included in these forms is another HWC **102**. For example, each HWC **102** may communicate its GPS position such that all the HWCs **102** know where all of HWC **102** are located.

[0024] FIG. **2** illustrates a HWC **102** with an optical system that includes an upper optical module **202** and a lower optical module **204**. While the upper and lower optical modules **202** and **204** will generally be described as separate modules, it should be understood that this is illustrative only and the present invention includes other physical configurations, such as that when the two modules are combined into a single module or where the elements making up the two modules are configured into more than two modules. In embodiments, the upper module **202** includes a computer controlled display (e.g. LCoS, DLP, OLED, etc.) and image light delivery optics. In embodiments, the lower module includes eye delivery optics that are configured to receive the upper module's image light and deliver the image light to the eye of a wearer of the HWC. In FIG. **2**, it should be noted that while the upper and lower optical modules **202** and **204** are illustrated in one side of the HWC such that image light can be delivered to one eye of the wearer, that it is envisioned by the present invention that embodiments will contain two image light delivery systems, one for each eye. It should also be noted that while many embodiments refer to the optical modules as "upper" and "lower" it should be understood that this convention is being used to make it easier for the reader and that the modules are not necessarily located in an upper-lower relationship. For example, the image generation module may be located above the eye delivery optics, below the eye delivery optics, on a side of the eye delivery optics, or otherwise positioned to satisfy the needs of the situation and/or the HWC **102** mechanical and optical requirements.

[0025] An aspect of the present invention relates to launch technologies related to unmanned aerial vehicles (UAVs). In embodiments, the launch system is adapted to use a grenade launcher (e.g. 40 mm grenade launcher) for ease of field integration. In embodiments, the launch system is adapted to be relatively quiet to allow for covert operations. When a grenade launcher is normally used in the field, quietness is not a significant requirement because the grenade being launched is going to land at a relatively short distance from the launcher and there is going to be a rather large noise made by the exploding grenade. The inventors of the present invention have realized that the use of a grenade launcher can provide

ease for field integration and the launch should be relatively quiet to allow for those instances where one wants to launch the UAV and remain unnoticed. The inventors have also discovered that the use of an explosive charge to send the UAV to it's usable or near usable height can significantly save on UAV battery life and hence increase the fly time of the UAV.

[0026] FIG. **3** illustrates a UAV launch system according to the principles of the present invention. In this embodiment, the launcher **320** may be a grenade launcher, such as a standalone grenade launcher, grenade launcher rifle combination, etc. An explosive charge may then be used to launch the UAV **314** from the grenade launcher **320**. In embodiments, the UAV **314** is held in a launch position inside of a separable case **318**. The separable case **318** may be designed to encase the UAV **314** in a launch position and the separable case **318**, with the UAV inside, can be fired out of the launcher **320**. The separable case **318** may then separate from the UAV in mid-flight. Once released from the separable case **318**, the UAV may deploy flight sustaining elements, such as counter rotating blades that can keep the UAV in-flight in a controlled system, as indicating as unfold UAV position **312**. Once the UAV achieves its fully deployed position **304** it may fly autonomously or through the control of a remote operator. The fully deployed UAV **304** may take the form of a dual counter rotating blade helicopter and it may operate a self contained camera with a field of view **310** to image the surroundings, sensors to sense environmental conditions of the surroundings, etc. The output from the camera and other sensors may be communicated to other systems through communication channel(s) **308**. The UAV **304** may be controlled by a person on the ground in near proximity to the UAV. For example, a person wearing a HWC **102** may control the UAV as an externally controlled device **108** through the use of gestures **116**, external control devices **104**, etc. (as described herein elsewhere) with the HWC **102** communicating with the UAV either directly or indirectly.

[0027] As indicated in FIG. **3**, the UAV may communicate with devices on the ground, such as HWC(s) **102**, server(s), etc. to get files, streams, etc. from the UAV's camera and other sensor systems to persons in need of such information. The ground devices may further be used to control the flight and sensor systems of the UAV. For example, a person on the ground wearing a HWC **102** may receive files and streams of information from the UAV **304** and the person may also control the functions of the UAV by using control technologies described herein elsewhere.

[0028] FIG. **4** illustrates a UAV launch system adapted to be loaded and fired from a grenade launcher (not shown). The UAV launch system illustrated in this embodiment includes a separable launch case **318**, which houses the UAV copter **314** in a launch configuration. The separable launch case **318** is secured to a retained propellant case **418**. Both the separable launch case **318** and the retained propellant case are configured to be loaded into a grenade launcher for launching. The retained propellant case **418** houses a piston **410** that travels on a post **404**. The piston **410** is illustrated in the pre-launch or down position. The retained propellant case **418** also includes a propellant container that contains a propellant **408**. The grenade launcher (not shown) will trigger the propellant **408** to initiate the UAV launch. The propellant container has vents that allow the propellant to expand rapidly into the nearby container once triggered. The expanding gas pushes the piston **410** towards the UAV **314** and the separable launch case **318**. The piston travels along the post **404** and the piston is stopped by the stop **402** towards the top of the post **404**. The piston **410** has a seal **412** that seals, at least temporarily, the vessel below the piston **410** to contain a substantial amount of the gas that expands into the vessel from the triggered propellant. The upper portion of the piston **410** may also be sealed to help prevent the expanding gas from escaping into the surrounding environment. The seal **412** contains the expanding gas and resulting pressure and also prevents a loud noise from being generated by containing the gas. If the gas were allowed to escape to the surrounding environment quickly a loud noise would occur and the launch event would be marked by a loud audio signature. The seal(s) **412**, or others, causing the expanding gas to be contained may permit the gas to slowly escape following the launch; so long as the leak is slow it will not cause a loud noise. The purpose of the seals is to contain the gas pressure to prevent a loud launch noise, so a substantial portion of the gas needs to be contained for at least a short period of time and then the gas can slowly escape around the seals.

[0029] FIG. **5** illustrates a UAV communication network in accordance with the principles of the present invention. Once deployed, the UAV **304** may communicate with ground personnel via optional communications links **508**. For example, the optional communications links **508** may include a communication protocol that involves the UAV **304** communicating to a server node **504** on the ground and then the server node may communicate the information with the HWC **102** nodes **502**. In other embodiments, the UAV **304** may communicate with an HWC **102** node **502** directly. The HWC **502** nodes and the server node may be arranged in an ad-hoc self-healing network arrangement. In other embodiments, the network topology and protocols may be otherwise arranged (e.g. spoke and hub, IP, etc.).

[0030] Although embodiments of HWC have been described in language specific to features, systems, computer processes and/or methods, the appended claims are not necessarily limited to the specific features, systems, computer processes and/or methods described. Rather, the specific features, systems, computer processes and/or and methods are disclosed as non-limited example implementations of HWC. All documents referenced herein are hereby incorporated by reference.

We claim:

1. An unmanned aerial vehicle (UAV) launch system, comprising:

a. A retained propellant case adapted to be loaded into a grenade launcher and to be retained by the grenade launcher following launch of the UAV, comprising:
   i. a propellant in a propellant cavity; and
   ii. a gas pressure containment cavity; wherein the propellant cavity further includes a vent connecting the propellant cavity and the pressure containment cavity;
   iii. a piston arranged to move by a force caused by an increase in gas pressure in the gas pressure containment cavity resulting from a triggered propellant, the piston further arranged to move towards the UAV for a pre-determined distance, the piston further including a seal that substantially contains the increase in gas pressure in the gas pressure containment cavity as the piston moves to the pre-determined distance; and

b. A separable launch case adapted to be loaded into the grenade launcher, wherein the separable launch case is secured to the retained propellant case in a position such

that the separable launch case is pushed by the piston as the piston moves towards the UVA, the separable launch case further comprising a UAV cavity adapted to hold the UVA in a launch position and to separate from the UAV in flight after launch.

2. An unmanned aerial vehicle (UAV) launch system, comprising:

a. A retained propellant case adapted to be loaded into a grenade launcher and to be retained by the grenade launcher following launch of the UAV, comprising:

i. a gas pressure containment cavity adapted to contain, for a period of time after launch of the UAV, substantially all of an expanding gas that is used to push the UAV out of the grenade launcher, the period of time used to suppress a sound that would result if the expanding gas expanded outside of the gas pressure cavity and into an uncontained environment;

b. A separable launch case adapted to be loaded into the grenade launcher, wherein the separable launch case is secured to the retained propellant case in a position such that the expanding gas causes the separable launch case to be projected from the grenade launcher, the separable launch case further comprising a UAV cavity adapted to hold the UVA in a launch position and to separate from the UAV in flight after launch.

3. The system of claim **2** wherein the grenade launcher comprises a 40 mm launcher.

4. The system of claim **2** wherein the UAV comprises a copter with counter rotating blades.

5. The system of claim **2** wherein the UAV is adapted to communicate with an HWC within a proximity of the UAV after the UAV is launched from a grenade launcher.

6. The system of claim **5** wherein the HWC is adapted to communicate with other HWC's in an ad-hoc self healing network.

7. The system of claim **2** wherein the gas pressure containment cavity comprises a piston that substantial seals an expanding gas in the pressure containment cavity for at least a period of time to prevent a loud noise from the expanding gas.

8. The system of claim **2** wherein the UAV is flight controlled through a control command captured by a HWC.

* * * * *