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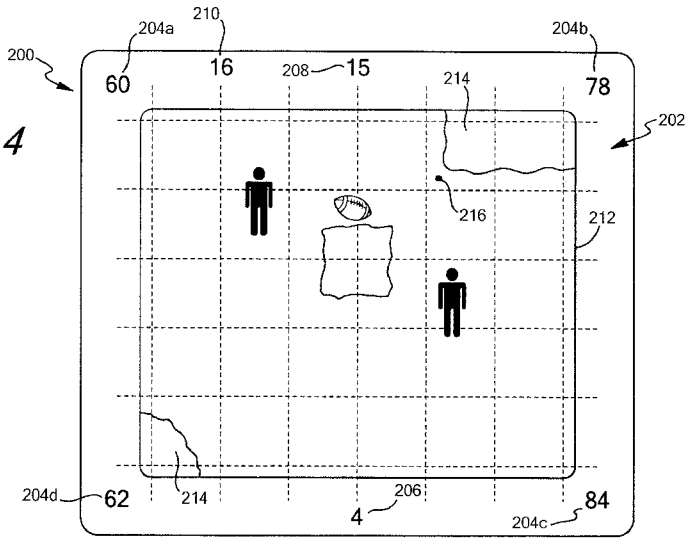
(54) **Title**: CONTROL SYSTEM AND METHOD FOR AN AERIALLY MOVED PAYLOAD SYSTEM

FIG. 4



(57) **Abstract**: A system and method for controlling an aerially moved payload having at least one information capturing device and at least one line, reel, and motor combination for maneuvering the payload. The system includes a database having at least one control parameter or location parameter input therein. An image viewing device is provided for displaying information from the at least one information capturing device and software for overlaying at least one of the at least one control or location parameter.

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TITLE OF THE INVENTION

Control System And Method For An Aerially Moved Payload System

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Serial No. 61/529,676 entitled "3D Aerial Camera System" filed August 31, 2011; U.S. Provisional Application Serial No. 61/529,697 entitled "Control System for a 3D Aerial Camera" filed August 31, 2011; U.S. Provisional Application Serial No. 61/532,788 entitled "Digital Microphone and Digital Microphone Control System for an Aerially Moved Payload" filed September 9, 2011; U.S. Provisional Application Serial No. 61/532,741 entitled "Control System For An Aerially Moved Payload System" filed September 9, 2011; U.S. Provisional Application Serial No. 61/607,993 entitled "Aerial Camera System Having Multiple Payloads" filed March 7, 2012; U.S. Patent Application No. 13/471,924 entitled "Control System And Method For An Aerially Moved Payload System" filed May 15, 2012; and, U.S. Patent Application No. 13/471,924 entitled "Control System And Method For An Aerially Moved Payload System" filed May 15, 2012 – the contents of all of which are fully incorporated herein by reference.

FIELD OF THE INVENTION

[0001] The present invention is directed to a control system for controlling, monitoring, and maneuvering aerially moved payload system, and in particular an aerially moved payload system reporting or providing usable information from the payload.

BACKGROUND OF THE INVENTION

[0003] Aerial movement systems are useful for moving a payload, like for example a camera, over large expanses such as arena and stadium floors, open fields, or even military testing sites. Examples of such systems which may be used to aerially move a payload may be found, for example, in U.S. Patent Nos. 6,809,495; 6,873,355; 6,975,089; 7,088,071; 7,127,998; and, 7,239,106.

[0004] As described in various embodiments of the aforementioned patents, aerial movement systems having a payload, like for example a platform and/or a camera, typically include one or more lines (e.g., a cables, ropes, strings, cords, wires, or any other flexible materials) attached to the payload. The one or more lines typically extend to the payload from four or five support beams surrounding the surface over which the payload traverses, and are controlled by one or more motor reels which extend and retract the one or more lines attached to the payload. The motor reels may be controlled using timers, software algorithms, remote controls, or any means known in the art. As the line(s) are extended and retracted, the payload may be moved in three-dimensions, *i.e.* in the x-direction, the y-direction, and the z-direction.

[0005] In aerially moved payload systems including, for example, a camera used to record or live-broadcast events, currently there are two individuals responsible for obtaining the video footage – a pilot who is responsible for maneuvering the payload and a "cameraman" responsible for adjusting, tilting, angling, and rotating the camera to obtain the video footage. In addition to in place of the "cameraman," individuals may also be needed to control and analyze any sound and/or data captured by the payload.

[0006] Presently, a pilot responsible for maneuvering the payload must constantly monitor two different screens in order to maneuver the payload, insure that the system is functioning properly, and insure that the cameraman or other individual has the best possible

positions and angles for capturing the footage sought to be recorded and/or broadcasted by a camera, or is obtaining the full scope of sound and data the individual wants to capture.

[0007] The first screen a pilot must monitor is a screen containing a grid system showing the location of the payload over the area being filmed or broadcasted. This grid screen may additionally include information related to the status of a z- or vertical floor set by the pilot to insure the payload is not brought below a certain height, torque values for the reels to insure the lines controlling the payload aren't overly stressed, the x-, y-, z- direction joystick feedback sensitivity for the pilot joystick, the speed the payload is travelling at, the bounded flyspace and grid for insuring the payload is being moved within the flyspace and properly positioned, and the actual flight path of the payload shown as a trail of black or white dots. This screen may additionally include highlighted areas of obstacles or stationary objects in or around the flight path to instruct the pilot where the payload may not be safe or where the payload could potentially crash.

[0008] The second screen a pilot must look at displays information captured by the payload. For example, the second screen may display a video feed showing images captured by a camera in the payload. The video feed allows the pilot to view what the cameraman is working with to capture the footage in the area over which the payload is traversing. Seeing the video feed enables the pilot to position the payload in the best possible spot for the cameraman to capture a desired angle or shot for the recording or broadcast.

[0009] Because a pilot is presently required to monitor two separate screens, it requires the pilot's attention to be split and prevents the pilot from creating the best possible shot for the cameraman, while constantly monitoring the operating parameters of the aerially moved payload system, insuring the safety of the payload and any structures or individuals located in the area proximate the payload.

[0010] Therefore, it would be advantageous to create a control system where a pilot could monitor the operating parameters of the payload system while at the same time monitoring any information captured by and transmitted from the platform to insure complete safety and that the best and most complete information is captured. It would be further advantageous if such a system was capable of providing additional alarms to indicate if an operating parameter is at or near a threshold limit, or if a particular operating parameter has not been set.

[0011] The present invention is provided to solve these and other issues.

SUMMARY OF THE INVENTION

[0012] Accordingly, the present invention is directed to an improved control system for aerially moved payloads. The control system is configured to report operating parameters set in an associated database and measured by the system, position sensing of the payload, and any information captured by an imaging device, microphone, or other data gathering instrument included in the payload on a single video monitor or screen for monitoring of the payload by a pilot controlling the payload.

[0013] In some embodiments of the invention, visual and/or audible alarms may also be set and configured in the system to alert the pilot and any associated payload crew if particular thresholds, both high and low, are reached by any of the system components.

[0014] Alarms may additionally be set to notify the pilot and payload crew if any portion of the payload is malfunctioning or if a particular alarm has not been turned on prior to the system being activated or re-activated after a period of inactivity. The system may also be configured to provide a reminder or warning if any alarms are deactivated during usage for any reason.

[0015] An alarm may also be set to notify the pilot and payload crew if the payload is approaching any obstacles located proximate the surface over which the payload traverses. The alarms may be set to notify that the payload is approaching an object or that a portion of the payload, like for example a camera or imaging device, is rotating in a manner which may result in a portion of the captured information being blocked by an object.

[0016] Other advantages and aspects of the present invention will become apparent upon reading the following description of the drawings and detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 shows an aerially moved payload system as contemplated by the invention;

[0018] FIG. 2 shows an aerially moved payload system as contemplated by the invention;

[0019] FIG. 3 shows a flow chart for controlling an aerially moved payload as contemplated by the present invention; and,

[0020] FIG. 4 shows a visual display as viewed by a payload operator while maneuvering an aerially moved payload as contemplated by the present invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0021] While this invention is susceptible to embodiments in many different forms, there is described in detail herein, preferred embodiments of the invention with the understanding that the present disclosures are to be considered as exemplifications of the principles of the invention and are not intended to limit the broad aspects of the invention to the embodiments illustrated.

[0022] An exemplary system 10 for aerially moving a payload 12 is shown in FIG. 1. Payload 12 includes at least one information capturing device 14 carried by platform 16. In order to move payload 12 and platform 16 in at least one of the x-, y-, and z- directions, at

least one line, shown as lines 18a-18d, are connected to the platform in four locations, shown as corners 20a-20d. Coupled to and driving lines 18a-18d is at least one reel and motor combination, shown as motor and reel combinations 22a-22d. Motor and reel combinations 22a-22d act in conjunction with lines 18a-18d to move platform 16 and payload 12 in at least one of the x-, y-, and z- directions. Sheaves 24a-24d may be used in conjunction with motor and reel combinations 22a-22d in order to redirect lines 18a-18d to the platform. Sheaves 24a-24d may be attached to pillars or posts 26a-26d in an elevated position to better enable payload 12 to traverse over a desired area.

[0023] As should be appreciated by those having ordinary skill in the art, lines 18a-18d may contain, or have attached thereto, coaxial, optical, or other cables capable of transmitting and receiving information to and between a remote location and payload 12. For example, embedded or attached lines may be used to transmit any data or signals collected or obtained by payload 12 and control signals for moving platform 16 in at least one of the x-, y-, and z-directions. The embedded or attached lines may also be used to provide control signals from a remote production or control center to the payload in order to control and maneuver any instruments located on the payload.

[0024] The at least one information capturing device 14 may include any known camera or imaging device known in the art, any microphones or other sound capturing mechanisms known in the art, or any instruments used to measure any location characteristics or parameters. Examples of instruments which may be included in the payload include but are not limited to, spectrum analyzers or other devices capable of measuring frequency or signal strength at the payload location, thermometers or other temperature sensing devices, pressure sensing devices, light intensity or wavelength sensing devices, and wind speed and direction sensors.

[0025] Camera or imaging devices which may be included in the payload may include but are not limited to a standard or high definition camera having a zoom or prime lens, it may be a digital camera capable of taking both still shots and video or a high-speed, slow motion, or motion detecting camera, or it may be a camera having a lens or filter designed to remove or enhance a particular color, color spectrum, or an infrared or ultra-violate camera. Alternatively, the imaging device may be a night vision camera, a thermal imaging device, or an elevation or topography imaging or mapping device. The present invention contemplates that any camera or image capturing device be capable of broadcasting, recording, providing, and/or filming optical images. In some embodiments payload 12 may include more than one camera or imaging device capable of providing images. For example, payload 12 may include a high-definition camera and 3 prime lens cameras or a thermal imaging device and an elevation or topography mapping device. When utilizing multiple cameras and/or imaging device, any combination may be utilized by the system to obtain any images the operator desires.

[0026] An alternative embodiment of the aerial system shown in FIG. 1 is shown in FIG.2. As seen in FIG. 2, rather than traverse over an area, it is contemplated by the invention that aerial movement system 12 may allow for payload 16 to traverse along side an area. As seen in FIG. 2, posts or pillars 26a-26d may extend substantially parallel to and/or above a ground surface or floor, allowing the payload to travel along side an area to be recorded. In such embodiments movement may be limited to only two directions, like for example the x- and z- directions. Configuring the system in this manner allows the payload to travel along side an area to obtain information when such is desirable or required.

[0027] In either aerial system, it is contemplated that not sheaves may be used, but rather reel and motor combinations 22a-22d maybe be directly affixed to any posts or other supporting structures. It should also be appreciated by those having ordinary skill in the art

that though four motor and reel combinations are shown in FIGs. 1 and 2, it is contemplated by the invention that more or less motor and reel combinations may be used depending on the required movement of the system and nature of the environment. In some aerial systems as few as one motor or reel combination may be utilized while others may desire or require the use of more than four.

[0028] Once a system like those shown in FIGs. 1 and 2 or one similar one installed proximate the area to be recorded (step 100 in FIG. 2), the pilot or another individual associated with the system can input control parameters into a control system database for the payload and system to guide the navigation of the payload while insuring safe and secure operation (step 102).

[0029] The control parameters for the payload system and the payload transport system (*i.e.* the lines used to maneuver the payload) may include, for example, the environment parameters and any obstacles for the area over which the payload traverses, information related to floor or minimum elevation above the area the payload should travel, the maximum torque settings of each reel, the layout, boundaries, and gridding of the area over which the payload is to traverse, the maximum speed the payload should travel, and set sensitivity for the joystick or controller used by the operator to move the payload about the area.

[0030] In addition to setting control parameters, the pilot or another associated individual may set alarms to notify the pilot and crew if particular thresholds are being approached, a malfunction or non-operation of a system parameter, or any location obstacles or objects are being approached (step 104). For example, alarms may be set to notify the pilot and crew that the payload has travelled below a floor or that a floor has not been set, that a particular reel/line combination has exceeded or dropped below a particular torque value, if a motor/reel combination is no longer functioning, or if the speed of the payload is at or above a particular threshold.

[0031] Once the control parameters and alarms have been set, operation of the system may safely commence. Upon start up, a monitor will be provided to the pilot which will display information captured by the at least one information capturing device in the payload (step 106). The display will provide the pilot with any information captured by the payload, like for example images captured by a camera or data captured by a sensor, in order to insure that the payload is properly maneuvered to capture desired information.

[0032] A portion of all of the database information and associated software codes used to display the stored operating/control parameters previously will then be overlaid on top of the displayed information (step 108) on a single monitor. Rather than having two separate screens showing the operating parameters and captured information, requiring the operator to split his or her attention, overlaying allows the operator to monitor the information obtained by the payload, while at the same time continuously monitoring the position of the payload, the location of any obstacles or stationary objects, and the values of any monitored operating parameters.

[0033] The displayed values and indicia may be parameters set in the database, like for example the value of the floor, any objects, and the grid system for the area over which the payload will traverse, or instead may be values fed back to the system from (step 110), for example, from feedback lines associated with one or all of the platform or line/reel/motor combinations. For example, while a maximum speed and torque may have been set in the operating database, rather than display the maximums, the actual measured value provided by a feed back line associated with each may be displayed on the visual overlay to provide information to the operator (step 112). Feedback lines may likewise be used to provide the location of the payload relative to the area grid and/or any motor/reel combinations used to control the device. The feedback lines may be incorporated or embedded in, or attached to,

lines 18a-18d in FIG. 1. The feedback lines may be any used or unused lines used to recover any information from the payload additionally or alternatively.

[0034] In order to provide feedback, it is contemplated by the invention that any sensors required to monitor, for example, the speed, location, or torque may be provided to any of the payload and reel/motor combinations. The sensors may obtain a value which is then provided to remotely located database and pilot directly via the feedback line, or alternatively may be provided to a modem which converts the data to an audio signal which is then embedded in a video signal and provided to a control center containing the database and operator. In order to recover the data from the audio signal, it should be appreciated by those having ordinary skill in the art that a demodulator or similar device may be used to convert the audio signals back to a data signal.

[0035] As a further alternative, it is contemplated by the invention that rather than use feedback lines any feedback data may be provided via RF signals wireless transmitted from the payload and/or any reel/motor combinations to the control center for use in the database and display for the operator. The RF signals may be generated and received using any means known in the art.

[0036] RF wireless signals may likewise be used to transmit any captured information from the payload to a remote production or control center utilizing the information. In such embodiments, rather than use embedded or attached coax or fiber optic lines, for example, both the payload and control center may include an antenna capable of transmitting and receiving RF signals. In order to transmit the information, it should be appreciated by those having ordinary skill in the art that any necessary media converters or the like may be included in both the payload and control center to allow for all information to be transmitted using wireless signals (or in the case of, for example wired optics signals).

[0037] The software overlaying the parameter information may also be configured to provide the audio or visual alarms if any value thresholds are being approached or have been reached, or if any value threshold controls have not been turned on or enabled. For example, when a floor or minimum elevation threshold is set in the database, the system will typically prevent the payload from traveling below that floor or elevation. The present system may be configured to provide, for example, a blinking light on the single monitor indicating that the floor has not been set, or the floor value itself may be highlighted in a different color and blink to indicate to the pilot that the floor was not set. If the pilot continues to maneuver the payload without setting the floor for a period of time, or if the pilot maneuvers the payload to a position below an internal system or previously set floor before the floor is turned on, a second auditory alarm may be provided by the system, notifying the pilot that the floor is not set and/or the payload is now located below the floor. Such video and audio alarms may be used for any maximum or minimum value set in the database, including torque values of any reels or the speed of the payload, or to alert that a particular object or obstacle is being approached.

[0038] Though the control parameters may be set before operation, it is contemplated by the invention that pilot or another associated individual may change or alter any parameters after the device begins operation. The altered values will adjust and appear on the overlaid visual display as they are adjusted. An alert or other indication may be provided to the operator to notify him or her that a particular value has changed.

[0039] FIG. 3 shows a visual display or image viewing device 200 as contemplated by the invention. As shown in FIG. 3, the background view shows information in the form of images being captured by at least one of the image device located on the payload while operating parameters are overlaid thereon. As seen in FIG. 3, grid system 202, reel torque values 204a-d, joystick sensitivity value 206, floor value 208, payload speed 210, boundaries

212, obstacles 214, and the location of the payload 216 may all be overlaid the image. It should be appreciated by those having ordinary skill in the art that any overlaid values or images may be any color which will be visible over the images provided by the imaging device. It should also be appreciated that any grid and location indicia provided on the screen may not correspond to the current image being provided. Inasmuch as the grid and location indicia, including the location of the payload and objects located proximate the area, are provided for the entire area and the image is only for a particular shot, the image may only contain a small portion of the total area.

[0040] While FIG. 3 shows information in the form of images captured by a camera, it should be appreciated by those having ordinary skill in the art that other information captured by other information capturing devices may be displayed. For example, a graph or similar data plotting device may be used to show the current measured signal strength from a spectrum analyzer or other frequency or signal strength measuring device.

[0041] While in the foregoing there has been set forth a preferred embodiment of the invention, it is to be understood that the present invention may be embodied in other specific forms without departing from the spirit or central characteristics thereof. The present embodiments, therefore, are to be considered in all respects as illustrative and not restrictive, and the invention is not to be limited to the details given herein. While specific embodiments have been illustrated and described, numerous modifications come to mind without significantly departing from the characteristics of the invention and the scope of protection is only limited by the scope of the accompanying claims.

CLAIMS

I claim:

1. A method for controlling an aerially moved payload comprising the steps of:

installing an aerially moved payload system proximate an area over which the payload will travel, the payload including at least one information capturing device and at least one line, reel, and motor combination for maneuvering the payload;

inputting at least one control parameter for the payload system or at least one location parameter for the area into a database;

providing an information feed to a viewing device from the at least one information capturing device for an operator to remotely view the information being captured; and,

overlaying at least one of the at least one control or location parameter on the information feed on the viewing device.

2. The method of claim 1 further comprising the step of inputting at least one of the following control parameters: a minimum elevation over the area the payload should reach, a maximum speed the payload should travel, a maximum or minimum torque value for the at least one line, reel, and motor combination, and a joystick or controller sensitivity for remotely controlling movement of the payload.

3. The method of claims 1 or 2 further comprising the step of inputting at least one of the following location parameters: any obstacles located above or proximate the area over which the payload will travel, the boundaries of the area over which the payload will travel, the layout of the area over which the payload will travel, and a grid of the area over which the payload will travel.

4. The method of any one of the preceding claims further comprising the step of providing feedback from at least one of the payload and the at least one line, reel, and motor combination, the feedback indicating at least one of the current speed of the payload, the

location of the payload over the area, and the current torque placed on the at least one line, reel, and motor combination.

5. The method of claim 4 further comprising the step of setting an alarm if any feedback values are substantially approaching any maximum or minimum parameter value.

6. The method of claim 5 further comprising the step of setting a visual alarm to appear on the viewing device if any feedback values are substantially approaching any maximum or minimum parameter value.

7. The method of claim 5 further comprising the step of setting an audio alarm if any feedback values are substantially approaching any maximum or minimum parameter value.

8. The method of claim 4 further comprising the step of overlaying at least one feedback value indicating the current speed of the payload, the location of the payload over the area, and the current torque placed on the at least one line, reel, and motor combination over the image provided from the at least one information device on the viewing device.

9. The method of any one of the preceding claims further comprising the step of providing at least one visual or audio alarm if a control parameter is not set in the system before operation.

10. The method of any one of the preceding claims further comprising the step of providing feedback indicating the location of the payload over the area.

11. The method of claims 3 or 10 further comprising the step of setting a visual alarm to appear on the viewing device if the location of the payload approaches any obstacles input into the system or any area boundaries over which the payload is to travel.

12. The method of claim 11 further comprising the step of setting an audio alarm if the location of the payload approaches any obstacles input into the system or any area boundaries over which the payload is to travel.

13. The method of any one of the preceding claims further comprising the step of providing information on the viewing device in the form of an image feed.

14. The method of any one of the preceding claims further comprising the step of sensing at least one location characteristic at the payload.

15. The method of claim 14 further comprising the step of providing information on the viewing device related to the sensed location characteristic.

16. A system for controlling movement of an aerially moved payload having at least one image device, the system comprising:

a payload having at least one information capturing device and at least one line, reel, and motor combination for moving the payload;

a database having at least one control parameter or location parameter;

a viewing device;

at least one line providing information from the at least one information capturing device to the viewing device; and,

software for overlaying at least one of the at least one control or location parameter on top of the displayed information.

17. The system of claim 16 further comprising at least one line providing feedback from at least one of the payload and the at least one line, reel, and motor combination.

18. The system of claim 17 wherein the software is capable of overlaying any values provided by the at least one feedback line on the viewing device.

19. The system of claim 18 wherein the software is configured to provide an audio or visual alarm based on feedback provided by the at least one feedback line and any control or location parameters contained in the database.

20. The system of claim 19 wherein the database includes at least one control parameter from the group comprising: a minimum elevation over the area the payload should reach, a

maximum speed the payload should travel, a maximum or minimum torque value for the at least one line, reel, and motor combination, and a joystick or controller sensitivity for remotely controlling movement of the payload.

21. The system of claim 19 wherein the database includes at least one location parameter from the group comprising: any obstacles located above or proximate the area over which the payload will travel, the boundaries of the area over which the payload will travel, the layout of the area over which the payload will travel, and a grid of the area over which the payload will travel.

22. The system of any one of the preceding claims wherein the software is configured to provide an audio or visual alarm if any control parameters are not located in the database.

23. The system of any one of the preceding claims wherein the at least one information capturing device includes at least one image capturing device.

24. The system of any one of the preceding claims wherein the at least one information capturing device includes at least one device for sensing or measuring a location characteristic.

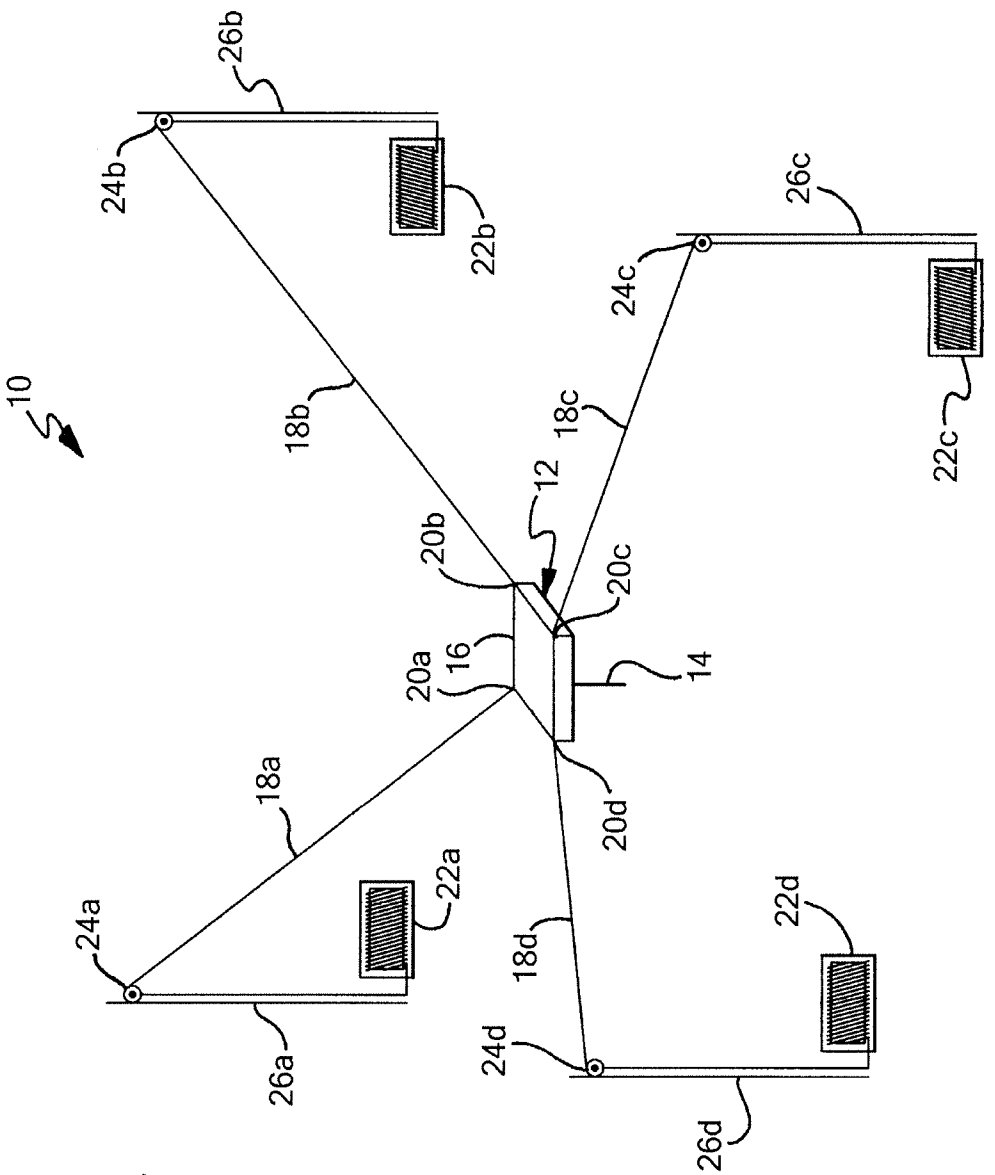
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FIG. 1

FIG. 2

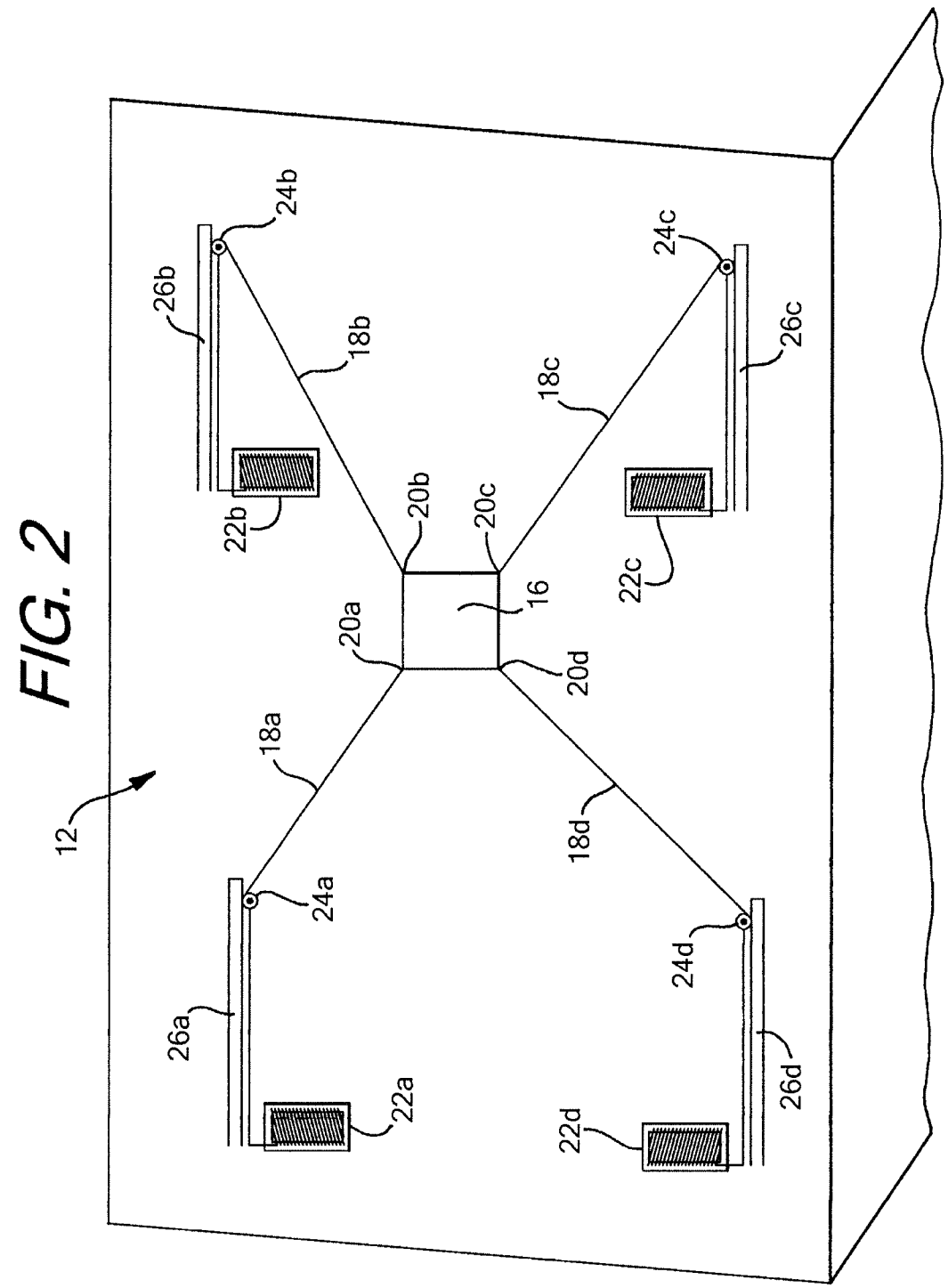
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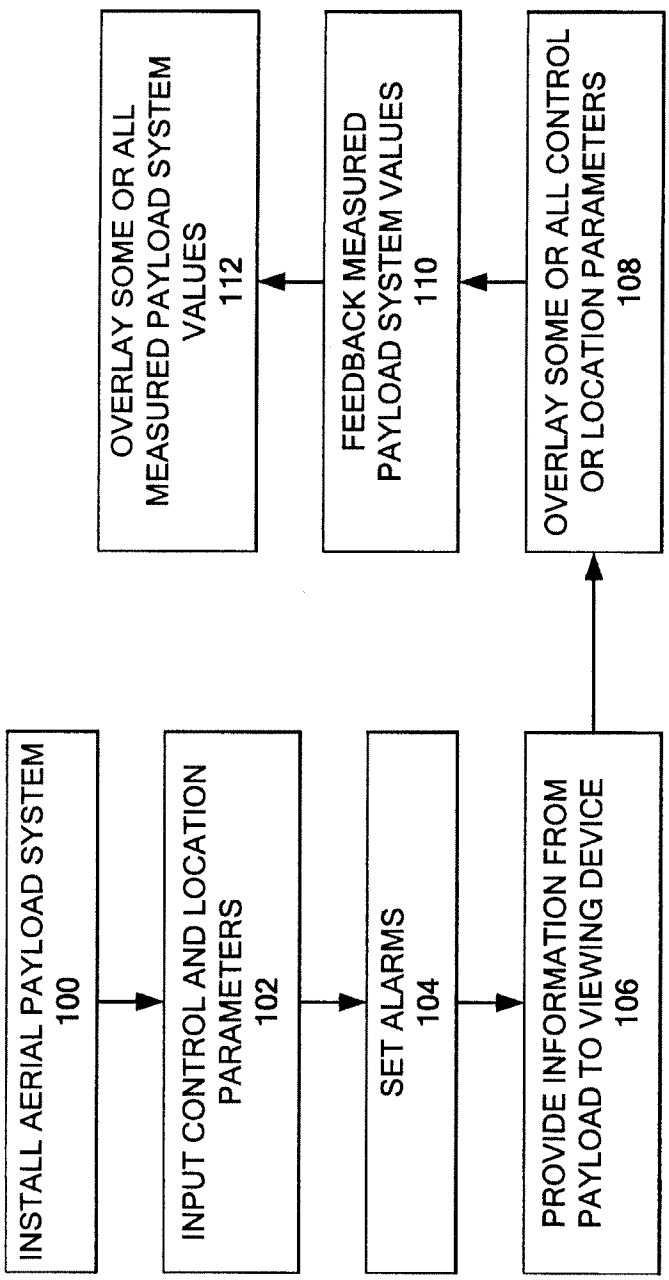
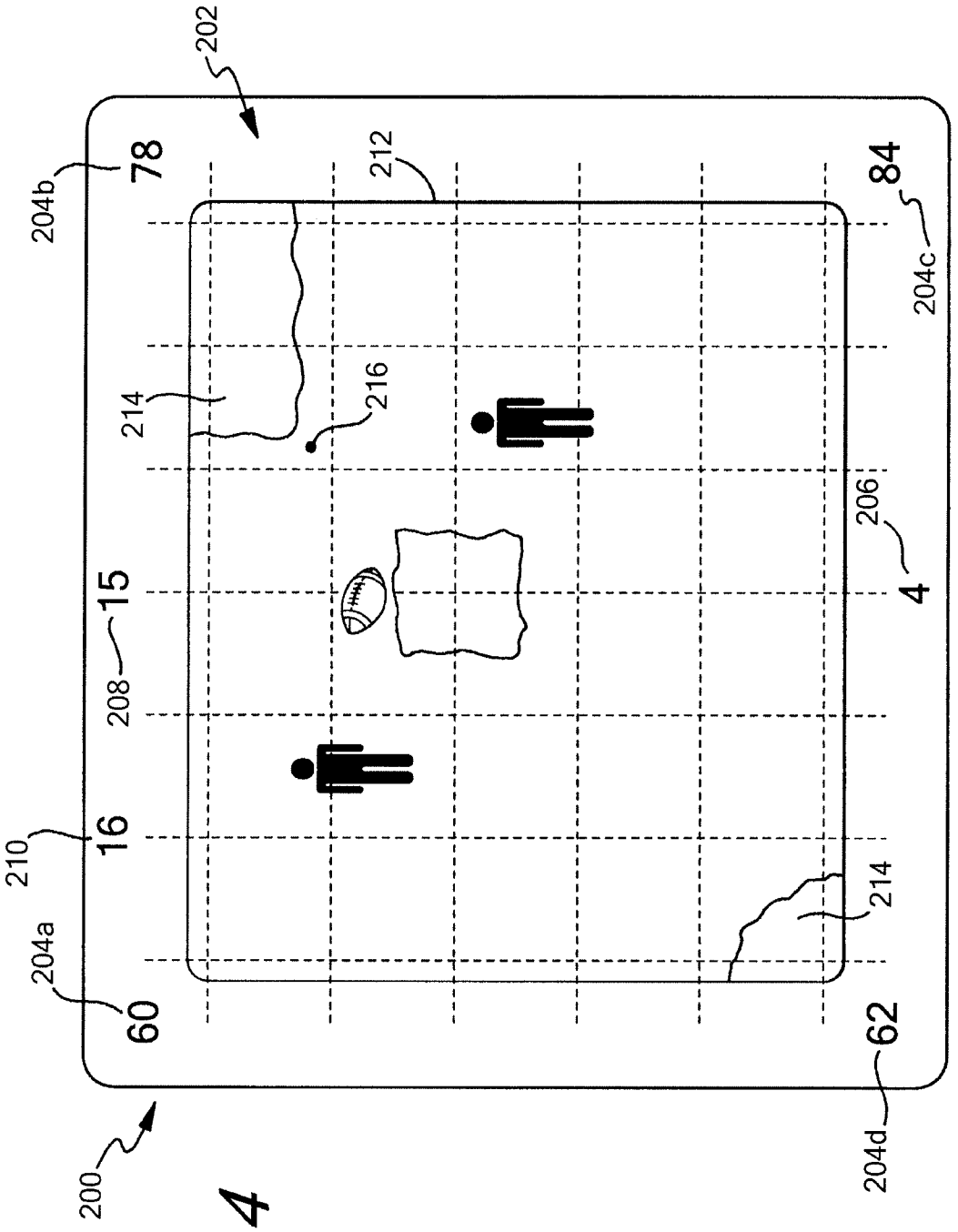
FIG. 3


INSTALL AERIAL PAYLOAD SYSTEM
100
INPUT CONTROL AND LOCATION PARAMETERS
102
SET ALARMS
104
PROVIDE INFORMATION FROM PAYLOAD TO VIEWING DEVICE
106
OVERLAY SOME OR ALL CONTROL OR LOCATION PARAMETERS
108
FEEDBACK MEASURED PAYLOAD SYSTEM VALUES
110
OVERLAY SOME OR ALL MEASURED PAYLOAD SYSTEM VALUES
112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214
62
204d
200

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/053299

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H04N 07/18 (2012.01)
USPC - 348/144
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - H04N 07/18, H04N 05/225, G08B 21/00, G05D 01/02, G06F 17/10, G06G 07/78 (2012.01)
USPC - 348/144-147, 157, 207.1, 207.11, 340/665-668, 701/300-302

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/0207250 A1 (BENNETT et al) 20 August 2009 (20.08.2009) entire document	1-3, 16-21
Y	US 6,023,302 A1 (MACINNIS et al) 08 February 2000 (08.02.2000) entire document	1-3, 16-21
Y	US 6,152,246 A1 (KING et al) 28 November 2000 (28.11.2000) entire document	19-21
A	US 7,492,306 B2 (HUMPHREY et al) 17 February 2009 (17.02.2009) entire document	1-3, 16-21
A	US 2011/0204196 A1 (WHARTON) 25 August 2011 (25.08.2011) entire document	1-3, 16-21
A	US 6,873,355 B1 (THOMPSON et al) 29 March 2005 (29.03.2005) entire document	1-3, 16-21
A	US 4,565,099 A1 (ARNOLD) 21 January 1986 (21.01.1986) entire document	1-3, 16-21

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 November 2012	23 NOV 2012
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/053299

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-15, 22-24
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.