A shock and vibration system for an infant care transport system with an enclosed infant care device. The shock and vibration system utilizes multiple damping systems that create a floating patient support system that allows the infant care device to move in the various axes of motion instead of being rigidly mounted to the frame or sub-frame, or any substructure.
Declarations under Rule 4.17:
— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(H))
— as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(H))

Published:
— with international search report (Art. 21(3))
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))
Title

Infant Care Transport Device with Shock and Vibration System

Cross-Reference to Related Applications

[001] This application claims the benefit of US Provisional application 61/788,592 filed March 15, 2013.

Background

[002] This disclosure relates to various infant warming and transport devices that are used to protect newborns immediately after birth, and particularly those that are used for transport of the infants either within hospital environments or between hospitals via ground or air transport. In the treatment of infants, and particularly those born prematurely, it is necessary to provide heat to the infant during the care and treatment of the infant and to minimize heat loss from the infant's body. This disclosure will refer to these devices generically as infant care transport devices. They can be called neonatal incubators, infant warmers, neonatal transporters, etc. This disclosure anticipates any of those names.

[003] Such an infant care device is often a rigid box-like enclosure in which an infant can be kept in a controlled environment for observation and care. The infant care device may include a temperature control system, an air circulation system, including a fan, a humidity control system, a control valve through which oxygen may be added, and access ports for nursing care. To facilitate transport this structure is often mounted on a support system that may include wheels.

[004] Infant care transport devices are exposed to shock and vibration effects during movement that transmit those shocks to the patient. In transport systems like neonatal incubators, shock and vibration occurs during
loading and unloading of the infant care transport device into the transport vehicle, from rough roads, impacts from take-off and landings in planes and helicopters, movements of the aircraft in-flight, and just movement of the infant care transport device over rough surfaces as well as shock and vibration that occurs inside of the hospital due to thresholds, elevators, and accidental impact of the infant care transport device into walls, etc. These effects can result in serious life threatening injuries to comprised patients, especially premature infants where shock and vibration can cause brain hemorrhages and injury.

[005] There is a need then to provide damping systems to these infant care transport devices that can dampen these shocks and vibrations and to take all axes (x, y, and z) into account.
**Brief Summary**

[006] This need can be met by incorporating multiple shock and vibration damping systems to minimize those conditions being transmitted to the patient. Embodiments that may be included in this approach include a set of z axis dampers incorporated into the main structure, a similar set of dampers for x & y axes, and the addition of a floating patient support system that allow the patient system to move in the axis of vibration instead of being rigidly mounted to the frame as in current systems. The system also adds over-travel protection for extreme conditions to ensure that the free movement of these axes will be limited in extreme conditions as a fail-safe mode.
Description of Drawings

[007] There are disclosed in the drawings and detailed description to follow various embodiments of the solution proposed herein. It should be understood, however, that the specific embodiments given in the drawings and entailed description do not limit the disclosure. On the contrary, they provide the foundation for discerning the alternative forms, equivalents, and modifications that will be encompassed in the scope of the eventual claims.

[008] Figure 1 is a view of an infant care transport device or neonatal incubator that can include the inventive concept to be described in this disclosure.

[009] Figure 2 is an alternate view of an infant care transport device or neonatal incubator that can include the inventive concept to be described in this disclosure.

[0010] Figure 3 is an alternate view of an infant care transport device or neonatal incubator that can include the inventive concept to be described in this disclosure.

[0011] Figure 4 is a side view illustration of an overall damping system. For an infant care transport device or neonatal incubator.

[0012] Figure 5 is a more detailed illustration of a possible patient support z-axis bed damper.

[0013] Figure 6 is a more detailed illustration of z-axis vertical isolators.

[0014] Figure 7 is a more detailed illustration of a radial damping system to reduce shock and vibration in the x and y axis.
[0015] Figure 8 is an illustration of over-travel protection limits for more extreme shock and vibration conditions.
Detailed Description

[0016] Referring now to Figures 1, 2, and 3, several views of an infant care device or neonatal incubator system that can include the inventive concepts to be described in this disclosure. Figure 1, shown overall by the numeral 1, is the infant care device. On the side of the infant care device system there is a ventilator system 20, a user interface 30, and a monitor 40. A chamber 10 covering and protecting the patient sits on top, including a light 60 and side ports 25 providing access for care givers.

[0017] Figure 2, represented by the numeral 2, is an alternate view of the same system with the chamber removed, showing the patient support 80 that underlies the infant.

[0018] Figure 3, represented by the numeral 3, is a front view of the same system with the chamber 10 in place, and again showing the ventilator 20, user interface 30, and monitor 40.

[0019] Figure 4, represented by numeral 100, illustrates an embodiment of the overall shock and vibration system for an infant care transport device. The system consists of multiple damping systems including one or more z-axis dampers 110 attached to and under a patient support 105 and further attached to the infant care device main frame 130. Z-axis bed dampers 110 dampen z-axis shock and vibration movement between the patient support 105 and the infant care device main frame 130. One or more vertical isolators 120 (z axis) are mounted to a lower sub-frame 150 or directly to a stretcher, cart or other device (not shown) to limit the initial shock transmitted to the system caused by the mounting of the infant care device to another system, and a radial x-y axis damper 140 to limit the lateral (x & y axes) shock and vibration movements to the system.
[0020] The radial x-y axis damper 140 can absorb shocks in any direction in the x-y plane. More details of an embodiment of a radial x-y axis damper is shown and discussed in later drawings. The z-axis bed dampers 110 and vertical z-axis isolators 120 can use a variety of damping technologies such as springs, air bladders, bellows, elastomeric materials, magneto-rheological, piezoelectric, or other electronically controlled variable damper system as well as viscous or fluidic type dampers or other art known techniques to absorb these shocks and any of these possibilities are anticipated herein. It most likely will be a combination of materials tuned for the infant care transport device weight and the vibration environment the infant care transport device is subject to.

[0021] Each of these separate damping systems can act independently of each other so as not to interfere with the damping of each axis when there is a complex multi-axis shock or vibration that occurs.

[0022] It is possible and envisioned that these multiple damping systems could be combined into a single isolator system that multiple independent damping axes contained within it for ease of assembly and manufacturability.

[0023] The shock and vibration system also has an over-ride system that acts as a limit stop in cases of extreme situations that might over-drive the system. The combination of these systems creates a floating patient support that is isolated from the infant care device main frame, allowing it to move relative to the direction of shock or vibration.

[0024] In another embodiment the shock and vibration system contains a method of locking the damping system so that the axes are no longer free floating.

[0025] Figure 5 (numeral 200) illustrates a more detailed example of z-axis bed dampers 110 under a patient support 105. These z-axis dampers are mounted to the infant care transport device main frame 130 in order to create free a floating patient support. For illustrative purposes the z axis bed damper 110 is shown as a spring. However, as mentioned previously this could be implemented with a variety of damping technologies such as
springs, air bladders, bellows, elastomeric materials, magneto-rheological, piezoelectric, or other electronically controlled variable damper systems as well as viscous or fluidic type dampers or other art known techniques to absorb these shocks and any of these possibilities are anticipated in this disclosure.

[0026] Figure 6 (numeral 300) illustrates an example of vertical z-axis isolators 120 (equivalent to isolators 120 in figure 4) that are deployed between the infant care transport device main frame 130 and the lower sub-frame 150. The z-axis isolators reduce the shock and vibration being transmitted from the device the infant care transport device is mounted to, and the infant care transport device main frame. As mentioned previously the vertical z-axis isolators 120 can be any design of damper such as springs, air bladders, bellows, elastomeric materials, magneto-rheological, piezoelectric, or other electronically controlled variable damper systems.

[0027] Figure 7 (numeral 400) illustrates one embodiment of a example of a radial (x-y) axis damper (equivalent to the damper 140 in figure 4) that can be deployed between the infant care transport device main frame and lower sub-frame to limit any lateral shock and vibration that occurs in any direction in the x-y plane. Illustrated is a top and side view. A radial damper housing 410 is attached to the infant care transport device main frame 130. This radial damper housing is shown in both the top view and it is shown in the side view in a cut-away. Within this housing 410 is a lateral radial x-y axis damper 430. Surrounding the radial damper housing 410 and attached to the infant care transport device sub-frame 150 is a stop 420. In the drawing illustration the radial damper housing 410, the radial x-y axis damper 430 and the stop 420 that surrounds the housing and damper are shown as completely circular for illustrative purposes, but other shapes, such as elliptical or others could be envisioned. This disclosure anticipates any shape that would surround the radial x-y axis damper with a stop.

[0028] In this embodiment the infant care transport device floats radially (in the x-y plane) and does not contact the sub-frame stop 420 until the radial x-y axis damper responds to a possible shock or vibration. The radial damper
stop 420 surrounds the radial damper in order to take the forces in any x-y axis direction. The damper could use a variety of damping technologies such as springs, air bladders, bellows, elastomeric materials, magneto-rheological, piezoelectric, or other electronically controlled variable damper system as well as viscous or fluidic type dampers or other art known techniques to absorb these shocks and any of these possibilities are anticipated herein.

[0029] It should be recognized that the embodiment described herein regarding the radial x-y axis radial damper could be "flipped" in the sense that the radial damper housing and its enclosed x-y axis damper could be attached to the infant care transport device sub-frame while the "stop" is attached to the infant care transport main frame and still encircling the radial damper housing. This embodiment would operate in the same way to dampen shocks and vibrations in any x-y axis direction.

[0030] Figure 8 (numeral 500) illustrates a more detailed example of the over travel limit springs 510 that are connected to the infant care transport device lower sub-frame 150 that would limit extreme z travel under severe conditions by the spring hitting the hard stop 530 mounted to the infant care transport device main frame 130. The hard stop is a safety measure required to make provisions for an extreme or catastrophic condition that is beyond the capability if the damping systems.

[0031] The system described herein reduces the shock and vibration transmitted to the device and patient during transport and movement of the device. Current systems can subject the patient to high levels of shock and vibration under transport conditions that can lead to permanent injury.

[0032] Although certain embodiments and their advantages have been described herein in detail, it should be understood that various changes, substitutions and alterations could be made without departing from the coverage as defined by the appended claims. Moreover, the potential applications of the disclosed techniques is not intended to be limited to the particular embodiments of the processes, machines, manufactures, means, methods and steps described herein. As a person of ordinary skill in the art
will readily appreciate from this disclosure, other processes, machines, manufactures, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufactures, means, methods or steps.
Claims

What is claimed is:

1) An infant care transport device with a shock and vibration system comprising:
   ▪ an enclosed infant care device comprising a patient support that underlies an infant;
   ▪ one or more z-axis bed dampers connecting the patient support to an infant care transport device main frame to dampen z-axis vertical movement of the patient and patient support relative to the infant care transport device main frame; and
   ▪ one or more radial x-y axis dampers acting to dampen x-y axis movement between the infant care device main frame and a lower sub-frame of the infant care transport device that is used to mount the device to other systems such as carts, stretcher adapters, stretchers, etc.

2) The infant care transport device with a shock and vibration system of claim 1 further comprising:
   ▪ one or more vertical z-axis isolators between the infant care transport device main frame and the lower sub-frame of the infant care transport device to dampen z-axis movement.

3) The infant care transport device with a shock and vibration system of claim 1 wherein the one or more radial x-y dampers comprise:
   ▪ a radial damper housing attached to the infant care transport device main frame but not attached to the infant care transport device sub-frame;
   ▪ a radial x-y axis damper deployed within the radial damper housing;
   ▪ a stop attached to the infant care transport device sub-frame and encircling the radial damper housing.
4) The infant care transport device with a shock and vibration system of claim 1 wherein the one or more radial x-y dampers comprise:
   - a radial damper housing attached to the infant care transport device sub-frame but not attached to the infant care transport device main frame;
   - a radial x-y axis damper deployed within the radial damper housing;
   - a stop attached to the infant care transport device main frame and encircling the radial damper housing.

5) The infant care transport device with a shock and vibration system of claim 3 wherein the radial damper housing, the radial x-y axis damper, and the stop that encircles the radial damper housing are circular in shape.

6) The infant care transport device with a shock and vibration system of claim 3 wherein the radial damper housing, the radial x-y axis damper, and the stop that encircles the radial damper housing are elliptical in shape.

7) The infant care transport device with a shock and vibration system of claim 4 wherein the radial damper housing, the radial x-y axis damper, and the stop that encircles the radial damper housing are circular in shape.

8) The infant care transport device with a shock and vibration system of claim 4 wherein the radial damper housing, the radial x-y axis damper, and the stop that encircles the radial damper housing are elliptical in shape.

9) The infant care transport device with a shock and vibration system of claim 2 wherein the z-axis bed dampers employ elastomeric materials for damping.
10) The infant care transport device with a shock and vibration system of claim 2 wherein the radial x-y axis dampers employ elastomeric materials for damping.

11) The infant care transport device with a shock and vibration system of claim 2 wherein the z-axis isolators employ elastomeric materials for damping.

12) The infant care transport device with a shock and vibration system of claim 2 wherein the z-axis bed dampers employ springs for damping.

13) The infant care transport device with a shock and vibration system of claim 2 wherein the radial x-y axis dampers employ springs for damping.

14) The infant care transport device with a shock and vibration system of claim 2 wherein the z-axis actuators employ springs for damping.

15) The infant care transport device with a shock and vibration system of claim 2 wherein the z-axis bed dampers employ magneto-mechanical, piezoelectric, or other electronically controlled variable damper systems for damping.

16) The infant care transport device with a shock and vibration system of claim 2 wherein the radial x-y axis dampers employ magneto-mechanical, piezoelectric, or other electronically controlled variable damper systems for damping.

17) The infant care transport device with a shock and vibration system of claim 2 wherein the z-axis isolators employ magneto-mechanical, piezoelectric, or other electronically controlled variable damper systems for damping.
18) The infant care transport device with a shock and vibration system of claim 2 wherein the z-axis bed dampers employ air bladders or bellows for damping.

19) The infant care transport device with a shock and vibration system of claim 2 wherein the radial x-y axis dampers employ air bladders or bellows for damping.

20) The infant care transport device with a shock and vibration system of claim 2 wherein the z-axis actuators employ air bladders or bellows for damping.

21) The infant care transport device with a shock and vibration system of claim 2 wherein shock and vibration system contains a method of locking the damping system so that the axes are no longer free floating.

22) An infant care transport device with a shock and vibration system with a floating patient support or bed surface that is isolated from the infant care transport device main frame allowing it to move relative to the direction of shock or vibration.

23) An infant care transport device with a shock and vibration system with a floating main frame and a sub-frame below the device that allows it to move relative to the direction of shock or vibration in the vertical axis.

24) An infant care transport device with a shock and vibration system with a floating main frame and a sub-frame below the device which is mounted to a rigid structure such as a cart, stretcher, or stretcher adapter that allows the system to move relative to the direction of shock or vibration in the lateral axes.
25) An infant care transport device with a shock and vibration system that allows the damping systems for each axis to act independently of each other so as not to interfere with damping of each axis when there is a complex multi-axis (x, y, and z) shock or vibration that occurs.

26) An infant care transport device with a shock and vibration system with an over travel limit system (x, y, or z axes) that prevents the individual damping systems for reaching full travel in the event of an extreme or catastrophic condition.

27) An infant care transport device with a shock and vibration system that contains a method of locking the damping system so that the axes are no longer free floating.

28) The infant care transport device with a shock and vibration system of claim 1 wherein the enclosed infant care device is enclosed with a chamber covering and protecting the infant.

29) The infant care transport device with a shock and vibration system of claim 28 wherein the chamber covering and protecting the infant comprises side ports providing access to the infant for caregivers.

30) The infant care transport device with a shock and vibration system of claim 1 wherein the enclosed infant care device further comprises a ventilation system for maintaining ventilation within the device.

31) The infant care transport device with a shock and vibration system of claim 1 wherein the enclosed infant care device further comprises a temperature control system for controlling temperature of the infant.

32) The infant care transport device with a shock and vibration system of claim 31 wherein the temperature control system comprises a heated mattress.
33) The infant care transport device with a shock and vibration system of claim 1 wherein the enclosed infant care device further comprises a humidity control system.

34) The infant care transport device with a shock and vibration system of claim 1 wherein the enclosed infant care device further comprises a control valve through which oxygen can be added.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

A61G II/00(2006.01)i, A61G 7/08(2006.01)i

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)
A61G 11/00; A47C 3/100; A47B 81/06; A61B 6/04; A47D 9/02; A61G 7/08

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

X "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
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"&" document member of the same patent family

Date of the actual completion of the international search
04 May 2014 (04.07.2014)

Date of mailing of the international search report
07 July 2014 (07.07.2014)

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### International Search Report

**Information on patent family members**

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