A transportable medical facility (10), is convertible between a compacted condition for transport on a low loading trailer, and an expanded, free-standing condition for use. The transportable medical facility (10), when in its expanded condition, comprises a base structure (11), a roof structure (13) and external walls (14,16), which together define an enclosed working area (17). Further internal walls (19,20) are also provided, which define an operating theatre (21) within the working area (17). A portion of the roof structure (13) which overlies the operating theatre (21) has a laminar flow hood (31) mounted therein, such that a laminar airflow may be established within the operating theatre (21) when the transportable medical facility is in use.
Transportable Medical Facility with Laminar Airflow

This invention relates to a transportable medical facility. In particular, it relates to a transportable medical facility having an operating theatre in which a laminar airflow is established.

The use of mobile surgical units capable of being used for the performance of routine or elective surgery has developed considerably in recent years. This growth has been due partly to increases in the availability and accessibility of non-invasive routine procedures and elective surgery, whilst political pressure to reduce hospital waiting lists may also be a contributory factor.

Typically, mobile surgical units are housed in a specially adapted trailer of an articulated heavy goods vehicle (HGV). The HGV can be driven to the desired location, e.g. adjacent a door of a hospital, where the mobile surgical unit can be deployed into its operational condition. This deployment often involves expanding the sides of the trailer so as to create an internal working area having a total width somewhat greater than that of the trailer when in transit. Within this working area will usually be defined an operating theatre or procedure room, often accompanied by rudimentary pre- and post-procedural induction and recovery areas. The trailer will often be provided with ramps or walkways to enable the internal working area to be directly connected to the door of the hospital, and/or to other mobile surgical units.

Because such mobile surgical units are built upon the chassis of the adapted trailer, there is a limit to the extent to which the sides of the trailer can be expanded, and thus a limit to the central body width of the internal working area. This means that the floor area available in the procedure rooms within such mobile surgical units is inevitably somewhat restricted as compared to operating theatres in fixed hospital buildings. Consequently, procedure rooms in mobile surgical units are limited to the accommodation of essential equipment and fittings as opposed to the full range found in fixed site hospital operating theatres.

The nature of the construction of mobile surgical units within adapted HGV trailers also prevents certain features of hospital operating theatres being included, since the constructional elements of such trailers (walls, roof, floor) do not lend themselves to the housing of certain sophisticated sterile air conditioning,
purification and circulation systems – in particular, laminar airflow systems – found in hospital operating theatres. The level of air quality achievable within chassis-mounted mobile surgical units is thus generally limited to European Union Good Manufacturing Practice (EU GMP) Grade C. This level is acceptable for a range of non-invasive and invasive surgical procedures, but is not acceptable for deep orthopaedic surgery such as joint replacement. As a result, the use of mobile surgical units has been restricted to non-invasive procedures and invasive procedures other than deep orthopaedic bone surgery, since the required degree of air purify for such procedures cannot be achieved.

Laminar airflow systems have been used in a variety of applications where air purity is paramount. In addition to their use in hospital operating theatres, laminar airflow systems are employed in chemical and biological laboratories, and in manufacturing plants for electronics components. The principle of laminar airflow is that air purity within a designated enclosed air space can be greatly enhanced by causing the entire body of air within that space to move with uniform velocity in a single direction along parallel flow lines. Turbulence within the air space is thus eliminated (or in practice, at least greatly reduced) so that any particles of impurities are flushed out of the air space.

The air must be filtered prior to entering the designated space and then, after passing through the air space, be re-circulated via a series of return channels to be filtered again before re-entering the air space. To achieve the required level of air purity, High Efficiency Particulate Air (HEPA) filters are used, and are preferably deployed in a grid substantially overlying the designated air space.

According to the present invention there is provided a transportable medical facility, convertible between a compacted condition for transport on a low loading trailer, and an expanded, free-standing condition for use, said transportable medical facility, when in its expanded condition, comprising:

- a base structure, a roof structure and external walls, defining an enclosed working area;

- internal walls defining an operating theatre within said working area; and
- a laminar flow hood provided in a portion of the roof structure overlying the operating theatre, thereby to establish a laminar airflow within the operating theatre when in use.

The term "transportable" as used herein refers to a medical facility capable of being transported from one location to another atop a low loader trailer of an HGV, but which is independent of the trailer chassis. The transportable medical facility is then deployed to stand freely of the HGV, which may then be driven off the site until such time as a subsequent re-location of the transportable medical facility is required. The dimensions and construction of the transportable medical facility of the present invention are therefore not bound by the constraints imposed upon the adapted trailer-based mobile surgical units of the prior art. In particular, the increased central body width of the deployed transportable medical facility leads to a greater available floor area within the procedure rooms, as compared to known mobile surgical units.

The transportable medical facility of the present invention may be constructed in a range of different sizes, depending on the surgical application for which it is intended. At present however, it is generally preferred that the facility should be constructed so as to have a length of substantially 15 m, a height of substantially 3.25 m, and a width of substantially 3.25 m when in its compacted condition, said width increasing to substantially 6.9 m when the facility is converted to its expanded condition.

The construction of the transportable medical facility of the present invention thus permits the inclusion of a laminar flow hood for establishing a laminar airflow within the operating theatre, thus leading to considerably higher levels of air purity, and thus sterility, in the operating theatre. The level of air quality within the operating theatre of the transportable medical facility of the present invention typically achieves EU GMP Grade A, as is required for deep invasive orthopaedic surgery. The transportable medical facility of the present invention may thus be utilised for the performance of deep invasive surgery, such as knee or hip joint operations, as well as less invasive procedures.

The laminar flow hood comprises a plurality of High Efficiency Particulate Air (HEPA) filters, arranged in a grid substantially overlying the entire area of the
operating theatre, when said facility is in its expanded condition. Each HEPA filter is preferably a 600 mm square, and is capable of preventing the passage of all airborne particles having a diameter greater than 0.2 m. It is envisaged that the filters will require replacing about every 6 months to maintain performance standards. The total area of the laminar flow hood, is preferably substantially equal to at least 75% of the area of the operating theatre therebeneath, and most preferably overlies substantially the entire operating theatre. In a currently preferred embodiment of the present invention, the laminar flow hood is defined by a rectangle having a width of substantially 2.7 m and a length of substantially 3.2 m, said area being bound by a polycarbonate surround depending from the hood.

The laminar flow hood communicates with one or more air ducts formed in the roof structure. The ducts preferably also house one or more further air conditioning and/or purifying elements such as pre-filters, further HEPA filters and fans arranged to drive circulation of the air through the ducts and the laminar flow hood, and ultimately through the operating theatre.

The inlet and exhaust vents for the air ducts are preferably located in portions of the roof structure which, when the facility is in its expanded condition, overlie parts of the working area outside the operating theatre. Most preferably, the working area further comprises a pre-operational induction room and a post-operational recovery room, each defined externally of the operating theatre, and the inlet and exhaust vents are located in the roof structure overlying said induction and recovery rooms. The air ducts in the roof structure overlying each of said induction and recovery rooms are preferably also provided with two further HEPA filters. The recovery room is preferably equipped to accommodate up to three patients on trolley-mounted beds, whilst the induction room is intended to accommodate a single patient.

To facilitate the re-circulation of the air once it has passed through the operating theatre in a laminar airflow, the internal walls defining the operating theatre preferably include one or more return channels in communication with the air ducts which feed the laminar flow hood, said return channels being located externally of the laminar airflow established within the operating theatre. Most preferably, each return channel has an inlet located adjacent the floor of the
operating theatre to permit the ingress of air to be returned to the laminar flow hood. The location of the inlet adjacent the floor of the operating theatre ensures that as close as possible to the entire volume of air in the operating theatre is entrained in a laminar airflow.

In addition to the re-circulation of air which has passed through the operating theatre in a laminar airflow, it is also highly desirable that a proportion of the air passing through the laminar flow hood should be fresh air, thus enabling the air within the operating theatre to be constantly replenished. The air ducts which feed the laminar flow hood are therefore preferably divided into a central portion in communication with air drawn from the ambient through one or more pre-filters, and one or more outer portions in communication with the return channels.

By monitoring and controlling the relative amounts of air flowing through said central and outer air duct portions, the rate at which the volume of air within the operating theatre is completely replenished can be accurately controlled. It is currently preferred that the system be configured to deliver substantially 30 complete air changes per hour to the operating theatre.

The operating theatre is preferably equipped with an operating table which, when the facility is in its expanded condition, is arranged substantially perpendicular to the longitudinal axis of the facility, and directly beneath the central portion of the laminar flow hood – *i.e.* the portion of the laminar flow hood fed by the central air duct portion. The fresh air discharged from said central portion is thus directed onto said operating table.

In order that the laminar airflow with the operating theatre can be monitored and controlled, the transportable medical facility of the present invention preferably further comprises one or more sensors arranged to measure the velocity of the laminar air flow established within the operating theatre and/or the air pressure generated thereby. Preferably, said air flow sensors are mounted at substantially 1 metre from the floor of the operating theatre. Under normal operating conditions the preferred velocity of the airflow reported by the sensors should be substantially 0.2 m/s. Air pressure sensors are preferably provided in both the operating theatre and the other working areas, namely the induction and recovery rooms. Under normal operating conditions, the pressure sensors should report a positive pressure
differential of substantially 15 to 20 pa between the operating theatre and said other working areas. The data collected by the sensors is used to adjust airflow and pressure to ensure that the level of air quality complies with EU GMP Grade A.

The transportable medical facility of the present invention, when in its expanded condition, preferably further comprises an auxiliary section defined within the working area and having further internal walls defining one or more rooms selected from a changing room, “clean” and “dirty” utility rooms, a staff locker room and a scrub room.

To enable the conversion of the transportable medical facility between its compacted and its expanded conditions, each of the base structure and the roof structure are preferably formed with one or more fold lines parallel to the longitudinal axis of said facility, and at least one external wall is mounted on a pair of hydraulic rams.

The deployment of the transportable medical facility from its low loader trailer to its free-standing position is preferably achieved by means of hydraulic lifting legs provided on the base structure. The base structure is preferably further provided, at spaced reinforced locations, with a plurality of adjustable feet, adapted to support said facility in a level position when deployed in its expanded condition. Most preferably, ten such adjustable feet are provided. It is envisaged that deployment of the transportable medical facility from its compacted condition on a low loader trailer to its expanded, free-standing condition will be achieved in substantially 1 hour and 10 minutes.

In order that the present invention may be more fully understood, preferred embodiments thereof will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 shows a cross-sectional plan view of a preferred embodiment of transportable medical facility according to the present invention, when deployed for use in its expanded condition;

Figure 2 shows a cross-sectional plan view of the transportable medical facility of Figure 1, when in its compacted condition for transit;

Figure 3 shows cross-sectional side view of the operating theatre of the transportable medical facility of Figure 1;
Figure 4 shows a cross-sectional plan view of the roof structure of the transportable medical facility of Figure 1; and

Figure 5 shows a perspective view of the roof structure of Figure 4.

Referring first to Figure 1, a transportable medical facility, generally indicated 10, according to the present invention is shown in its expanded condition, deployed ready for use. The facility 10 comprises a base structure 11 (not visible in Figure 1), having upstanding end members 12, a roof structure 13 (not visible in Figure 1) and external side walls 14. For ease of representation, the transportable medical facility 10 is shown in Figure 1 with the roof structure 13 substantially removed. The roof structure 13 will be described in more detail below with reference to Figures 4 and 5.

The external side walls 14 are adapted to move in and out of the facility 10 so as to effect conversion of the facility between its expanded and compacted conditions. The side walls 14 are provided with end wall portions 15, which combine with the upstanding end members 12 of the base structure 11 to form external end walls 16 of the facility 10 when said facility 10 is in its expanded condition.

An internal working area, generally indicated 17, is defined within the external side and end walls 14, 16. As can be seen from Figure 1, one side wall 14' of the facility 10 is adapted to move further from the base structure 11 than is the other, thus defining an auxiliary section, generally indicated 18, of the working area 17. A first pair of internal walls 19 are provided transversely across the working area 17, which first pair of walls 19, together with a second pair of internal walls 20 arranged parallel to the longitudinal axis of the facility 10, define an operating theatre 21 generally centrally within the facility 10. The first pair of internal walls 19 also serve to divide the remaining working area 17 into a pre-operational induction room 22, and a post-operational recovery room 23. Further internal walls 24 are provided within the auxiliary section 18, thus sub-dividing it into “clean” and “dirty” utility rooms 25, 26, a scrub room 27 and a changing room 28, each fitted with appropriate units, sinks, lockers, cupboards etc. 29.

In an area of the roof structure 13 substantially overlying the operating theatre 21 is provided a laminar flow hood 31, as will be described in more detail
below with reference to Figures 3 to 5. An operating table 32 is provided in the operating theatre 21, arranged centrally beneath the laminar flow hood 31, and substantially perpendicular to the longitudinal axis of the transportable medical facility 10.

Referring now to Figure 2, this shows the transportable medical facility 10 in its compacted condition for transit on a low loader trailer (not shown). Again, for ease of representation, the transportable medical facility 10 is shown in Figure 2 with the roof structure 13 removed. To achieve the compacted condition of Figure 2 from the expanded condition shown in Figure 1, the side walls 14 move inwards to lie substantially flush with the upstanding end members 12 of the base structure 11.

As can be seen from Figure 2, in said compacted condition, the end portions 15 of the side walls 14 are nested within the interior of the facility 10, whilst the first pair of internal walls 19 are either partially removed by means of removable sections (not shown) or collapsed by means of a telescopic or sliding arrangement. The working area 17 comprising the operating theatre 21, pre-operational induction room 22 and post-operational recovery room 23 is thus substantially compacted. However, the second pair of internal walls 20, and the further internal walls 24 within the auxiliary section 18 remain in place, so that the clean and dirty utility rooms 25, 26, scrub room 27 and changing room 28 defined thereby remain intact.

Referring now to Figure 3, this shows the operating theatre 21 viewed along the longitudinal axis of the transportable medical facility 10. The laminar flow hood 31 is formed as part of the roof structure 13, and overlies substantially the entire working area of the operating theatre 21. The laminar flow hood 31 is fed by a series of air ducts 33 formed in the roof structure 13, which are divided into a central portion 34 and two outer portions 35. The central air duct portion 34 is in communication with air drawn from the ambient, as will be discussed in more detail below with reference to Figure 4 and 5. The outer air duct portions 35 are each in communication with a return channel 36 formed in the second pair of internal walls 20 defining the operating theatre 21. Fans 37 are located at the top of the return channels 36, to drive the re-circulated air from said return channels 36 into the outer air duct portions 35. Further like fans 37 are arranged to drive the fresh air
through the central air duct portion 34, as will be discussed in more detail below with reference to Figures 4 and 5.

The flow of air through the operating theatre 21, as illustrated by the arrows in Figure 3, will now be discussed. The air ducts 34, 35 feed the laminar flow hood 31, where the combined air streams are passed through a grid of High Efficiency Particulate Air (HEPA) filters (not shown in Figure 3) encased by a polycarbonate surround 38. The surround 38 extends into the operating theatre 21 and is shaped so as to impart a unidirectional downward flow to the air stream driven therethrough by the fans 37.

As shown in Figure 3, the laminar airflow passes downwardly through substantially the entire height of the operating theatre 21, before being channelled into the return channels 36 by inlets 39 formed in the internal walls 20 closely adjacent the floor 41 of the operating theatre 21. The action of the fans 37 then draws the air up the return channels 36 and returns it to the outer air duct portions 35 which then feed the laminar flow hood 31, together with replenished fresh air from the central air duct portion 34. At each pass, a proportion of the re-circulated air is carried away along the central air duct portion 34 to be expelled, as will now be discussed below with reference to Figures 4 and 5.

The flow of air through the transportable medical facility 10 will now be further discussed, referring simultaneously to Figures 4 and 5, which show different aspects of the roof structure 13. Fresh air is drawn from the ambient into the facility 10 by a further set of fans 37', through an inlet vent 42 provided with a pre-filter 43, and located in the upstanding member 12 of the base structure 11 adjacent the pre-operational induction room 22. The air is then driven by the fans 37' through an air duct 33 over the pre-operational induction room 22, provided with further pre-filters 43 in communication with the pre-operational induction room 22. The pre-filters 43 may desirably also be HEPA filters.

As discussed previously, when the air duct 33 reaches the roof structure 13 overlying the operating theatre 21, the duct 33 is split into a central portion 34 and two outer portions 35. The fresh air is channelled through the central portion 34 which feeds the laminar flow hood 31, consisting of a grid of HEPA filters 44. Here, a proportion of the fresh air will be driven through the laminar flow hood 31 into the
operating theatre 21, combining with the re-circulated air driven through the outer air duct portions 35 by the fans 37 from the return channels 36, as described above with reference to Figure 3. However, a proportion of the fresh air will combine with a proportion of the re-circulated air, and be channelled into a continuation of the air duct 33 overlying the post-operative recovery room 23. This part of the air duct 33 is provided with exhaust vents 45 in communication with the post-operative recovery room 23, and ultimately the ambient. By the provision of sensors (not shown) in the air ducts 33, 34, 35, the return channels 36, and the operating theatre 21, and by varying the relative power of the fans 37, 37', the ratio of re-circulated to fresh air passing through the operating theatre 21 can be controlled, as can the number of complete air changes in a given time period.
CLAIMS

1. A transportable medical facility, convertible between a compacted condition for transport on a low loading trailer, and an expanded, free-standing condition for use, said transportable medical facility, when in its expanded condition, comprising:
   - a base structure, a roof structure and external walls, defining an enclosed working area;
   - internal walls defining an operating theatre within said working area; and
   - a laminar flow hood provided in a portion of the roof structure overlying the operating theatre, thereby to establish a laminar airflow within the operating theatre when in use.

2. A transportable medical facility as claimed in claim 1, wherein the laminar flow hood comprises a plurality of HEPA filters, arranged in a grid substantially overlying the operating theatre, when said facility is in its expanded condition.

3. A transportable medical facility as claimed in claim 1 or claim 2 wherein the roof structure has one or more air ducts formed therein, in communication with the laminar flow hood, and optionally houses one or more further air conditioning and/or purifying elements

4. A transportable medical facility as claimed in claim 5 wherein said one or more further air conditioning and/or purifying elements include one or more further HEPA filters, and/or one or more fans arranged to drive circulation of the air through the ducts and the laminar flow hood.

5. A transportable medical facility as claimed in claim 3 or claim 4, wherein the enclosed working area further comprises a pre-operational induction room and a post-operational recovery room, each defined externally of the operating theatre, and wherein the air ducts communicate with inlet and exhaust vents located in the roof structure overlying said induction and recovery rooms.

6. A transportable medical facility as claimed in any of the preceding claims wherein the internal walls defining the operating theatre include one or more return channels in communication with the air ducts which feed the laminar flow hood, said return channels being located externally of the laminar airflow established within the operating theatre.
7. A transportable medical facility as claimed in claim 6, wherein the return channel has an inlet located adjacent the floor of the operating theatre to permit the ingress of air to be returned to the laminar flow hood.

8. A transportable medical facility as claimed in claim 6 or claim 7, wherein the air ducts which feed the laminar flow hood are divided into a central portion in communication with air drawn from the ambient through one or more pre-filters, and one or more outer portions in communication with the return channels.

9. A transportable medical facility as claimed in claim 10, wherein the operating theatre further comprises an operating table which, when the facility is in its expanded condition, is arranged substantially perpendicular to the longitudinal axis of the facility, and directly beneath the central portion of the laminar flow hood, such that air discharged from said central portion is directed onto said operating table.

10. A transportable medical facility as claimed in any of the preceding claims, further comprising one or more sensors arranged to measure the velocity of the laminar air flow established within the operating theatre and/or the air pressure generated thereby.
INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/062630

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61G3/00

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

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 practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>WO 03/020550 A (HAMISH, CHANDRU, SHAHANI) 13 March 2003 (2003-03-13) figure 3a page 9, line 39 - page 10, line 4 page 11, lines 20-26</td>
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X Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:
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Date of actual completion of the international search
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