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US 3815548 A **US 3633547 A**
US 3530831 A **US 2735400 A**

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(54) Title of the Invention: **Agricultural building**
Abstract Title: **An agricultural building with multiple floors**

(57) An agricultural building for rearing animals comprises a multi-level structure 5 having a plurality of levels for rearing animals. Each level comprises a floor 11, 14 and animal access 17 between the levels to allow animals to move between the levels. The animal access 17 may comprise a movable floor section or a ramp. At least an upper portion of the structure may be domed. The levels of the structure can have a circular footprint. The structure may have a core 12 which communicates with each of the levels of the structure. The arm may be configured to supply either food or water. The arm may comprise cleaning means for cleaning the floor. One or each level may have an arm (30 figure 4) which is movable across a surface of the floor. The arm may rotate about the core of the structure.

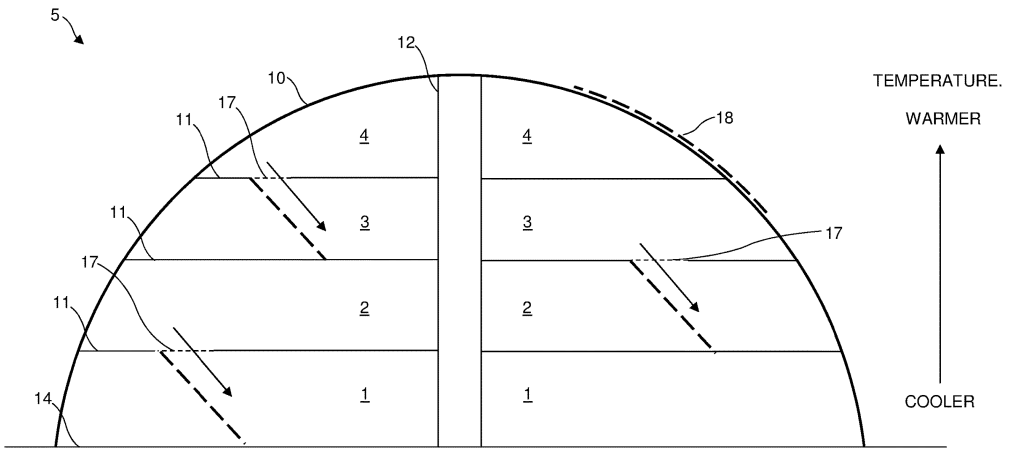

Fig. 1

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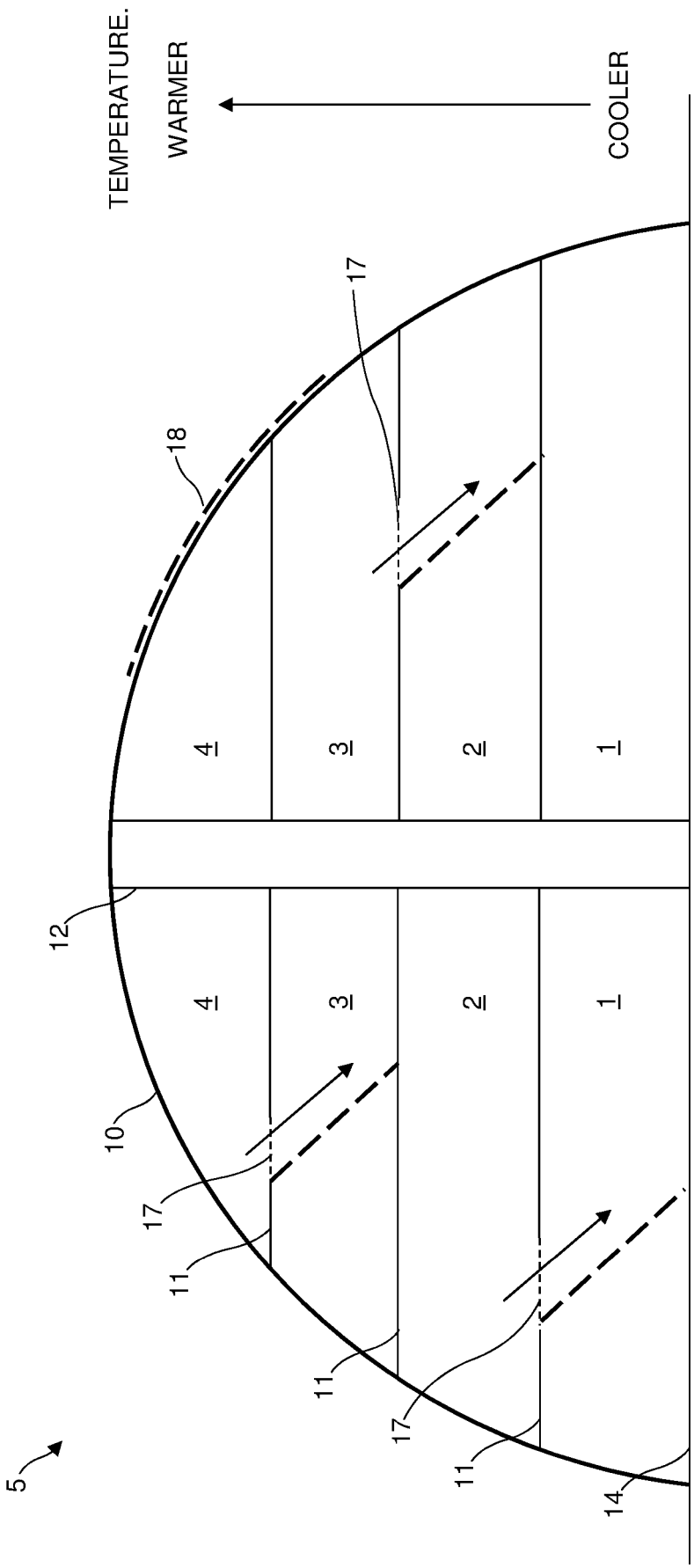


Fig. 1

Fig. 2A

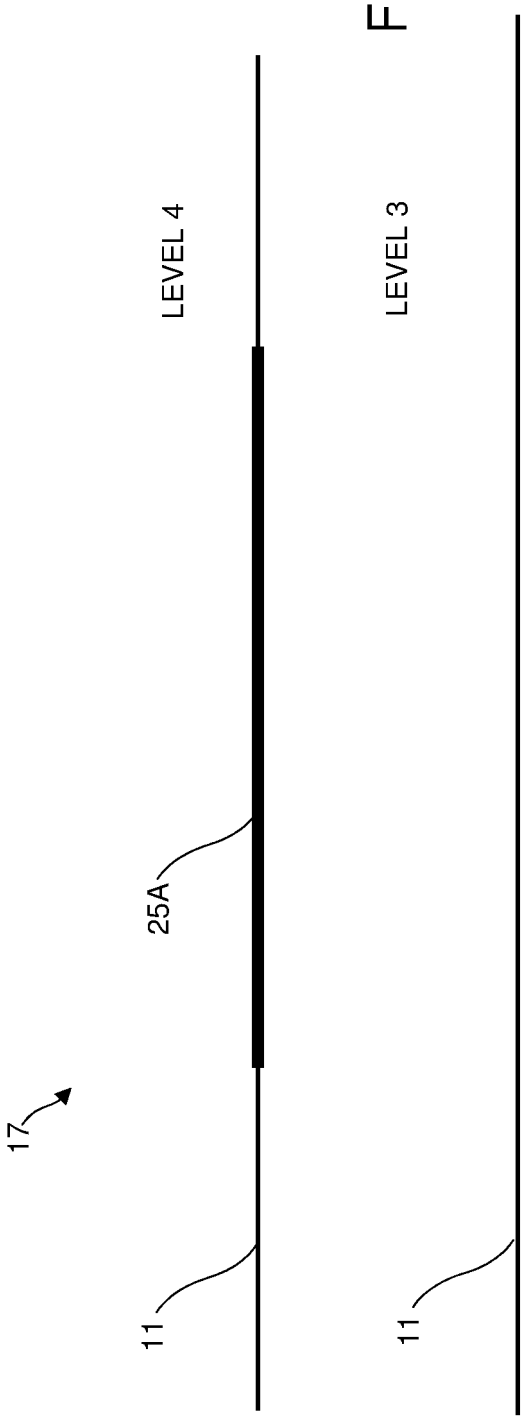
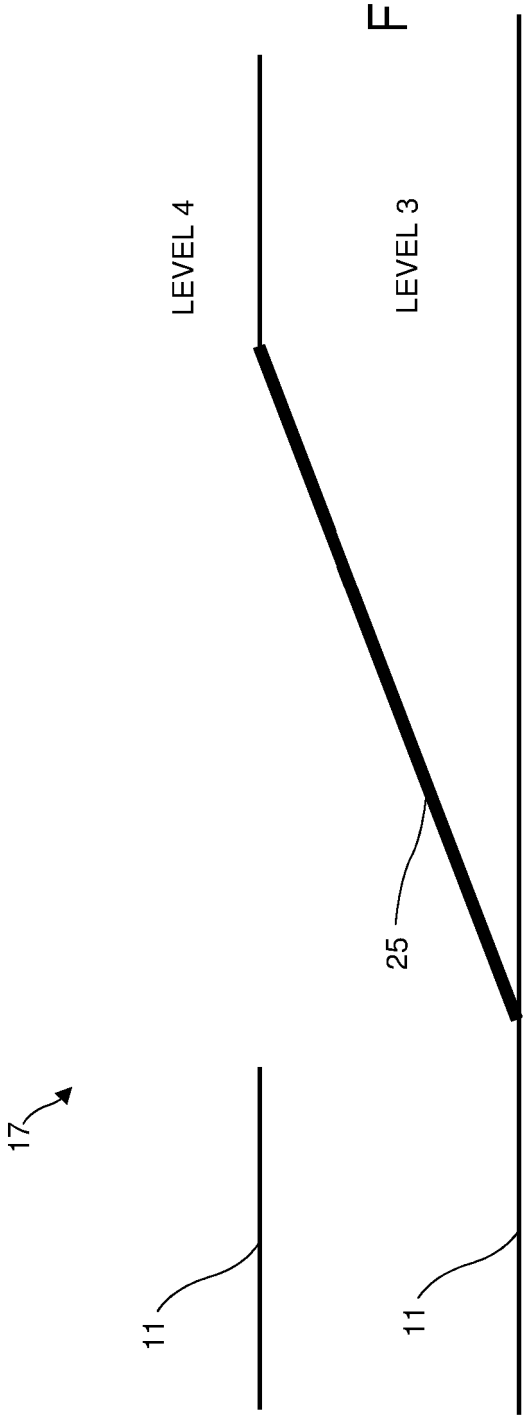


Fig. 2B



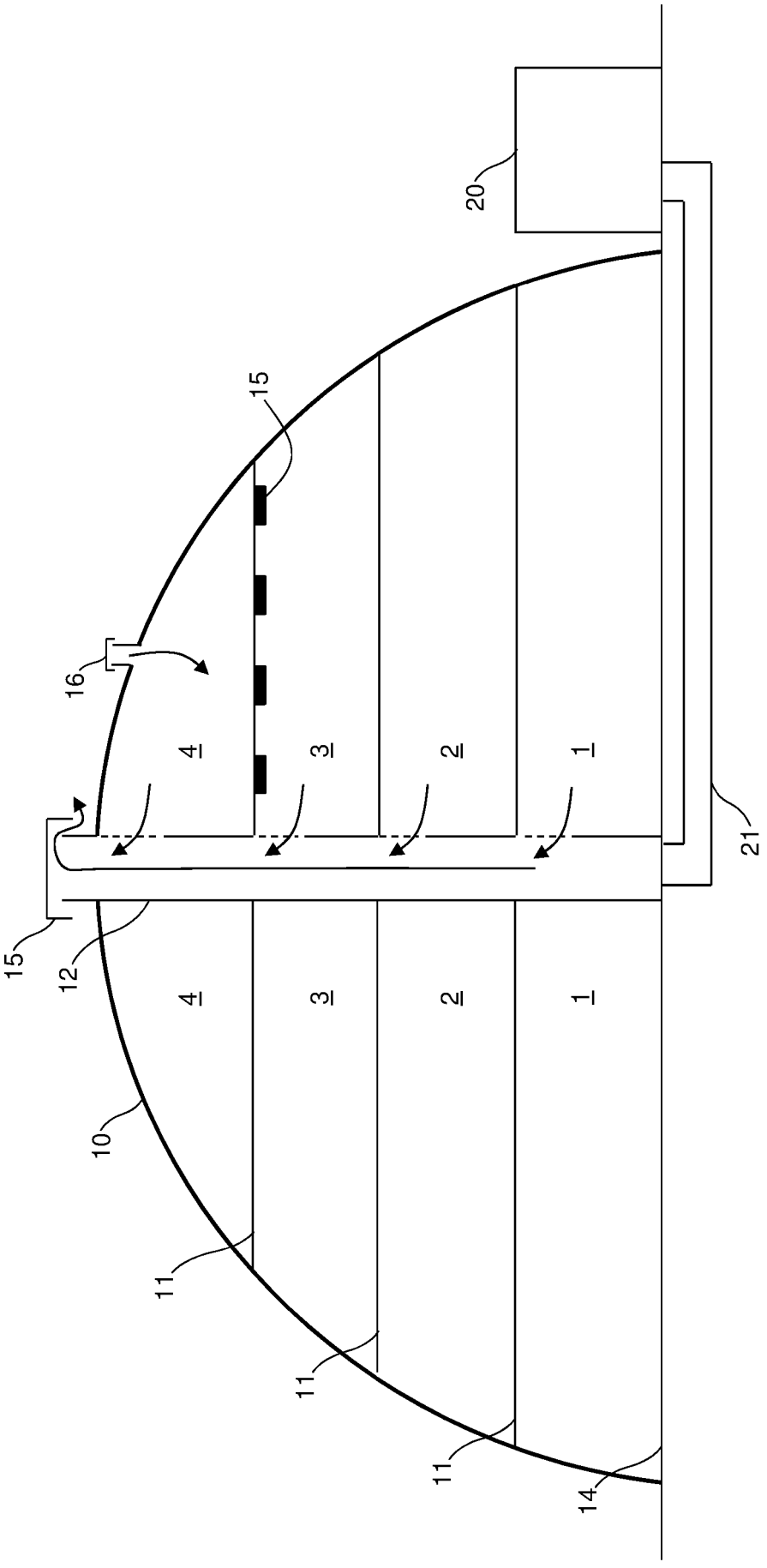


Fig. 3

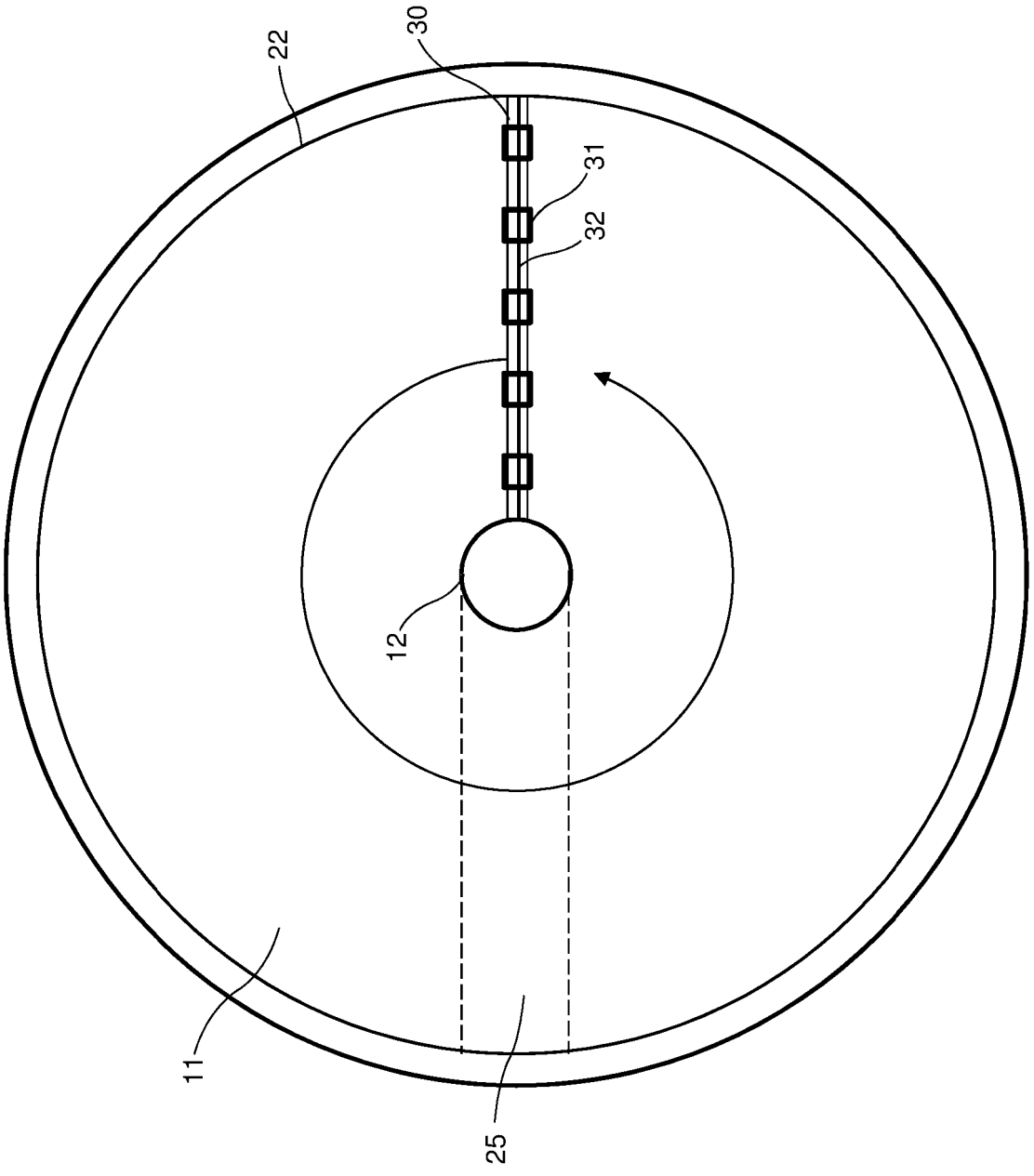


Fig. 4

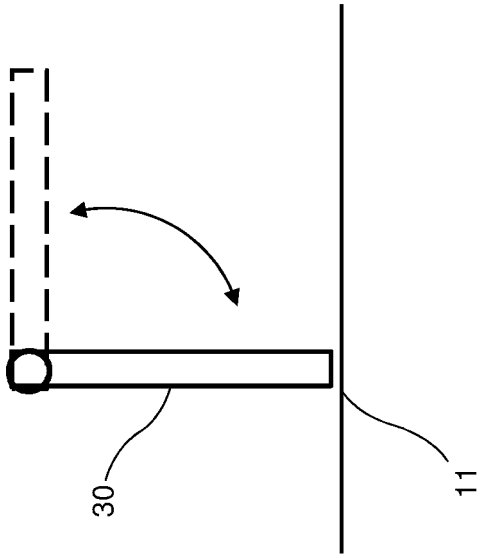


Fig. 5B

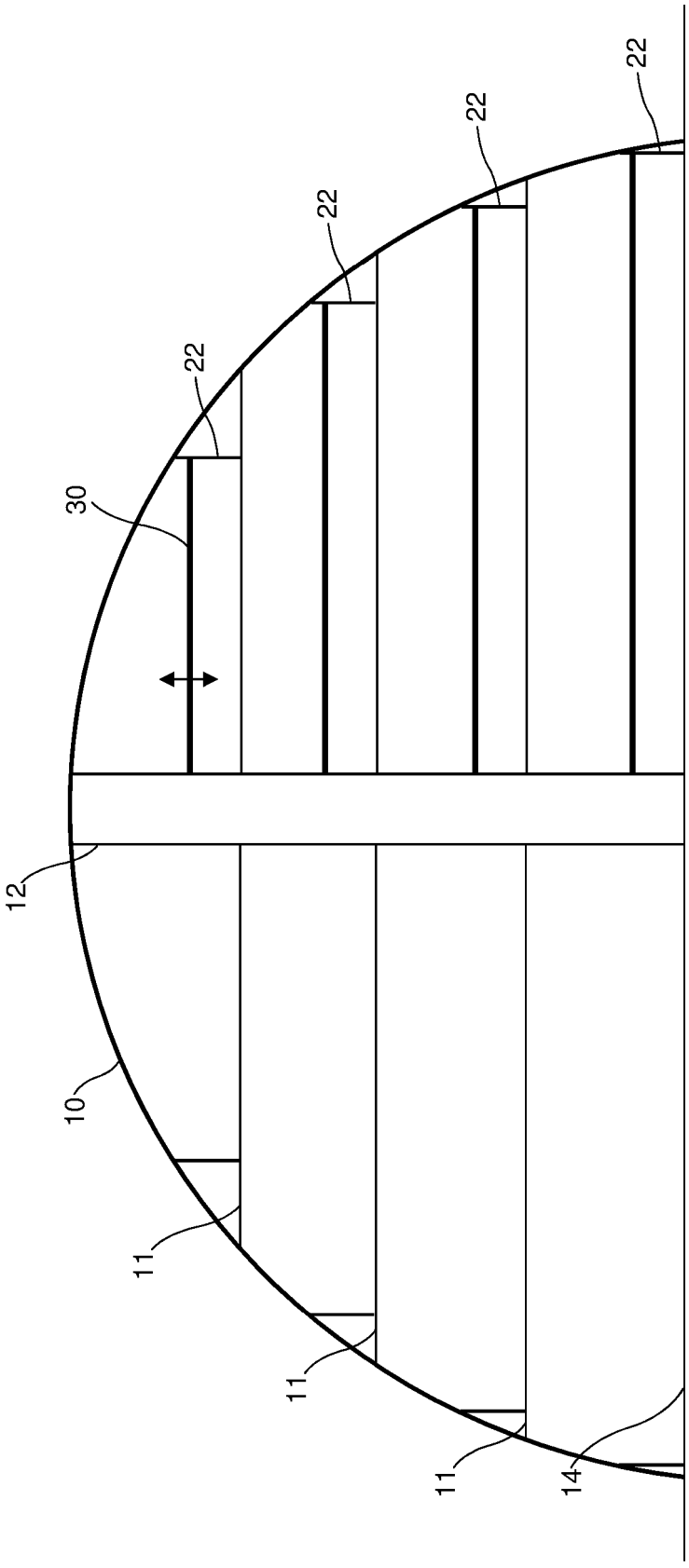


Fig. 5A

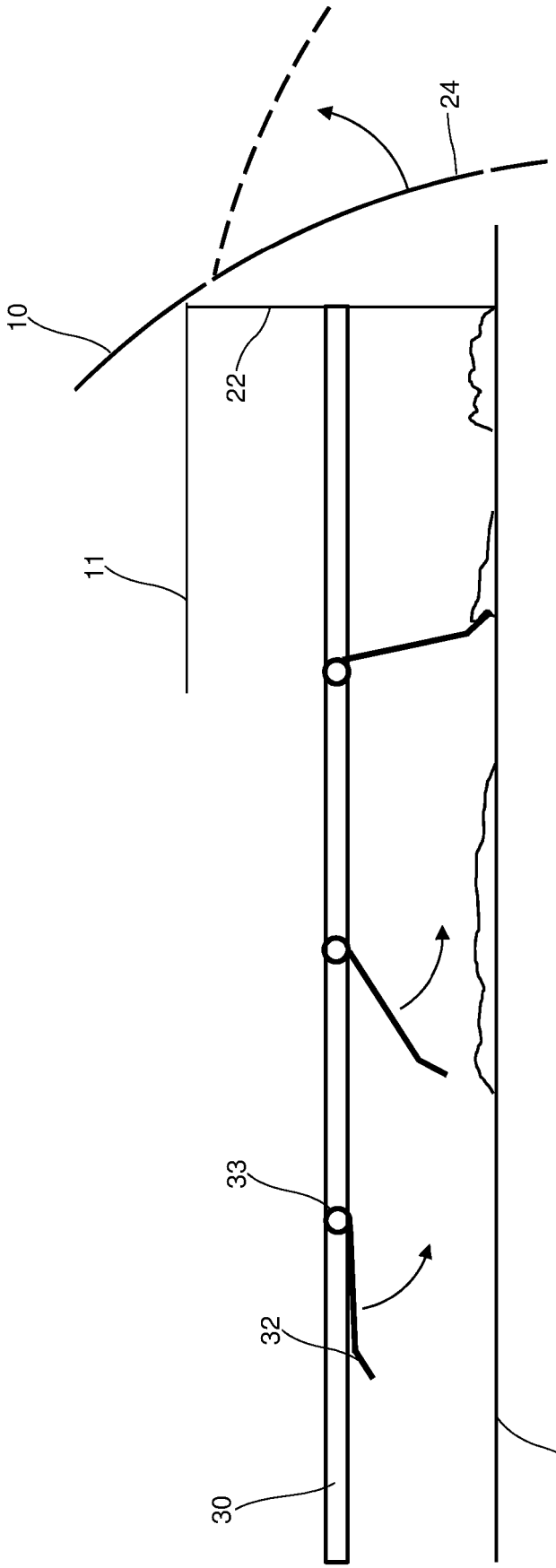


Fig. 6

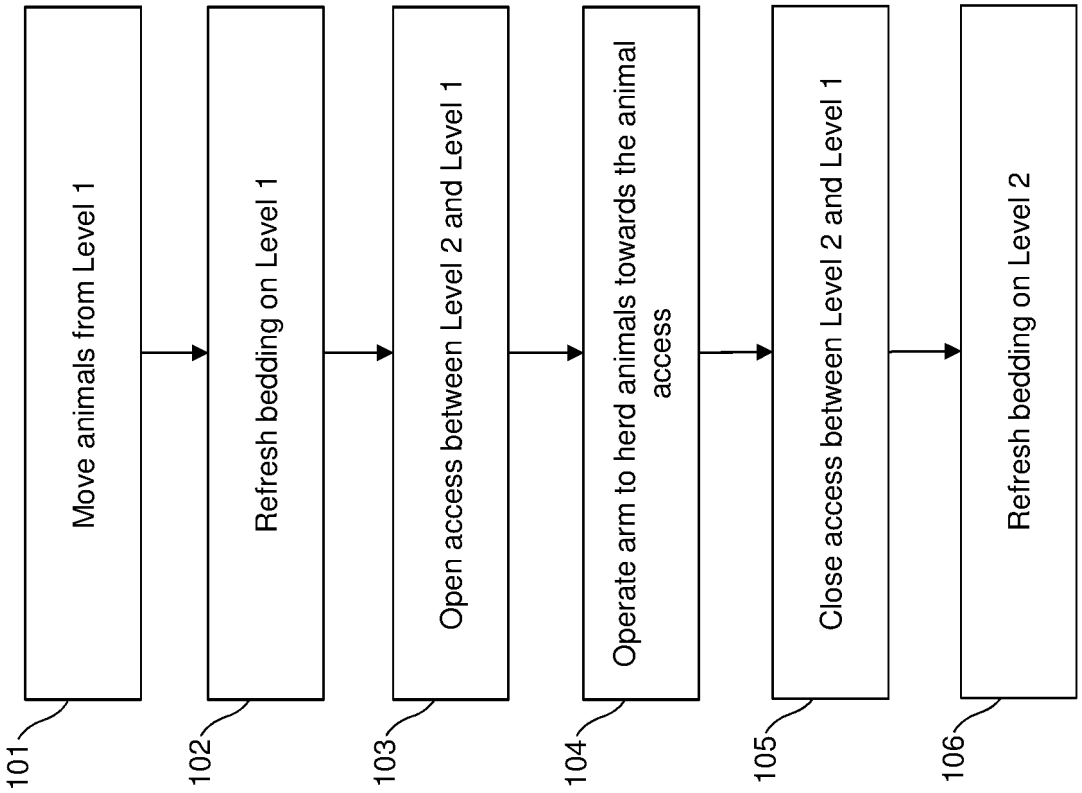

Move animals from Level 1
Refresh bedding on Level 1
Open access between Level 2 and Level 1
Operate arm to herd animals towards the animal access
Close access between Level 2 and Level 1
Refresh bedding on Level 2
101
102
103
104
105
106

Fig. 7

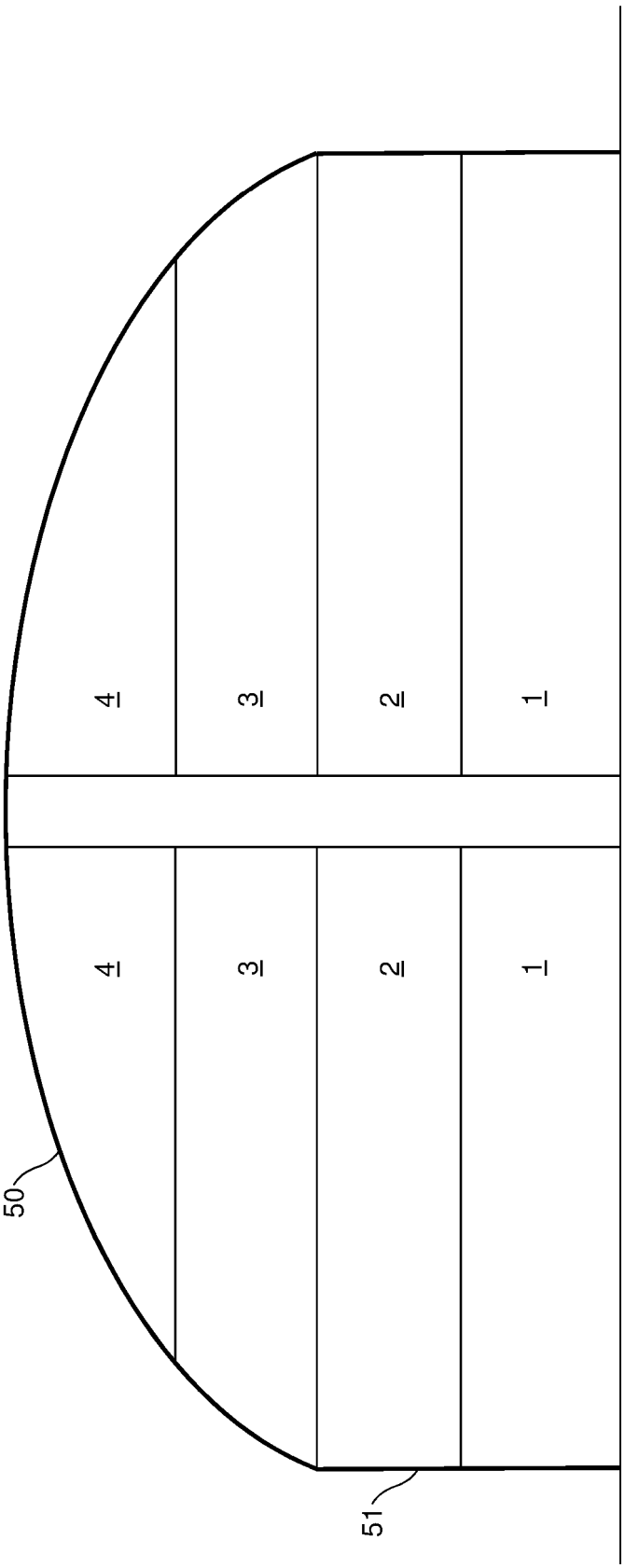


Fig. 8

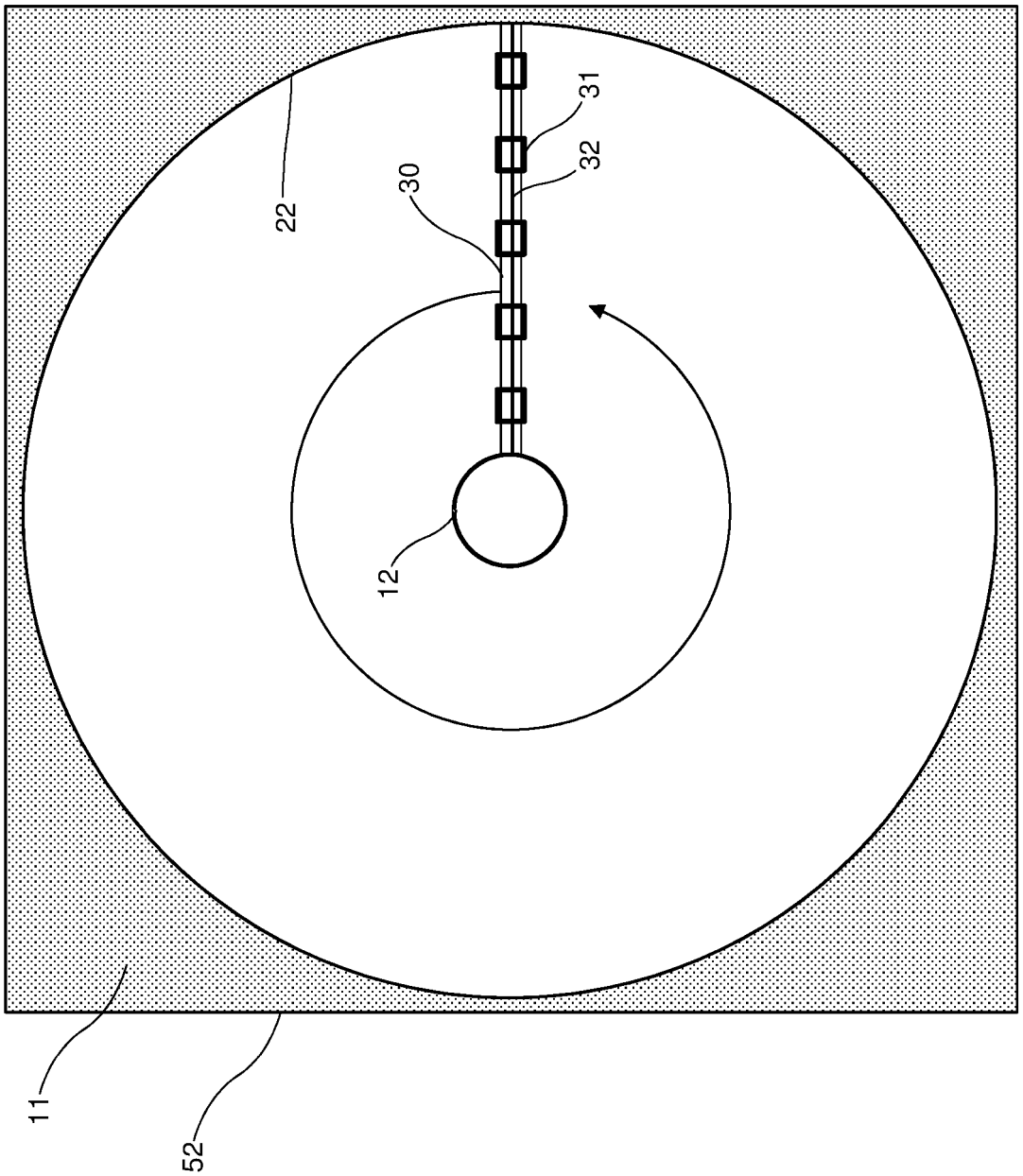


Fig. 9

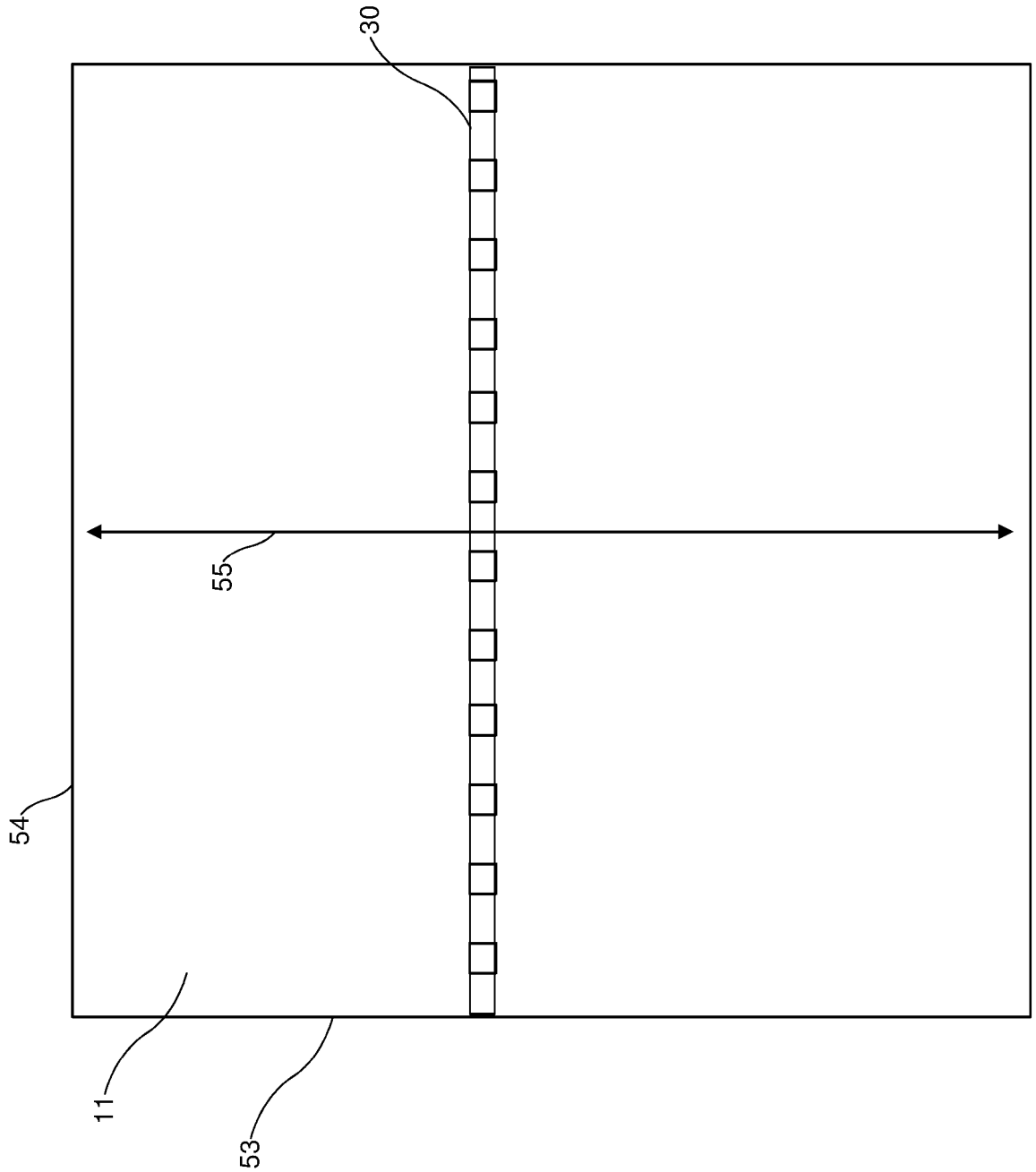


Fig. 10

AGRICULTURAL BUILDING

TECHNICAL FIELD

The present invention relates to an agricultural building. In particular, but not exclusively, the invention relates to an agricultural building for rearing animals, such as poultry.

BACKGROUND

It is known to rear poultry in indoor buildings. Typically, these are large single-storey structures with a rectangular footprint and a pitched roof. Existing poultry rearing buildings require a large land area.

There is a pressure to reduce the cost of rearing animals, while also maintaining healthy conditions. One measure of poultry production is the Feed Conversion Ratio (FCR). This is the ratio of the amount of feed required, per bird, to the increase in weight (meat) of the bird. A low FCR is desirable, as it minimises the cost of food production. However, factors such as human contact or insufficient heat while poultry is reared can increase the FCR and can raise the cost of food production.

It is an aim of the present invention to address disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

Embodiments of the invention may be understood with reference to the appended claims.

An aspect of the invention provides an agricultural building for rearing animals comprising:

a multi-level structure having a plurality of levels for rearing animals, each level comprising a floor; and

animal access between the levels to allow animals to move between the levels.

Floor area may decrease with height of the structure over at least the two highest levels of the structure.

Floor area may decrease with height of the structure over all of the levels of the structure.

At least an upper portion of the structure may be domed. The entire structure may be domed. A domed structure can have advantages in respect of reduced construction cost, increased strength, and reduced drafts during windy conditions.

The levels of the structure may have a circular footprint.

The structure may have a core which communicates with each of the levels of the structure.

The core may provide at least one of: access for farmers between the levels; ventilation for the levels; service distribution to the levels.

The building may comprise a blower apparatus which is configured to perform at least one of: extract material from at least one of the levels through the core; and deliver material to at least one of the levels through the core. The material may be bedding or other waste.

The building may comprise a boiler which is configured to use material extracted from the building, such as bedding material.

The building may comprise, on at least one level of the building, an arm which is movable across a surface of the floor.

The structure may have a core and the arm may be rotatable about the core to move across the surface of the floor.

The floor of the at least one level may have a circular footprint, or a circular region defined by a boundary. The structure may have a core located in a centre of the floor. The arm may extend radially outwardly from the core. The arm may be rotatable about the core across the floor area.

The arm may be adjustable in height with respect to the floor.

The arm may be rotatable about a longitudinal axis of the arm.

The arm may be configured to perform one or more of: distribution of food; distribution of water; distribution of liquid; sweeping the floor; herding animals across the floor surface;

herding animals across the floor surface towards the animal access between levels; removing waste material.

The arm may comprise at least one scraper which is rotatable with respect to the arm.

The animal access may comprise a movable floor section which is movable between a closed position in which the floor section lies in the plane of a remainder of the floor and an open position in which the floor section is angled to the plane of the remainder of the floor to provide access between levels. The arm may be configured to herd animals towards the animal access.

There may be one arm per level of the building.

The animal access between levels may comprise at least one of: a movable floor section; a ramp; steps.

The movable floor section may be movable between a closed position in which the floor section lies in the plane of a remainder of the floor and an open position in which the floor section is angled to the plane of the remainder of the floor to provide access between levels.

An aspect of the disclosure provides an agricultural building for rearing animals comprising:

a structure having a floor and a boundary defining an area for retaining animals; and

an arm which is movable across the area within the boundary.

The area may be circular in footprint, or some other shape, such as square or rectangular. The arm may be rotatable about a point, or movable in a linear manner across the area.

An aspect of the disclosure provides bedding material which is a mixture of at least two of: miscanthus, softwood shavings, shredded cardboard and hemp. On example comprises bedding which is a blend of 50% miscanthus, 20% softwood shavings, 20% shredded cardboard and 10% hemp

An advantage of at least one example is a reduction in footprint of the building, thereby reducing the amount of land needed for rearing animals.

An advantage of at least one example is a reduced energy need for the building. In a multi-level building, heat from animals on a lower level can contribute to heating animals on a higher level, thereby reducing the overall energy needs of the building.

An advantage of at least one example is reduced human contact with animals. This can reduce stress on animals, and improve the FCR. An arm, such as a rotatable arm, can help to reduce contact with humans by automating certain activities which would normally be undertaken by humans.

An advantage of at least one example is an automation of certain functions, such as cleaning a floor of the building, feeding animals, herding animals, and other duties. This can reduce the cost of rearing animals, can reduce the length of the rearing cycle, and can reduce the time that humans spend in the building with the animals.

Within the scope of this application it is envisaged that the various aspects, embodiments, examples and alternatives, and in particular the individual features thereof, set out in the preceding paragraphs, in the claims and/or in the following description and drawings, may be taken independently or in any combination. For example features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

For the avoidance of doubt, it is to be understood that features described with respect to one aspect of the invention may be included within any other aspect of the invention, alone or in appropriate combination with one or more other features.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying figures in which:

FIGURE 1 shows, in cross-section, an example of a multi-level building for rearing animals;

FIGURES 2A and 2B show detail of providing animal access between levels of the building of Figure 1;

FIGURE 3 shows, in cross-section, further features of the building of Figure 1;

FIGURE 4 shows, in plan view, a level of the building and a rotatable arm;

FIGURE 5A shows, in cross-section, a set of arms in a building;

FIGURE 5B shows an arm, viewed along a longitudinal axis of the arm;

FIGURE 6 shows detail of an arm and attachments;

FIGURE 7 shows a method of operating a multi-level building;

FIGURE 8 shows another example of a multi-level building for rearing animals;

FIGURE 9 shows, in plan view, a non-circular level of a building and a rotatable arm;

FIGURE 10 shows, in plan view, a rectangular level of a building and a movable arm.

DETAILED DESCRIPTION

Figure 1 shows, in cross-section, an example of an agricultural building 5 which can be used to rear animals. The animals may be poultry, such as chickens, ducks, turkeys, geese, or other types of birds. Alternatively, the animals may be cattle, pigs, sheep, goats, boar, ox, buffalo or deer. The building 5 comprises a multi-level structure. That is, the building has a plurality of levels 1-4 for rearing animals. In this example there is a total of four levels 1-4. The total number of levels can be as few as two, or any number greater than two. The structure comprises an outer shell 10 and floors 11, 14. Each level 1-4 comprises a floor 11, 14. For the lowest level 1, the floor 14 can be the ground on which the structure is built, a concrete floor or some other prepared surface, or a floor structure which is laid on top of the ground at the building site. For the higher floors 2-4, the floor 11 is supported by the structure of the building. The floors 11 may be supported entirely by an outer shell 10 of the structure, or by a combination of the shell 10 and a load-bearing core/column (e.g. core 12) of the structure.

The structure provides animal access 17 between levels of the structure. The term “animal access” means any structure which is suitable for allowing the type of animals housed in the structure to move between levels. The animal access 17 is shown schematically in Figure 1 as an opening in floor 11 and a ramp between adjacent levels. In an example of a building

for rearing poultry, the animal access is large enough to allow poultry to pass through it, and for poultry to walk between levels.

In the example of Figure 1 the floor area of each level 1-4 decreases with height of the structure. That is, floor 1 has the largest floor area, floor 2 has a smaller floor area than floor 1, floor 3 has a smaller floor area than floor 2, and floor 4 has the smallest floor area.

It is possible to use the building 5 such that youngest animals are reared on the highest level, and then the animals are moved down through the building as they grow. This conveniently matches the capacity of the floors of the building with the amount of space needed by the animals. Taking chickens as an example, young chicks requiring a small amount of space enter the building on level 4. They are reared on level 4 for the first 9 days. The chicks can then be moved down to level 3 when they are 9 days old to provide additional space for the young birds. The young birds continue to grow on level 3. The birds are moved down to level 2 when they are 18 days old. This gives the birds extra space. The birds continue to grow on level 2 and are moved down to level 1 when they are 27 days old. Again, this gives the birds extra space. The birds continue to grow on level 1 until they are 36 days old. After this time, the birds may be transported off site. The length of time per level is an example. Other lengths of time per level are possible. Time per floor will differ for other types of animal, such as pigs, cattle, buffalo, boars etc. The relevant regulations on the maximum amount of birds that can be kept is not specified in birds per m^2 but in kg of weight per m^2. It is possible to accommodate a large number of small chicks per m^2 of floor area on the upper (smaller) floors and reduce the number of birds per m^2 as the birds become bigger and heavier. The maximum weight of chickens (selling weight is 2.2kg per bird) per m^2 is of 17.73kg under UK regulations, and 19kg per m^2 under EU regulations.

The bedding can be changed for each level and can be tailored to suit the size and weight of the animals present. For example, the bedding on the upper floors may be smaller particles and/or finer pieces, such as 10-20mm, and the lower floors may be 50-100mm. Bedding on a floor may be retained for a longer period than bedding on another floor. For example, bedding on upper floor may be retained longer than bedding on a lower floor as there can be less mess to clean from the smaller birds. A feature/quality of the bedding is the absorption of liquids (e.g. bird urine and water from feeders). Miscanthus grass, pine shavings, and shredded cardboard are very absorbent materials and do not compact particularly easily while resisting the growth of fungi or moulds that can cause the birds health or respiratory problems which can reduce the weight gain. Bedding can comprise

one or more of: miscanthus, hemp, softwood (not hardwood) shavings (not sawdust) and shredded cardboard. The softwood shavings are not used for the chicks. The feed can be tailored to each level to suit the growth cycle and age of the animals present, thus optimising the nutrients and weight gain of the animals present. With less contact and less stress, better feed and bedding the birds should have a higher FCR (a lower number – ideally between 1.2 and 1.7) and potentially a shorter rearing cycle. For example, for chickens the rearing cycle may be reduced to between 32 and 35 days rather than a conventional 36 day cycle as the birds put on weight more quickly, and reach the 2-2.5kg weight required by the farmer in a shorter time. The time per floor may be reduced to 8 days. With four floors of birds the farmer/producer will have a full production cycle of birds every 8 days rather than 9 days for the same building footprint.

The temperature of the building 1 increases with height of the building. That is, the lowest floor is the coolest, and the highest floor is the hottest. This suits the needs of animals in the scheme described above, which prefer higher temperatures when they are young. Heating can be supplied to each level. One way of providing heating is by underfloor heating. Another way of providing heating is by space heaters, such as air-sourced heat pumps. A combination of these heating types can be used, e.g. underfloor heating and an additional 'top-up' (on lower floors) by space heaters. The heat from the animals on the lower levels will add to the heat from the underfloor heating on higher floors and therefore reduce the overall heat required per bird. In the building of Figure 1, heat is generated by animals on lower floors and rises through the structure. This can reduce the amount of energy which needs to be provided to heat the younger birds on the higher levels. This together with the efficiencies of the dome structure and shape could provide a total reduction in fossil-based energy of 80-90% over the lifecycle of the animals.

In the example of Figure 1, the structure is domed, i.e. dome-shaped. Each level of the structure has a circular footprint, i.e. circular in shape when viewed in plan. The term "domed" does not require the outer shape of the structure to be part of a true spheroid. The structure may have the shape of part of an oblate spheroid (flattened spheroid). The structure may be have a curved outer surface or may be formed as a geodesic structure. A geodesic structure is a dome shaped structure formed by a lattice of (planar) polygons, such as triangles or hexagons. A geodesic structure has the overall shape of a dome, as in Figure 1, but instead of a curved surface it will comprise a sequence of planar segments. A further alternative, shown below, comprises a straight vertical walls at ground level with a domed cap forming the roof section of the building.

There are a number of advantages of a dome shaped building over buildings with a more conventional pitched roof. The dome shape gives a lower building profile to prevailing weather conditions and reduces the heat loss from the building per unit area of floor. A domed shape building may use less building materials in the construction per unit area of floor compared to an equivalent rectangular building and the structure of a domed shape building is more adept at withstanding wind and weather conditions than a traditional building.

An advantage of using a domed building in poultry farming is the cost of heating. Per unit area, a domed building may use 40-50% less energy/heat to keep the inside of the dome at the required temperature than a rectangular box shaped building. This is primarily due to the fact that when the wind blows onto a domed building it is equally separated and flows around and over the dome of the building. In contrast, in a rectangular box-shaped building wind will mainly impact a single wall, or pair of walls. This single cold wall (or pair of walls) causes drafts and air flow within the square building which in turn lowers the temperature of the inside of the building. This effect does not happen in the domed building with all the walls surface being more equalised in temperature.

Optionally, at least a part of the outer surface of the structure may be covered with solar panels 18, i.e. photovoltaic (PV) panels which convert light energy into electrical energy. The solar panels can be flexible to follow the contours of the domed structure, thereby retaining the benefits of the domed shape with regards to wind. Panels having an efficiency of around 16-18% and 1.5m^2 can provide an output of around 200-250 watts per panel.

Figures 2A and 2B show an example of animal access between levels in more detail. A section 25 of the floor 11 is movable between: (i) a closed position in which the floor section 25 lies in the plane of a remainder of the floor 11 (Figure 2A), and (ii) an open position in which the floor section is angled to the plane of the remainder of the floor to provide access between the levels (Figure 2B). The floor section 25 could be hinged to the floor 11. The angle of the slope between levels formed by the floor section 25 is selected such that it is safe for the animals housed within the building. In the open position shown in Figure 2B animals can walk, or be herded, down to the lower floor. In an example described below, a mechanical arm can guide, or herd, animals towards the floor section 25. Any suitable mechanism can be used to raise and lower the floor section 25, such as a motor-driven or hydraulically-driven actuator, winch etc. Another example of animal access is a fixed ramp

between floors and an access door in the floor 11 which is openable, at certain times, to allow access to the ramp. At other times the door is closed to prevent access between levels. Steps can be used instead of ramps.

In the example of Figure 1, the structure has a core 12 which communicates with each of the levels 1-4 of the structure. In one example, the core 12 is a hollow column. The column can be in the form of a solid-walled tube with at least one access door per level, or an open lattice structure.

The core may provide support to the structure, or may be a non-structural element. The cross-section of the core 12 (when viewed from above) may be circular, or a polygon (e.g. triangle, square, etc.) The core may allow human access between the levels. The core may house a staircase (e.g. a spiral staircase), a ladder or rungs may be mounted in the inner wall or outer wall of the core 12 to allow a farmer to access each level 1-4. An access door (not shown) can be provided in the wall of the core 12 to allow access between the core 12 and a floor of a level. An access door can be provided per level 1-4.

The core can provide ventilation for the levels 1-4. Figure 3 shows possible ventilation paths through the building. Air can enter a level through a vent 16 in an outer wall of the structure, pass through the level and exit the level through a vent located in the core 12. Exhaust air from levels is vented from the building through a vent 15 at the top of the core 12. This form of passive ventilation is effective and can be achieved without the use of electrically-powered fans, thereby reducing energy needs of the building.

Vents can be provided which are openable and closable. The vents may communicate with the lower and upper floors of the building to exit/feed through to a central vent in the centre of the roof of the building. This would create a flow of air to cool the birds during the summer and also a controlled flow of air to circulate and reduce levels of ammonia within the building. The airflow would be laminar and out of the roof of the building (well above human height) and so reducing the smell of the sheds and production for people around the production site and in the local environment. Ventilation can draw air into the bottom of the building and out of the top of the building. Alternatively, ventilation can draw air into the top of the building and out at the bottom of the building. Fans can be provided to draw or push air through the building, as required.

The core 12 can provide service distribution to the levels 1-4. Services can be delivered to the core 12 via an underground path, as shown in Figure 2, or via an external path. Figure 2 shows a service conduit or tunnel 21 between the core 12 of the building and a service or plant building 20 located outside building 5. The service conduit 21 can carry one or more of: water, food, bedding, waste material, medicines, cleaning product, antibiotics, disinfectants. Water can be carried via a pipeline within conduit 21. The pipeline can extend to each level 1-4. Food (e.g. in granular form) can be delivered by a conveyor along conduit 21 or by an air-based delivery system which blows food along a pipeline through the conduit 21 to the base of the core 12. The air-based delivery system can extend through the core to levels 1-4. As an alternative to the underground path shown in Figure 3, services can be delivered to the core 12 via an external path over the outer surface of the structure 10, or via a path within the outer surface of the structure 10. Machinery needed to pump liquid or support an air delivery system can be housed within the core 12, or in the adjacent building 20. Local distribution of water (or other liquids) to each level 1-4 can be made via distribution pipes housed on an underside of a floor 11, or along distribution pipes mounted on or above the floor 11. An alternative scheme uses rotatable arms described below.

Figure 3 shows lighting 15 on a ceiling of a level. For clarity, lighting is only shown on part of level 3, although lighting can be provided in a similar way throughout a level, and on all levels.

Figures 4 and 5 show the use of arms in a building having a circular footprint. Figure 4 shows a plan view of a single level of the building. Figure 5 shows a cross-section through the building. An arm 30 extends radially between the core 12 and an outer wall 22 of the level. The arm 30 is rotatable about the core 12 in a horizontal plane. That is, the arm 30 is rotatable about the core 12 in a plane which is parallel to the floor 11. The arm 30 is rotatable about a full 360° sweep around the core 12. This allows the arm 30 to pass across the entire floor area. The outer wall 22 is vertical (Figure 5) and has a circular footprint. One purpose of the wall 22 can be to provide support for a distal end of the arm 30. While it is possible for the arm to be supported by the floor 11 (e.g. by a support extending between the arm 30 and the floor with a wheel to run along the floor) it is advantageous to avoid contact between the arm and the ground to avoid trapping animals. The wall 22 can provide support for the arm 30 at a distal end. A drive mechanism for the arm 30 can be located within the core 12. The drive mechanism is shielded from the animals. An inner guard

structure (e.g. a wall of core 12, or a wall or fence) protects animals accessing the inner part of core 12.

Another purpose of the wall 22 is to wall off unusable space. As best seen in the cross-section of Figure 5, the domed building has a small area adjacent the circumference of each floor 11 in which the inner surface of the dome 10 forms an acute angle with the floor 11. The wall 22 prevents animals or debris from collecting in this undesirable area.

In addition to movement across the floor 11, the arm 30 may be capable of movement in one or more other ways. The arm 30 may be rotatable about a longitudinal axis of the arm. Figure 5B shows an arm, viewed from one radial end of the arm and along the longitudinal axis of the arm. Normally, the arm can be set at an angle of 90 degrees to the floor 11, as shown in solid form in Figure 5B. The arm 30 can be adjusted so that it is inclined at an acute angle with respect to the floor, or such that the arm lies parallel to the floor 11, as shown in dashed form in Figure 5B. This can allow the arm to be adapted for different functions, such as functions where the arm is needed to be close to the ground (e.g. sweeping, herding) or functions where the arm is needed to be spaced above the ground (e.g. feeding, spraying). For herding, the arm can be positioned just above the height of the bedding so that only the animals are moved, rather than a mixture of birds and bedding. In the lowest setting, the arm is positioned such that it can scrape the floor. In the highest setting, the arm is positioned above the animal heads to deliver food and water, antibiotics etc. In an intermediate position, the arm can be used to deliver cleaning chemicals/disinfectant via a spray/mist outlet.

The arm 30 may be movable in the vertical plane. That is, the height of the arm 30 with respect to the floor is adjustable. This can allow the arm 30 to perform different functions more effectively.

The arm 30 can have any construction which provides a combination of high strength and low weight. The arm 30 can be in the form of a truss, such as a truss formed of longitudinal tubes and interconnecting struts in a lattice configuration, or a honeycomb configuration. The arm 30 can support pipework, liquid outlets (e.g. nozzles, spray heads)tools (e.g. scraper). The arm could be a planar structure of a structure having a polygonal cross-section (e.g. triangular, square, rectangular) similar to a crane jib.

The mechanical arm 30 can have several functions. A first function of the arm 30 is to distribute water to animals. Distribution points 31 are located along the length of the arm 30. A pipeline 32 connects between the core 12 and the distribution points 31. Other liquids (e.g. disinfectant) can be distributed in a similar way via another pipeline and set of distribution points. The arm 30 can distribute food to the animals. The arm 30 may use a conveyor, air-blower system or other delivery system to convey the food. A distribution point 31 on the arm may correspond with a channel/trough on the floor 11 at a certain radius from the core 12 for food or water. This helps to separate the food and water from the bedding. The arm 30 can deliver the liquids as a mist, spray or stream depending on the automatic or manual rotation of a nozzle on the arm 30. Antibiotics, medicines and/or dietary supplements can be distributed to animals via a spray or mist, for inhalation by the animals. Conventionally a person may walk around a floor with a spray lance and tank. The arm can also perform this function. This spray/mist function may apply small amounts of water to the birds to cool them down in the summer if they overheat or become stressed.

A second function of the arm 30 is to scrape the floor 11. A scraper element attached to the arm 30 can scrape used litter/bedding from the floor 11.

A third function of the arm 30 is to gently herd (guide) the animals to an access between levels. Figure 4 shows a floor section 25. The floor section 25 is movable between: (i) a closed position in which the floor section lies in the plane of a remainder of the floor, and (ii) an open position in which the floor section is angled to the plane of the remainder of the floor to provide access between levels. When the arm 30 is at a low height with respect to the floor 11, it can serve as a barrier. As the arm 30 is moved, it acts as a guide, guiding animals towards floor section 25. This provides a useful function which can be labour-intensive in conventional buildings. It can also keep the animals herded together in a small area. The area can reduce in size as animals are put into boxes/transport cages for movement offsite. Staff working as catchers can more easily catch the animals, saving time and money by keeping the animals tightly corralled as they are picked up.

A fourth function of the arm 30 is to move bedding around the floor. The arm 30 may be rotated about the longitudinal axis such that it has an acute angle (less than 90 degrees) to the floor surface, with a leading edge near to the floor surface. The bedding can be blown onto the floor in front of the arm 30 in a pile using an air driven blower (the bedding is specially designed and the particles sized to ensure that it can be easily blown and not block or break the blower motor/mechanism) and the arm 30 is then moved over the pile. The

bedding then comes out from under the blade of the arm 30 at the set height of the blade. As the bedding goes out the pile reduces in size, like buttering a piece of toast with a knife that has butter on the blade and spreads over the toast in a set layer.

The arms can have an advantage of reducing the length of time that the animals interact with humans, thereby reducing stress to the animals and improving the Feed Conversion Ratio (FCR), i.e. the amount of feed per bird converted into meat on the bird. Another advantage of the arms is to reduce the personnel needed to monitor and take care of the birds and also reduce the time and effort taken from cleaning out one set of birds then preparing and populating the dome for the next set of birds.

The floors of the building can also be cleaned and watered by using the scraping arm and the used litter also brought to one place for easy removal thus also saving in time and personnel expense. Figure 6 shows a feature of the arms 30 and building in more detail. A set of scrapers 32 are mounted on the underside of the arm 30. Each scraper 32 is rotatable 33 about the underside of the arm 30. The scrapers 32 are movable in a plane perpendicular to a longitudinal axis of the arm, and perpendicular to the plane of the floor 11. The scrapers 32 are movable between (i) a storage position in which the scraper is retracted so that it lies parallel, or almost parallel, to the arm 30 and floor and (ii) a working position in which the scraper is rotated so that a working end of the scraper is brought towards the floor and perpendicular to the floor 11. The scraper 32 is rotatable back and forth to move material along the floor 11. The path of the scraper 32 is aligned with the longitudinal axis of the arm 30, i.e. a radial direction across the floor of Figure 3. The set of scrapers serve to move material radially, so that it is collected adjacent to the wall 22. In a case where the floor 11 includes a trough or channel, the scraper can be provided with a flexible extension (e.g. rubber or other flexible polymer material) to extend into a channel/trough. In addition to, or instead of, the scrapers 32 shown in Figure 5, a scraper may be located on a base of an arm, and extend along longitudinal axis of the arm such that the scraper acts on a radial line of the floor as the arm is rotated.

Figure 6 also shows a door 24 located in an outer wall of structure 10. The door 24 is movable between a closed position (shown in solid form) and an open position (shown in dashed form). In the open position, a farmer can access the level to remove debris (e.g. waste bedding) and provide fresh material (e.g. provide fresh material). The amount of time required by personnel is reduced, as the sweeping of the floor 11 has already been performed by the arm 30. The central core 12 can also contain a central shovel

arrangement to then push out the bedding and waste from the centre to the door 24. Alternatively the bedding can be removed by suction. The blower can be changed to a suck mode in which it applies suction. Used bedding is sucked out of the building and off the floor. There could be a three-way valve and two tanks in this system after the reversible motor. Used bedding exits the sucking/blowing machine into a used bedding tank where it can then be used by a boiler, such as a biomass/CHP/Trigeneration boiler and turbine system. When the bedding has all been sucked up and disinfectant/water etc. put down with the arm onto the bare floor, the machine can be set from suck to blow and the three-way valve switched from "open to the used bedding tank" to "open to the fresh bedding tank", the fresh bedding would then be blown into the building and onto the floor in front of the scraper arm in a pile that the arm would then distribute evenly according to the height of the blade above the floor.

The arm could also be used to push the birds round the floor gently and when a full cycle has been complete the central shovel can bring any dead birds caught in the arm to the outside for collection. The shovel attachment of the arm would have to be positioned to be above the level of the bedding to leave this undisturbed / behind but low enough to catch the body of a dead chicken to bring it round to the door.

Figure 7 shows part of a method of operating a multi-level building for rearing animals. Starting at block 101, animals are moved from Level 1. At block 102 bedding is refreshed (if needed) on Level 1. This can be achieved manually, or by use of the arm 30 on Level 1. The arm 30 can perform a sweep around the floor of Level 1 to gather used bedding. Optionally, scrapers on the arm (Figure 5) can then be used to move used bedding towards a door on Level 1 where the bedding can be removed. Optionally, the arm 30 can also supply disinfectant/mould inhibitor/anti-fungal treatment by spraying the floor. Fresh bedding is deposited on Level 1. The arm 30 can be used to distribute the fresh bedding. Optionally, disinfectant/cleaning product can be added to the top of the fresh bedding before the next batch of animals arrive. With Level 1 vacant and refreshed, the method proceeds to block 103. Animal access between Level 2 and Level 1 is opened. Optionally, at block 104, an arm 30 on Level 2 can slowly herd animals towards the animal access. When Level 2 is vacant, the method proceeds to block 105 and the animal access between Level 2 and Level 1 is closed. Optionally, at block 106, bedding is refreshed (if needed) on Level 2. The method proceeds in a similar manner upwards through the building to move animals downwards from Level 3 to Level 2, and from Level 4 to Level 3. New animals can be introduced on Level 4. A controller can be configured to co-ordinate the operations

described above. For example, a computer can execute software to cause the opening and closing of each animal access, movement and function of the arms, etc.

A number of features can help to reduce energy needs of the building. At least a part of the outer surface of the structure may be covered with solar panels 18 to provide electricity which can be used directly at the building 5 (or by plant in the adjacent building 20, Figure 3), or provided to the grid to offset energy costs.

The multi-level structure of the building can help to reduce the overall heating needs. The domed building can reduce drafts. Underfloor heating is an effective way to heat and maintain temperature within the building. It can be up to 30% more efficient than space radiators or air heaters and cause less draughts and air currents within the building.

Thermoelectric cells can also be provided. Thermoelectric materials are materials that cause an electric current to flow when presented with two surfaces – one that is hot and the other that is cold. The energy from the hot side is keen to get to the cold side and so obey Newton's second law of Thermodynamics but the thermoelectric material is very good at conducting electricity but very poor at conducting heat (a good insulator). To overcome this problem the material converts the heat energy to electrical energy and starts to move through the material this causes an electrical current which can be tapped off and used as DC voltage. For new materials such as Skutterudite this means thermoelectric cells can be produced for low cost with good figures of merit. Other low cost materials such as Mg2Sn0.75Ge0.25 can also be used but these must be manufactured rather than produced from ore.

A layer of thermoelectric cells below the underfloor heating elements would not only be a very good reflector / insulator to stop heat escaping into the ground but also generate significant quantities of electricity. It is estimated that new efficient cells can produce approximately 1MW of electricity from 10Mw of heat. Thermoelectric cells can also be attached the hot pipework around the biomass boiler and the pipes leading to the underfloor heating for extra generation. This could provide enough electricity to power the lights and the motors of the production unit and as long as the heat is on in the floor the electricity will flow through the cells. The thermoelectric material used in the cell can be specially constructed/adapted/manufactured for low temperature environments such as that found in the pipes of warm/hot water coming from the fossil fuelled boilers.

An energy plant for the building 5 can use Trigeneration, co-generation, combined heat and power (CHP) or a biomass boiler. The boiler can also be replaced/substituted with a gasifier that produces a syngas of CO + H2 + CH4 + N2 etc. This gas can then be burnt in a turbine/generator creating electricity and the hot flue gases can be used to heat water and heat the domed building. Used bedding obtained from the levels of the structure can be used in the boiler/gasifier. One suitable type of bedding is mmiscanthus (elephant) type grass, softwood shavings, shredded cardboard, hemp either individually or as a blend of one or more of these components in a variety of concentrations. For instance a blend of 50% miscanthus with 20% softwood shavings, 20% shredded cardboard and 10% hemp would be a very good all round bedding material with good blower/suck properties and liquid absorption/resistance to crushing or packing properties.

A possible construction method for a domed building will now be described. The method uses a heavy duty flexible bag (e.g. plastic/nylon/polymer bag) manufactured in the shape of the domed building that is to be constructed. Firstly, the bag is positioned at the site of the building. Next, the bag is inflated from the inside. Industrial blowers can be used to inflate the bag. Next, a polyurethane resin/foam is sprayed on the inside surface of the inflated bag and allowed to harden. An additional layer, or layers, of resin/foam can be applied in subsequent steps. Then, a reinforcing structure is attached to the polyurethane resin. The reinforcing structure can be a metal grid, frame of metal spars/bars which is set into the first layer of polyurethane. The second layer fixes the reinforcing structure in place before the shotcrete finishes the process. Then, the structure is sprayed with concrete (e.g. shotcrete) slurry and allowed to set. The cost of this production method can be in the range of around £400 per m^2 of the dome structure.

After the dome has been constructed in this way, holes can be cut into the structure for doors, windows and vents etc. The concrete floor and underfloor heating can be installed at this point. This construction method can provide a high level of insulation and noise reduction. This production method can achieve a strong and long lasting building structure with dome which is self-supporting. Although a central core can be provided, the core does not have to support the dome.

Figure 8 shows an alternative building structure. The building structure has a domed upper part 50 surrounding the upper floors and a cylindrical part 51 surrounding the lower floors. In this example, the upper two floors lie within the domed part 50 of the structure. Any of

the features described above in respect of the fully domed structure can be combined with the structure of Figure 8.

In another multi-level building structure (not shown) the floor area decreases with height, and the footprint of each level is circular, but the outer surface of the building has a stepped profile rather than a domed profile.

Figure 9 shows the use of an arm in a building having a non-circular footprint. Features are similar to Figure 4, and like reference numerals are used for like elements. Figure 9 shows a plan view of a single level of a building. In this example the level has a square footprint 52. The level may have any non-circular footprint, such as rectangular, or other polygon or irregular shape. A wall 22 defines a circular region within the footprint 52 of the building. As previously described for Figure 4, an arm 30 extends radially between a core 12 and the wall 22. The arm 30 is rotatable about the core 12 in a horizontal plane. The arm 30 is rotatable about a full 360° sweep around the core 12. This allows the arm 30 to pass across the entire floor area. The outer wall 22 is vertical and has a circular footprint. The arrangement shown in Figure 9 can form part of a multi-level structure, or can form the only level in a structure. This aspect can be combined with features of the earlier aspects. For example, an animal access can be provided in the floor. The arm 30 can perform any of the features described above in respect of arm 30.

Figure 10 shows the use of an arm in a building having a rectangular or square footprint 53. The building has a floor 11. An arm 30 extends across the floor 11. The arm 30 is movable in a horizontal plane across the surface of the floor 11. The arm 30 is movable along a linear path 55. The arm 30 is parallel to one of the sides 54 of the floor 11, and the path 55 is perpendicular to that same side 54. This allows the arm 30 to pass across the entire floor area. The arrangement shown in Figure 10 can form part of a multi-level structure, or can form the only level in a structure. This aspect can be combined with features of the earlier aspects. For example, an animal access can be provided in the floor. The arm 30 can perform any of the features described above in respect of arm 30.

Throughout the description and claims of this specification, the words “comprise” and “contain” and variations of the words, for example “comprising” and “comprises”, means “including but not limited to”, and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

CLAIMS:

1. An agricultural building for rearing animals comprising:

a multi-level structure having a plurality of levels for rearing animals, each level comprising a floor; and

animal access between the levels to allow animals to move between the levels.

2. A building according to claim 1 wherein floor area decreases with height of the structure over at least the two highest levels of the structure.

3. A building according to claim 2 wherein floor area decreases with height of the structure over all of the levels of the structure.

4. A building according to any one of the preceding claims wherein at least an upper portion of the structure is substantially domed.

5. A building according to any one of the preceding claims wherein the entire structure is substantially domed.

6. A building according to any one of the preceding claims wherein the levels of the structure have a substantially circular footprint.

7. A building according to any one of the preceding claims wherein the structure has a core which communicates with each of the levels of the structure.

8. A building according to claim 7 wherein the core provides at least one of:

access for farmers between the levels;

ventilation for the levels;

service distribution to the levels.

9. A building according to claim 7 or 8 further comprising a blower apparatus which is configured to perform at least one of:

extract material from at least one of the levels through the core;

deliver material to at least one of the levels through the core.

10. A building according to any one of the preceding claims further comprising a boiler which is configured to use material extracted from the building.

11. A building according to claim 9 or 10 wherein the material is bedding.

12. A building according to any one of the preceding claims further comprising, on at least one level of the building, an arm which is movable across a surface of the floor.

13. A building according to claim 12 wherein the structure has a core and wherein the arm is rotatable about the core to move across the surface of the floor.

14. A building according to claim 12 or 13 wherein:

the floor of the at least one level has a substantially circular footprint, or a substantially circular region defined by a boundary;

the structure has a core located in a centre of the floor;

the arm extends radially outwardly from the core; and

the arm is rotatable about the core across the floor area.

15. A building according to any one of claims 12 to 14 wherein the arm is adjustable in height with respect to the floor.

16. A building according to any one of claims 12 to 15 wherein the arm is rotatable about a longitudinal axis of the arm.

17. A building according to any one of claims 12 to 16 wherein the arm is configured to perform one or more of:

distribution of food;

distribution of water;

distribution of liquid;

sweeping the floor;

herding animals across the floor surface;

herding animals across the floor surface towards the animal access between levels;

removing waste material.

18. A building according to any one of claims 12 to 17 wherein the arm further comprising at least one scraper which is rotatable with respect to the arm.

19. A building according to any one of claims 12 to 18 wherein the animal access comprises a movable floor section which is movable between a closed position in which the floor section lies substantially in the plane of a remainder of the floor and an open position in which the floor section is angled to the plane of the remainder of the floor to provide access between levels; and

the arm is configured to herd animals towards the animal access.

20. A building according to any one of claims 12 to 19 wherein there is one arm per level of the building.

21. A building according to any one of the preceding claims wherein the animal access between levels comprises at least one of:

a movable floor section;

a ramp;

steps.

22. A building according to claim 21 wherein the movable floor section is movable between a closed position in which the floor section lies substantially in the plane of a remainder of the floor and an open position in which the floor section is angled to the plane of the remainder of the floor to provide access between levels.

23. A building substantially as herein described with reference to the accompanying drawings.

Intellectual Property Office

Application No: GB1511975.3 **Examiner:** Mr Christopher Saul

Claims searched: 1 - 22 **Date of search:** 18 December 2015

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 4 - 17, 21.	US3530831 A (CONOVER) See column 1 lines 26 - 49, column 2 line 62 to column 3 line 3 and figures
X,Y	X: 1 - 11, 21 Y: 12, 13, 14, 17, 18, 20	US3633547 A (STEVENS et al.) See column 3 lines 45- 73, column 7 line 73 to column 8 line 21 and figures
X,Y	X: 1 - 11. Y: 12, 13, 14, 17, 18, 20	US3815548 A (BLAIR) See column 3 lines 14 - 53 and figures
Y	12, 13, 14, 17, 18, 20	US2735400 A (STUBBS) See column 5 line 64 to column 6 line 23 and figures

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A01K

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
None		