Fig. 10

Fig. 11

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With modern building techniques, although it is possible to erect the shell of a building, such as a box of flats, in a comparatively short time, the total construction time is much longer because a large proportion of the total time taken to complete the building is consumed in finishing the building internally. This internal finishing consists in laying floors, fitting door frames and doors, applying plaster and other finishes and providing services such as water and electricity.

The proportion of the total construction time taken in internal finishing is particularly high in the construction of flats where the building is subdivided internally among a large number of comparatively small rooms, and a number of internal fittings are necessary, for example built-in kitchen cabinets, sinks and also bathroom fittings.

The proportion of total construction time taken in internal finishing and the proportion of cost reflected in internal finishing are also particularly high in dwelling construction because it is usually carried out on site where the organization is at the mercy of the weather and also where the organization is necessarily such that a multiplicity of trades, not only those concerned with internal finishing, are working on the job at the same time in a manner which is often only roughly co-ordinated.

According to this invention we construct a building by prefabricating a number of box-like units with their sides provided internally with finishes and fittings to form the floors, ceilings and walls of the rooms and other spaces within the building and the units are then fixed together in layers on site to form the building.

This method is especially applicable to flats and other multi-storey dwellings, but it can also be used with houses, particularly terrace houses in which there are only two or three floors. The units are also preferably provided with electrical wiring, plumbing, other services and also built-in furniture where this is required, before they are erected on site.

In this way all or nearly all the internal partitions in the buildings together with all finishes, fittings, services and built-in furniture can be produced in a factory by mass production techniques. The erection of the units on the site of the building is then comparatively simple matter which can take place very rapidly indeed. The fact that a large proportion of the construction of the building is carried out in a factory under factory conditions has a number of advantages. First of all, the developer of the building is able to plan and order ahead leaving only the actual erection to be carried at the time that the site becomes available. This enables the factories to plan ahead and large seasonal fluctuations in labour demands in the building industry can be avoided to a very considerable extent with a consequent saving in costs. Further, a large variety of different buildings can be constructed by the selection of different combinations of standard units. It is possible therefore to achieve variety while still achieving the savings of standardisation.

The units themselves may be wrapped up or otherwise protected as they are transported from the factory to the site of erection, but preferably the units themselves are made weatherproof and able, by themselves to stand up to the stresses imposed upon them during transport and erection. For this purpose, where more than one unit is necessary to make a single room or other open space, the units are initially closed on all sides before erection and then at least some of the units have bulkheads which are removed after erection to open the spaces within two or more separate units into a single space.

The internal wall surfaces and finishes together with their fittings may be detachably fitted within the units themselves so that the units can be redecorated or modified as the owner may require after the construction of the building.

The units may be fixed together in layers by first of all constructing a framework of columns and beams and then inserting the units into this framework so that they are supported side by side and in layers one above the other. Preferably, however, the units themselves are stacked together in layers and are then fixed to each other to form the building structure. So that the structure has sufficient strength, particularly in multi-storey buildings, to support the weight of the storeys above, the units themselves may incorporate sections of columns and beams which are connected together when the units are fixed to each other to form a framework for knitting in with the units. As an alternative to this, the units may be fixed to each other with spaces between them and these spaces, both horizontal and vertical may then be filled with concrete which itself forms the weight supporting structure. The finished concrete structure is in the form of a three dimensional egg box with the units in the spaces between the crossing walls and the floors forming the box.

Especially when concrete is used to form the structure between the box-like units, the units are preferably made with double-skinned walls including studs with the internal wall finishes fixed to their inner faces and an outer skin fixed to their outer faces. The concrete is then placed between the outer skins of adjacent units so that there are air spaces between the concrete and the internal wall finishes. This avoids difficulties due to moisture from the concrete penetrating the wall finishes and damaging them during erection and it also assists in sound and thermal insulation between adjacent rooms or other spaces. Use may also be made of these spaces for the circulation of hot air for central heating purposes. When this is done, ducts are provided for supplying the hot air to these spaces and the spaces surrounding different units are separated from each other by divisions and the ducts have separate closures to allow the different spaces to be supplied with hot air as required.

To make it simple to fix the units together in different combinations, the units are preferably either all the same size and shape as each other and all the units are preferably rectangular. The units may have chamfered edges so that the spaces between adjacent units are increased in width at the adjacent edges of the units. When concrete is placed between the units, the thickness of the concrete filling is thus increased at the edges to form stiffening beams and columns. The units may be fixed to each other by clips which are fixed to the outside of the studs in the walls of the units these clips being themselves fixed together by members which are held by the clips on adjacent units. Each of these members may consist of a ladder comprising two flanges with connections between them and each clip then comprises a pair of side arms which embrace one of the flanges of the ladder. With this arrangement, there may be a number of clips arranged along the length of each stud in the studs and then the ladder is slid into position with its flanges sliding into the clips on two adjacent studs on different units.

Apart from the method of constructing buildings in...
accordance with the invention, the units used in this method are also novel and form another aspect of the present invention. According to this, such a unit comprises a closed rectangular box having on its internal walls remains and fittings to form the floor, walls and ceiling of a room or other space within a building and having fixed to its outside means for fixing the unit to other externally similar units in layers.

In many of the units, where rooms or other spaces are to be formed by more than one unit, one side at least will be formed by a removable bulkhead. This bulkhead remains in place until the unit has been erected on site and the concrete, where this is used, has been placed.

Various examples of units and methods of using them to construct buildings in accordance with the invention will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is a perspective view from above and from one corner, which is partly diagrammatic of one unit with parts broken away for clarity;

FIGURE 2 is a partly diagrammatic perspective view of another unit with one side wall removed to show the internal construction;

FIGURE 3 is a horizontal section to an enlarged scale showing the connection between two adjacent units;

FIGURE 4 is a diagrammatic perspective view showing a unit containing a staircase;

FIGURE 5 is a plan to a smaller scale illustrating the formation of a single room by two units fixed together side by side;

FIGURE 6 is a plan showing the formation of a single room with three units fixed together side by side;

FIGURE 7 is a partly diagrammatic sectional view showing the formation of a single room by four units fixed together with the tops removed to show the internal construction;

FIGURE 8 is a partly diagrammatic perspective view showing details of the construction of a building with three units fixed together and with concrete placed in between them;

FIGURE 9 is a front perspective view of another three units fixed together with concrete between them and with their fronts removed to show internal details;

FIGURE 10 is a diagrammatic perspective view illustrating different units and the method of fixing them together; and,

FIGURE 11 is a diagrammatic perspective view illustrating yet another method of fixing the units together in layers.

The unit shown in FIGURE 1 is substantially cubical with chamfered edges, being approximately 8 feet wide and 9 feet long in plan and 8 feet high in internal dimensions. The walls of the unit are formed by frames comprising vertical timber studs 1 with horizontal timber battens 2 between them. The vertical edges of the unit are chamfered as shown at 3 and horizontal timber battens 4 extend across these chamfers.

The top and bottom of the unit is formed with similar studding 6 with cross battens 7. Spaced above the studding 6 and cross battens 7 in the top of the unit are two diagonally extending roof beams 8 and 9 which are shown partly cut away and form the structural members which support the layer of units above the layer in which the unit illustrated is placed. They may alternatively support the roof when the unit is placed in a top layer. To the inside faces of the studding 1 and 6 and the battens 2 and 7 is fixed panelling 10 and 11 and also flooring (not shown) which form the finished internal wall, floor, and ceiling surfaces of the room formed by the unit.

Sheets of metal mesh 12 and 13 are fixed to the outside of the studding 1 and 6, respectively, so that there are air spaces between the mesh 12 and 13 and the adjacent panels 10 and 11. Instead of metal mesh, strong sheets of hessian may in some circumstances be used.

In the particular unit illustrated in FIGURE 1, there is a window opening 14 fitted with an opening sash window 15. This face of the unit is intended to form an external face of the completed building and in this instance is not covered with metal mesh. The face of the building may be finished with a separate exterior panelling. Where these panels are only intended to extend over the face of a single unit, they may be fitted in position in the prefabrication operation before the unit is erected in position, but where a single panel extends over the face of more than a single unit, the panels are fitted in position after erection of a number of units forming the face of the building.

The unit shown in FIGURE 1 is fitted with wheels 16 shown diagrammatically. These wheels may be provided solely for ease in moving the unit on the site, but alternatively they may be fitted temporarily for transporting the unit to the site by road or railway.

The unit shown in FIGURE 2 is constructed in a generally similar manner to the unit shown in FIGURE 1 with timber studding and cross battens 1, 6 and 7 as shown in FIGURE 1, but instead of the diagonally extending roof beams 8 and 9 the roof trusses 17 and 18 extending directly across the centre section of the unit. There is again a window 19 in one side of the unit and in an adjacent side is a door 20. The internal floor surface 21 is supported on diagonally braced timber beams 22 having bottom chord members 23 which perform a similar function to the bottom studs 6 shown in FIGURE 1.

The nearest side wall of the unit in FIGURE 2 is shown broken away to illustrate the internal details of the unit, but the right hand side of the unit, that is the side opposite the side having the window 19, has an opening 24 surrounded by a frame 25. During transport the site and erection the opening 25 is closed by a removable bulkhead fixed to the surrounding frame 25 and the unit is fixed with a similar opening in another unit closely adjacent to it. This second opening also has a removable bulkhead and when erection is complete, both the bulkheads are removed so that the unit shown in FIGURE 2 and the adjacent unit together form a single room. Two such units fixed together side by side are illustrated diagrammatically in FIGURE 3 of the drawings where both units have openings 24 which are fixed to each other. One unit is provided with a door 26 and both units are provided with windows 27.

Three units 28, 29 and 30 may be fixed together as shown in FIGURE 6 to form a stairway space within the building. In this instance, the unit 28 has a door 31 and a single opening 32 surrounded by a frame 33. The unit 29 has two openings 34 and 35 surrounded by frames 36 and 37, respectively. This unit also has two windows 38 and 39 arranged side by side. The unit 30 also has two openings but these are in opposite sides of the unit, one opening 40 being in register with the opening 35 and being surrounded by a frame 41. The second opening 42 is surrounded by a frame 43 and leads to a further unit 44. The unit 44 is provided with a partition 45 to enable a cupboard 46 to be formed in the manner to be described later with reference to FIGURE 9, between the units 30 and 44.

As shown in FIGURE 7, a single substantially rectangular room may be formed by four units 47, 48, 49 and 50 fixed together in a square. Each of these units has two adjacent walls and openings in the other two adjacent walls. The corners of the units 51, 52, 53 and 54 are bounded by battens extended between those sides of each unit which have openings, fit together and enclose a space between them which will form a column in the middle of the room. The tops of the units are supported by four diagonal beams 55, 56, 57, and 58 which are indicated in outline in FIGURE 7. These beams span between the central column formed at the corners 51 to 54 and similar columns formed at
the four corners of the room. Alternatively, the corners 51 to 54 may be parts of the removable bulkhead and there is then an unobstructed space with no columns. There are then only two diagonal beams which span from corner to corner of the space.

The fixing of the units to each other side by side is best illustrated in FIGURES 3 and 8 of the drawings. As shown most clearly in FIGURE 3, the vertical studs 1 of two adjacent units have U-shaped clips 59 fixed to them through rubber pads 60. These clips are arranged at intervals along the length of the studs 1. The clips have inward bent tips 61 on the side arms. Between adjacent rows of clips 59 are connecting members in the form of ladders 62. Each ladder 62 consists of two rolled steel T-sections 63 and 64 connected together by a wavy rod welded to either one of the sections 63 and 64 at each of its changes in direction. The ladders 62 are thus similar to fabricated steel beams sometimes used in buildings as floor supporting joists. The T-sections 63 and 64 have their outer arms which are not welded to the rod 65 embraced by the side arms of the clips 59.

Between the studs 1 are the horizontal battens 2 and the cladding in the form of the metal mesh 12. Extending across the inside faces of the studs 1 and fixed to the battens 2 are the internal wall panels 10. There are therefore air spaces between the mesh sheets 12 and the wall panels 10.

As shown in FIGURE 8, the spaces between the mesh sheets 12 are filled, after a number of the units have been placed side by side and stacked together, with concrete 64. The concrete closely surrounds the ladders 62 which act as reinforcement. The buildings have a large number of walls formed by the concrete 64 which gives great strength to the finished building. Concrete 65 is also placed, as shown in FIGURE 8, between the different layers of units which are stacked one on top of the other. The concrete 65 which forms floor slabs is reinforced by the diagonally spanning beams 8 and 9 shown in FIGURES 3 and 8 of the drawings.

In FIGURE 8 the right hand lower unit is shown with a partly broken away external cladding panel 66 fitted to its front. Separate panels such as this may be fitted to the outsides of all those units which form the exposed faces on a building, but as an alternative to this, a single panel may be fitted in situ after the erection of the units and this panel extends over the faces of a number of units.

In FIGURE 9 three units are shown fixed together again with concrete interposed between them and this concrete is placed in a similar manner to that illustrated in FIGURES 3 and 8 of the drawings. The ladders 62 are not however shown for simplicity and clarity, but there are air spaces surrounding the units on all sides. Extending through these air spaces is ducting 67. This ducting has a number of branches 68 leading from it with one branch leading into the space surrounding each separate unit. The spaces surrounding adjacent units are separated from each other by dividing partitions, which are not shown. Each of the branches 68 is provided with an outlet valve 69 which is operable by a control extending into the adjacent unit. By opening or closing these valves, heating air supplied through the ducting 67 can be discharged as required into the spaces surrounding the various units for central heating purposes. The heating is particularly effective because the internal walls of the unit are entirely surrounded by a blanket of hot air. Further ducting may be provided for conducting away the cooled air so that there is a continuous circulation of air through those spaces where it is required at any particular time.

As shown in FIGURE 9 the three units connected together 70, 71 and 72 differ in minor details from the units shown in the earlier figures of the drawings. Instead of having the external roof beams 8 and 9, or 17 and 18, the unit 70 is fitted with internal roof beams 73 which are enclosed between the top of the unit 74 and a false ceiling 75. This unit has a seat 76 around the two internal walls shown and its floor 77 is at the bottom of the unit. On the other hand, the two units 71 and 72 have external roof beams similar to the beams 17 and 18, but not shown, but their floors 78 and 79 are supported above the bottoms 80 and 81 of the units and the leaves space 82 and 83 in which electric wiring, plumbing and other services are fitted. When provided, these services are fitted in the units during the factory prefabrication of the units and they are arranged with connectors so that the services in adjacent units can be connected up as necessary when the units are erected.

Furthermore, the unit 72 is provided with an open side 84 which is surrounded by a frame 85 which prevents the concrete 86 entering it and spaced away from this open side is a partition 87. The partition 87 forms the back of a cupboard 88 to which access is obtained through a door 89 in the side of the unit 71. This arrangement enables a larger room to be formed by the whole of a single unit and for access to be provided from this unit to a cupboard formed in the adjacent unit which thus provides less room space.

All the units illustrated in FIGURES 1 to 3 and 5 to 9 of the drawings contain various living spaces, but, in the case of flats, in particular, the passages, landings and staircases are also formed in units. One such unit is illustrated in outline in FIGURE 4 and this shows a staircase having two flights 90 and 91 with a half landing 92 between them. In this case the top 93 of the unit is formed by a removable bulkhead and so also is the side 94. The staircase 90, 91 and 92 is prefabricated in the factory complete with tread finishes and hand-rails, although these are not shown in the drawing.

Three modified methods of fixing the units to each other and forming the building structure are illustrated in FIGURES 10 and 11 of the drawings. These are useful for multi-storey buildings such as flats. As shown in FIGURE 10, each of the units 95, which are illustrated diagrammatically, has fixed to it a column 96 at one corner, a cross beam 97 which extends diagonally across it, and a column 98 at the diagonally opposite corner. When the units are stacked one on top of the other as shown, each of the lengths of column 96 and 98 is fixed to the top of the length of column below. In FIGURE 10 the column 96 and the beam 97 are shown as rolled steel joists and the column 97 as reinforced concrete. In practice all three of these members are of the same material and all may be either steel sections or reinforced concrete. When the members are steel they are welded together or connected by riveted gussets and when of concrete they are connected by cast in-situ concrete sections.

As shown in FIGURE 11, a building frame 99 is first formed with columns 100 and cross beams 101 to form a three dimensional grid. The pockets formed in this grid between the beams 101 and the columns 100 are arranged to fit the units 102 and the entire frame is first completed either from rolled steel sections or out of reinforced concrete and the units 102 are then fitted in position and later connected to each other. Only two units 102 are shown in FIGURE 11 but of course all the spaces formed in the grid are in fact filled with units.

We claim:

1. A building comprising a plurality of prefabricated box-like units stacked together in layers with spaces between them, each of said units including side walls comprising vertical studs horizontally spaced from each other, internal wall sheeting fixed to the inside of said studs, wall finishes and fittings on the inside of said sheeting, and a sole outer sheet made of flexible fluid-permeable fibrous textile material fixed to the outside of said studs and bowed toward but spaced from said sheeting, the space between the outer sheets of adjacent units being substantially filled with concrete and said internal wall sheeting, studs and outer sheets defining air spaces between said concrete and said internal wall sheeting.

2. A building as claimed in claim 1 in which said flex-
ible fluid-pervious sheeting is Hessian and said studs are timber.

3. A building as claimed in claim 1 in which the walls of adjacent units are connected by rigid spacing members.

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