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(54) System of prefabricated tunnel and portal elements and accessories made of structural light concrete for the total erection of 1 to 8 storey buildings for any use

(57) The prefabricated "tunnel-shaped" parallelepiped element - which is the main element of the system - and its accessories allow buildings for any type of housing to be erected in a relatively brief time. The elements are made of structural light concrete.

The main characteristic of this element is that of giving already defined rooms by combining more than one consecutive element. In fact, in these elements partition walls and outside walls are already laid out with door openings. They have groove-and-tongue dap joints and holes both at the four corners and at the center of the floor slabs section.

These holes are obtained by using iron pipes for the passing of the steel tie rods required during assembly - to be made according to special rules - to consolidate the elements that will compose the building.

The tunnel elements have two slabs, floor and ceiling. Portal elements are used for additional storeys.

To build single-storey buildings we can use either tunnel elements if a terrace roof covering is required or elements with double-pitch roof covering if a roof-type covering is required.

For the last storey in buildings having more than one storey with sloping-pitch roof-covering, we can use the portal elements with double-pitch roof covering.

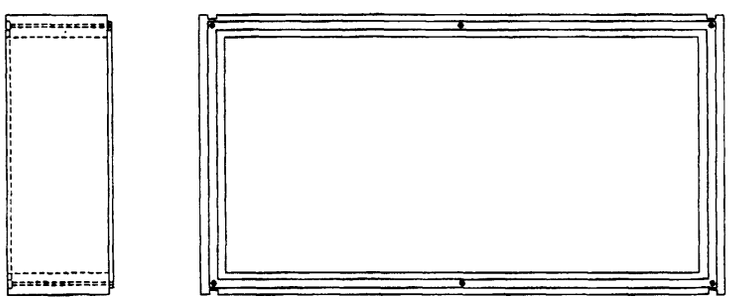
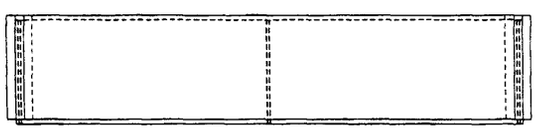


FIG.1



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Description

[0001] The prefabricated "tunnel-shaped" parallelepiped element - which is the main element of the system - and its accessories allow buildings for any type of housing to be erected in a relatively brief time. Youth hostels, students' hostels, Elderly' houses, hospitals, medical surgeries and schools can also be erected.

[0002] The prefabrication of elements suitable for erecting housing buildings have interested designers from many countries for a long time. These designers have committed to create prefabricated houses in various systems and modular elements that would allow, together with other elements, the erection of mainly government houses. From 1920 to 1925, the idea of using steel in prefabricated elements for building houses develops first in England and then in the United States. In 1933 at the Chicago Exhibition, the General Houses Incorporated shows a house totally made of pressed steel, based on standard elements. The idea was to make houses as machines, but as it turned out later, this was not a very lucky idea because the materials were not well accepted and also because steel could not be used as bricks. Great architects such as Wright, Le Corbusier, Alvar Aalto, Walter Gropius, Mies van der Rohe, Richard Neutra, Renzo Piano, Mangiarotti, and many others, designed elements made of iron, wood and reinforced concrete to accelerate, even with special structural and architectural expedients, the erection of housing buildings. The current prefabrication produces specific elements, such as self-supporting or "stopper

- filing" panels, structures such as plinths, pillars and beams, breastwork for balconies, objects such as balconies to be used in conventional brick buildings, but many jobs must still be done in erecting yards, jobs that should be eliminated by prefabrication so as to perform only elements assembly and required finishing in the erection yard. In this way we will have:
- uniformity of materials
- quickness in erecting the building
- a cost known from the start
- possibility of making in a short time new housing conglomerates with various services in the case of floods, earthquakes, war destruction, etc. with clearly defined and obviously lower costs for the government

[0003] The prefabricated tunnel parallelepiped element with all its variations offers the possibility of erecting in a relatively short time one-family houses, two-family houses, terraced houses, buildings with more than one storey, hospitals, hotels, schools and any other desired type of building.

[0004] The main characteristic of this element is to give already defined rooms by combining more than one consecutive element.

[0005] In fact, in these elements partition walls and outside walls are already laid out with door openings.

[0006] They have groove-and-tongue dap joints and holes both at the four comers and at the center of the floor slabs section. These holes are obtained by using iron pipes for the passing of the steel tie bars required during assembly - to be made according to special rules - to consolidate the elements that will compose the building.

[0007] The elements for erecting buildings can have different measures. For the exposition of our system we chose the following dimensions: 6.60x1.20x3.30 meters (external measures).

[0008] The elements are composed of two vertical walls which are 1,20 m. wide, 3,30 m. high and 0,30 m. thick (external measures) while the floors and the ceilings are 6,00 x 1,20 m. (internal measures) and 0.25 m. thick. The horizontal parts of the elements will be reinforced as if they were slabs. They are lightened by using either PVC pipes or thin steel pipes. The vertical parts can be differently reinforced depending on the situation: **FIG. 62, FIG.63, FIG.64, FIG.65, FIG.66**.

[0009] The tunnel elements have two slabs, floor and ceiling. They are named:**FIG.1, FIG.2 FIG.3, FIG.4, FIG. 5, FIG.6, FIG.7, FIG.8, FIG.9, FIG.12** .

[0010] Portal elements are used for the additional storeys. They have vertical masonry structures and slab with various partition walls as for the tunnel-type elements. They are named: **FIG. 19, FIG. 20, FIG. 21, FIG. 22, FIG. 23**.

[0011] To build single-storey buildings we can use either tunnel elements (as described above) if a terrace roof covering is required or elements with double-pitch roof covering if a roof-type covering is required. They are named: **FIG. 27, FIG. 28, FIG. 29, FIG. 30, FIG. 31**.

[0012] For the last storey in buildings having more than one storey with sloping-pitch roof-covering, we can use the portal elements with double-pitch roof covering. They are named: **FIG. 32, FIG. 33, FIG. 34, FIG. 35, FIG. 36**.

[0013] We also have the following elements: element with window sill **FIG. 14**; element for covering two elements with incorporated lintel **FIG. 13**; adjacent elements **FIG. 6** and **FIG. 7** and **FIG. 8** with dap joints for the cm. 20x10x30h lintel. For buildings with more than one storey or above the ground we also have the balcony elements **FIG. 9** and **FIG. 10**. The tunnel element with window opening **FIG. 12** allows walls with windows to be made by simply combining tunnel elements **FIG. 1** alongside one another without using lintel elements.

[0014] The elements will rest on foundations, which are also prefabricated, composed of rectilinear, angled and T-shaped elements **FIG. 67, FIG. 68, FIG. 69**. The dimension is determined depending on the load incidence and on the ground and subsurface resistance. For the exposition of our system these elements can have for example the dimensions of cm. 50x50h with a cm. 10x5 upper rectangular dap joint and lateral groove-

and-tongue dap joints which change according to the foundation height, which in our case we hypothesize to be cm. 15-20-15. This element rests on an underpinning which lays perfectly flat horizontally and which has an impression as wide as the foundation beam. The element in section has two holes on both the upper and lower parts and 4 1-inch pipes buried in concrete which will allow the passing of the steel tie rods used for tightly consolidating the various elements of the foundation.

[0015] With 8 elements we can build a 48 sqm. environment, with 9 elements a 54 sqm. environment, with 10 elements a 60 sqm. environment, and so on so forth. The element arrives at installation already finished, ie already plastered and/or with outside finish such as outer surface dressing, outside finishing, outer panel coverings, etc. An element is combined with another by means of coupling profiles that can be two males, a male and a female, two females. In the superimposition of the elements there are groove-and-tongue dap joints.

[0016] Other elements present in the system are: window sill for **FIG. 17**; rectilinear panel **FIG. 18**; triangular roof covering **FIG. 15**; covering slab with one or two lintels inserted **FIG. 16**, one on one side and one on the other. Other elements have slots inside the walls to allow the passage of sewage **FIG. 37**, of ducts for both the hydraulic system **FIG.38**, and the interior wiring.

[0017] These elements are made by using formworks that, depending on the type of element, can be easily modified with inserts so that various types of elements can be made with one formwork.

[0018] To give an idea of what can be done with the tunnel system, we have prepared various projects which clearly demonstrate how many different structures can be obtained using a prefabricated system.

[0019] This system is remarkably flexible, giving for example the possibility of enlarging a house, a hospital, a school, a motel, in a swift and homogeneous way without altering the architectural form.

[0020] The designer will start the project by using the module as he wants, integrating it with other compatible prefabricated elements if needed

SYSTEM ELEMENTS

[0021] The following prefabricated elements in CLS (structural light concrete) - which is composed of expanded clay of different granulometries, highly resistant cement and sand - vibrated in dedicated formworks, characterize the system:

FOUNDATION BEAMS MADE OF REINFORCED CONCRETE

[0022] **FIG. 67** - Rectilinear beam

[0023] **FIG. 68** - Angular beam

[0024] **FIG. 69** - T-shaped beam

SELF-SUPPORTING TUNNEL ELEMENTS MADE OF CLS

[0025]

FIG. 1 - Parallelepiped tunnel element that can have the following internal measures (which can vary), for housing use: base length 6.00 m.; width 1.20 m.; height 2.75 m.; thickness of perpendicular walls 0.30 m.; thickness of base floor and of ceiling 0.25 m.

FIG. 2 - Element as **FIG.1** with partition parallel to the walls

FIG. 3 - Element as **FIG. 1** with partition and door

FIG. 4 - Element as **FIG. 1** with partition, wall and door

FIG. 5 - Element as **FIG. 1** with wall and window

FIG. 7 - Element as **FIG.1** with left dap joint for lintel

FIG. 6 - Element as **FIG.1** with right dap joint for lintel

FIG. 8 - Element with right and left dap joint for lintels

FIG. 11 - Lintel element

FIG.13 - Covering element with incorporated

FIG. 9 - Element for one balcony

FIG.10 - Element for two balconies

FIG. 12 - Element with window and breastwork

FIG. 14 - Element with two windows and breastwork

FIG. 15 - Triangular element for roof

FIG. 16 - Lintel element

FIG. 17 - Breastwork element

FIG. 18 - Panel element

FIG. 19 - Portal element required for storeys above the ground floor, including covering if of the terrace-type.

FIG. 20 - Element as **FIG.19** with partition parallel to walls

FIG.21 - Element as **FIG.19** with partition and door

FIG. 22 - Element as **FIG.19** with partition, wall and door

FIG. 23 - Element as **FIG.19** with partition, outside wall and windows

FIG:24 - Element with left dap joint for lintel

FIG:25 - Element with right dap joint for lintel

FIG:26 - Element with left and right dap joints for lintels.

FIG. 27 - Element with double-pitch roof

FIG. 28 - Element with double-pitch roof with partition

FIG. 29 - Element with double-pitch roof with partition and door

FIG. 30 - Element with double-pitch roof with partition, door and wall

FIG. 31 - Element with double-pitch roof with partition, outside wall and windows

FIG. 32 - Element with double-pitch roof for top storey

FIG. 33 - Element as **FIG. 32** with partition parallel

to walls
FIG. 34 - Element as **FIG. 32** with partition parallel to walls, and door
FIG. 35 - Element as **FIG. 32** with partition, door and wall
FIG. 36 - Element as **FIG. 32** with partition, wall and windows

ELEMENTS FOR TWO-FLIGHT INTERNAL STAIRS

[0026]

FIG. 40 - Element with steps and landing for first flight
FIG. 42 - Element with steps and landing for second flight
FIG. 41 - Element with door for 1st floor (stairwell) on 2nd flight
FIG. 39 - Element with door for 1st floor (stairwell) on 1st flight

ELEMENTS FOR TWO-FLIGHT COMMON STAIRS

[0027]

FIG. 44 e FIG. 45 - Element with incorporated steps and landing for first flight
FIG. 47 e FIG. 48 - Element with incorporated steps and landing for second flight
FIG. 43 - Element with incorporated steps and landing for third flight
FIG. 46 - Element with incorporated steps and landing for forth flight

Elements **FIG. 43** and **FIG. 46** will be used for additional storeys

ELEMENTS FOR THREE-FLIGHT STAIRS WITH ELEVATOR SHAFT **FIG. 49**

[0028]

FIG. 50 - Element with incorporated steps and landing for first-flight
FIG. 51 - Element with steps for second flight
FIG. 52 - Element with incorporated steps and landing for third flight
FIG. 53 - Elements without steps for landing
FIG. 54 - Element with incorporated steps for fourth flight
FIG. 55 - Element with steps for fifth flight
FIG. 56 - Element with steps for sixth flight
FIG. 57 - Element for landing for first and additional storeys
FIG. 58 - Floor plan of the three-flight stairs with elevator shaft
FIG. 59 - Section three-flight stairs with elevator shaft
FIG. 60 - Element for elevator shaft
FIG. 61 - Element for base elevator shaft

TUNNEL ELEMENT WITH HYDRAULIC SYSTEMS

[0029] **FIG. 37** - Element for hydraulic system

TUNNEL ELEMENT WITH WASTE PIPE

[0030] **FIG. 38**-Element with waste pipe

PERFORMANCE PROCEDURE

[0031] The designer's line of action when designing any building, can be that of using prefabricates compatible with the conceived project or it can be that of using a prefabrication system, which is a more effective procedure, before starting the project.
[0032] Designing with c.a. in mind is different from designing while thinking of using steel which certainly has different characteristics with respect to c.a. as it is different to design bearing in mind brick masonry or squared stone masonry or stone masonry with brick. When designing it is a good thing to bear in mind that there are different prefabricates systems. Those that maybe are the most suitable for constructing any kind of building are represented by:

- the system with whole panels
- the system with reduced panels
- the system with tunnel elements
- the system with round elements

[0033] When this principle is fixed, first the preliminary design and then the outline design are made. The latter already allows tables listing the elements to be used for the construction, to be made out thus simplifying the carrying out of the detailed executive project which comes after.
[0034] When the designing phase is finished and therefore with the list of elements to be used for the construction made out, the building yard phase starts.
[0035] Things at the building yard proceed as for any construction.
[0036] The ground on which the construction/s are to be erected has already been studied during the designing phase from all points of view: town-planning, geological and geotechnical, which will determine the both dimensions of foundations and the type of underpinning.
[0037] With this prefabrication system, the perimeters of the construction will rest on the foundations and therefore these will be made of beams with a rectangular section with a rectilinear, angular or T-shaped profiles. The foundation will have such dimensions so as to never have the connections of the foundation beams coincide with the connections of the tunnel elements.
[0038] A concrete underpinning, laying perfectly flat and with a channel as wide as the foundation beams on

which the latter will rest, will be cast in the foundation excavation having a given width and which has been carried out with suitable mechanic mean.

[0039] Pressure-resistant waterproof material used to insulate the foundation will be opportunely placed on the underpinning.

[0040] When the foundations are finished, the laying of the TUNNEL elements will take place by means of a self-propelled crane anchored to the ground so as to avoid strong swings during the laying. The element, by means of hooking points, is lifted and placed in the correct position so that the first element can be consolidated with the second and so on so forth. Before positioning, suitable rubber cement to be put on connections and suitable mobile tie rods are required for consolidation.

[0041] When the last element is laid fixed tie rods must be also laid.

[0042] If the construction has to proceed with a first floor PORTAL elements are to be used. These portal elements - which are similar to the tunnel ones but do not have the floor slab - are to be transported with wall clamps which will be removed during the laying that will be carried out following the same procedure used for the tunnel elements.

[0043] If the covering is of the double-pitch roof type the element of the top storey will be a portal element with double-sloping-pitch.

Claims

1. System of prefabricated elements for the construction of buildings, characterized by the fact of having, as base element, an empty tunnel parallelepiped composed of a base, two vertical walls and one ceiling.

2. System of prefabricated elements as per claim no. 1, characterized by the fact that the tunnel element for buildings with only one floor has the floor, the ceiling and the walls.

3. System of prefabricated elements as per claims nos. 1, 2, characterized by the fact that the base element can be combined with other elements having the following coupling profiles: groove-and-tongue joints, female-female joints, male-male joints.

4. System of prefabricated elements as per claims nos. 1, 2, 3, characterized by the fact that the elements have various holes along the perimeter which is symmetrical with respect to the section axis of the floor, the ceiling and the walls, which are obtained by burying steel pipes in the corners and the walls, floor and ceiling center line, through which tie rods can pass to consolidate the elements.

5. System of prefabricated elements as per claims nos. 1, 2, 3, 4, characterized by the fact that the tunnel elements for storeys subsequent to the first become portal elements.

6. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, characterized by the fact that some tunnel elements have slots for the passage of waste pipes, water piping, electric ducts and of all necessary equipment.

7. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, characterized by the fact the tunnel elements can have partitions orthogonal to the walls with door or window openings if required.

8. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, characterized by the fact that some tunnel elements have partitions parallel to the walls.

9. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, characterized by the fact that the portal elements used for the first and for additional storeys have the same features of the tunnel elements.

10. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, characterized by the fact that for the construction of balconies there are elements with one or two overhangs.

11. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, characterized by the fact of having a lintel for the definition of the windows that fits in between two tunnel or portal elements.

12. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, characterized by the fact of having one element for window opening and breastwork that forms a C-shaped element.

13. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, characterized by the fact that there also is a panel rectilinear element to be used for the top storey, when needed for laying the roof element.

14. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, characterized by the fact of having a complete covering element for one-storey buildings complete with double-pitch slab with incorporated covering elements.

15. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,, 13, 14, characterized by the fact of having a portal element com-

plete with covering for buildings with more than one storey complete with double-pitch slab with incorporated covering elements.

16. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, characterized by the fact of having a triangular element for roof-covering composed of a double-pitch slab with or without incorporated roof tiles.

17. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, characterized by the fact of having two elements with two flights for internal stairs.

18. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, characterized by the fact of having a two-flight stair composed of two elements, one with the first flight and another with landing, second flight and landing.

19. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, characterized by the fact of having, for buildings with more than three storeys, a three-flight stair with elevator shaft in the stairwell composed of 4 elements per floor: the first with the first flight and landings, the second with the second flight, the third with the third flight and landings, the fourth with landings.

20. System of prefabricated elements as per claims nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, characterized by the fact that the three-flight stair of Claim no. 9 has four more elements for the first storey and for additional ones, one element with the fourth flight and landings, one elements for the fifth flight, one element for the sixth flight and landings, one element for landing.

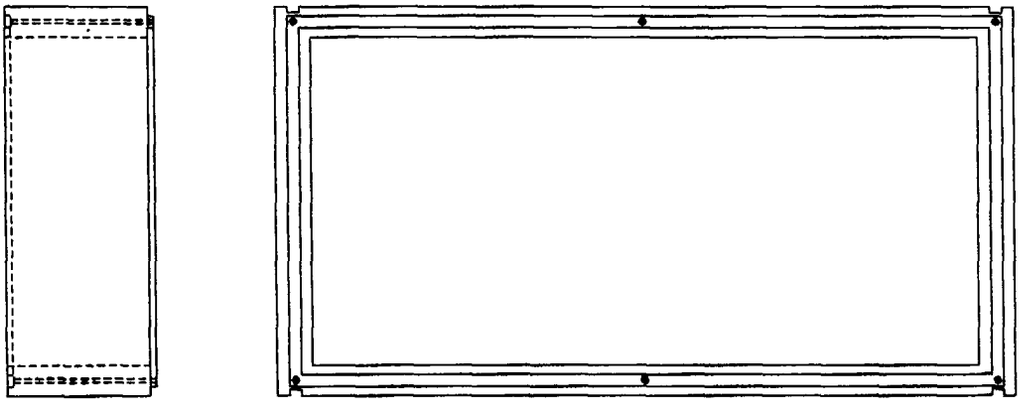
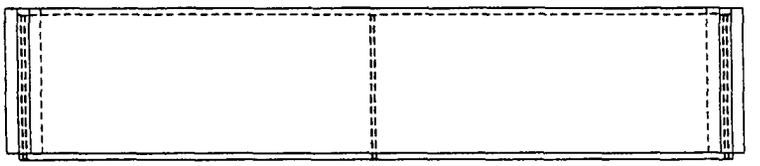


FIG.1



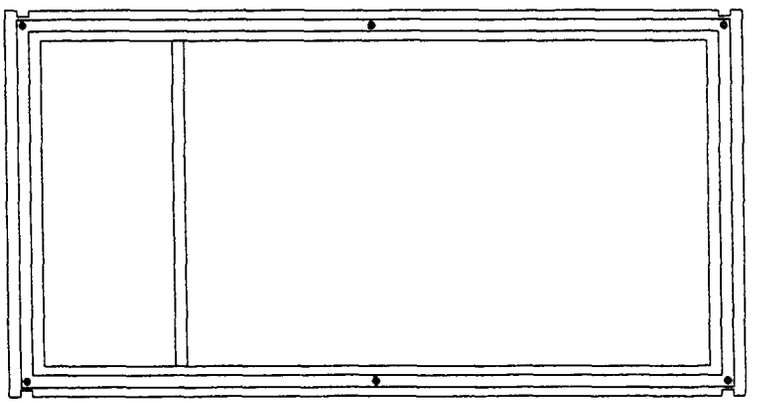
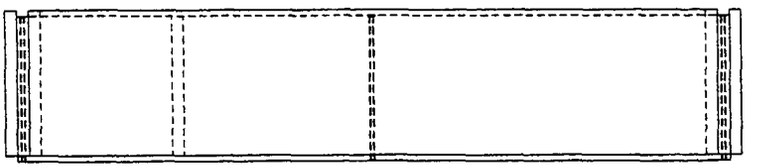


FIG.2



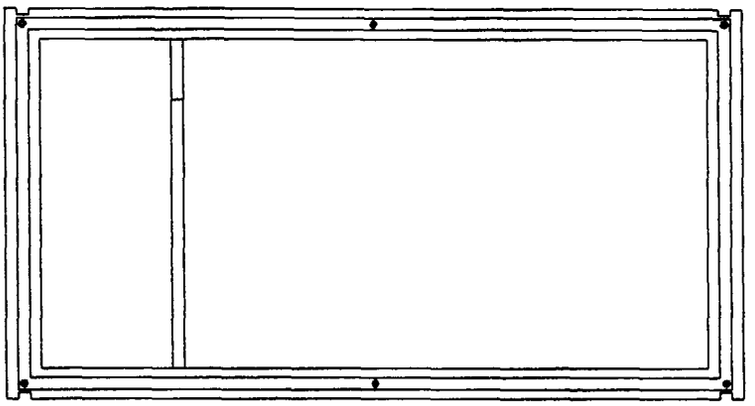
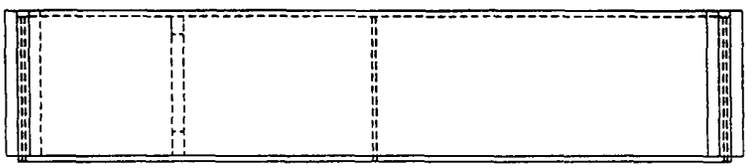


FIG.3



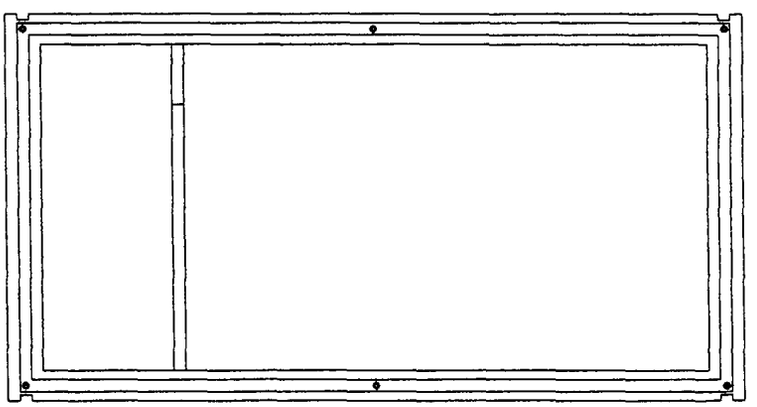
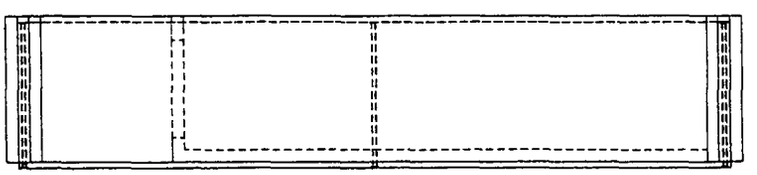


FIG.4



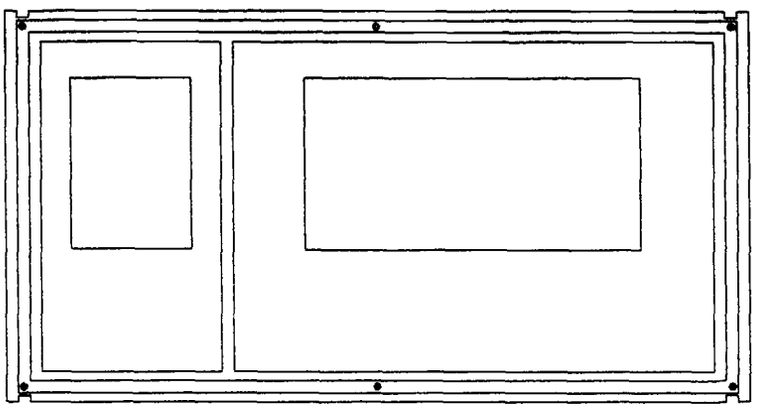
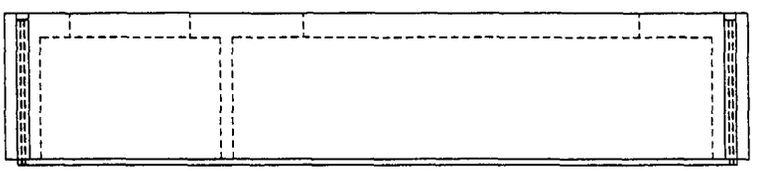


FIG.5



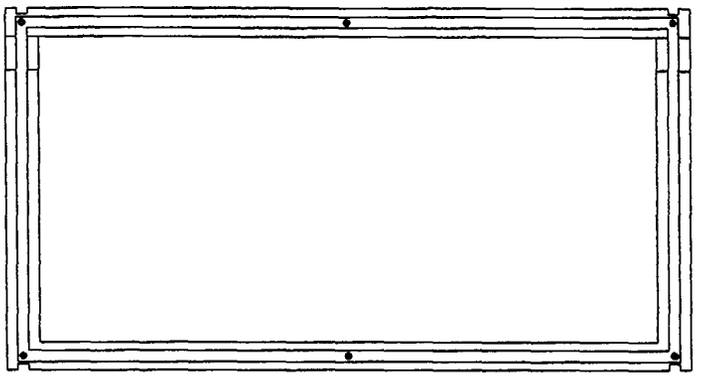


FIG.6

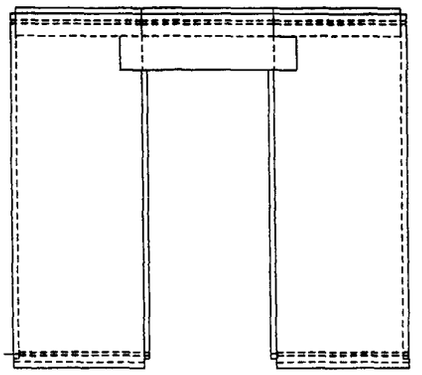


FIG.7

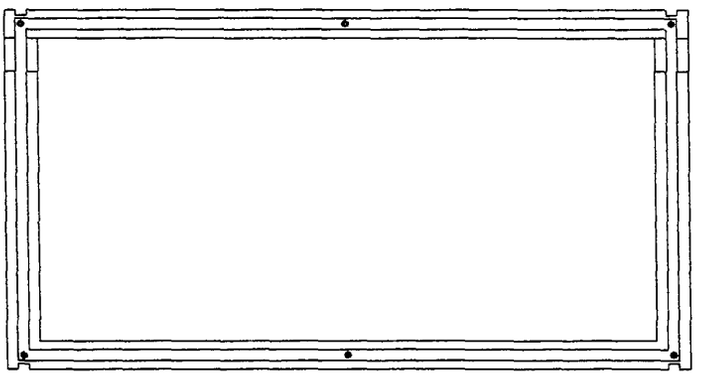


FIG.8

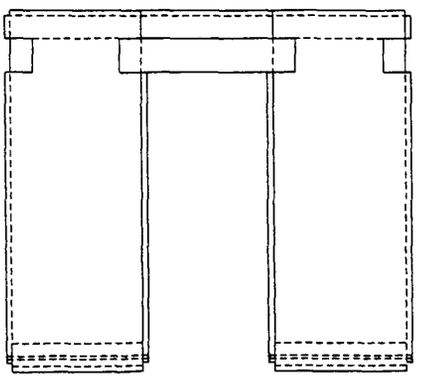


FIG.8

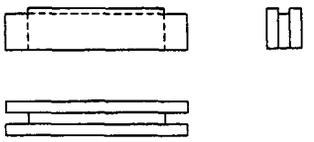


FIG.11

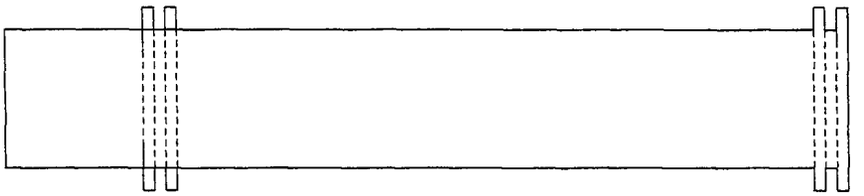
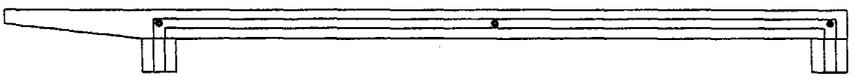


FIG.9



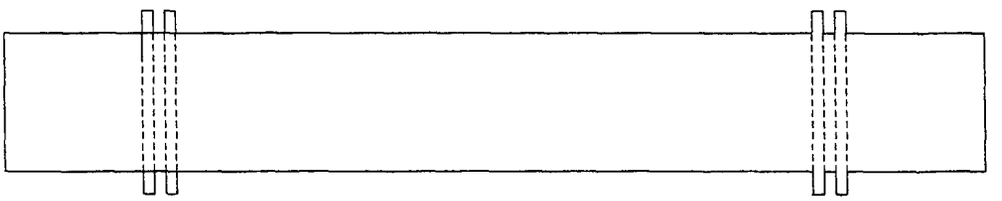


FIG.10

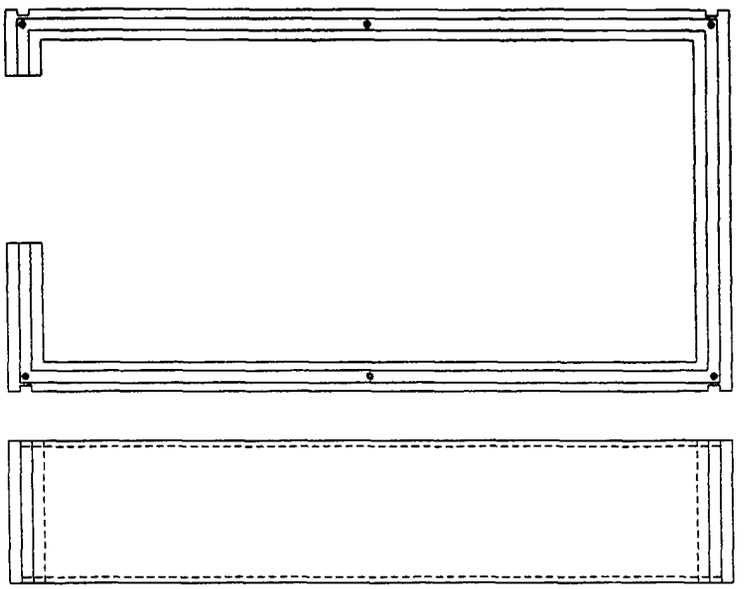


FIG.12

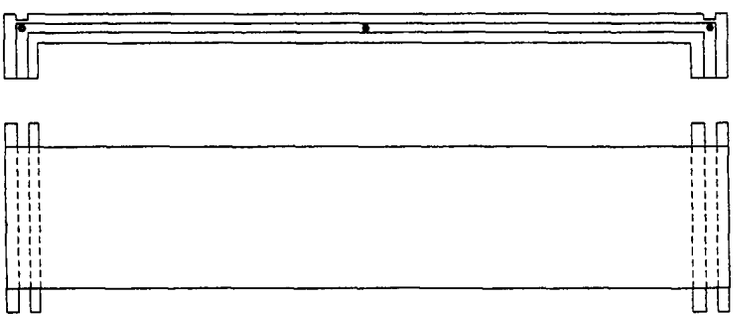


FIG.13

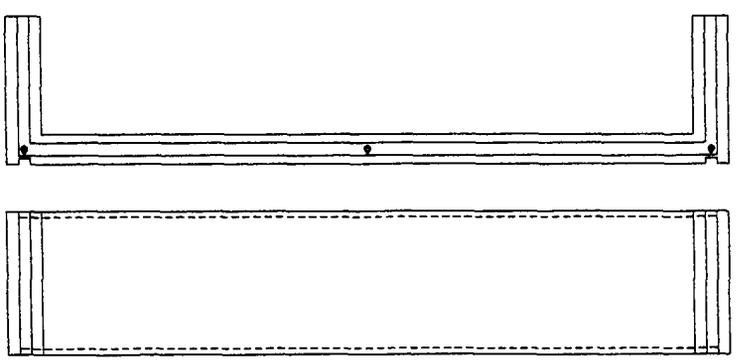


FIG.14

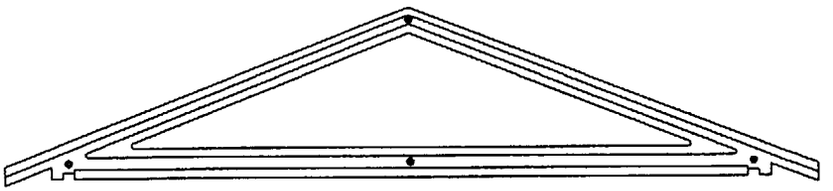


FIG.15

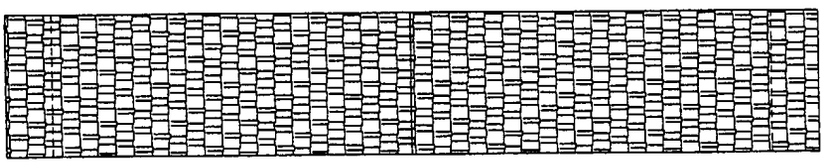


FIG.16

FIG.17

FIG.18

FIG.19

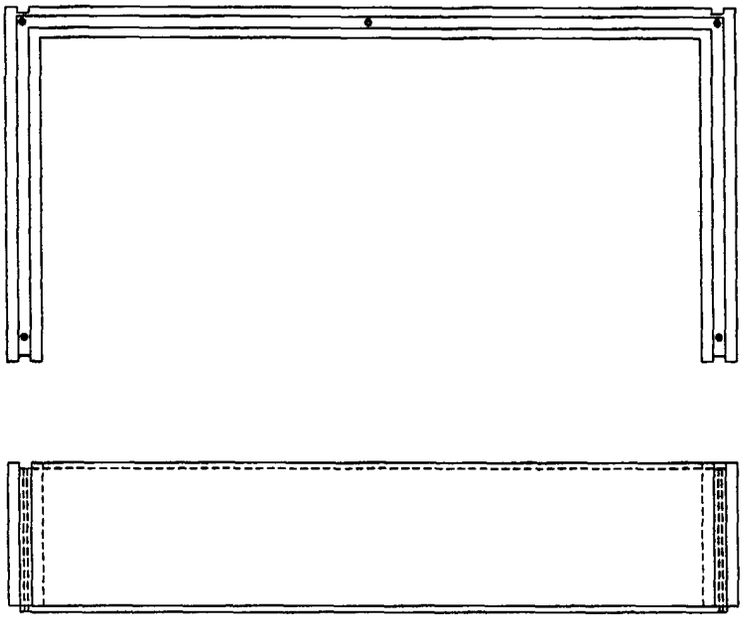
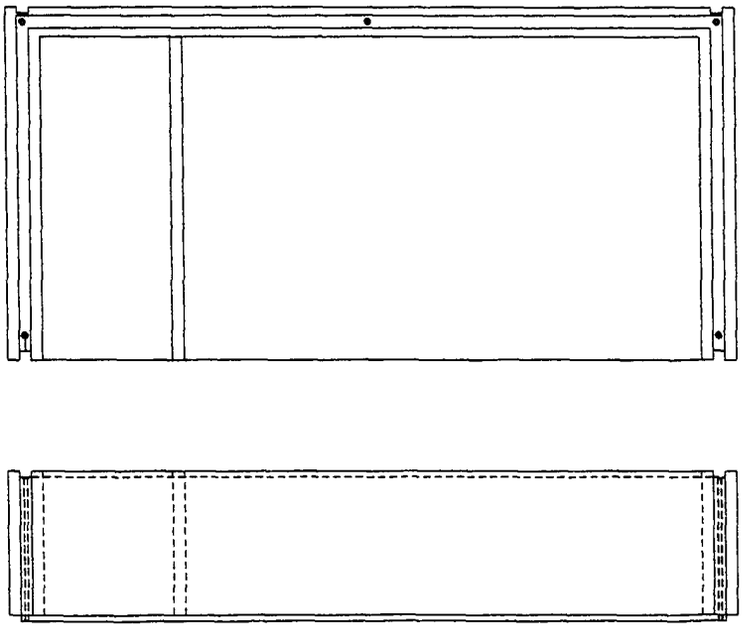


FIG.20



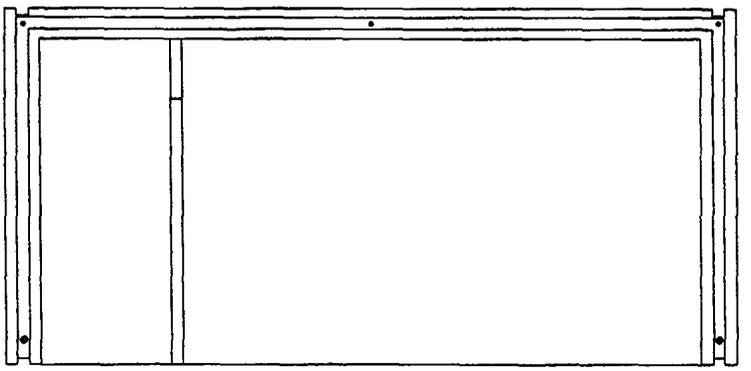
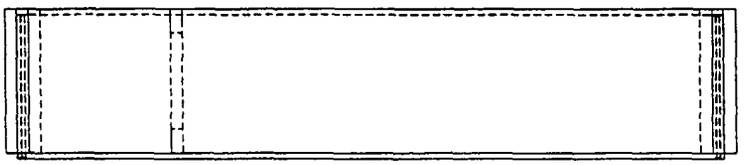


FIG.21



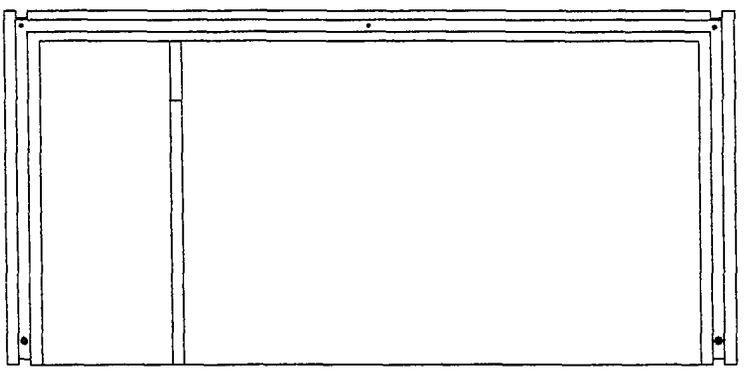


FIG.22

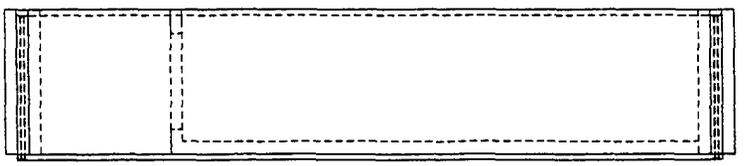
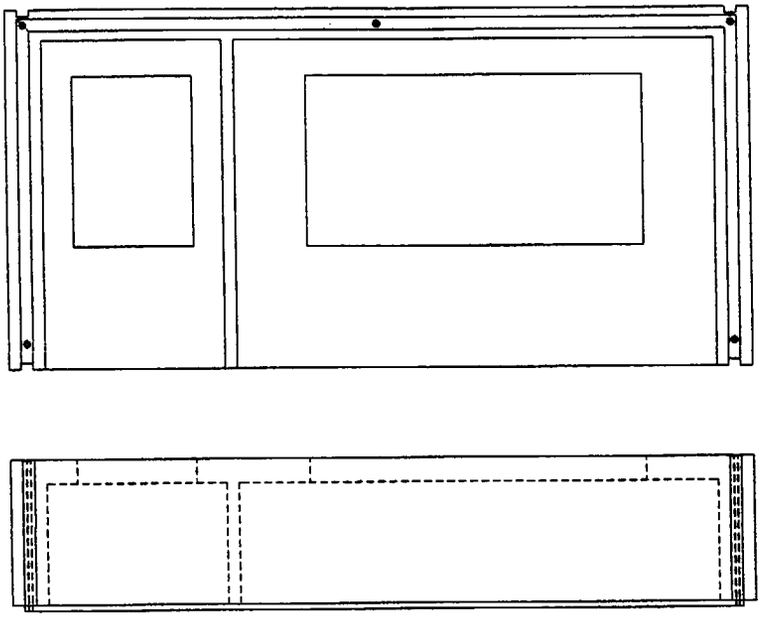


FIG.23



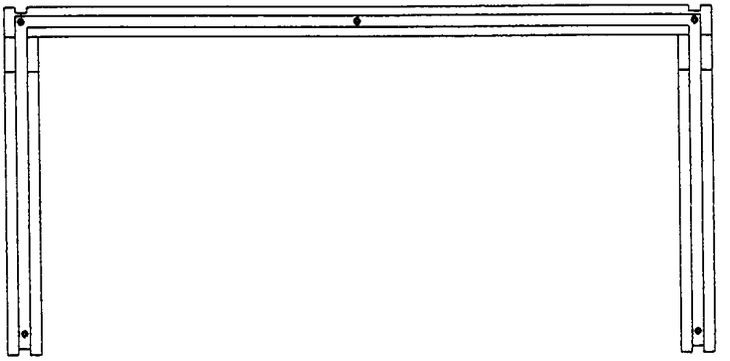


FIG.24

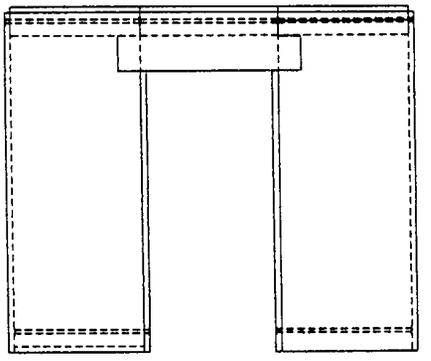


FIG.25

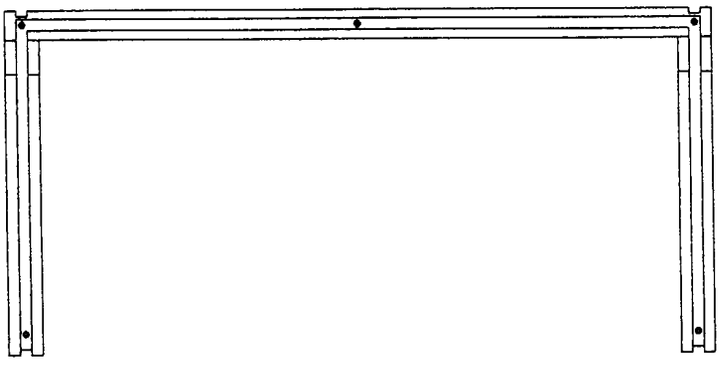


FIG.26

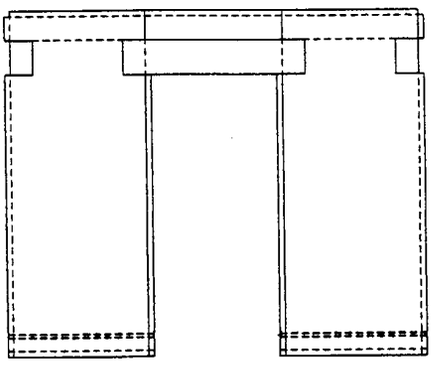


FIG.26

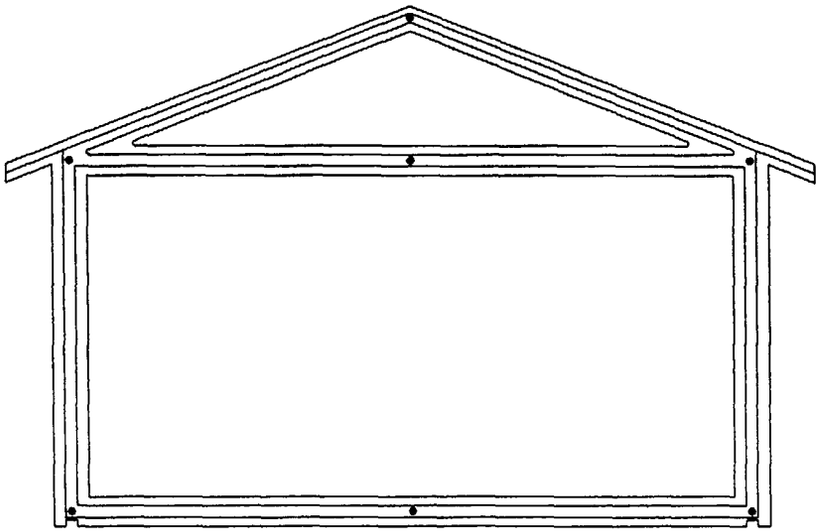
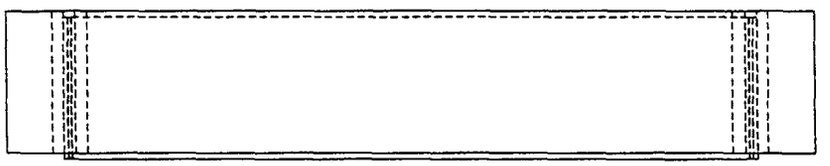


FIG.27



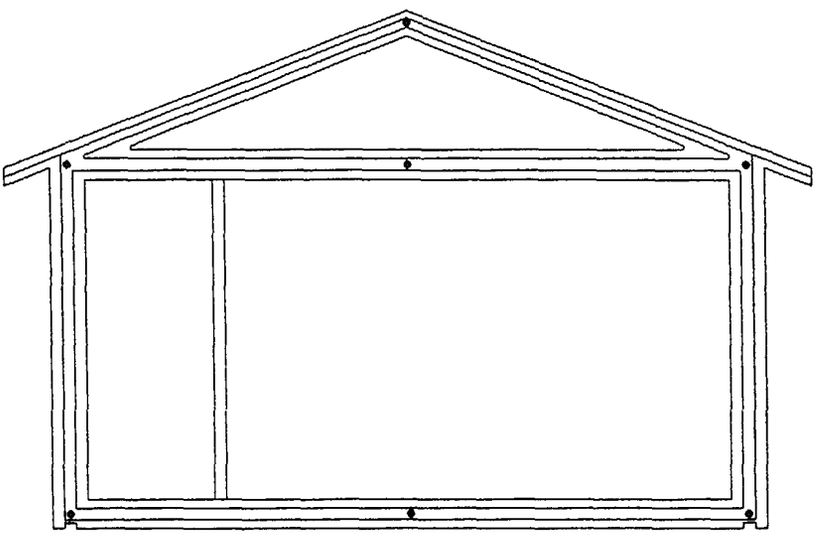
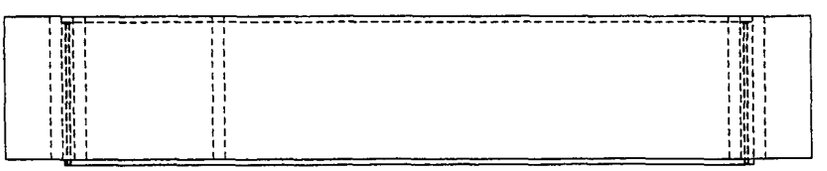


FIG.28



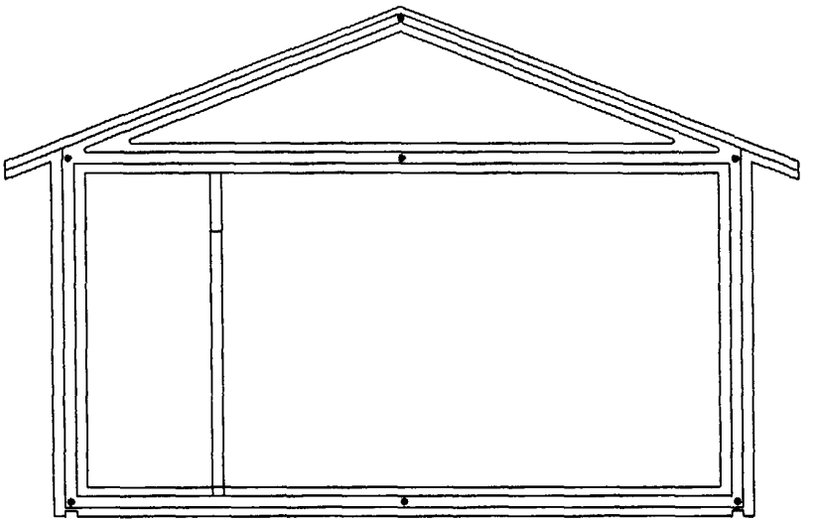
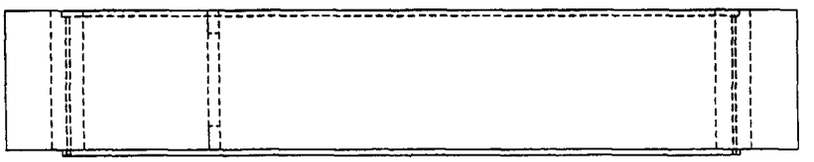


FIG.29



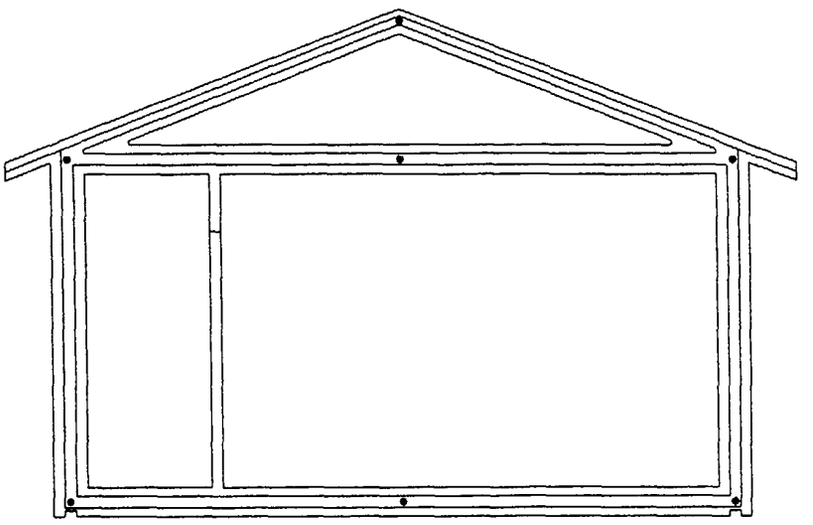
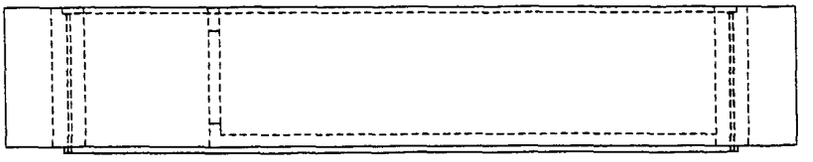


FIG.30



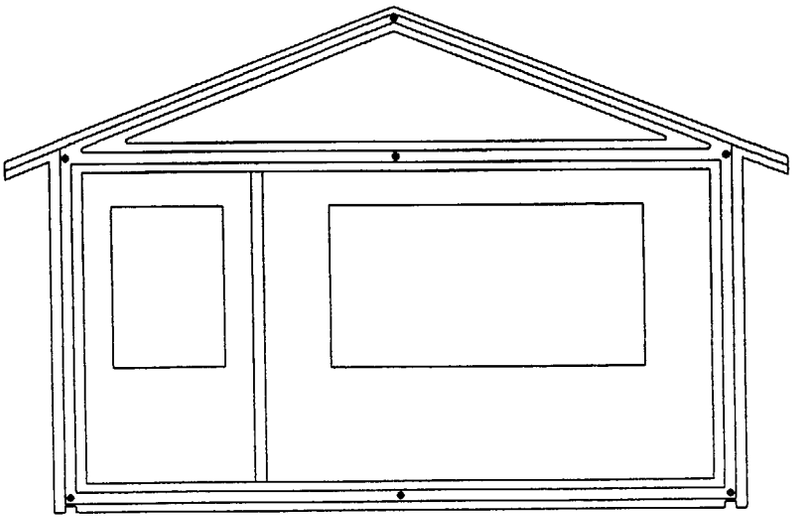
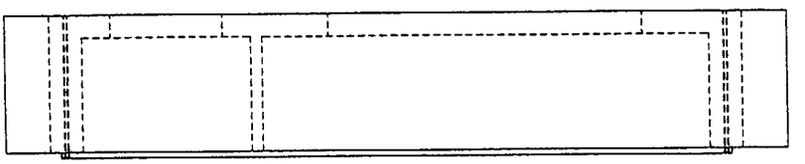


FIG.31



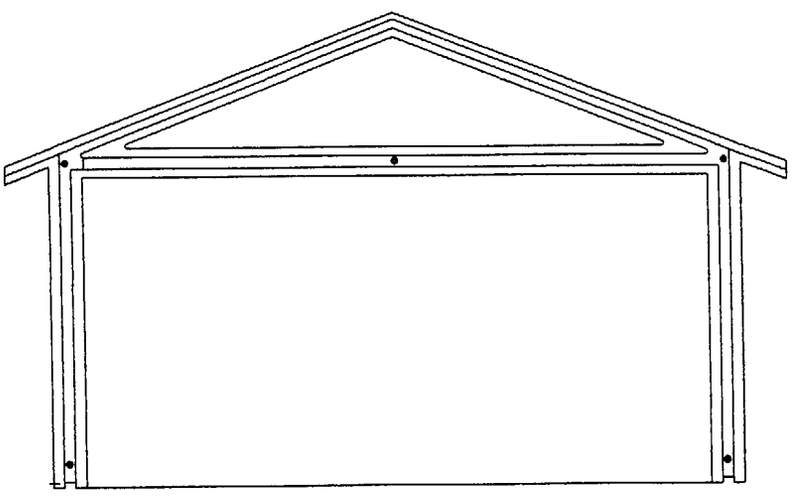
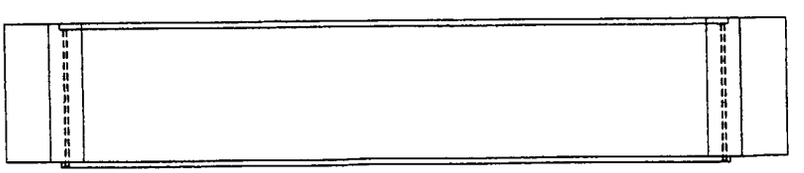


FIG.32



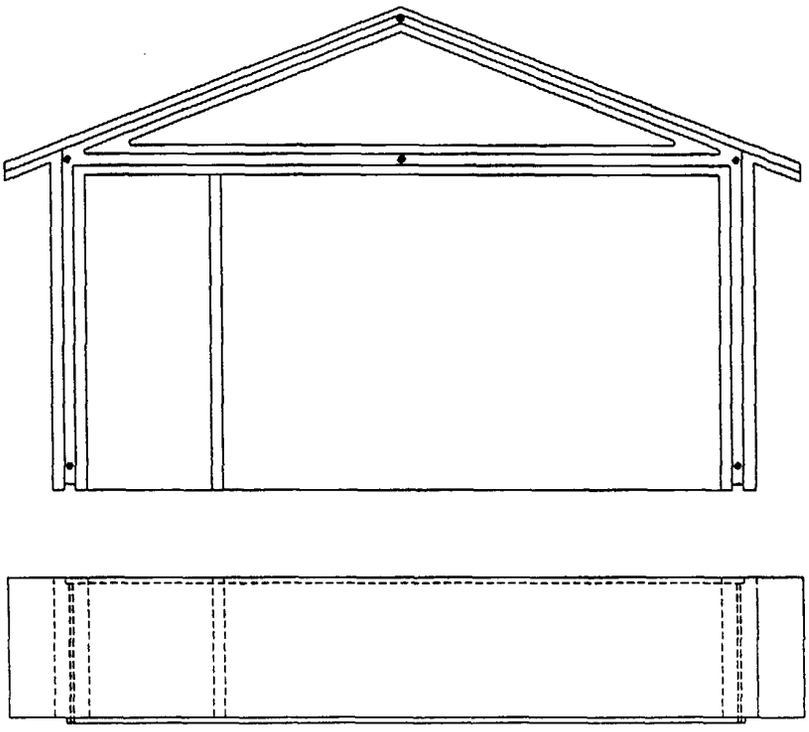


FIG.33

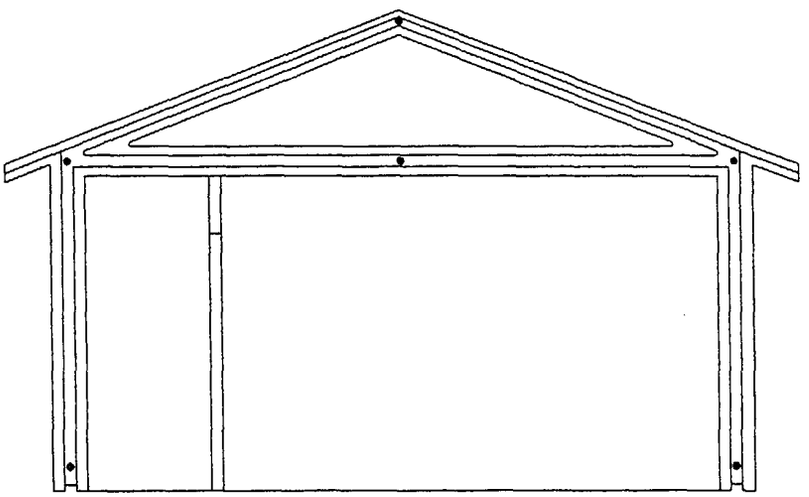
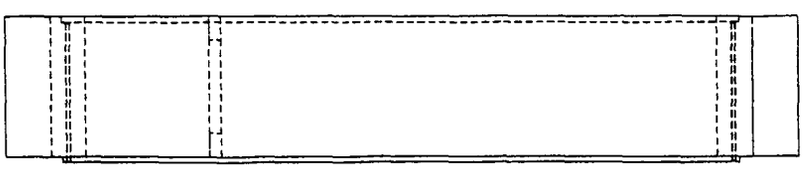


FIG.34



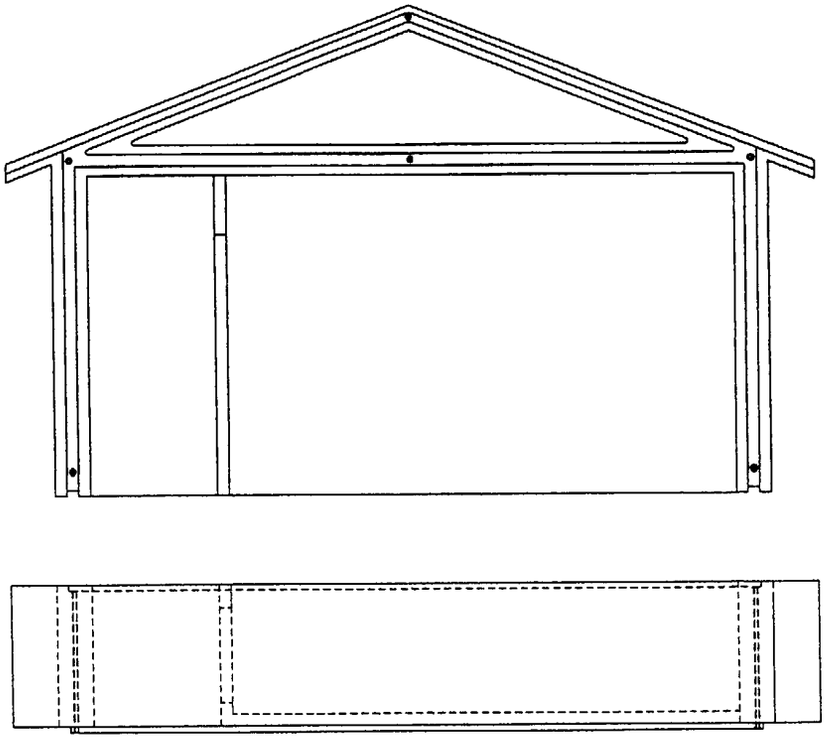


FIG.35

FIG.36

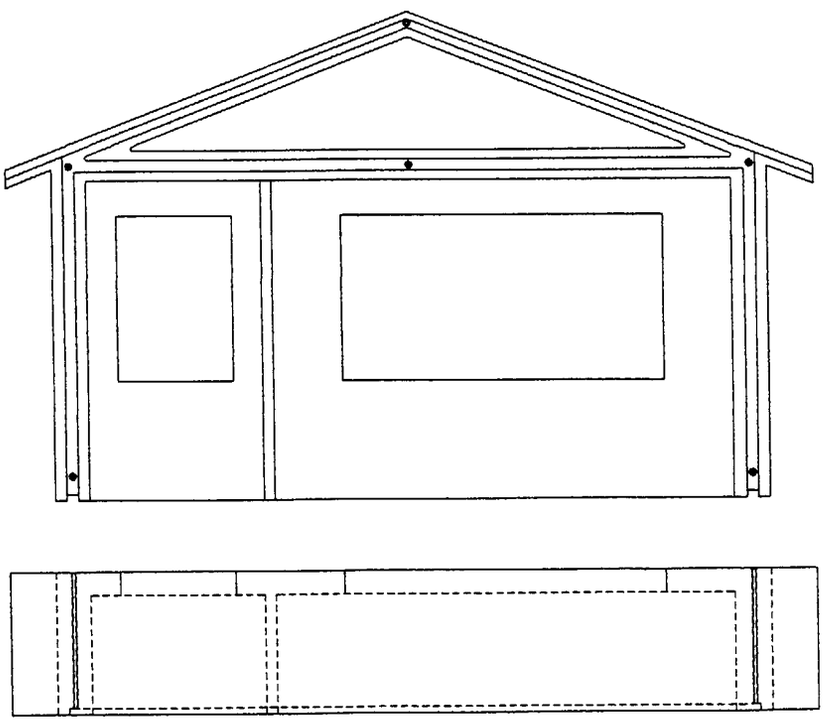


FIG.37

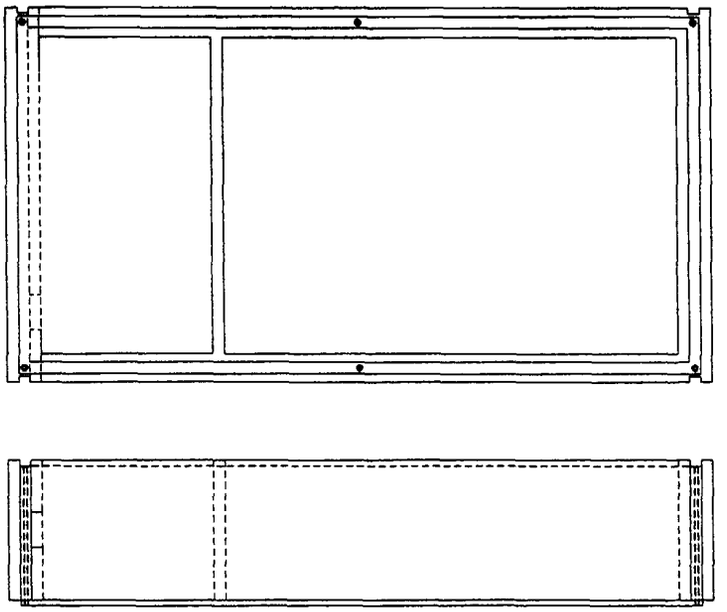


FIG.38

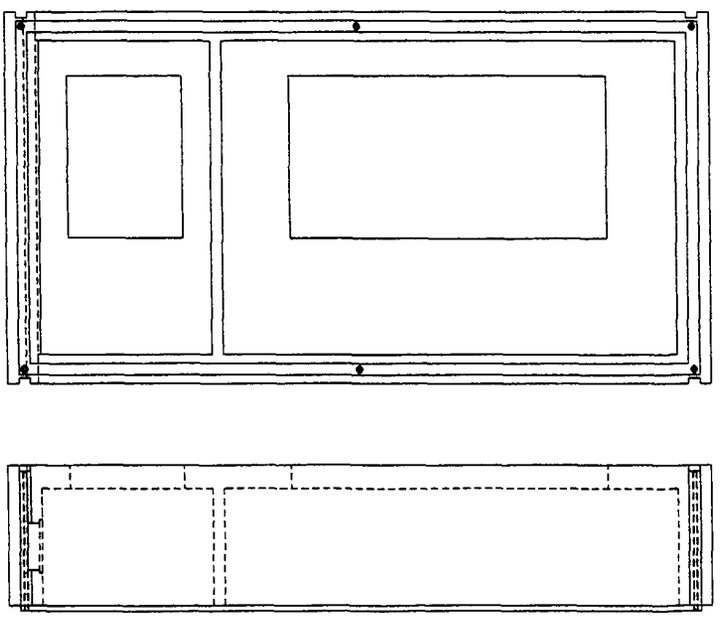


FIG.39

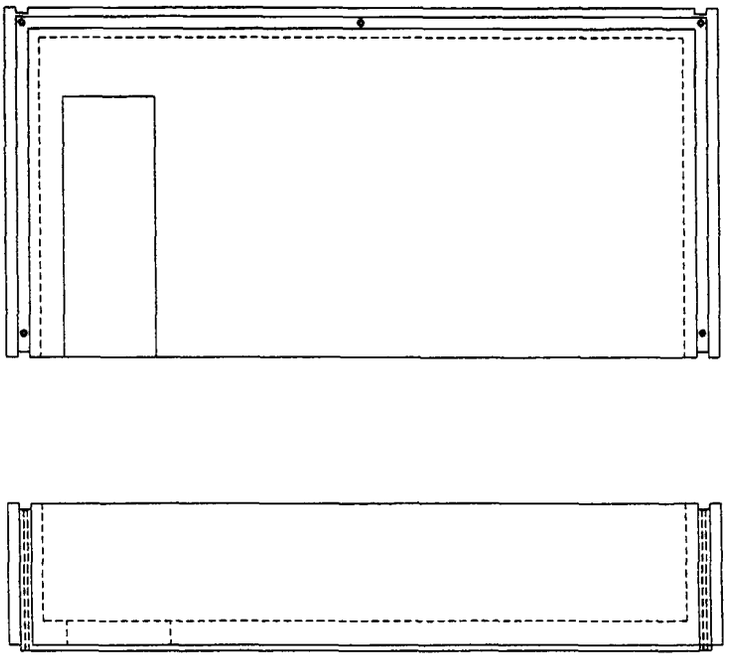


FIG.40

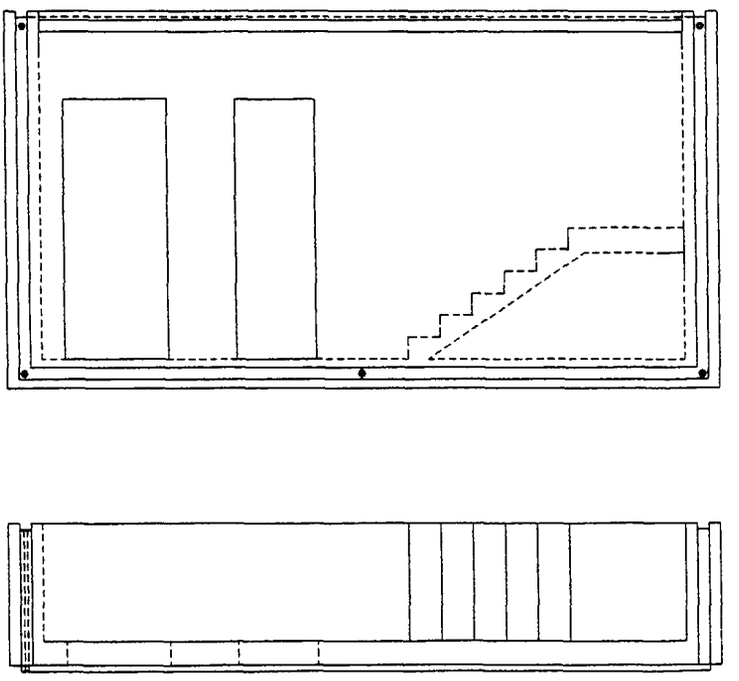


FIG.41

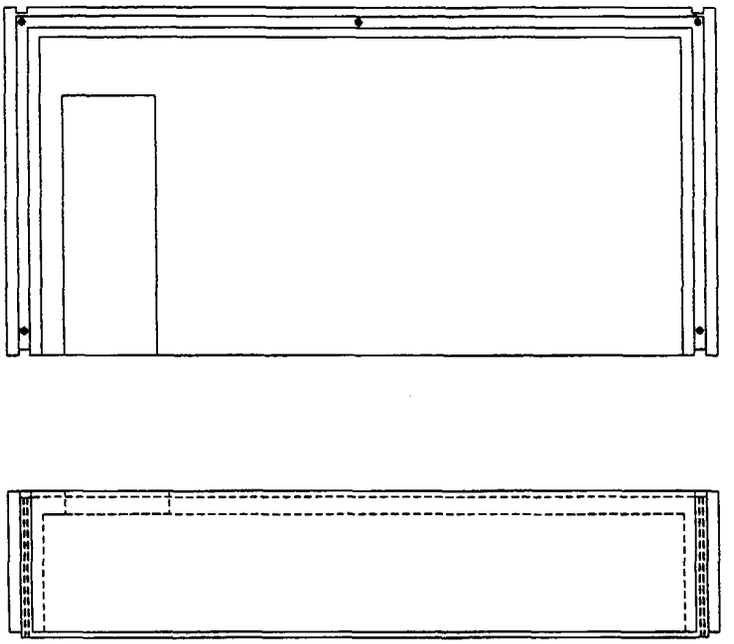
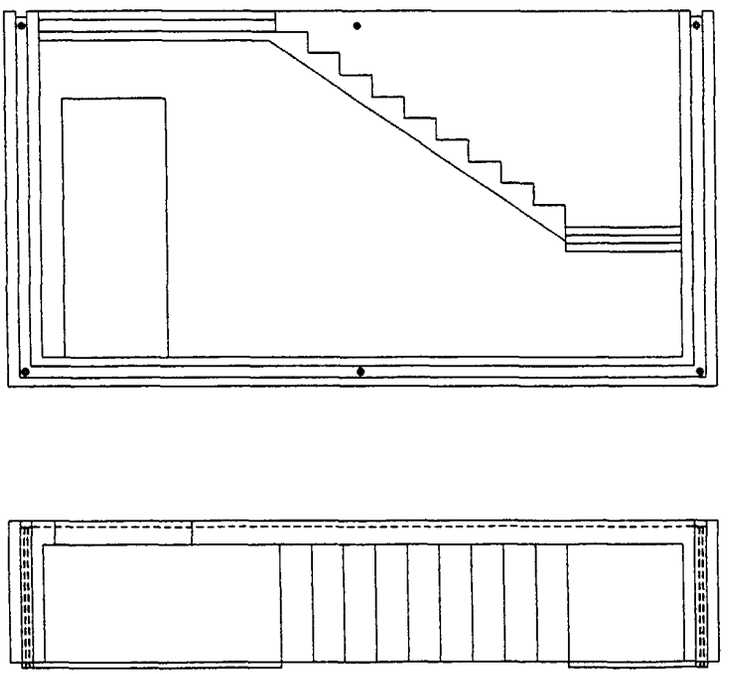


FIG.42



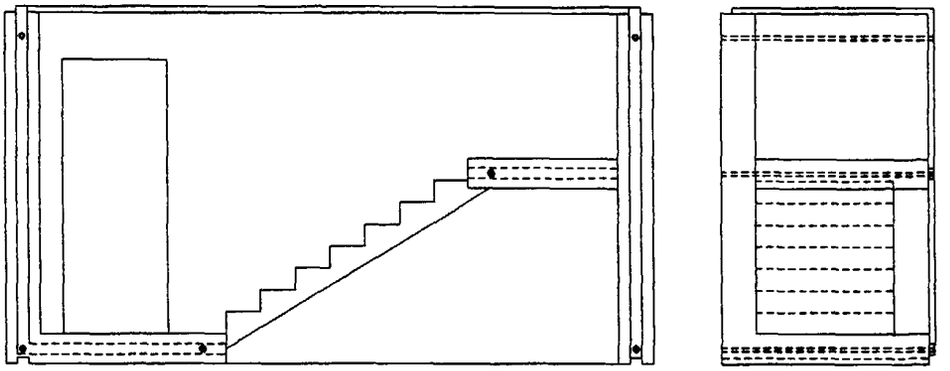


FIG.43

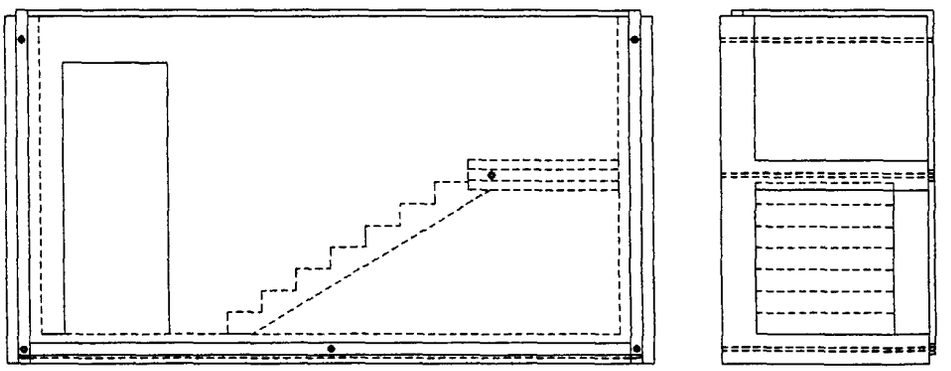


FIG.44

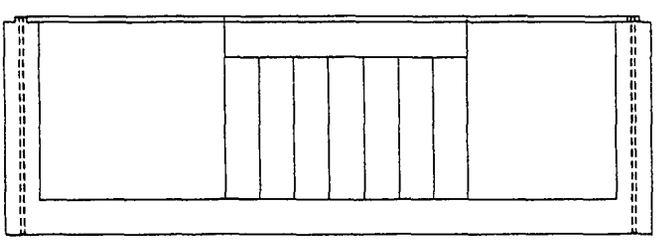


FIG.45

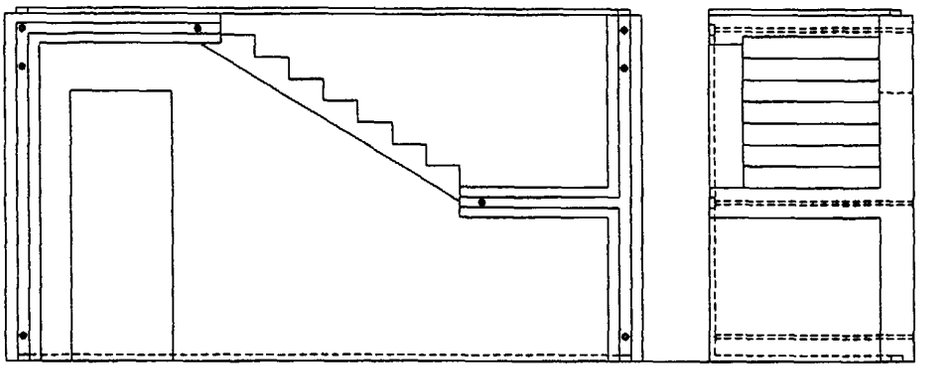


FIG.46

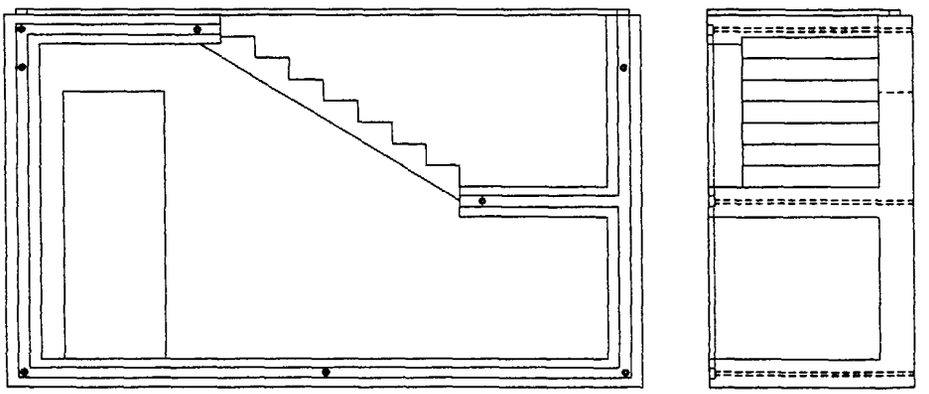


FIG.47

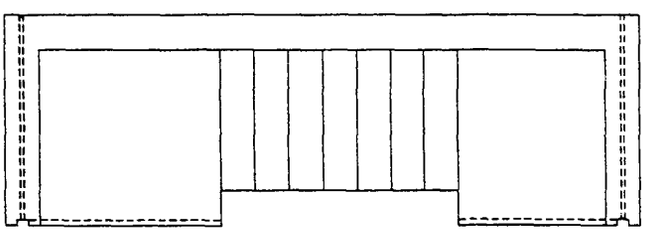


FIG.48

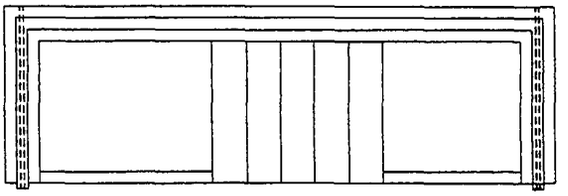


FIG.52

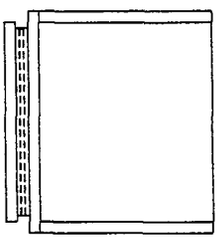


FIG.53

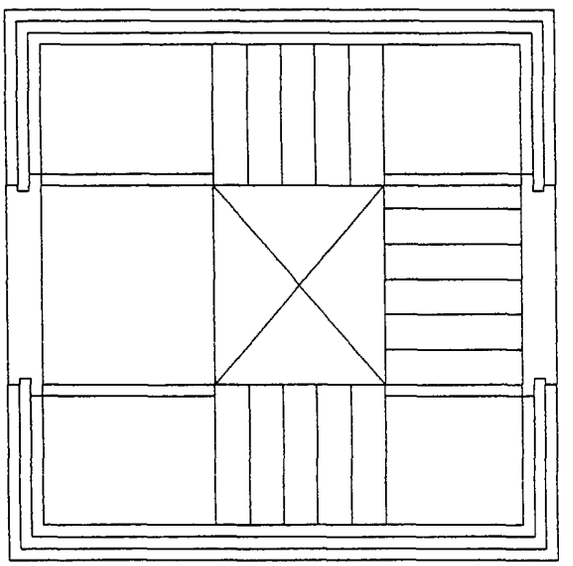


FIG.49

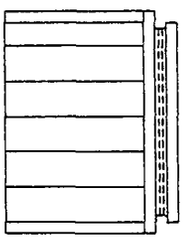


FIG.51

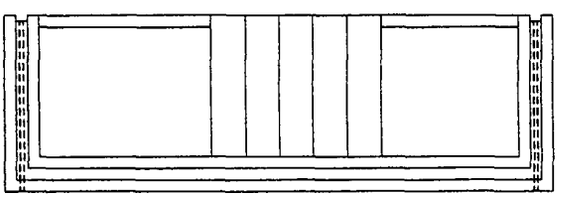


FIG.50

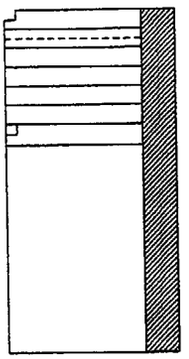


FIG.56

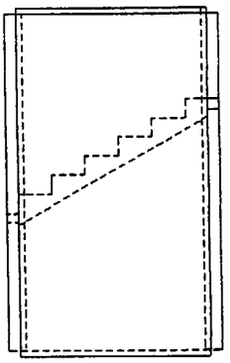


FIG.55

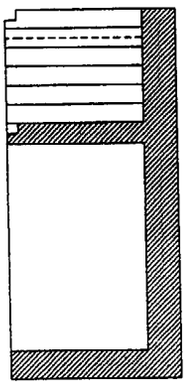


FIG.52

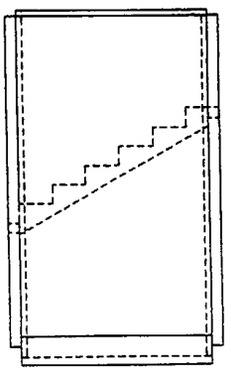


FIG.51

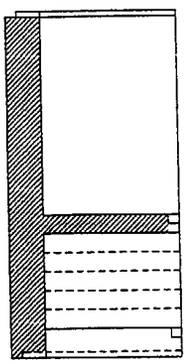


FIG.54

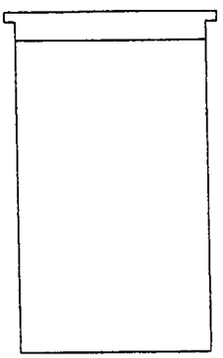


FIG.57

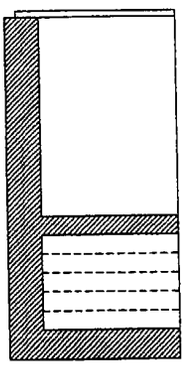


FIG.50

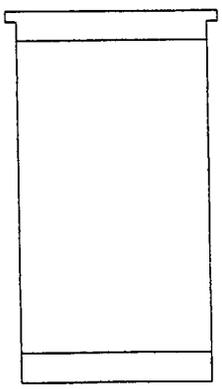


FIG.53

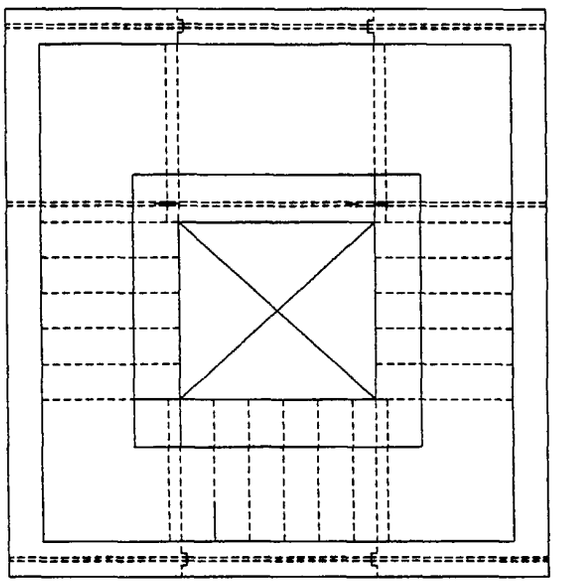


FIG.58

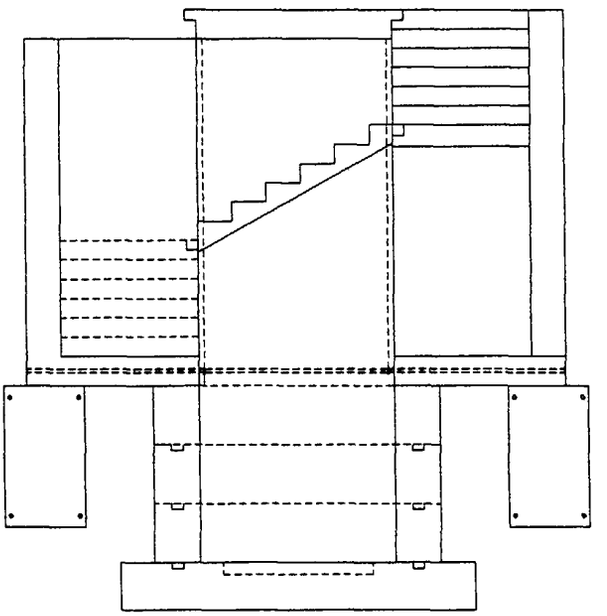


FIG.59

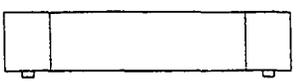


FIG.60

FIG.61

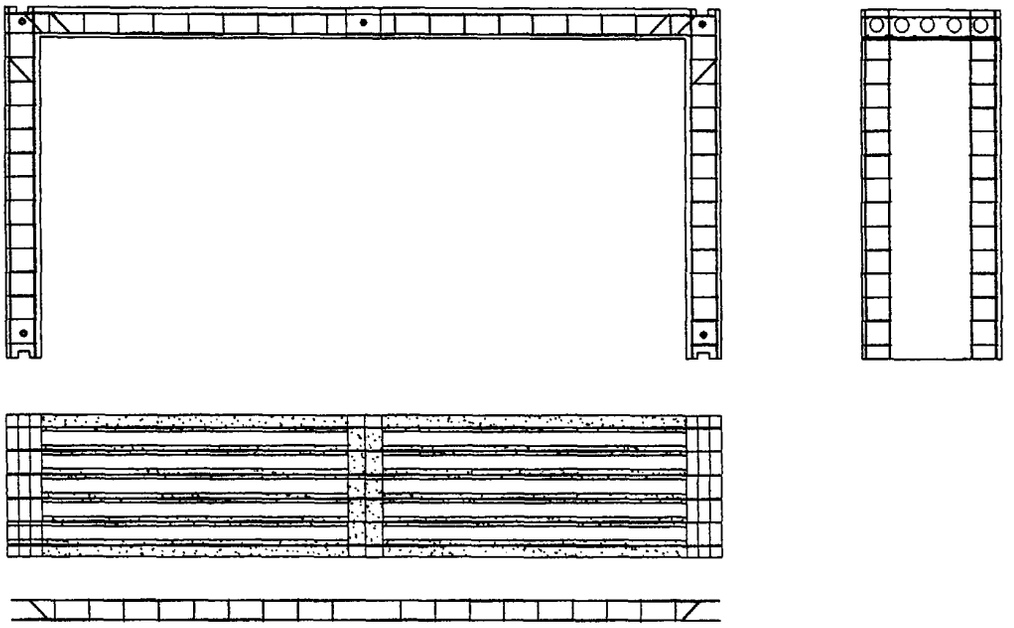


FIG.62

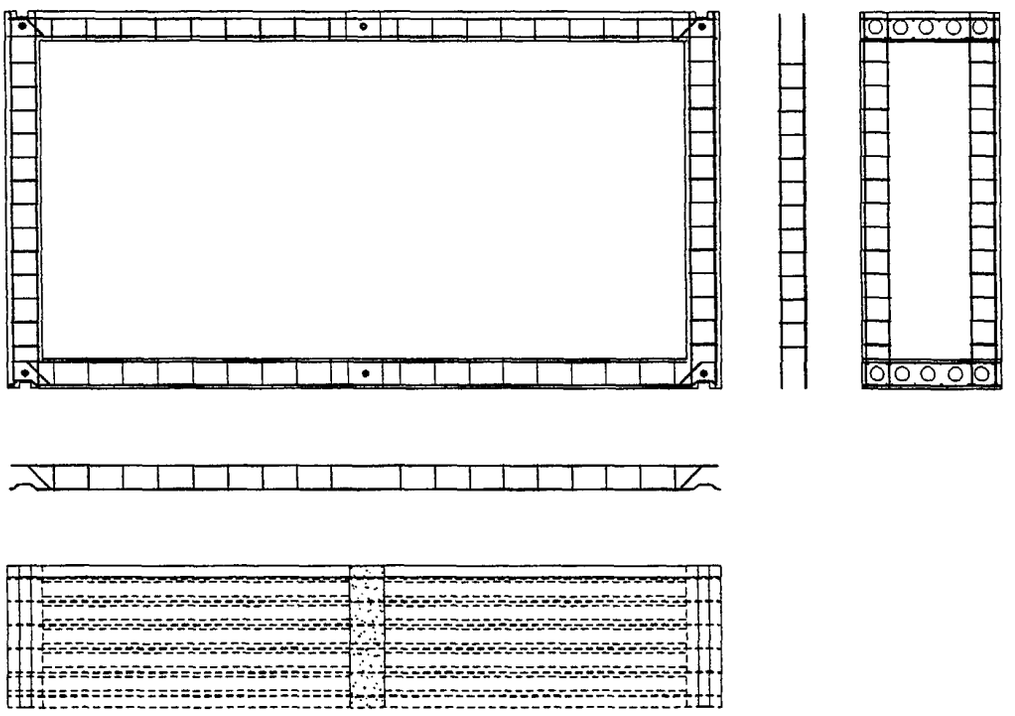


FIG.63

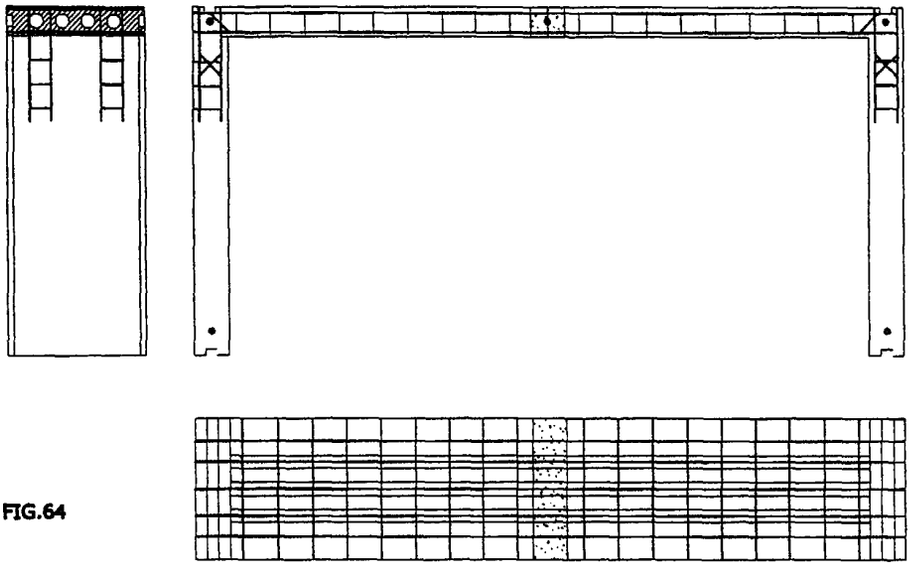


FIG.64

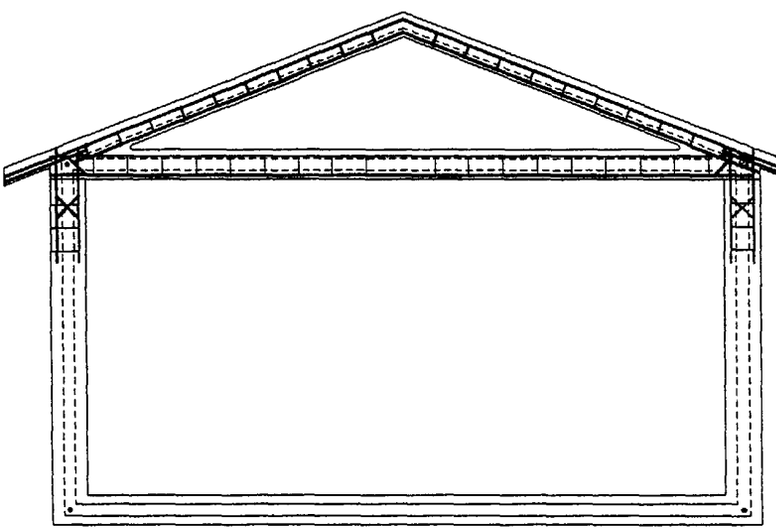


FIG.65

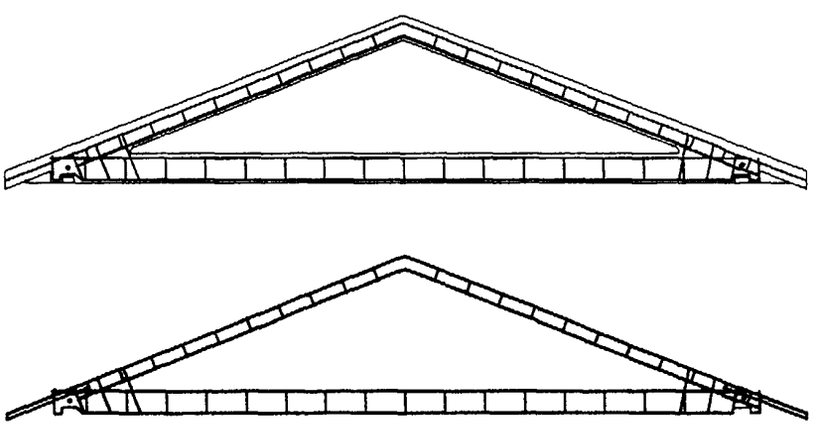


FIG.66

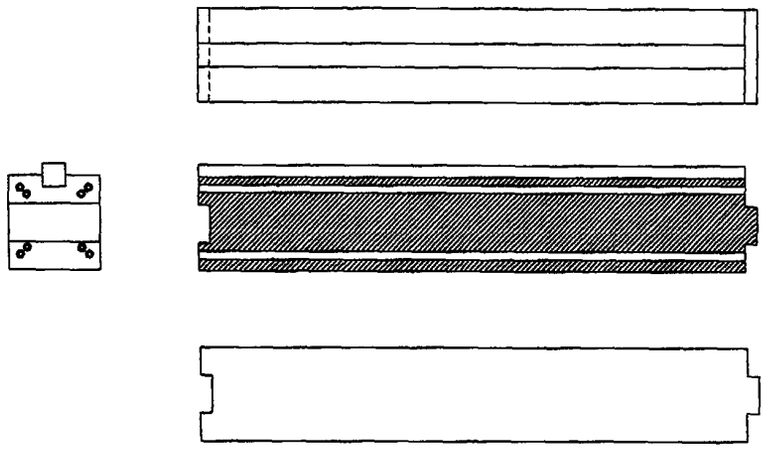


FIG.67

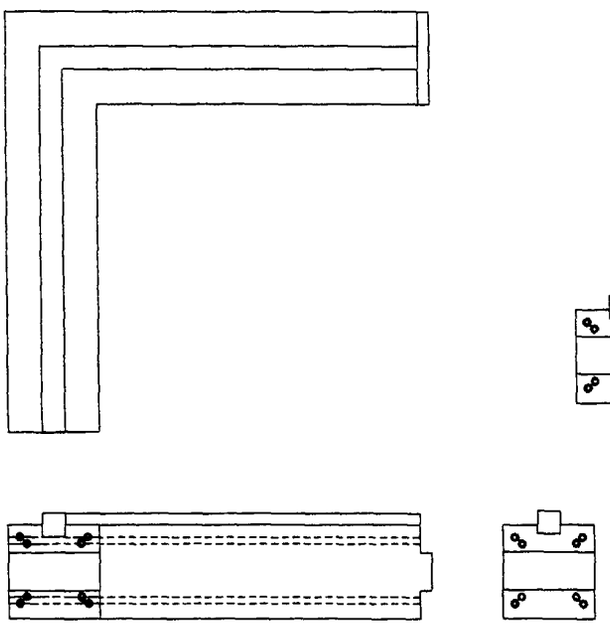


FIG.68

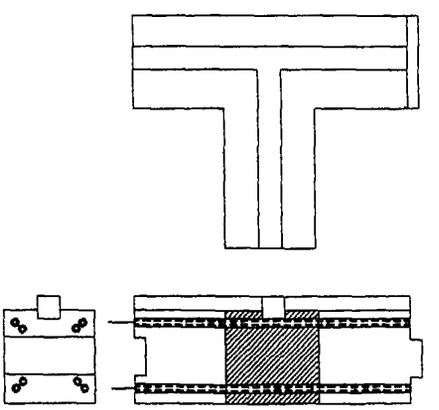


FIG.69