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United Nations Industrial Development Organization

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1/ [illegible] views and [illegible]ions expressed in this paper are those of the author and do [illegible] necessarily reflect the views of the secretariat of UNIDO. This document [illegible] been reproduced without formal editing.

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AUSTRIAN EXPERIENCE IN UP TO DATE LOW COST CONSTRUCTION

Summary

The Austrian building market is characterized by many small contractors scattered all over the country and a medium European standard of wages, which favours conventional building methods. Building industrialization in Austria had been put forward by large-panel systems for housing, mostly manufactured as reinforced concrete sandwich panels though Austria has rich resources of clay and wood.

Many enterprises have improved foreign licences to an extent that the licencers have changed their own system accordingly.

The economic distance of transport differs very much from large-panel systems (about 50 km on road) to components for industrial buildings (about 250 km on rail).

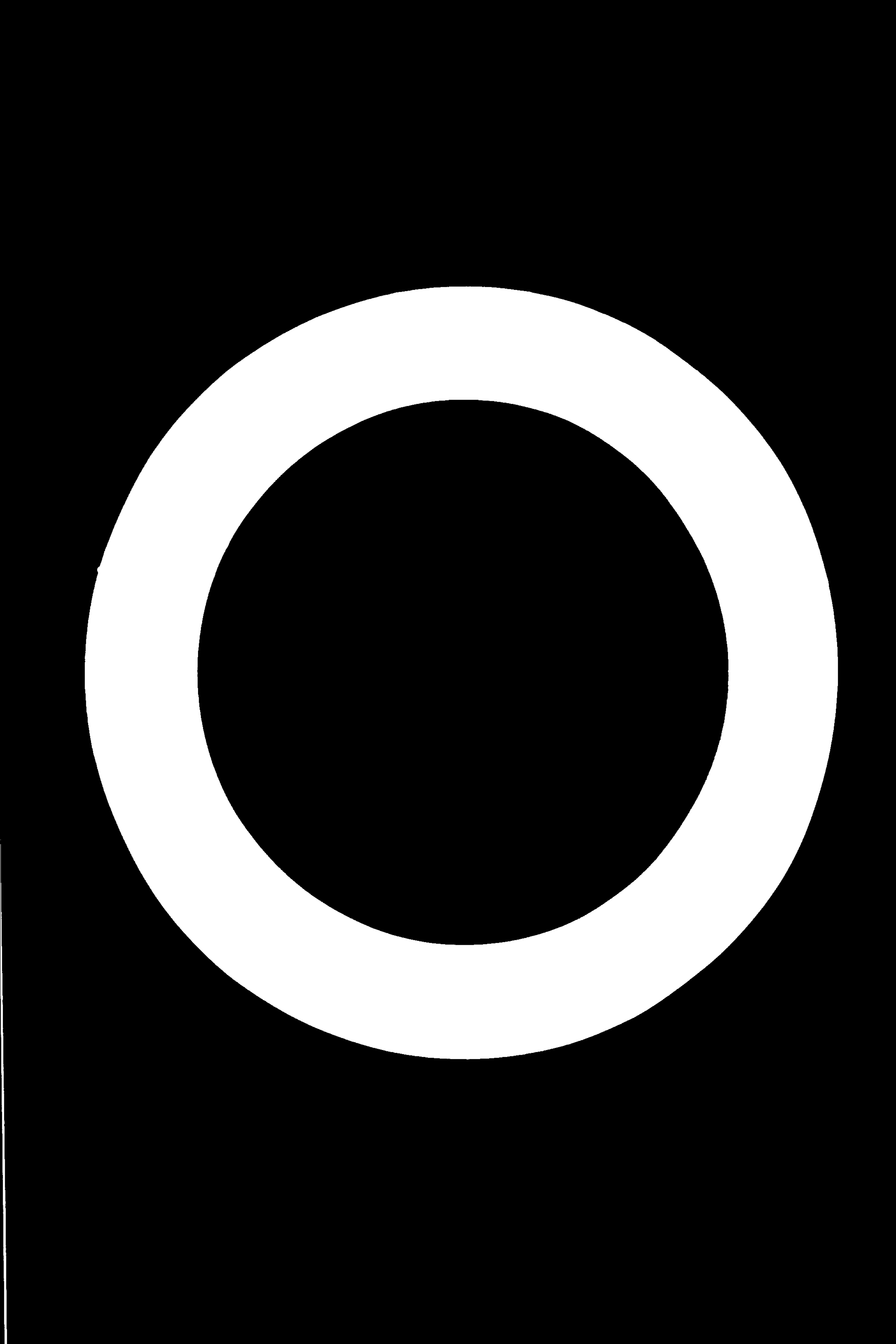
Rationalization of conventional wall and floor constructions gives many ideas for low-cost construction systems.

In large-panel construction a Viennese system offers a high standard of automation in production planning, manufacture and transport of panels, making use of computers for the optimization of the design of the particular project and for the controlling of the automatic production machines. This system is now going to be applied in developing countries.

Low-cost school building systems for countries with hot and dry climate are designed for minimum steel expenditure.

For industrial buildings and halls with large spans a circular cone-shaped suspension roof structure incorporates a high degree of variability at a reasonable expense.

CONTENTS



AUSTRIAN EXPERIENCE IN UP TO DATE LOW COST CONSTRUCTION

1 General Problems of Building Industrialization in Austria

1.1 Introduction

It is the author's opinion that low-cost construction is well based on the three following principles :

- a well balanced market of supply and demand, the competition situation,
- an adequate usage of available resources and manpower, the optimal construction,
- a high standard of mechanization and industrialization, the economic realization.

On the following pages the author wants to demonstrate the standard of industrialized building in Austria putting most emphasis on the problem of low cost construction including some remarks on the choice of the suitable material and adding some examples of offers and realizations of low cost constructions for some developing countries.

1.2 The Austrian building market

It is one of the characteristics of the Austrian building industry that small but potential building contractors and builders are scattered all over the country and the average wages are according to the geographical situation between the standard of the southern and western neigbours.

Thus the conventional building methods are favoured.
Since about [illegible] a basic change can be noticed which arises primarily from housing.
As a consequence of a trend towards building on larger areas which enabled the economic use of large-panel building systems, a number of factories for building components were located in the outskirts of Vienna, Linz and Graz at the same time.
Recently new developments seem to arise.

1.3 The material basis

More and more employers and also architects come to the conclusion that concrete as it was used so far need not necessarily give optimal results in prefabrication.
Light-weight and composite materials used in light-weight prefabricated building systems, very often meet the demands of up-to-date building construction and efficient component production. The success of light-weight standardized building components on the Austrian building market as for instance cellular concrete can be regarded as a first step in this direction.
According to Austria's rich resources of wood, timber is due to its ease treatment recently also very often applied in industrialized building and gives an economic raw material particularely for provisory buildings or buildings with planned short life-time. Although many of them have in fact a long life-time and in the Alpine region there can be found a plenty of old wooden houses.

The use of steel as a structural material seems, regarding the Austrian building scene, highly to depend on the current macroeconomic situation. For this reason and owing to its relatively high costs, steel structures mostly are designed for single projects. Nevertheless, some structural systems, in particular for factory buildings and halls, are being offered on the Austrian building market; one of them, a circular suspension roof construction, may , by the way, be regarded as one of the most ingenious structures developed so far in Austria.

The new building products bring about new techniques and, as a further consequenee, changes in the views of all being envolved in building, planning and construction.

.4 <u>The basic concepts of Austrian prefab building systems</u>

A considerable part of enterprises started their production on the basis of foreign licences which concern rather problems and means of production than the design of the building system. 5 of 1o firms which produce large panels for housing use a valid licence, 2 of them use more or less an expired licence; only 3 firms have developed their own building system.
In skeleton building systems own developments are predominant. It's worth mentioning that nearly all firms which started on the basis of foreign licence have developed their system in the course of the time, so that in some cases it's impossible to recognize a relationship to the original.

In a number of cases the foreign licences have altered and improved their system as a result of Austrian experience and know-how.
The small percentage of original Austrian system development might be explained by the fact that the industrialization of the Austrian building industry had to be achieved within a very short period . Thus it was not possible to instruct all people employed in the building process in time.

1.5 The production capacity of the Austrian building industry

At an inquiry of the Vienna University of Technology Building Construction Institute among the enterprises which produce reinforced concrete building components 16 of them stated that the annual production capacity was more than 10 mio Austrian shilling. While the capacity of those enterprises producing mainly components for industrial plants with one exception does not exceed 25 mio AS , there are several large-panel factories in Austria of far greater capacity, five of them with more than 100 mio AS, the average being around 100 mio AS or 400 to 500 dwelling units per annum, respectively.
As the prefabrication ratio - the percentage of building works being produced in the factory itself - differs according to the system and since the various secondary building components - as there are windows, doors, etc. - are often maufactured in the same enterprise, it's difficult to compare the figures stated above.

It has proved useful to indicate the production capacity in housing construction by dwelling units per annum, although there is a difference in the size of dwelling units in different parts of Austria (the figure is increasin from east to west).

The total of about 2 bio. AS can be diveded into industrial, office and school building construction (35%) and housing (65%). 75 % of the production capacity is situated in the area around Vienna, 15 % around Linz in Upper Austria, the rest of 10 % being scattered all over Austria. (see fig. 1).

All above stated figures are valid for about 1970.

1.6 The economic distance of transport of components in Austria

The fact that the location of factories producing heavy-part building systems such as large-panel systems depends on the regional demand leads to a concentration of plants producing reinforced concrete building components in the central areas.

Enterprises producing skeleton building components mention a sensible transport distance of 50 to 300 km (70 km on an average), large-panel manufacturers between 30 and 6o km (45 km on an average). (cf. fig. 1).

The small permissible transport distance of large-panel building components results from the fact that in housing there is a much more forced competition with conventional building methods which are applied all over the country so that longer distances are uneconomic.

[illegible] difference in the mentioned transport distance for concrete building components can be regarded as a consequence of the fact that a simple reinforced concrete beam can be sold economically only in the case of low transport costs, whereas for example a prestressed hyperbolic roof [illegible] with a relatively costly production equipment justifies longer transport distances.

A further criteria for economic transport distances is the means of transport. Some Austrian prefabrication plants have a railway connection of their own of which they make use for longer-distance transports if the building site can be reached by railway as well, which is often the case with industrial buildings. There is no combined railway-road transport at all. The upper limit for railway transport distance is about 300 km.

It could be found out that experienced and big companies mention shorter distances than smaller ones and in prefabrication less versed enterprisee. After all it can be stated that the problem of transport is always regarded in the general coet accounting contest of the enterprise and therefore of secondary relevance.

2. Particular Examples of Building Industrialisation in Austria

2.1 Rationalization of conventional wall construction

For wall constructions for housing there can be found on the Austrian building market many methods without the use of large building units. Three particular mthods represent three different but typical approaches to the mastering of the housing problem and shall be, therefor, described in the following.

. Improved masonry

For the considerable amount of demand for handy products for single family house building which is done to a great extent by the latter inhabitant himself the following principles are often implemented :
Almost fully automaticized manufacturing of two-hand-size units in the factory; ease assembling of wall on site without needing cranes or other heavy site installations.
Aerated concrete blocks which are cut from big blocks in very accurate dimensions allow the dispensing with the use of common mortar joints and enable to stick them together.
Thus, building up a wall can easily be done by one man himself.

. Mantled concrete wall units

It is regarded as one of the cheapest procedure for building single homes as well as blocks of flats of restricted volume to set hollow insulation wall units and to fill them with concrete thus building a mantled and insulated concrete wall.

the conveying of concrete to the filling place is very often done by pumping transported concrete, so that the site installation can be very simple. (see fig. 2)

Cast-in-place concrete cross-wall structures

For large projects and high apartment houses the casting of concrete cross-walls, usually combined with tunnel-like formwork for floor-slab concreting seems to be the most efficient house building procedure at present in Austria, though a high standard of formwork technology is essential for its breakthrough.

2.2 <u>Floor slab units used in conventional housing constr.</u>

For the realization of the floor construction in conventional buildings at low cost, besides the generally used precast concrete joist construction or reinforced concrete slabs, precast concrete composite slabs are now often being built in, using 4 cm thick slab units which are to be completed on site by concreteing the upper layer (cf. fig. 3)

A further new reinforced concrete floor system is shown in fig. 3 (middle). This prestressed hollow floor unit is made of concrete BN 600, is typified according to modular coordination and has a smooth ready-for-paint surface. Its load-bearing capacity allows a 100-M-span in the roof. The most recent development in this field is a selfsupporting (up to 7 m span) floor unit which enables in combination with an inserted wood slot a very economic floor construction with a plain underside. (cf. fig 3 bottom)

.4 Production methods applied in large-panel sytems in Austria

Most of Austrian dwellings, however, are built by large-panel systems.

For the production of large-panel wall and floor units various techniques are applied in Austria at present. Most of the enterprises use fixed tip-over table-moulds which allow an uncomplicated production though requiring a relatively large area. Besides that there are also several plants equipped with mouvable moulds. Battery forms for the production of simple wall and floor panels are used at an increasing rate because they allow a rise in capacity at an unchanged production area, which often becomes limited at an expanding enterprise. Besides that, battery forms help to cut down transport reinforcement and to produce components with a smooth surface at both sides of the panel. A floor panel f.i. can be produced so smooth, that without further treatment a textil floor covering may be applied.

Among the prefabrication plants which produce with movable table-moulds that of a company in the north of Vienna is particularely worth mentioning because there areto be found a number of new and original developments.

In order to enable the unrestricted design of buildings in large-panel construction, computer programmes were developed to plan production as well as the product within an integrated data flow, covering the entire construction process, and numerically controlled machines were constructed that allow automatical production.

[illegible] of [illegible] the production machine. [illegible] after the [illegible]. The [illegible] dimensional buil- [illegible]. [illegible] are re- [illegible] problem [illegible] computer. The input [illegible] the necessary infor- [illegible] walls. (fig.5 bottom) [illegible] programme to estimate [illegible], paying attention to means of production (maximum production length), means of transport (maximum transport length) and set up on site (crane parameters). The programm does the structural analysis as well and prints out sheets which contain every information necessary for the production of wall and floor units. (cf. fig. 6)

The forming machine removes the produced units from the mould and the new mould is assembled. The filling machine automatically pours strips of concrete while mouving along the form, leaving openings for doors and windows. Numerical control of the machines is provided by a computer program in the form of punched cards.

In order to minimise crane handling at the plant and at the building site and to rationalise transport, a special transporter had been constructed to pick up the unit containers which can be operated by one man and does it in 10 minutes.

The principle of an assembly line can as well be applicable to a relatively small enterprise as it is shown by a firm in the south of Vienna. Here the manufacturing is not done on mouvable moulds but with form sheets which are together with the panel drawn off the mould immediately after the casting and put into a heating chamber for hardening. As there are no doors and windows incorporated in the 1,00 to 1,30 m small components, the components are rather similar and are produced in 6 parallel lines.
A predominant item in the development of a large-panel system is often the demand for an economic use of the moulds. That means for the planning stage that the number of panel 'families' - the panels which demand different moulds - should be kept down to a small amount. On the other side the moulds should be constructed in such a way that they can be adjusted to various dimensions. Finally, a mould can only be economic if it is used in as short as possible intervals, i.e. the time between casting and removing should be as short as possible.
In addition to various sandwich constructions as they are used for large-panel systems (cf. fig. 4), large-panel systems based on hollow-brick blocks should be mentioned. The brick-panels are produced partly on the artificial-stone floors of the plants, partly on movable moulds.

.4 <u>Building systems and components for industrial buildings</u>

The product range of industrial building components produced in Austria is rather small. Most of the manufacturers prefere to produce special components for each project.

That may be due to the fact thatmodular co-ordination is juet now being introduced into the Austrian prefabrication industry and there is only little experience with its application to open-system building. Factory buildings are often priced in terms of sq-meters floor area thus handicapping typified halls; nevertheless, an increasing amount of factory buildings is being bought according to typified systems from stock.

In consequence to the above mentioned it will be clear that the manufacturers are interested to develope and apply construction systems which combine a great flexibility to dimensional variations and ways of use with an economic production method in small series.

More and more adjustable moulds of steel or plastic material are being used, particularly for the production of roof and floor panels, instead of wooden ones, which are fabricated only for a single project. An example of such a conetruction, combined of standardized as well as of freely dimensioned components the so-called HPV-roofs may be (fig.7) looked at. In a specially formed prestressing mould a uniformly sectioned prestressed hyperbolic roof panel can be produced at various lengths and gives a wide freedom to the designer in the choice of span, and by freely dimensionable length of columns and girders, also in the choice of height and length of a factory building as well as in the choice of thermal insulation, natural lighting, rain piping and external appearance. Various combinations of hall aisles and roof slopes can be realized as well.(fig 8)

The tendency towards a most variable component production is being followed in the development of various reinforced or prestressed T- and TT-like concrete panels, while the production of cassette-shaped panels involves some difficulties due to the cross rib. Here the client is bound to a series of prefabricated dimensions in the length of the building as well as in the broadth, or he has to accept uneconomic fitting pieces. (fig. 9 and 10)
The cold winter climate in Austria favours the use of aerated concrete panels for wall and roof constructions of industrial buildings, particularely when this material is used in accordance with its good thermal insulation and fire resistance properties. That may be well illustrated by the fact that also reinforced concrete component manufacturers are using those light-weight panels for the roofing of their skeleton structures.

Talking about building systems for industrial buildings some steel based systems should be mentioned as well. For small spans the steel skeleton structure shown in fig. 11 may be of interest owing to its light-weight elements.
A very ingenious and - for longer spans - economic system has been developed in the form of a circular building with a cone-shaped suspension roof, providing a large free-span area with diameters from 32 to 112 m and equipped with a circular crane. (cf. fig.12). This steel structure can be also very effectively be applied to roof constructions for swimming pools, sports halls , exhibition centers and the like (see fig. 13 and 14).

2.5 Building systems for other purposes (office buildings, school buildings, agricultural buildings)

In Austria multistorey skeleton buildings are used to be assembled from components which are manufactured only for a particular project and not as parts of a generally applicable system. Most of the producers of components agree to the various wishes and requirements of clients and architects. And this may also be the reason why many manufacturers are inclined to a compromise and produce the simple parts of the skeleton (as there are columns and beams) in cheap and shortlived moulds, whereas for components for floors and external walls adjustable moulds are used, which in consequence are also utilized for the production of roof and wall panels of industrial buildings. Different load-bearing capacities are easily attained by alteration of reinforcement or increase of thickness of concrete.

In fig. 15 are shown three examples of application of a system for school building construction which is a further development of a Danish system. School buildings and kindergartens are erected according to a small-panel system, whose sandwich-shaped external walls are assembled on site of precast concrete panels and mineral wool layers. In fig, 16 can be found a school building system which has been already very often been applied for the construction of schools in the municipality of Vienna and which is one of the few closed systems available in Austria for the construction of multistorey skeleton structures.

Fig. 17 shows another building system in its application for the construction of the provisory premises of the UNIDO-headquarters in Vienna.It may be regarded as a mixed skeleton and small-panel building system and has been designed in the objective manner with the restriction that it could be dismantled without destruction to be re-erected on occasion on another building site.
Almost no agricultural buildings are being made of prefab components in Austria. This may be due to the fact that there are nearly no demands for new premises in the traditional agricultural regions and new agricultural investigations in the urban regions tend towards industrialization.

2.6 Rationalization of completion

At present there is no box-unit system application in Austria, neither as a panel box unit nor as a skeleton box unit. Only for secondary cells, as there are sanitary rooms, elevator shafts and garage boxes, small box units are being prefabricated. One enterprise has f.i. developed an adjustable mould and makes use of it for the production of two types of sanitary boxes for housing and hotel building. Another manufactuer takes an other way and produces his sanitary box units by assembling separate panels of various dimensions thus providing a wide range of units to architects and clients. (cf. fig. 18 top).
Garage boxes are used to be cast in as special mould in one piece. A special transportation procedure has been developed by lifting the box units hydraulically on a special vehicle whose rear wheels run in holes of the

bottom slab of the lifted box unit. Thus no further hoisting means are needed neither in the factory nor on the building site.

Large-panel building construction in Austria has reached a standard which could be well described as follows : Due to the surface quality of the units, according to the production methods, rendering and plastering becomes unnecessary. The inner surface is generally being smoothed, painted or papered, the outer surface gets a dispersion paint.

Windows and door frames are put into the formwork and cast in; in some cases the windows are fixed after casting but before delivery to the site.

For electrical installations empty pipes are cast into the wall and floor units. Austrian clients do not like to live in rooms with visible conduits and pipes.

Sanitary installationsare layed partly in separate shafts, partly in wall-slits. A sanitary wall is shown in fig. 18, bottom. Heating pipes are layed vertically in shafts as well, horizontally mostly in the floor construction.

The flooring is similar to conventional building construction, although in some new developments a soft covering is layed directly on the floor slabs.The completion of kitchen and sanitary rooms is conventional as well.

Some exceptions should be mentioned, however. By casting the wall units in battery forms the surface quality can be improved to a standard that makes any filling or smoothing unnecessary. Some manufacturers apply the outer painting already in the factoryand obtain good results provided that the transport is done with.precaution, or that the units are produced on site. Outer surfaces with ceramic lining are now more rarely being applied than in earlier stages of large-panel building construction, due to the minor hygrothermal quality of such a wall construction in Austrian climate.

As there is still a low standard of coordination of dimensions and requirements in Austria, which might be improved by a system of modular coordination, modular jointing and functional specifications, some of the producers of prefabricated building components in Austria still try to concentrate all secondary works in the own factory. An extreme example for this tendency is a Viennes firm, which does all building trades works himself by employing all necessary tradesmen.

3 Special Low-Cost Construction Developments of the Austrian Building Industry for Developing Countries

There are only few remarkable Austrian developments for low-cost constructions, which have been offered to developing countries.

One of them is the large-panel building system described on fig. 4, 5 and 6, a further development of the automatic production system with respect to the needs of users in the subtropic climate and the material base in the relevant countries.

A further reinforced concrete building system which has been offered for school building in countries with hot and dry climate, is shown on fig. 19, 20 and 21. This system has been designed in large-panel wall- and U-shaped roof-construction with the additional restriction of minimal steel-reinforcement consumption.Between the ribs of the roof panels and a false ceiling fixed subsequently, a temperature rise in the classroom from above is avoided by means of a strong transverse ventilation. An additional thermal insulation of the walls may improve the thermal behaviour according to the local conditions. The walls and the floors are smooth and do not need any plastering. The concrete surface may stay unprocessed. The false ceiling may consist of wood-fibre panels, panels of plaster, etc. Water-pipes and electrical installation wires are fixed on the wall or above the false ceiling, resp. The design of an appropriate panel production plant is shown on fig. 22.

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ACKNOWLEDGMENTS

At the Building Construction Institute of the Vienna University of Technology the author's colleagues Helmut Eisenmenger and Ernst Illetschko had done a survey of the standard of prefabrication in the Austrian building industry of 1970 and made an inquiry of the building systems maunfacturers about their new developments and the available products. The author is very pleased to have the permission to use the results of that investigation, which had been worked out under the guidance of Prof. Aigner.

Furthermore, the author wants to express his thanks to his colleagues in the Austrian building industry who furnished him with actual information.

Fig. [illegible] : Prefabrication plants and transport distances, Austria

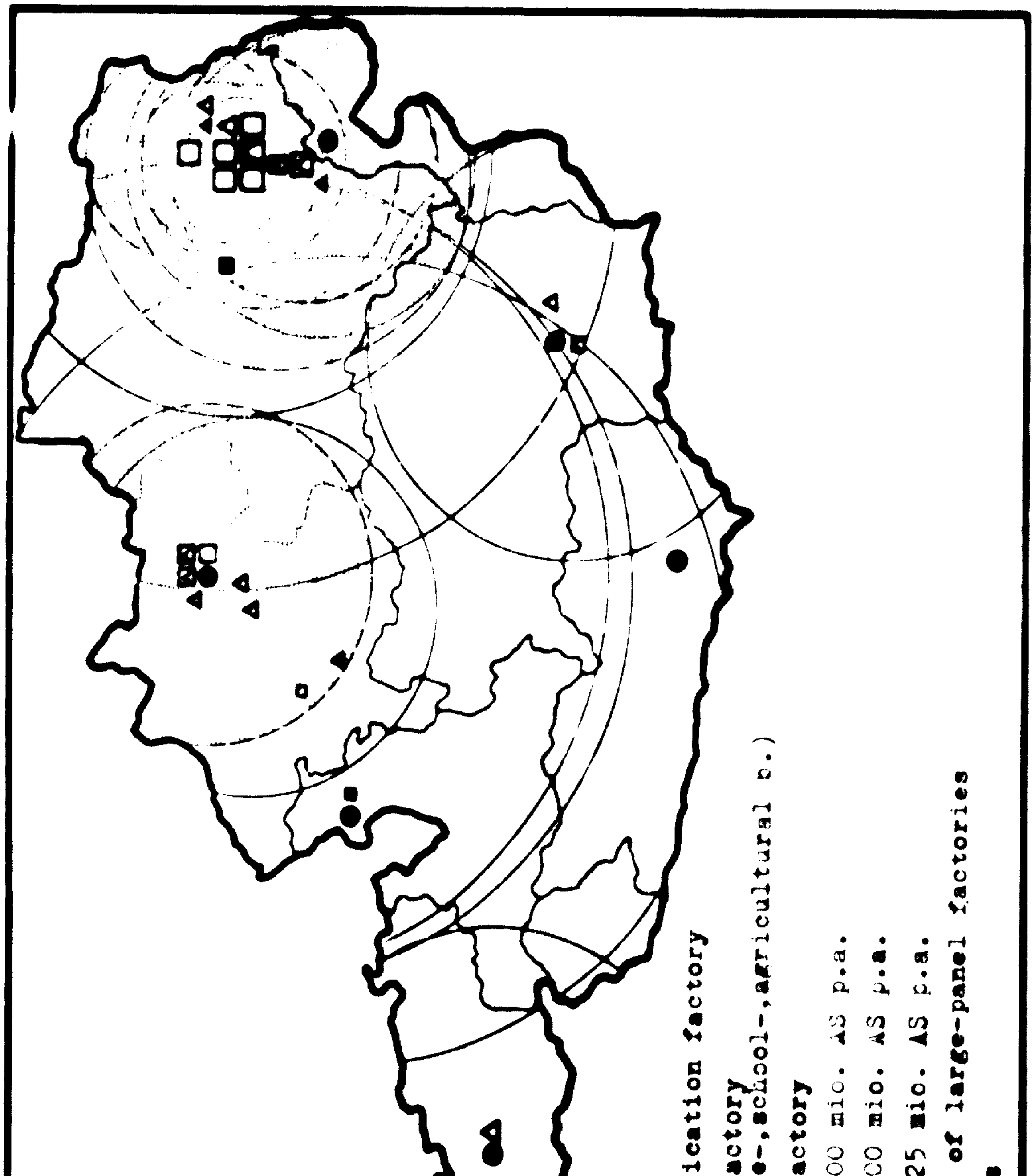


Fig. 2 : Insulation clay concrete

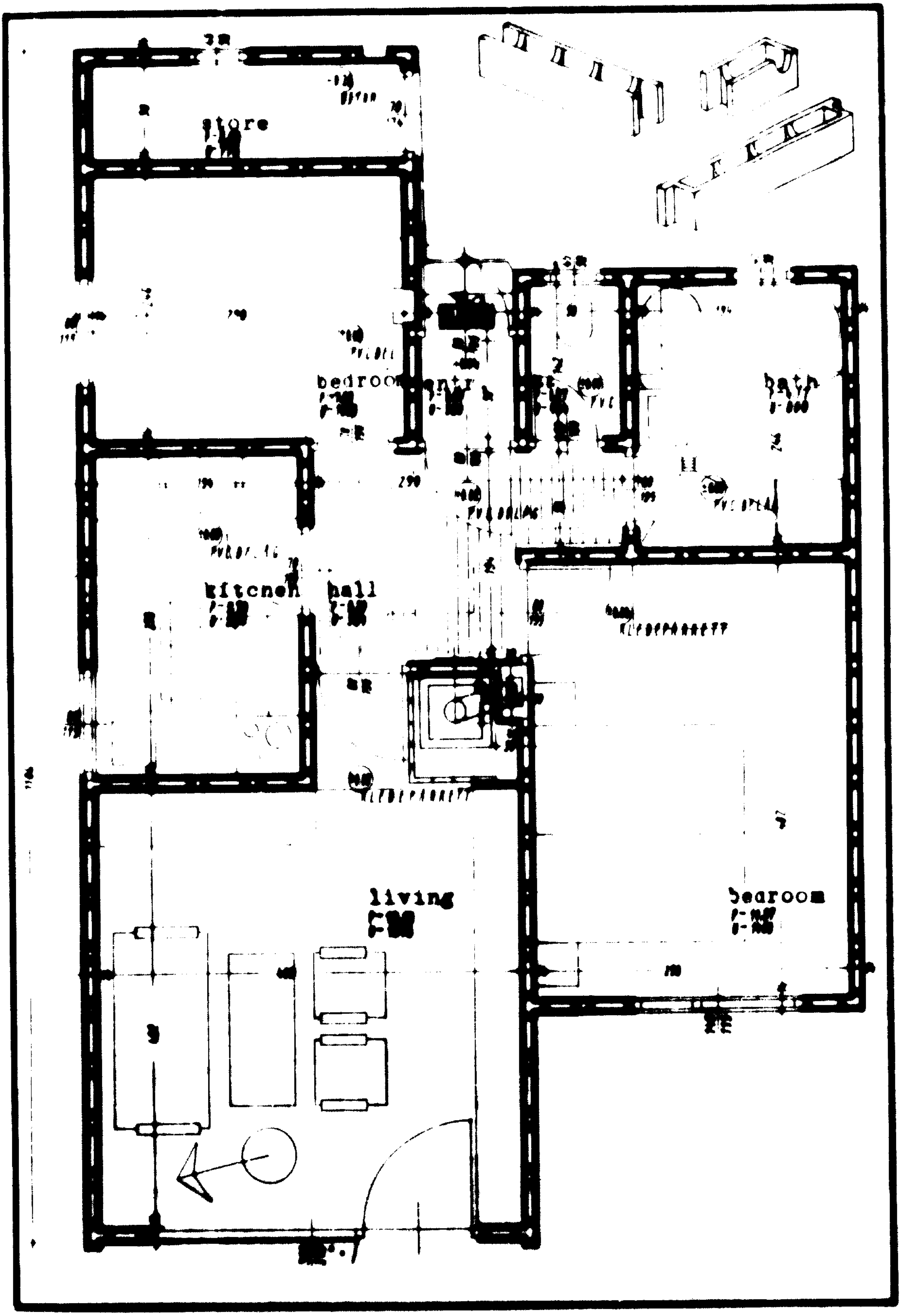


Fig. 3 : Precast floor units used in conventional building constr.

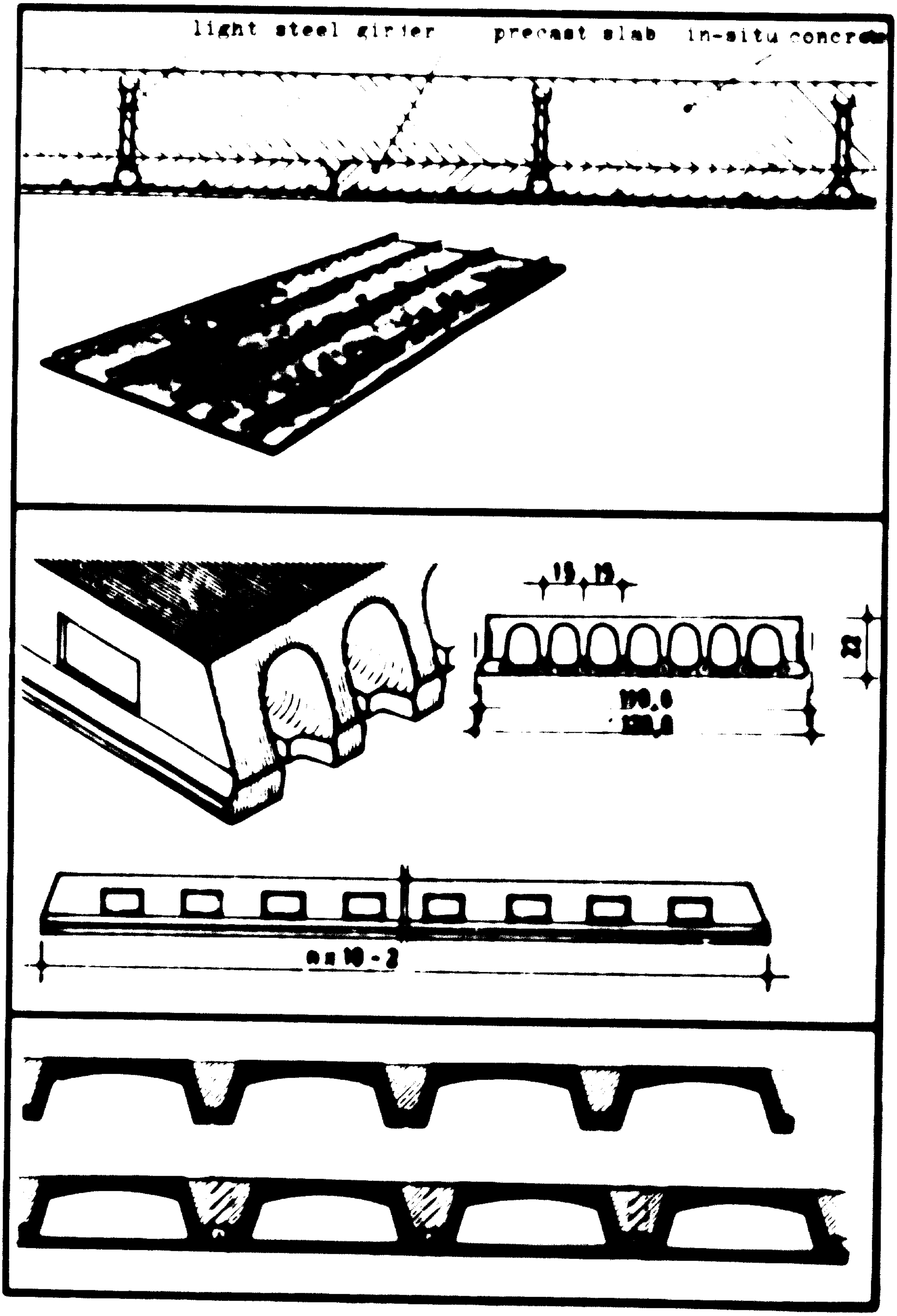


Fig. 4 : Two examples of plans of large-panel buildings

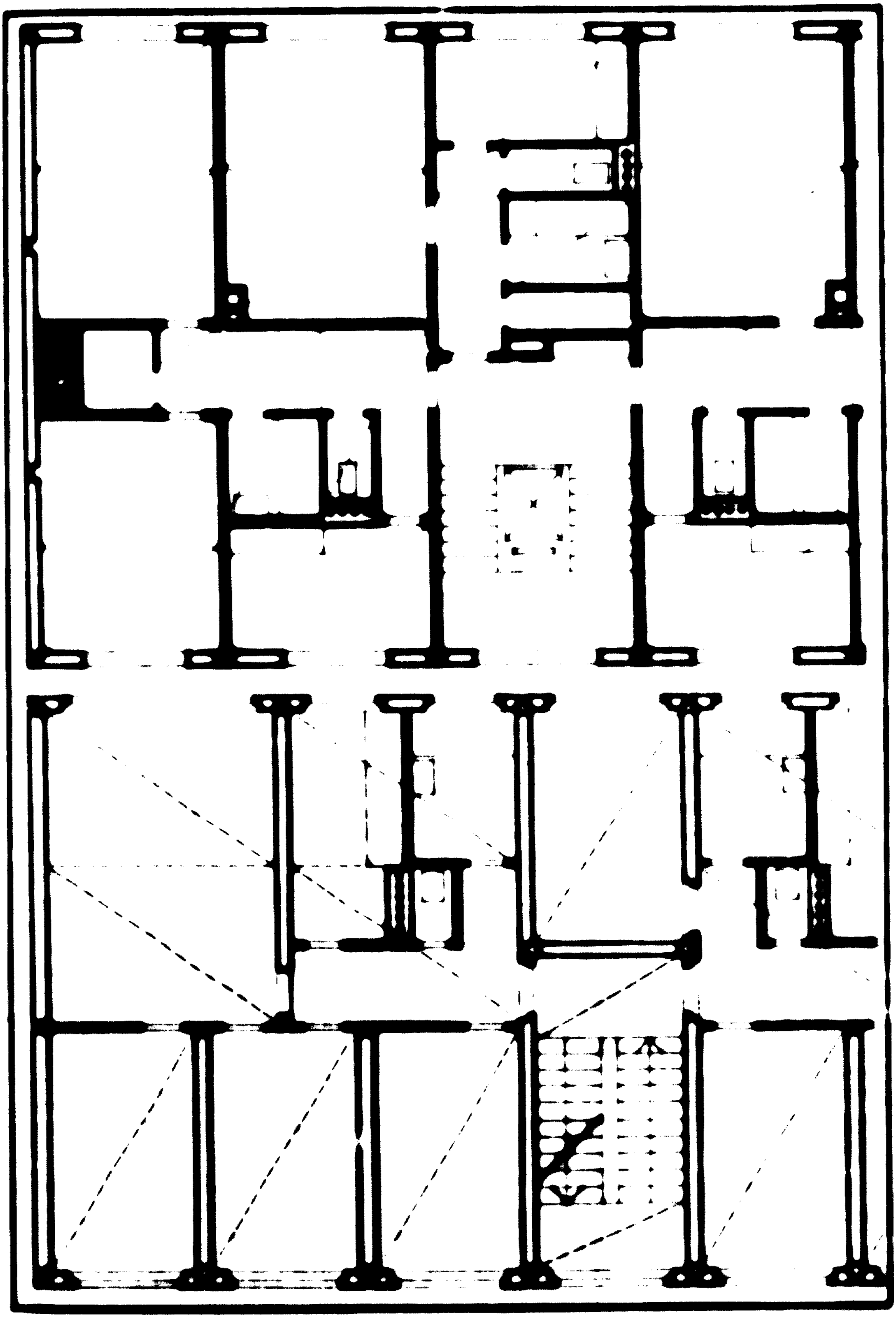


Fig. [illegible] : Transformation of architect's drawing to axis-drawings

Fig. 6 : Ready-for-production computer outprints of large-panels

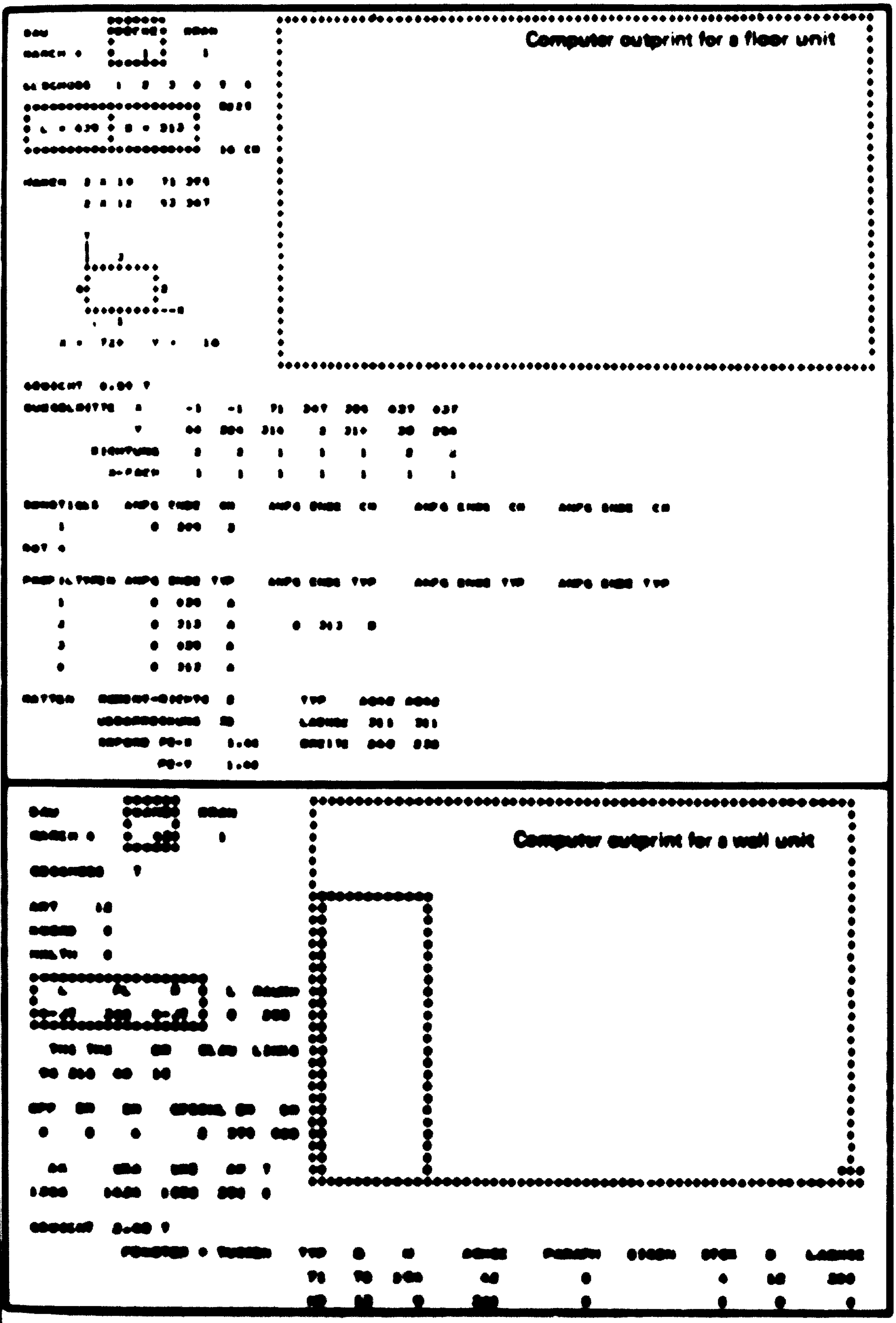


Fig. [illegible] : HPV-based industrial building system

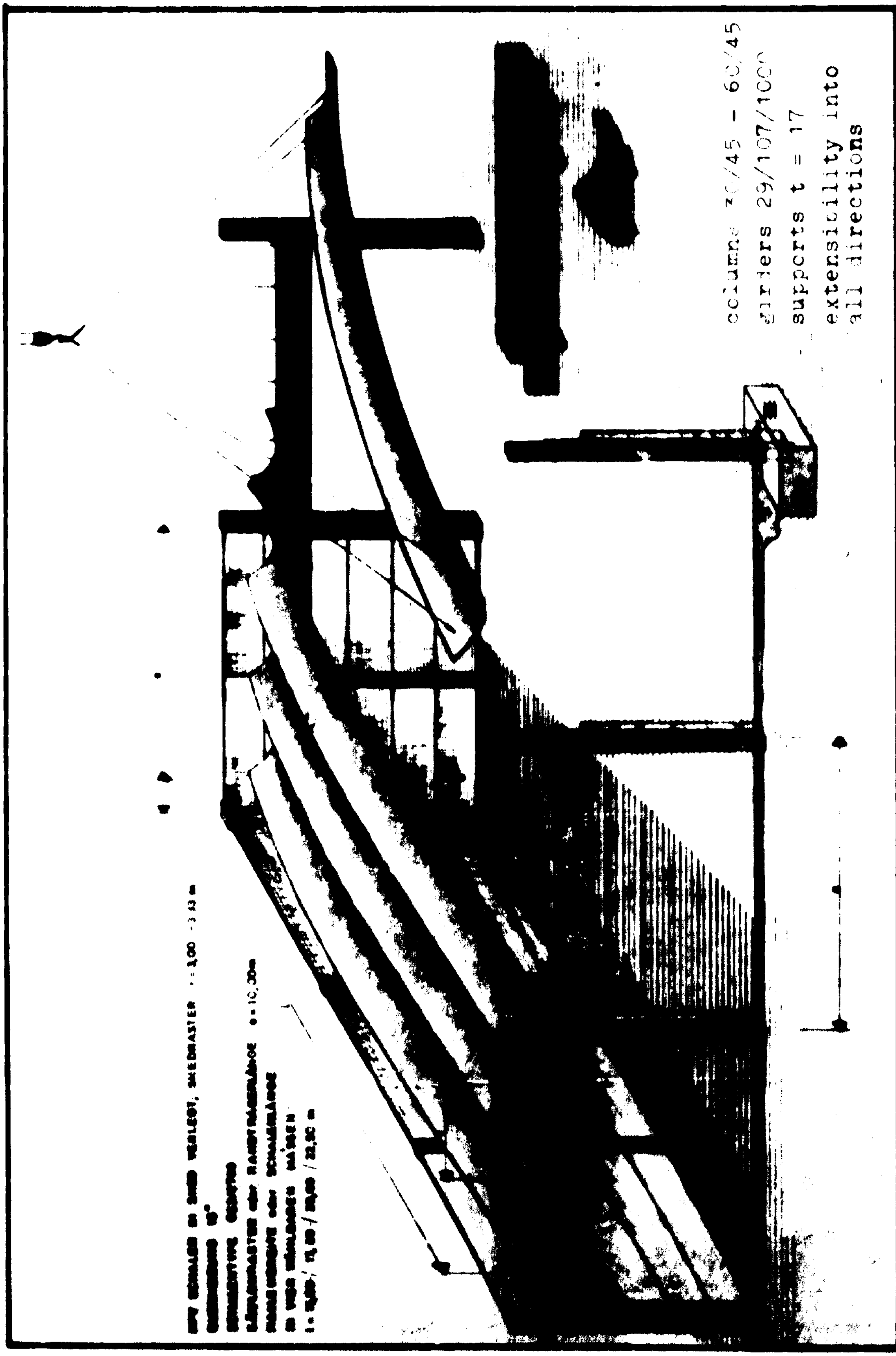


Fig. 8 : Variations of cross-sections of HPV-industrial buildings

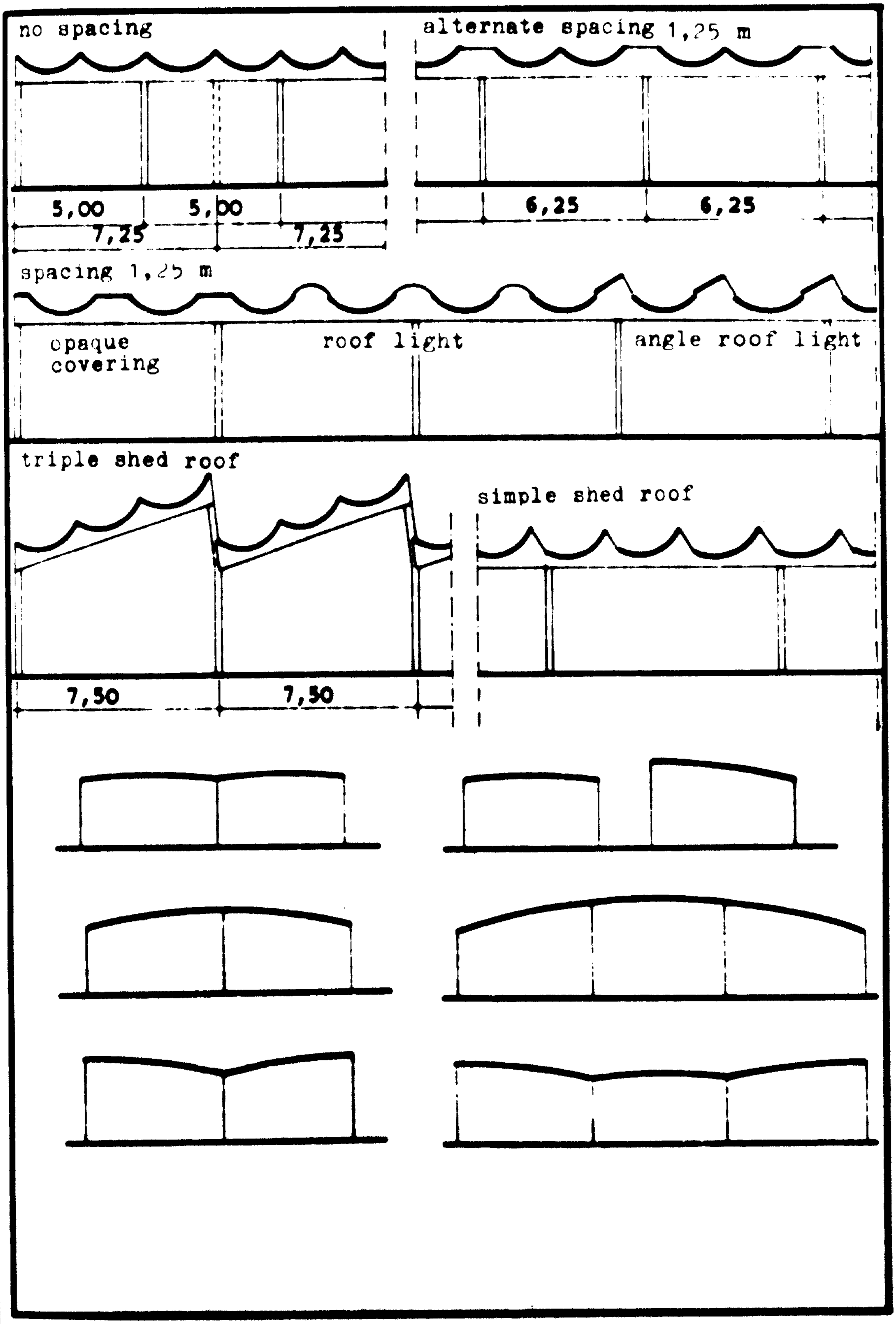


Fig. [illegible] : School building system using TT-panels and sandwich p.

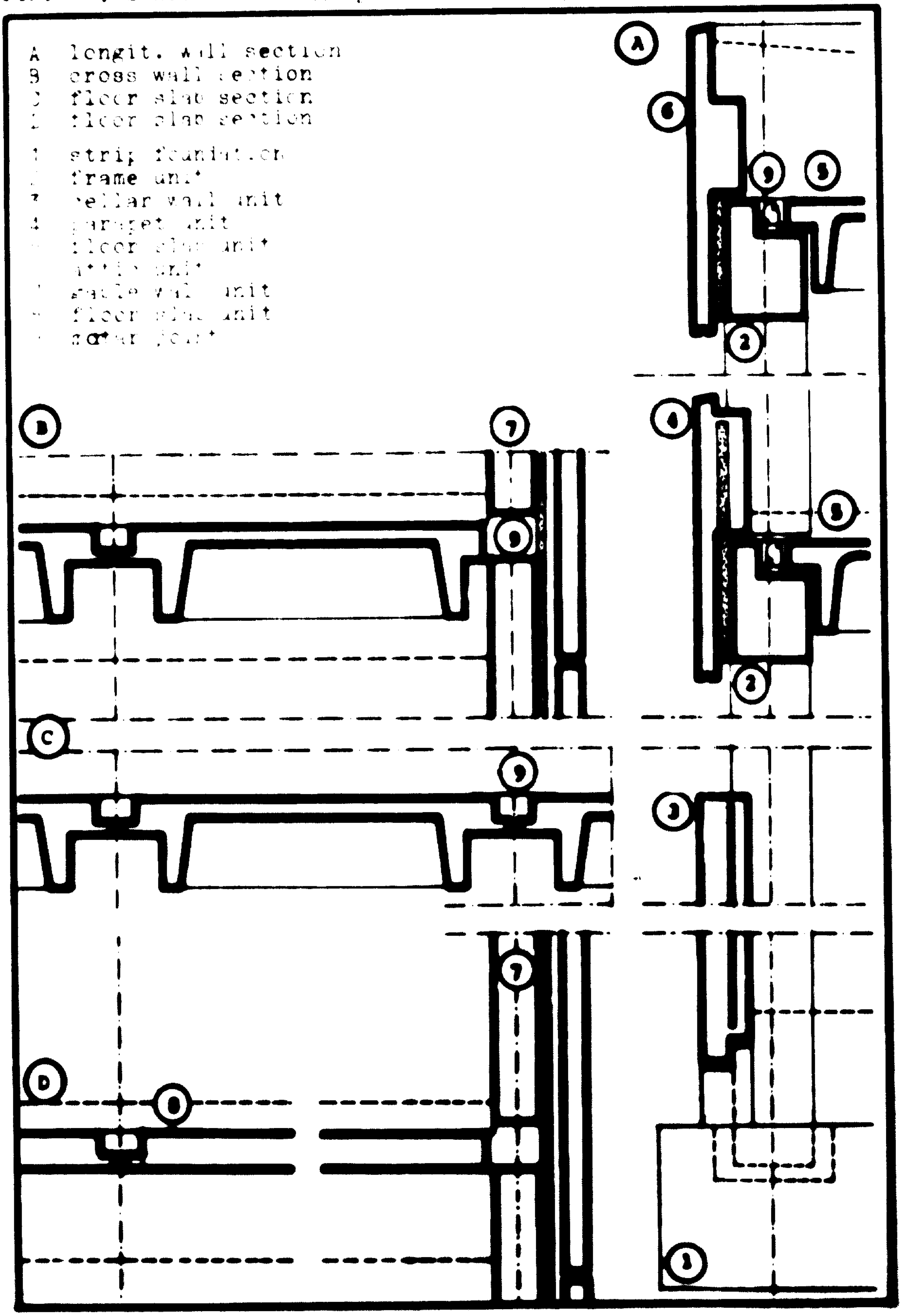


Fig. 10 : School building system, horizontal section

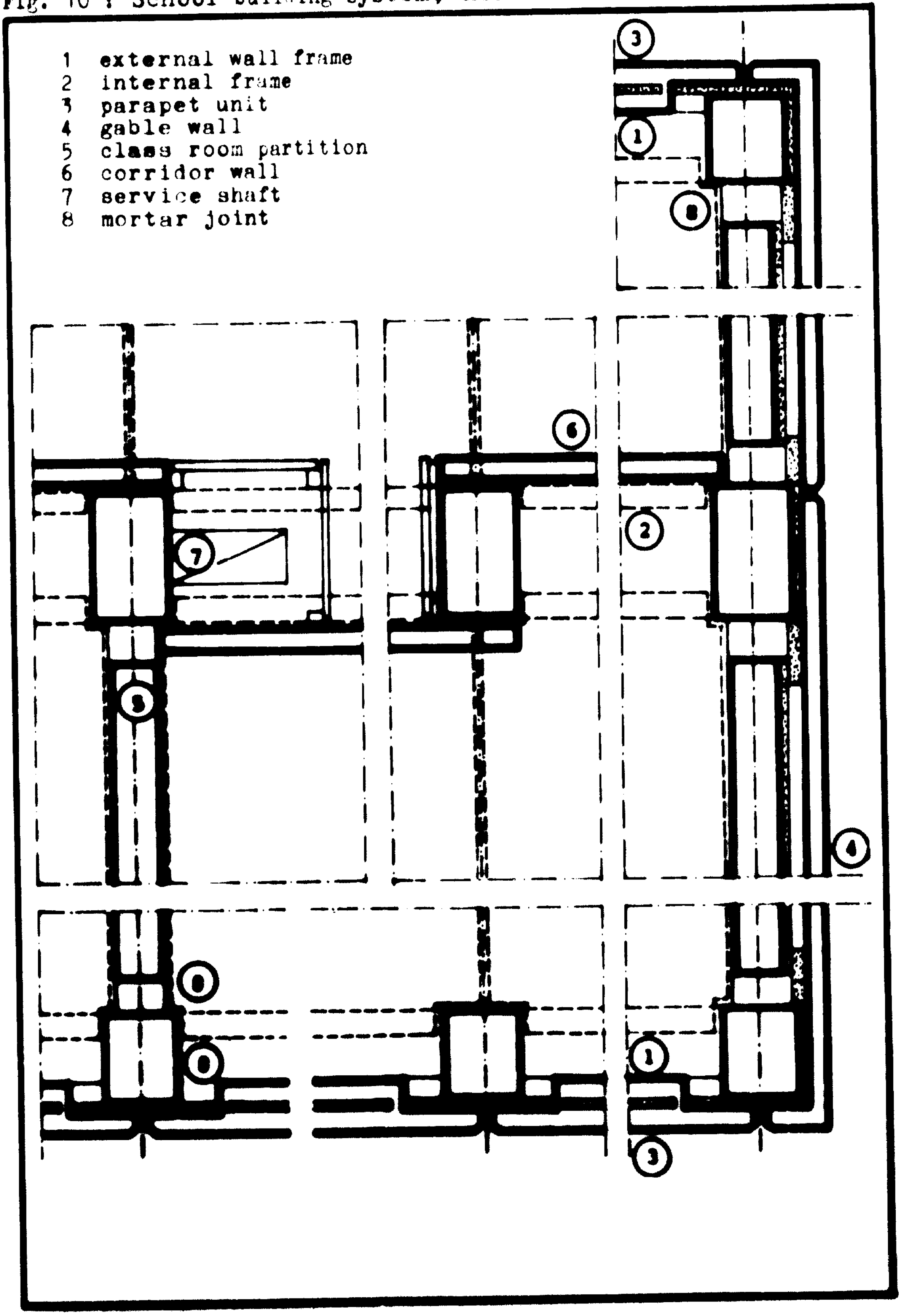


Fig. .. : Industrial building system with light-weight steel comp.

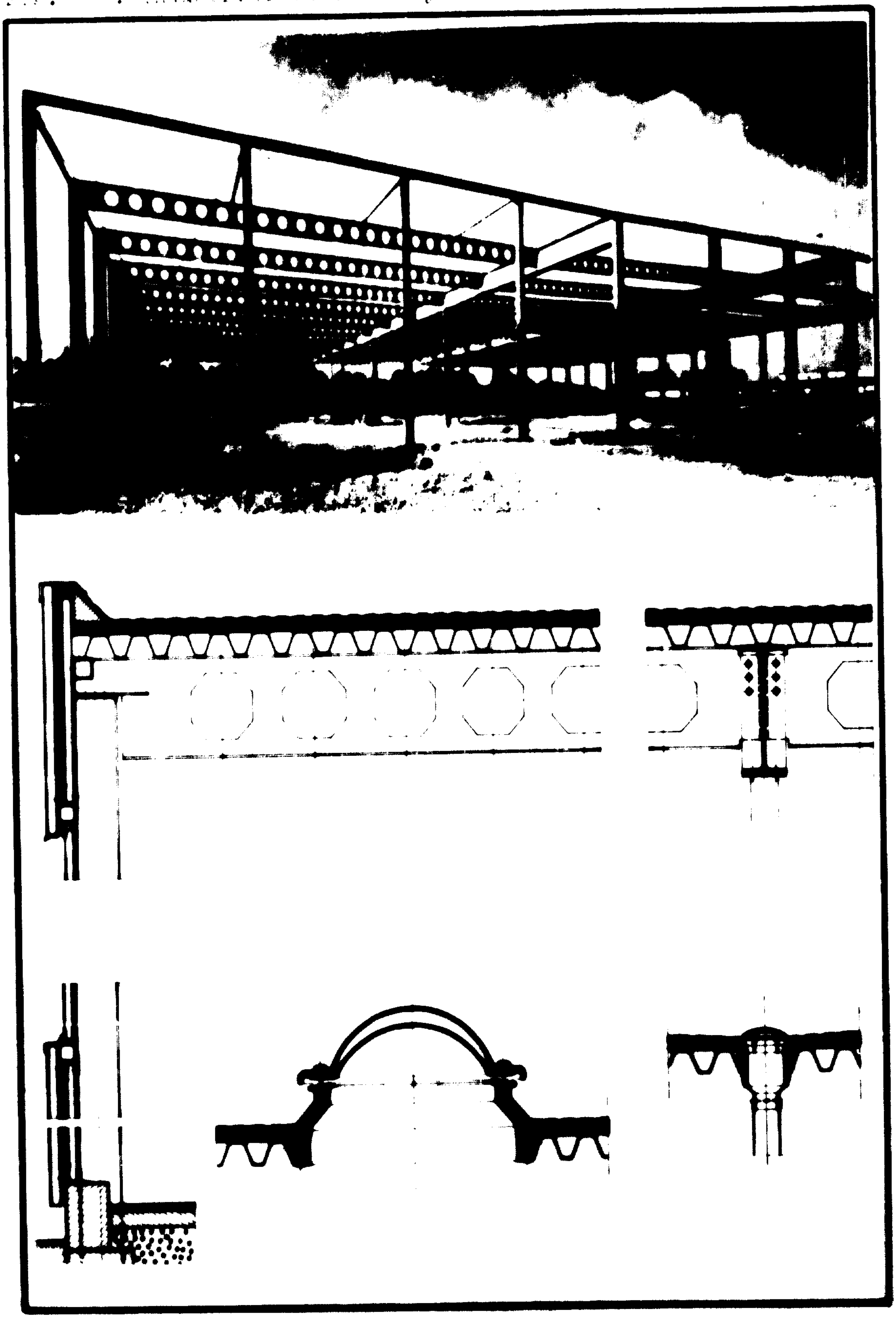


Fig. 12 : Industrial building with suspension conic roof system

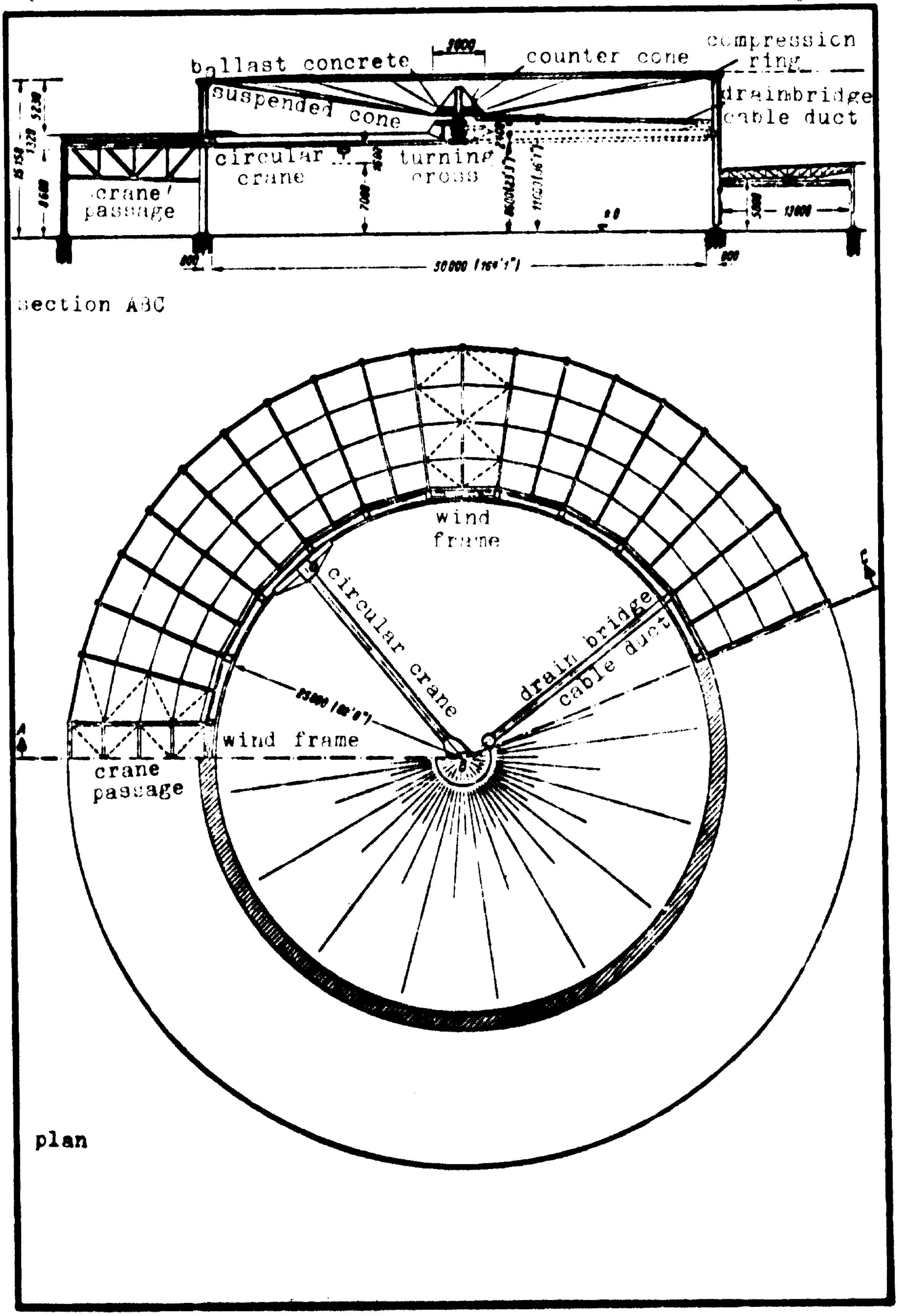


Fig. 13 : Sports building with suspension steel roof, vertically

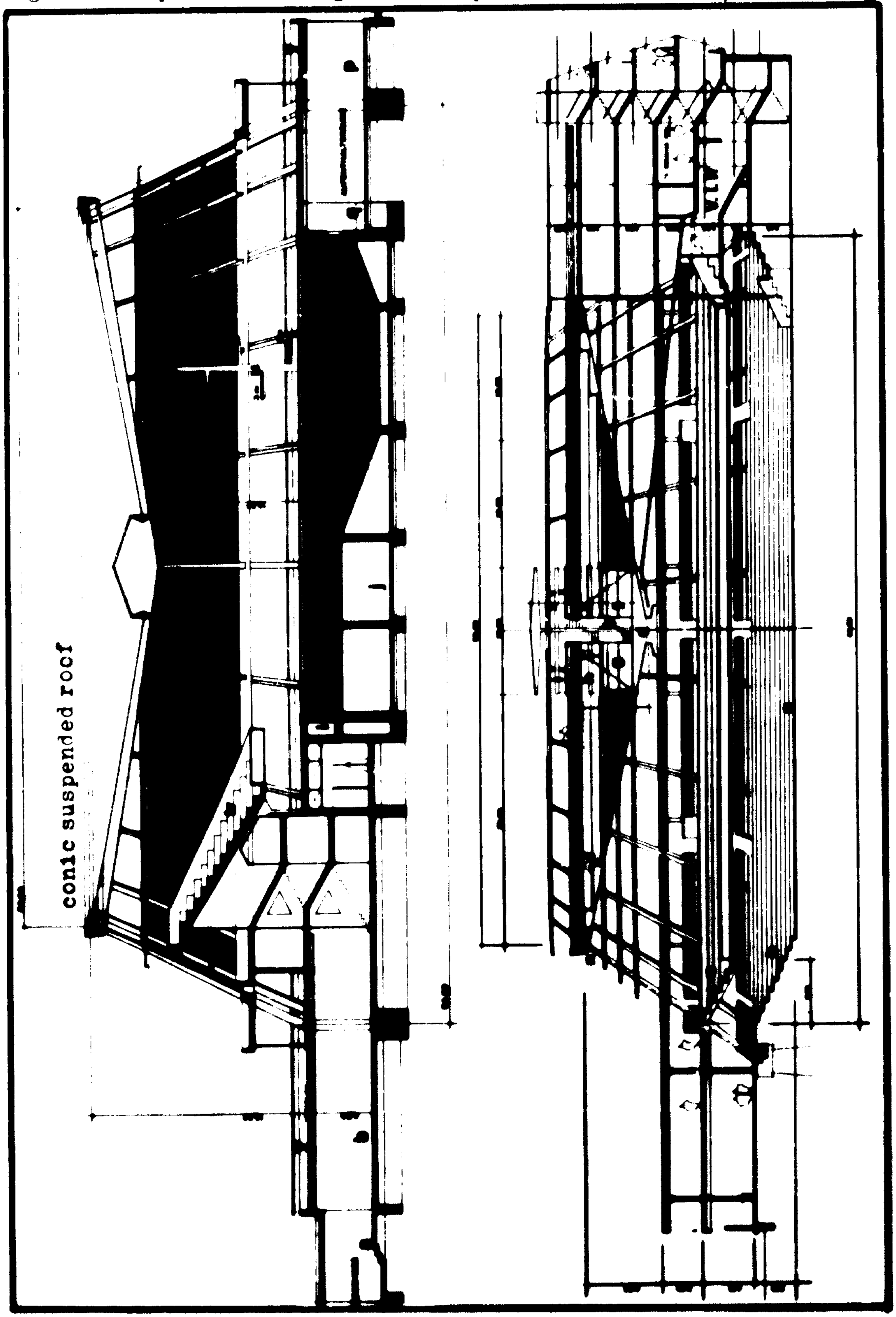


Fig. 14 : Sports building with suspension steel roof, plan

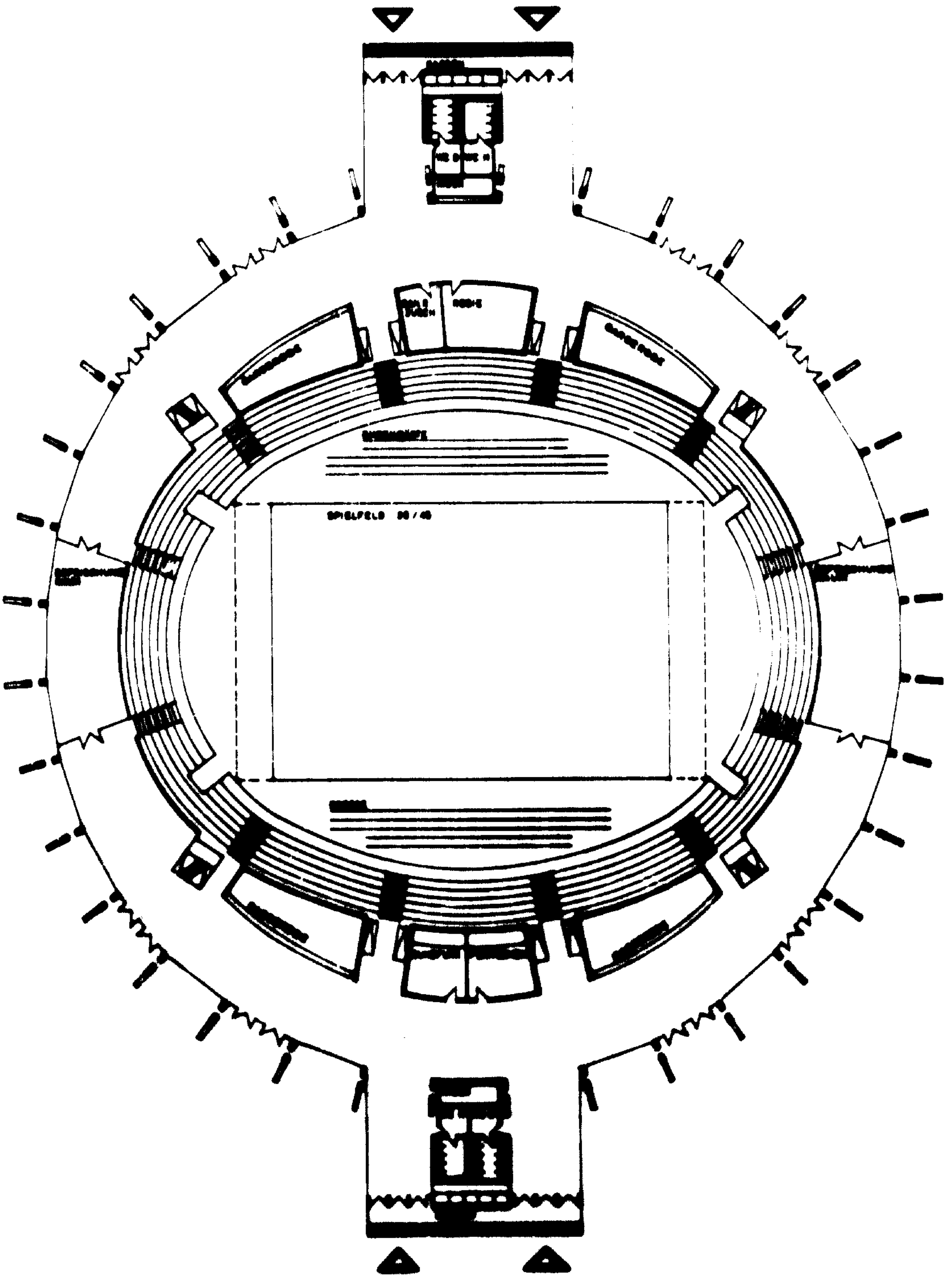


Fig. ... : School building system with on site assembled ext.wall

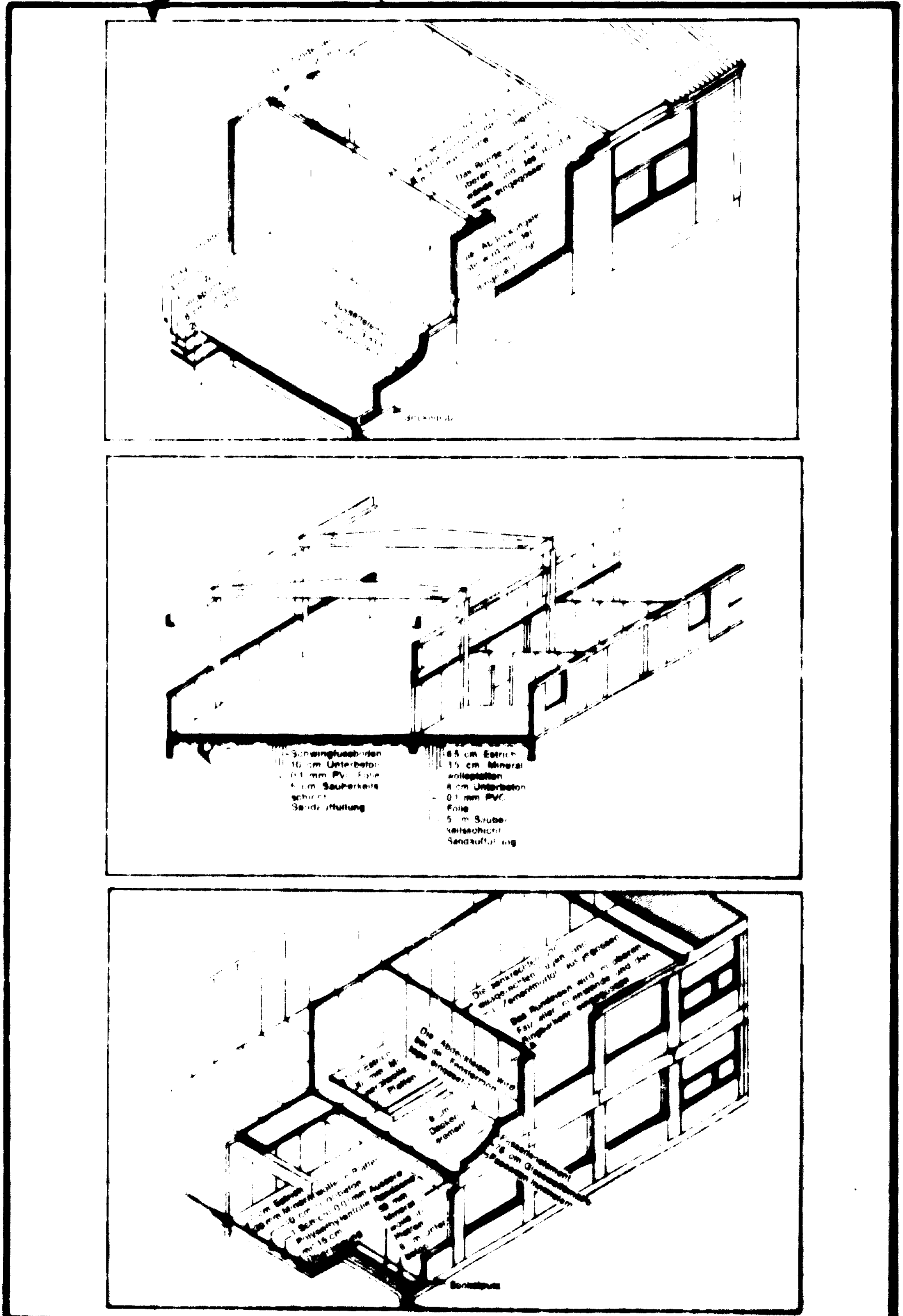
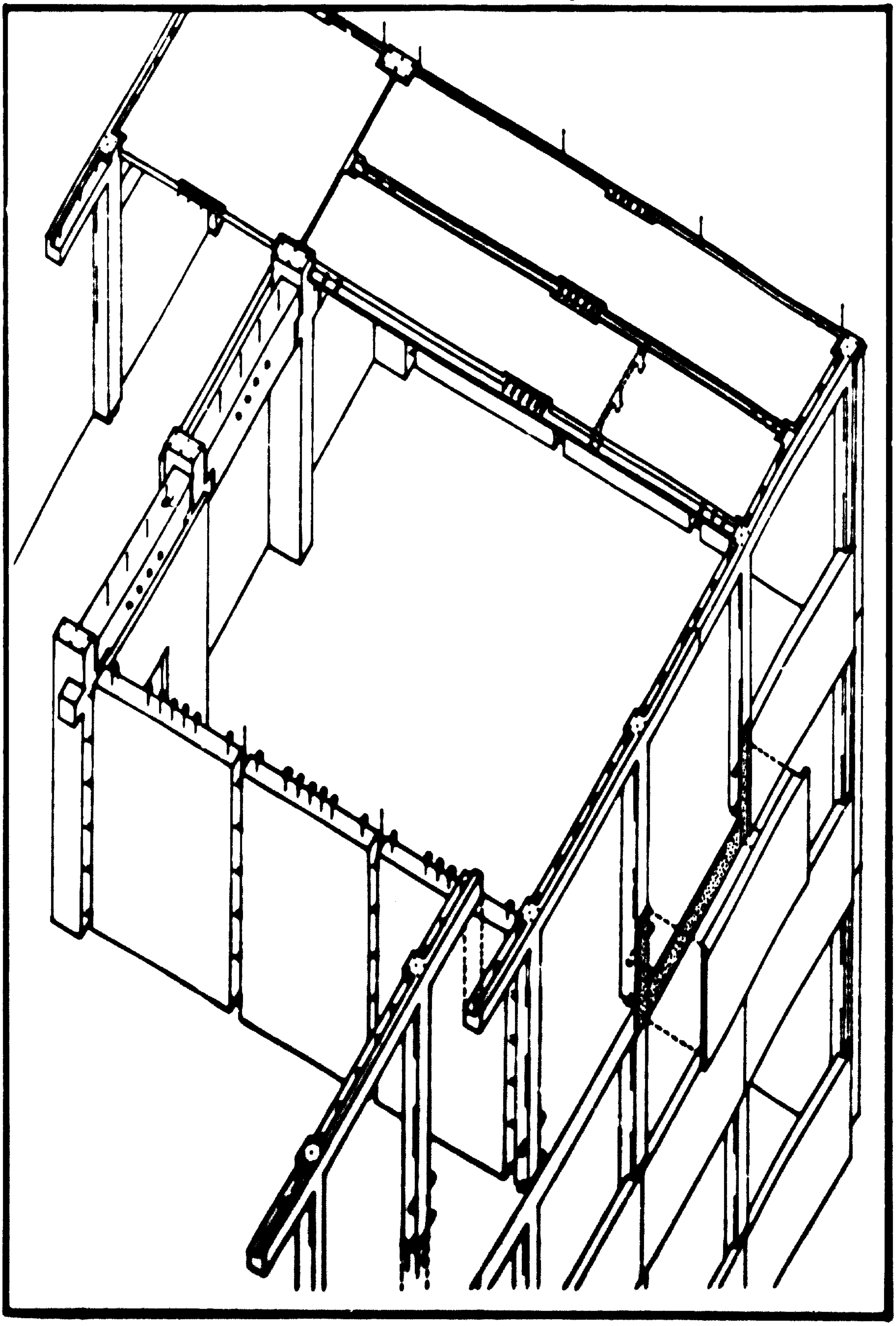


Fig. 16 : School building semi-skeleton system



[illegible] building system

[illegible] beam supporting	6 thermal insulation
[illegible]	7 welded connection
[illegible]	8 mortar joint
[illegible]	9 adjusting plate
[illegible]	10 sand infill
[illegible]	11 concrete joint

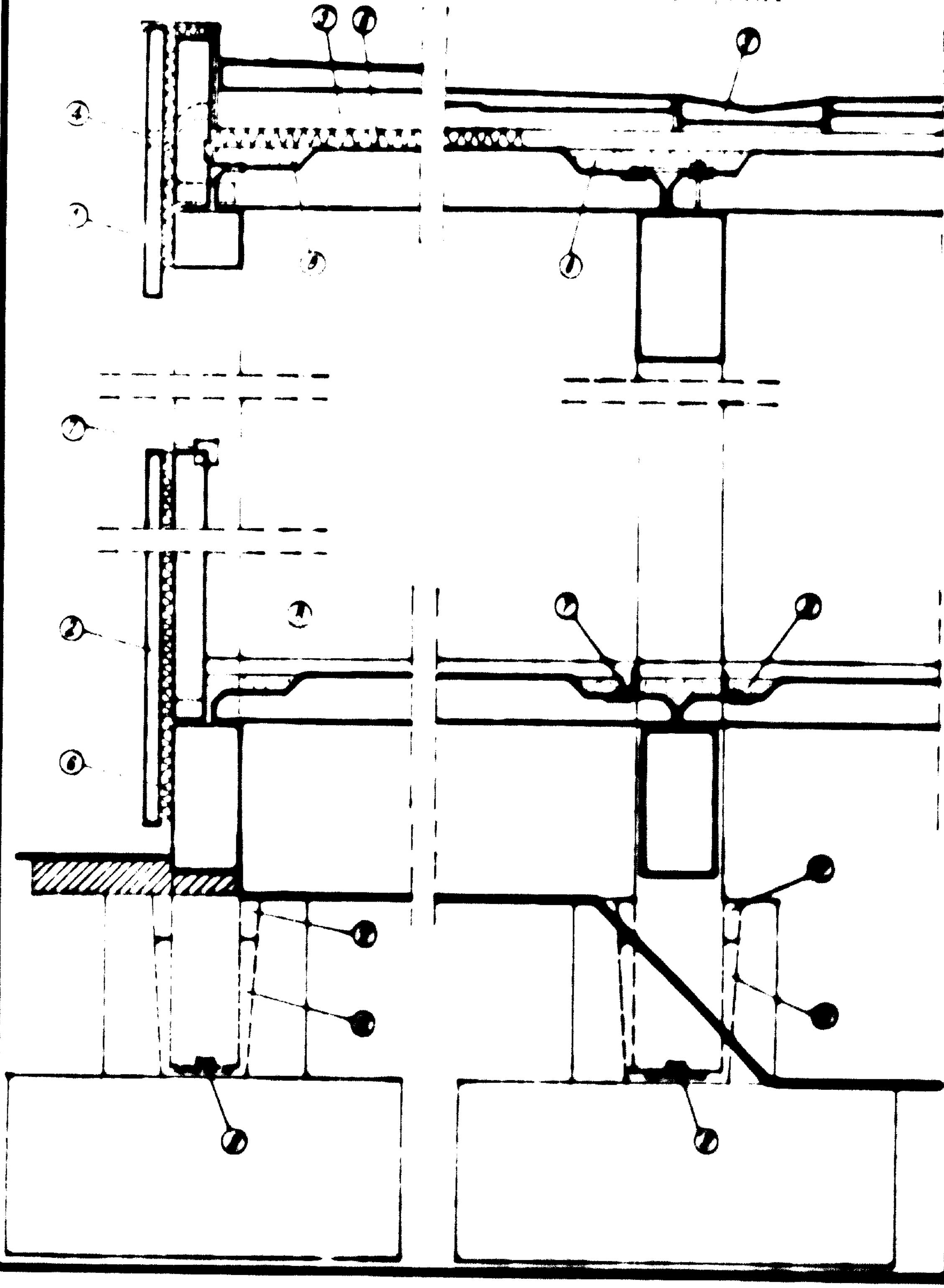
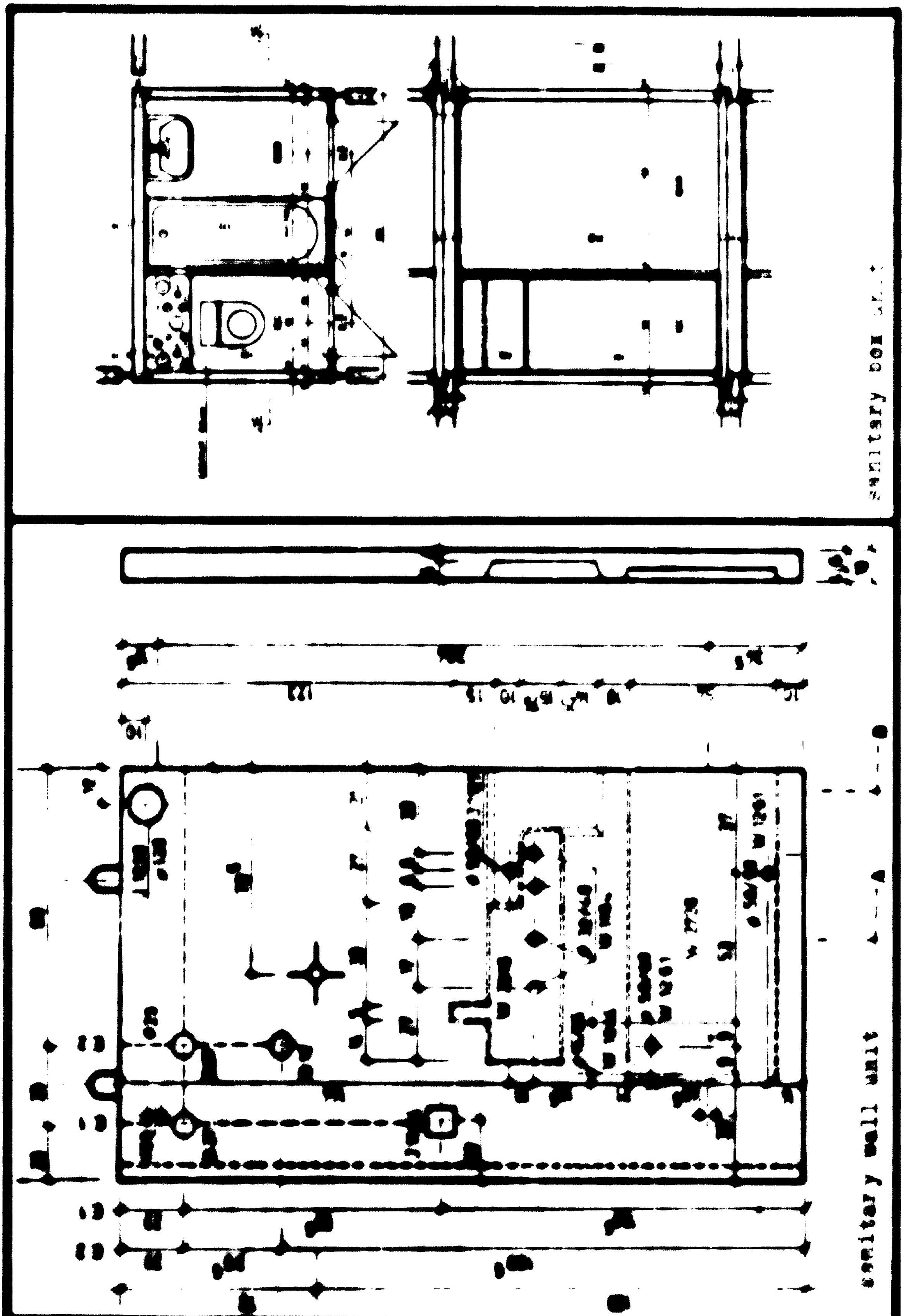
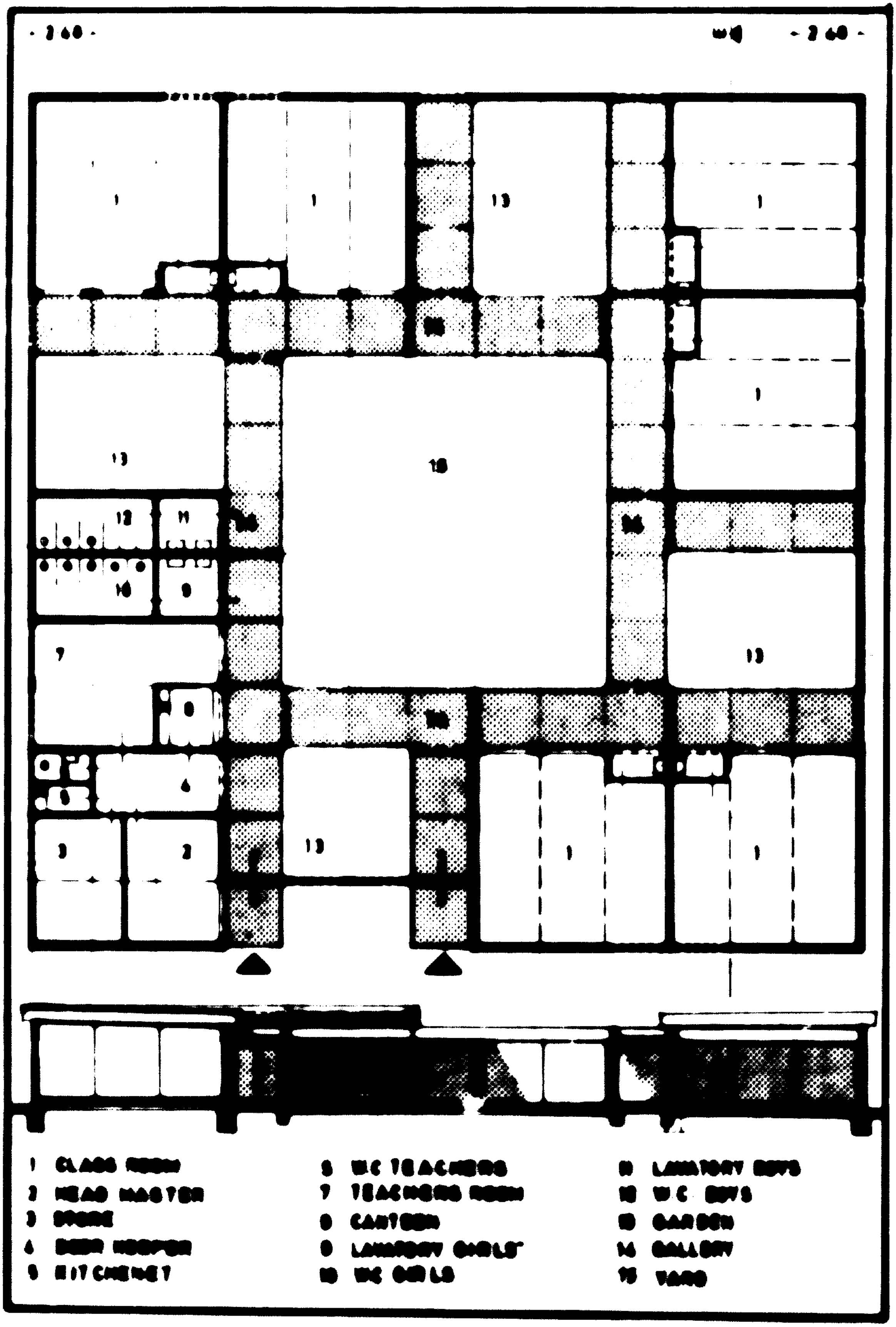


Fig. 18 : Prefabricated sanitary units : box unit, sanitary wall.





1 CLASS ROOM
2 HEAD MASTER
3 STORE
4
5 KITCHENET
6 W.C TEACHERS
7 TEACHERS ROOM
8 CANTEEN
9 LAVATORY GIRLS
10 WC GIRLS
11 LAVATORY BOYS
12 W.C BOYS
13 GARDEN
14 GALLERY
15 YARD

Fig. 2 : School building system for hot and dry climate, plan

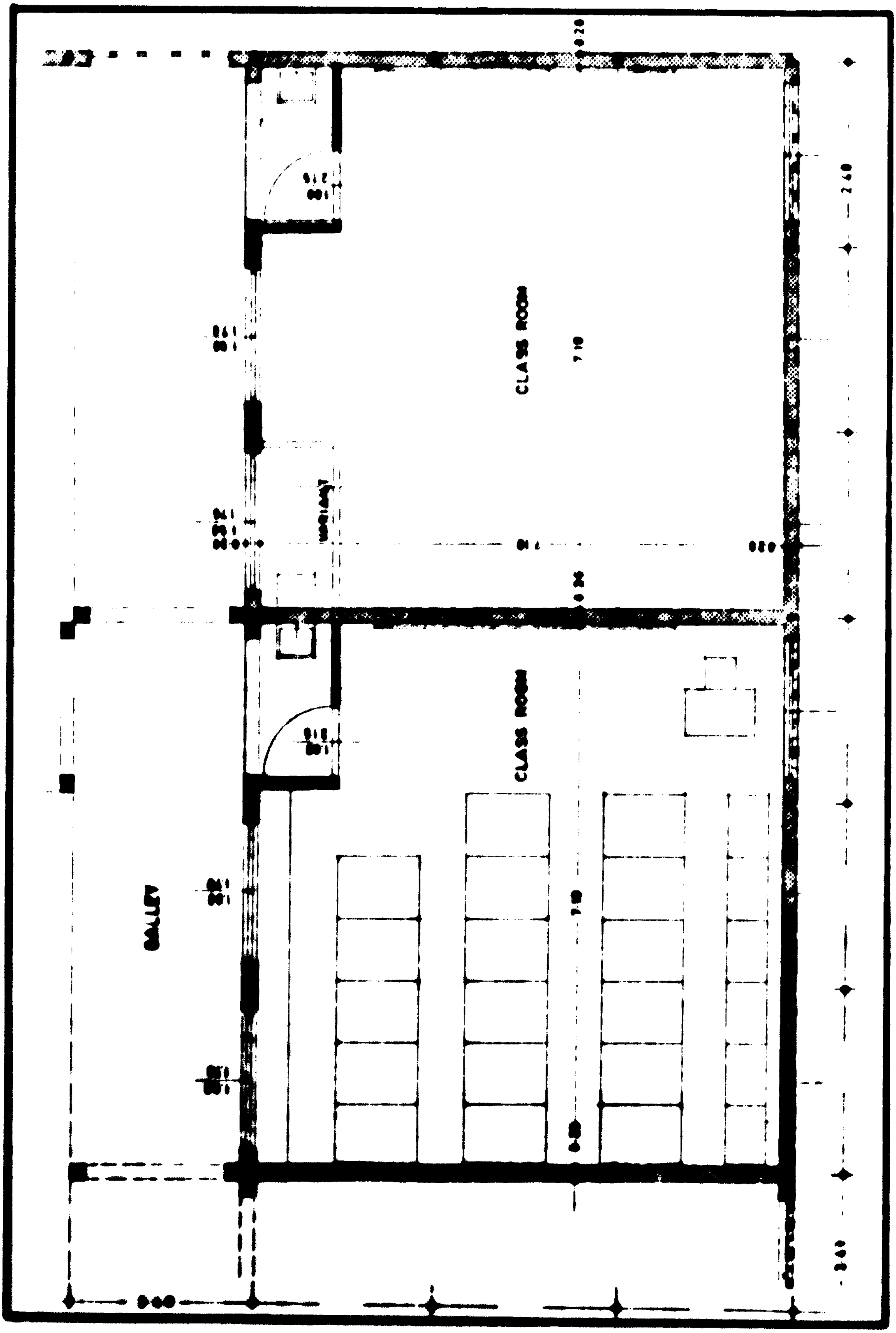


Fig. 21 : School building system for hot climate, section, elev.

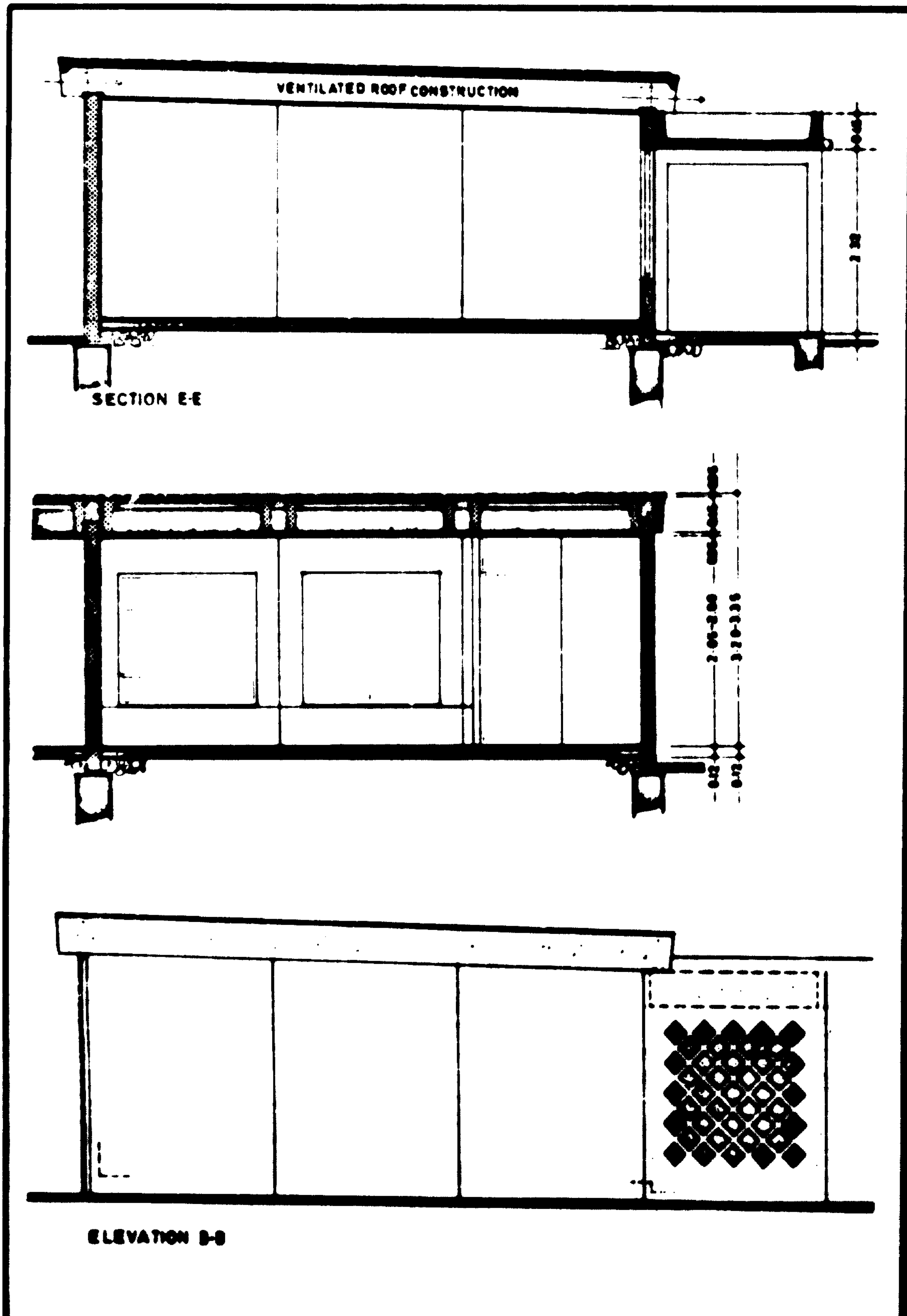
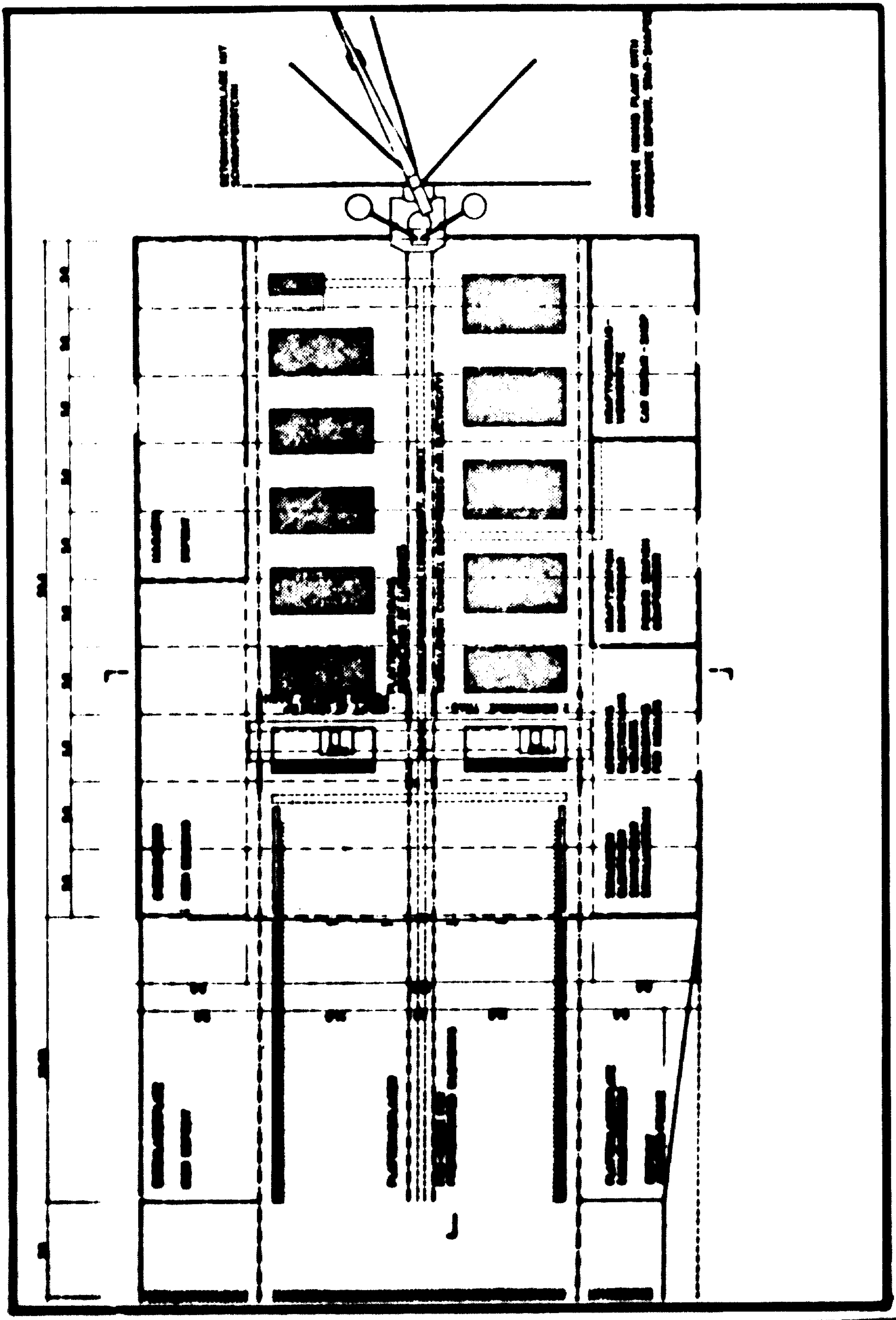


Fig. 22 : Plan of removable large-panel production plant



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