EVOLVING BUILDING SYSTEM FOR EXPANDABLE HOUSING BY MEANS OF CORRUGATED METAL SHEETS

by
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ABSTRACT

Large housing programs in developing countries built out of permanent materials are likely to be too costly for low-income people. Such housing would have to be subsidized or allocated to middle-income groups. For this reason, some governments provide sites and services that allow low-income families to live in temporary units. This intervention has enabled low-income families to live on regulated demarcated and serviced land if not in permanent dwelling units. While doing so, they are able to build incrementally more permanent dwellings according with their life-cycle and their changing financial resources.

This type of strategy supports the concept that housing is not a finished and static product but a continuos process over time. In order to adapt the initial temporary dwellings built by the low-income groups, and help with their transition to permanent buildings, this thesis proposed a building system which adapts to the dynamic and progressive building processes of these groups. The initial shelter is built out of corrugated metal sheets and steel members made out of thin metal sheets. The building system proceedes in stages from a simple temporary shelter -expanding and evolving- to a permanent dwelling. This transition is achieved by gradually strengthening the structure and transforming the surfaces of the dwelling with different levels of finishings.

Thesis Supervisor: Waclaw P. Zalewski
Professor of Structures

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"The world housing signifies much more than houses or dwelling units, it refers to the activities of people (and their organizations and institutions) building and using houses and the directly related utilities and services. In their words, when we write the word housing, we have in mind the actors, their activities as-well-as the material products or achivements of their actions." (Terner & Turner, 1972)

SYNOPSIS

This thesis deals with the description of a certain technique of approaching the housing problem for low-income people. The context of application is the developing countries with mild climates; the specific case study is Venezuela.

The following assumptions are explained in detail throughout the thesis and serve as a base in the development of the design proposal:

a)- The largest deficit of housing in most developing countries is found in low income groups. In order to provide a solution for a large number of people sites and services and the practice of self help are being adopted as a genericapproach to the problem of housing.

b)- Large scale industrialization has been abandon as the best solution for low-income housing. Instead partial industrialization based on existing industries and building components is considered to be of lower risk than full industrialization and can produce improvements in the production and construction of dwellings.

c)- Low-income groups have built their initial shelters out of light materials which are quick to assemble and allow self-help. This type of dwelling have a temporary character and they are often destroyed or abandoned when their inhabitants shift for more durable construction.

d)- Low-income groups have a limited savings capacity and a reluctance to get into long-term debts. There are no financial mechanisms available for this sector and the economical limitations of the families lead the construction to be realized in stages.

In this case most families cannot occupy the dwellings until certain stage of the construction is completed.

e)- It is common practice for families to build their houses themselves with the participation of community members and construction workers. In this type of construction the laborers involved are of low technical capacity.

f)- Changes in the family needs and its configuration happen frecuently in low-income groups. Dwellings are transformed and expanded to adapt this changes. Also, different levels of finishings are found in this type of construction according to different family economic resources.

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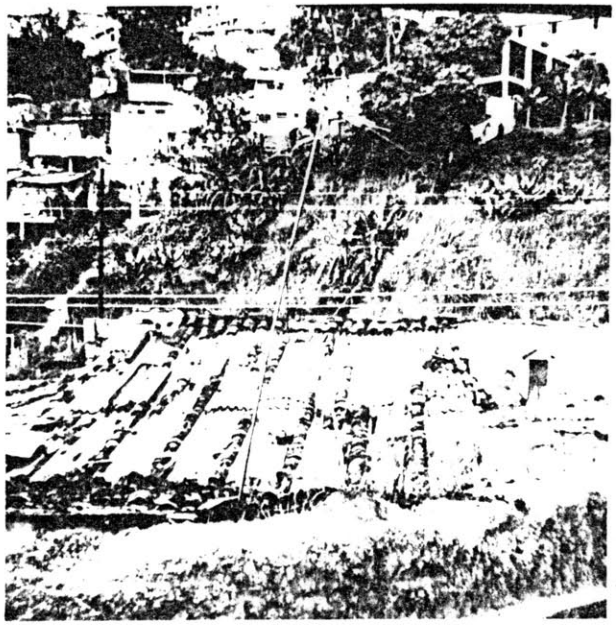


OVERVIEW

SCOPE

The deficit of low-income housing in developing countries is not a new or unknown problem. Its origins are complex and the causes have been changing over time from industrialization, wars, migrations from rural to urban areas and population growth. Whatever the causes are, the insufficient economic base of a developing nation compounds the problem.

For centuries and specifically during the Post War World II period, the strong belief was widely held that industrialization provided the most efficient solution to many housing problems. We are now not going to discuss the issues of the failure or success of industrialization in many countries around the world, but it clear that industrialized systems have not solved the larger national problem of housing for the poor.

In developing countries where economic growth has been very slow, industrialization cannot be promoted through high skill specialization, concentration of resources or high mechanization.

On the other hand, technology transfer has unfortunely been implemented without an understanding of local and indigenous construction traditions and without sensitivity to cultural values. For example the strong differences between sectors of the population and the correspondent diversification in housing types and conditions have largely been ignored.

Rationalization in this context should not be understood only as a mere static design problem or as an economic one. It "should be seen as the dynamic process which makes possible the optimization of the human resources and materials, together with the financial and organizational ways and means in order to achive the objectives of the development programs according to the socio-economic circumstances of each country." (IDEC,1985)

According to Seelig (1978), "Government and housing agencies have failed to realize that the issue they are facing is not merely the need to supply more housing; it is rather, the involvement of the residents themselves in the task of 'community building' that offer some hopes for solving the problem of the urban poor... Indeed what most have failed to realize is that the squatters who are the heart of the problem are also the core of the solution. They constitute the most important resource that has never been comprehensively organized and utilized to help improve their own living conditions."

The fact that a building system is introduced as a possible solution in this thesis should not imply that the key to low-cost housing lies simply in technological solutions or industrialized systems. But technology is a part of the problem. A part that is always in evolution. A part which demands for a constant study wherever the production processes and the social and economical relations may lead it.

HOUSING AS A PROCESS

The main concept of this thesis is that a house is an evolutionary process. A house is a "dynamic, continuous process over time, which proceeds in stages , rather than the static conception of housing as a definitive product." (Dluhosch, 1985) Such evolutionary dwellings call for the design of evolutionary building systems.

Construction technology for housing in the 'formal sector' has usually been directed toward a complete finished product which, to some extent, satisfies the housing needs of those sectors with sufficient economic resources. On the other hand, low-income groups themselves create a dynamic and variable construction production process. This process will be extensively explained in future sections.

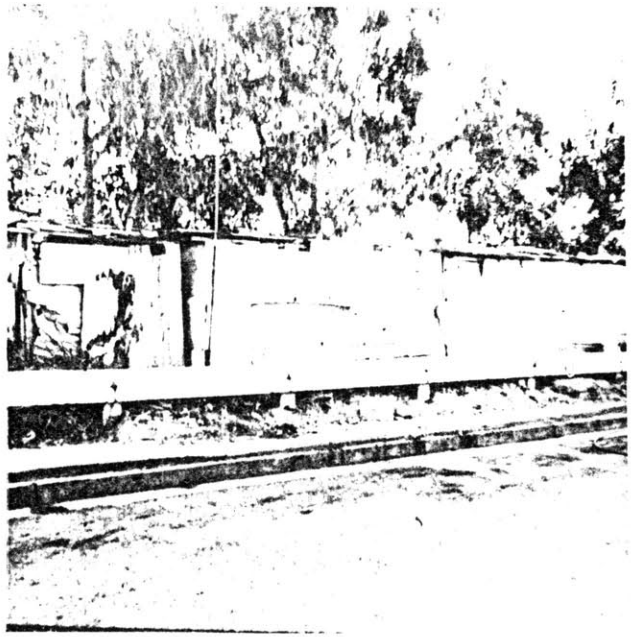
"While the architect wields control by means of expecting complete verisimilitude between paper simulation and realized object (to the last detail, as if born fully developed and complete), popular dwelling types are conceived as a continuous changing and evolving procees, marked by succesive stages of completion, in forms of increments of space, level of finish and varying living patterns over time. In that sense the 'informal' house is never 'finished' while -paradoxically- it is always complete." (Dluhosch, 1985)

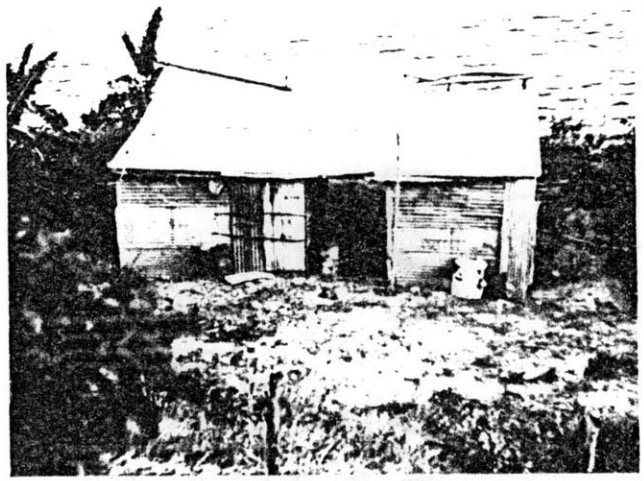
My proposal for an evolutionary building system is founded on this process of change. Building systems are rather static; they approach the problem of housing primarily in the structural sense. Self-built walls, which need not be structures, are much simpler to build, as evidence by the abundance of wooden, mud block and thin sheet metal materials use in developing areas. Their evolutionary character has a number of advantages over static, finished buildings. The most basic is financial. For most families, a house is the major purchase in their lives. The answer is then to

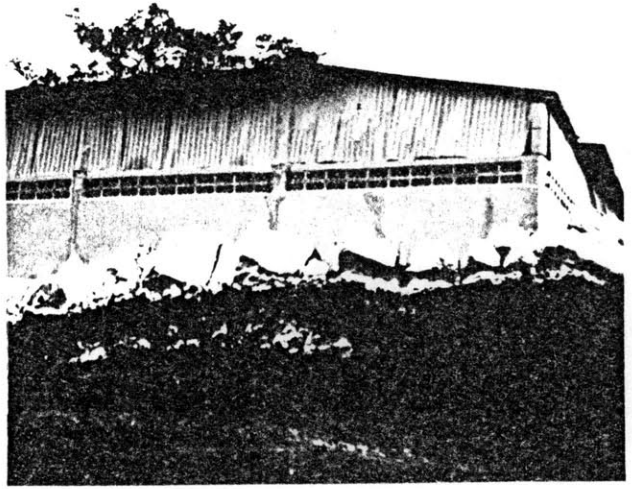
lower the initial cost of a basic dwelling and to allow for incremental invesments with incremental upgrading, and expansion, with the freedom to choose and design them.

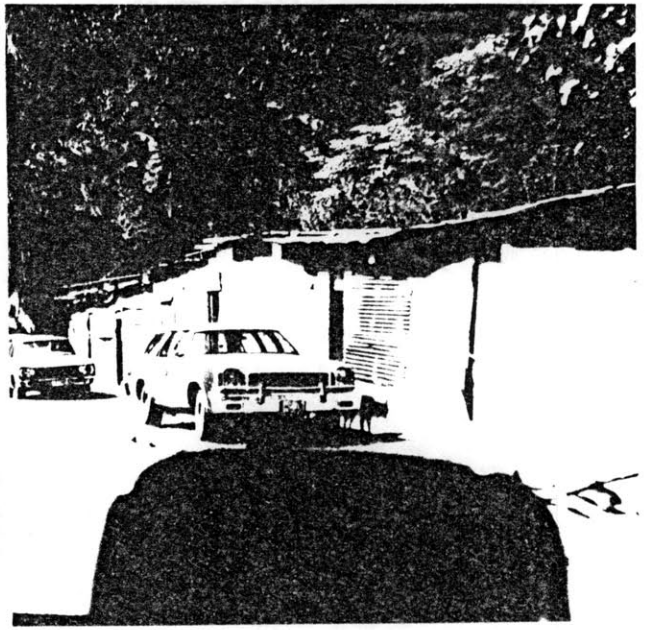
It is also important to consider that the processes, the materials and the life-cycle expectations of the construction are subject to change. These have to be thought of in terms of variability, flexibility and potential use in the future. Temporary and permanent materials will not be treated as separate. What the evolutionary system proposes is that if materials that are considered temporary are to be used, they should be capable of evolving and be able to behave as permanent.

CHAPTER TWO









THE PRODUCTION PROCESS OF THE INFORMAL SECTOR THE VENEZUELAN CASE

OVERVIEW

ORIGIN AND TRANSFORMATIONS

All over Latin America and many developing countries, we find houses built from any material available, concentrated in the cities, in its periphery and out in the country. They are called 'barrios de ranchos', 'callampas', 'villas miseria', 'barricadas', 'fabelas', ' shanty towns ', 'Bidon Ville',etc.. They are part of the morphology of the cities and they spread into the rural areas.

The origin, evolution and transformations of these settlements are very complex and have been becoming more so over time. In the specific case of Venezuela, the changes in the productive national sector have intensified the urban growth process. The relative reduction of the agricultural activity and the parallel growth of non-agricultural activities have modified the organizational structure of the labor force. Because the non- agricultural activities tend to concentrate geographically in urban areas, these production changes have produced a rapid growth of the existing demographic concentrations and created new ones.

Urbanization and economic growth has been produced by the growth of imports and not as a consequence of late industrialization. The government and the cities cannot supply enough work, enough infrastructure and enough adequate housing. The existing structure of the cities cannot handle the large numbers of migratory masses much less their growth. Consequently, the lowest-income groups of this population cannot find housing alternatives suitable to their resources.

This fact results in a vicious circle of monopolization of the national investments. The government capital derived from economic activities of the country is spent in the urban areas to try to cope with their problems, the rural areas are forgotten, the migration continues and the problems grow.

In Venezuela, the North-Central region, bordered on the north by the Caribbean sea, presents the highest concentration of population. The location of the capital city -Caracas- and the two main commercial ports, the concentration of economic, cultural and political activities and the existence of a better transport communication network, are the main reasons for the rural inhabitants to migrate. We find that for 1936, the rural population of Venezuela was 70% and the urban population was 30%; nowdays they are 20% and 80% respectively. (INAVI, 1984)

THE INFORMAL SECTOR

"The informal sector is seen as a hybrid in which traditional life style and rural cultural traits unfold into the urban settings, thereby creating a phenomenon that can be described as the ruralization of the cities." (United Nations, 1978). The informal sector (formerly illegal) is the sector of the construction which works out-side the official control and which relyes in non-conventional sources of capital and labor. This uncontrolled urban settlements are the manifestation of urban growth processes under exceptional conditions of rapid urbanization.

Charateristically, housing solutions of this sector operate outside of all building subdivisions, regulations and institutional control. The 'informal sector' establishes their 'barrios', outside of the processes of production and the organization of the construction industry.

The 'informal' settlements go through a fast, dynamic process of consolidation. The process of stabilization with the installation of services and infrastucture and the consequent upgrading process of the individual houses.

The rapid growth of these informal communities is as significant as the migration itself. In 1970 a case study showed that 27.6% of the heads of the families in these communities of main cities, were born in the same cities. Between 1978 and 1980, 37.9% of the families surveyed had resided previously in that same urban environment. In a specific area in Caracas, it was found that 74.5% came from Caracas itself. (Lovera, 1983)

ATTITUDES

The State policies in relation to the 'informal' settlements of the low-income groups have changed over time. The first attitude was of repression and repulsion. In 1954-58 the goverment tried to erradicate the slums by substituting 'Superblocks', 15-storey apartment buildings. People were moved to new high rise housing without preparation. The occupants of this project were people from the 'ranchos' accostumed to a type of dwelling unit with more open space. The new occupancy deprived them of any stage of transition and adjustment. What is more, nowadays we can see how 'ranchos' have been reproducing freely around these 'superblocks'. This and similar types of solutions have only partially give a solution to small parts of small low-income sectors.

A second attitude was to selectively allow 'informal' houses to exist, but when the land was required for some more profitable purposes, the families were moved from one settlement to another similar one, which destroyed the social and cultural relations of their community.

The third governmental attitude has, to some extent, rejected paternalistic solutions. These include the belief that housing is a right of the families and it is them a mandatory responsibility to provide them. This third attitude contemplate that the State will acquire new lands and provide them with services and infrastructure more than providing the house it self.

The problem is still that housing is treated mainly from a physical point of view consisting of finished products in which many of the solutions are not available for the lowest-income families. In consequence these housing projects are inhabited by middle-income families which also are not able to afford the dwellings that have

been built for them. The last group of dwellings are without a real market producing an artificial housing surplus.

The biggest deficit is found then in the low income groups. For 1981 32.97% of the national family groups had incomes lower than 2000 Bs per month ($167 at 11.98 Bs per dollar). For these families is imposible to acquire housing which exceed 59,000 Bs. ($4,924). This sector represents 24.31% of the housing deficit. On the other hand the group with incomes between 2001 Bs. and 4,000 Bs. per month ($167-$333.89) are 33.08% of the families population and represents 46.29% of the housing deficit. (INAVI,1984).

THE PROCESS OF PRODUCTION

A- LAND AND SERVICES

The acquisition of land by the lowest-income groups, has been very rarely done by legal means. This has been affected by the occupation of empty land in which the inhabitants have to fight in order to stay with the owner of the land: the State.

The fact that the State can request the land whenever it is needed gives the settlements a temporary character which determines consequently the manner of production of the dwellings. The issue of choice of materials becomes fundamental. The use of durable materials is in the begining, questionable not only by the chance of being removed from the sector but also because the economical positon of the users.

Usually the 'informal' settlements are located in the peripheral zones which are not actively claimed, lack services and usually belong to the State which make the current occupants negotiate to stay in the land if possible. Other ways to obtain the land is to buy it without services; 'illegal lots' are sold by private illegal agents. In this type of transaction, families think they are acquiring a piece of land but they have been cheated by artificial owners.

There are many reasons why low-income groups are not able to acquire land properties. Two obvious reasons are the cost of the land itself and the cost of the servicing. Formally the cost of the land represented a high percentage of the total cost of the house. Aside from the expensive urban areas, the only land available in terms of cost or possible occupation is in the peripheral areas. These areas are usually geological unsafe and they are difficult to provide with regulated services.

On the other hand, the cost only of servicing the land is as high as the cost of the land and in some cases even more. In areas where the squatters are already settled, the provision is not only physically difficult but costly mainly due to the lack of regularization of the residences established.

The approach to areas considered potentially safe for long- term settlement is to provide the low-income groups with sites and services in various degrees of completion depending on the specific group. According to Dluhosch (1985), the approach of sites and services "used as formula is effective only where consolidated empty tracts of land are made available, which are usually available only at the periphery of urban agglomerations, thus requiring extension of an already over extended municipal service system, or the construction of expensive new supply and disposal systems... Thus, sites and services must be regarded primarily as an interim solution to the larger problem of resource allocation..."

TYPE OF PRODUCTION

In the 'informal' settlements or 'barrios' we can find a conglomerate of the forms of production from the most underdeveloped of the construction forms to what is produced by more 'formal' construction sectors. There each form of production is interpreted by each specific social form of construction.

The construction of dwellings on these settlements has a constant: the participation of the user. Working on the building process, all the members of the family participate. Also friends and members of the community participate in the process. The solidarity and cooperation show up as traditional elements of the community. The result is generally a process of low productivity together with the poor utilization of the materials and the tools.

The prevailing way of production is so called 'semi- manufactured'. This form is half-way between the simple and the underdeveloped production and the manufactured process. In this process the owner participates in the construction with the help of his family and neighbors but what are called construction- workers also contribute in the process dealing with what is called self-construction. Several dwellings are produced under- contract by these constuction-workers who in many cases live in the same community. The economic control in this situation is under the owner, and the technical control is under the construction-worker.

This type of construction is probably not found in the very early stages of the dwelling construction when the family is in a transitory stabilizing situation. It is more common to find it when the settlement is consolidated, the family is established, and the construction of a more permanent shelter begins. This process from temporary to permanent construction depends on a complex aggregate of

factors which includes the economic conditions of the family and its growth, the stabilization of the land in terms of occupation and legality, etc. These factors determine the growth in stages of the dwellings. It is in the later stages of the construction that the occupants might find it advantageous to contract construction workers.

The expansion in the forms of production in the 'informal sector' shows that each time the socio-economic conditions allow it, the inhabitants abandon the most rudimentary ways of production and adopt step-by-step technological improvements in the construction. It is fair to believe that families overcome the more underdeveloped forms of construction and promote the participation of specialized labor.

MATERIALS

The materials used in the construction of dwellings in the 'informal sector' depend mainly on:

- The change of the construction process.
- The level of consolidation of the settlements and the lack or possession of land tenure.
- The socio-economic conditions of the family.
- The existing trends of the social groups in which they live.

The first image we have of a squatter is shanties made of disposable materials. These materials are used mainly because they are cheap or free and they are quick to build with. Raw materials, such as sand, wood, and stones, are low-cost and they can be directly obtained from nature. Natural raw materials are not always available, and disposable materials are more and more traded which increases their convenient original value. Another factor in some areas might be the scarcity of suitable building materials available in the market place.

These factors have moved the low-income groups to buy materials by unit price in small stores which increase their cost. In a case study in el 'Barrio La Cruz', Caracas, 86% of the houses were built with materials bought by unit price by the families. (Lovera, 1983)

The cost of the materials is the most significant investment of the house. They constitute one and a half of the surface area constructed. There is lack of diversification in the materials available which increases the price of the few

available. Also the transportation of the materials to the peripheral and distant urban and rural areas and the difficulty to access them, augment their value.

Generally, materials are accumulated when money or resources are available until there is enough to build one part of the house.

To be meaningful for low-income housing needs, building materials must be inexpensive.The most research to be done for materials is for those used in the enclosure and the internal partitions elements. Since construction materials can be changed or improved for better performance, various methods should be evaluated whereby local materials can be developed and improved for use in low-cost housing.

Considering the existing resources in Venezuela studies should be made in the utilization of metal and petroleum products taking advantage of the existing national industries and the availability of their materials. Also wood from the tropical forests might be considered if a good rationalization of wood conponents and its production is promoted.

Equipment-

Inside the squatter areas, the production is restricted by the use of tools. The scarcity of the resources and the scale of the production has prevented the use of more sophisticated equipment and machinery.

THE BUILDER AND THE WORK FORCE

The occupant of the squatters has lost, in the process of moving into an urban area, his abilities of building in his traditional way. The tendency caused the disappearance of the typical country hut and produce another precarious urban building.

The first shelter is simultaneously a temporary house and a work place. The initial shelter is produced by self-help and occasionally followed by the introduction of some skilled labor. But in general terms, the main characteristic of the 'informal sector' is the overflow of unskilled labor and the scarcity of skilled individuals. To this fact contributes the lack of long term programming, continuity and specialization on the construction industry side.

It is important to consider what the FVP (1982)has pointed out. "The lack of technical training, the long periods without effective improvements, the injuries of the initial stages due to inadequate use, and the change of the interest of the user during the upgrading process, influence in the waste of effort realized."

INDUSTRIES AND PRODUCTION

It is well known that the degree of possible industrialization is dependent on the extent that repetition is possible. Repetition is given by the market which ideally should be capable of satisfying within a 50 Km distance from the factory. In order to increase productivity, building variations are decreased and typifications in designs are produced to build thousand of dwellings. It is not likely that this solution will satisfy the informal sector which cannot be considered as a formal market.

The construction materials industry will have to admit that a large part of their production goes into the production of 'ranchos' and self-help housing. The market in these sectors will be recognized and stimulated to enlarge and improve the organizations that operate in this sector, such as community cooperatives and community administrative societies. What is important is that if self-organizations and self-managing communities are to be achieved and maintain standards which all should enjoy there must be co-operation with both market and state forces.

Industrial prefabricated sophisticated components and systems are highly dependent on the industry which assemble or produce the components. It is advisable to think of building systems which are designed in fuction of already existing elements or components which are easy to produce by existing industries. This will help to insure, to some degree, the continuity of the system and its availability over time . It will also prevent high investments not suitable for developing economies.

VALUE, COST AND FINANCING

It is paradoxical that the value of buildings in the 'informal sector' sometimes equals that of buildings produced by other, more advanced, means of construction. The reason for this is that so called 'underdeveloped' construction requires more labor and time than more advanced technology. The additional effort and time is not included in cost projections for this typt of construction.

We have mentioned that in many cases the materials are bought cases by unit price which also increases the cost of the house.

The other facet of the cost picture is the time when the houses go on the market. The market of temporary and permanent houses is created by the fluctuation of population moving from one area to another, maybe for job reasons. Permanent houses made out of solid and durable materials are sold or rented at almost the same cost as a temporary one. The real cost of these dwellings is not reflected in the rent or sale price. The houses are considered marginal housing with a high annual depreciation rate.

In the world of financing, the 'informal sector' resources are varied and complex. The members of the community borrow money from each other or borrow at high rates from small neighborhood shops. The vast majority of low-income residents, however, have no access to credit and no relationships with mortgage bankers. On the other hand family savings are typically used to construct a habitable but unfinished house which is then incrementaly expanded and improved as the needs of the dwellers -and their ability to pay- dictate.

Low-income groups are ineligible for conventional loans. Some groups, are not even considered 'credit worthy'; they are a step above the lowest-income families because to a certain extent, they are capable of saving for housing. But accumulated savings are almost never sufficient to pay for a complete dwelling. Also, inflation tends to reduce the savings practices. The high cost of the dwellings provided for low-income groups keeps low-income families from acquiring them and increases their incentive to enlargement existing buildings or even to build shanties.

According to the United Nations 1978 "it appears that the financial structure of Latin America has become highly effective for those who are able to use it. However, except for credit unions and to some extentet savings and loan associations and worker banks, the financial structure has not been made accessible to low-income groups, to say nothing of the lowest income groups." (United Nations,1978).In order to improve the financial base of low-income families and consequently their capacity to improve their housing, financial mechanisms for self- help need to be encouraged. In creating methods of financing housing, efforts should be first devoted to organizing local communities. Existing viable community groups should be strengthened wherever possible to handle directly the needs of their low-income members.

In Caracas the 'Fundacion de la Vivienda Popular' has successfully initiated a financial program which has totally upgraded the 'Barrio la Dolorita'. The Foundation created a system based on four components: 1- patronage unit, 2- financial mechanisims and resourses, 3- execution mechanisims and resources, 4- The Civil Association, the participative component of the system the Civil Association.

The Civil Association is formed by inhabitants of the settlement who have a dwelling which needs improvement and who will participate in the organization of the

improvement process. This entity has legal autonomy to administer the financial resources.

The Foundation's program includes an educational process in order to introduce the participants in the reality of the overall project, its needs and its solutions.

Any group created in the above programs should work not only in setting up the community but also during the life of the project to maintain the level of achievement and to strengthen links with financial institutions. Governing policies should be designed to reflect the saving and repayment capacities of the poor as well as to consider the timing and phasing of the construction of the dwellings independent of the methods used. Effective policy design helps to maintain adequate production levels and prevent the premature deterioration of the parts of the dwellings first constructed.

A last word on building material loans according to the United Nations, 1978. They "make more efficient the improvement or construction of the dwellings since the materials are obtained at once for specific components of the housing assembly process. A more rapid construction of self-built dwellings is also likely due to the reduced diversion of household funds to other necessities."

HOUSING PROGRAMS

For several decades the Venezuelan State has promoted solutions which have incremented the production and diminished the cost and construction time. For this reason rationalized building systems have been proposed from the normalization of the design to the industrial production. Lately the growing policy has emphasized the sites and service programs together with self- help programs to face the deficit of 1,225,000 houses estimated for 1985.

The description of the following programs serve as a frame in which the proposed building system can be applied. Five basic programs deal with the housing policy through the National Housing Institute (INAVI), which procure solutions for the different low-income groups depending on their needs and the social-economic conditions of the family. The programs are:

a) Progressive Habitation

Consists of the distribution of lots with minimun services which are appropiate for the construction of low-cost dwellings. The program allows the transition from temporary to permanent dwelling without the risk of using inappropiate lands for the construction or the lack of sanitation caused by lack of services. The lots and dwellings will be progressively upgraded and constructed. The time to be executed will depend on the organization of the communities. The norms will allow the use of traditional cheap materials, easy to fabricate or acquire, the construction in stages and the utilization of self-help.

b) Habitational Credits

This program favors the population under the progressive habitational programs and the consolidated settlements, which want to substitute, finish, improve or enlarge their dwellings. Credits are given in the form of materials or materials and labor.

c) Expandable Housing

The user will acquire a basic unit in a complete urban development with all the necessary services. The user will be able to enlarge his unit depending on his requirements. The typology of the lots also varies depending on the users needs and the type of development.

d) Complete Houses

For groups of higher acquisition capacity. Uni-family houses- realized by means of guided self-help or any other common type of construction of the Institute. Multi-family Housing- for metropolitan areas. The design should avoid the use of mechanical installations (elevators).

e) Rural Housing

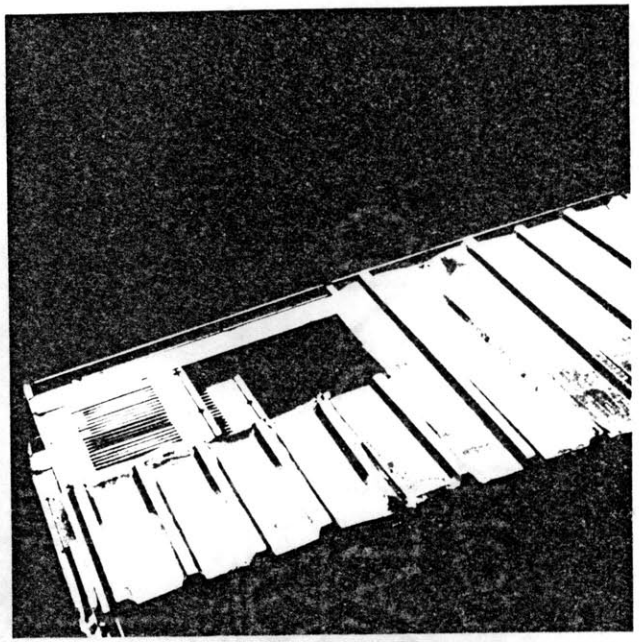
Attention will be given to population in rural areas under 15,000 inhabitants with the provision of rural houses.

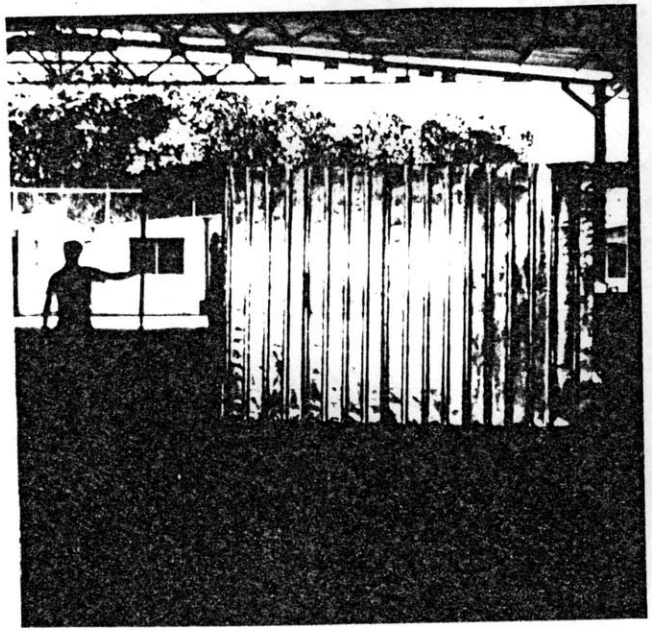
f) 'PROMAT': Program of Incentives in the Innovation of Production and Marketing of Components and Materials for Low- income Housing.

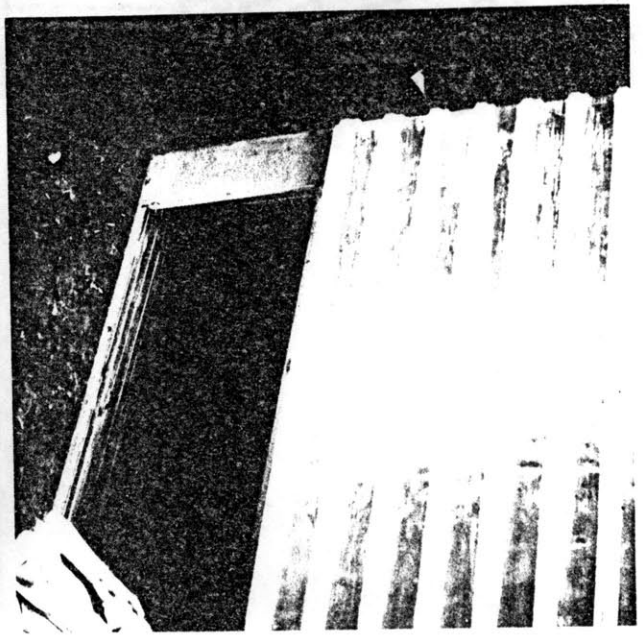
Promoted by "Oficina de Estudios Urbanos para el Desarrollo Habitacional- MINDUR. This program studies the production, distribution and marketing of components and building materials in order to minimize the cost and decrease the construction

time process. This is a program which supports the endowment of credits and land and is assisted by the program of Progressive Housing, Rural Housing.

CHAPTER THREE







THE SYSTEM

DESCRIPTION OF THE SYSTEM

The proposed building system is oriented to low density construction (one to four stories). It is an alternative for the problem of providing housing for low-income people in the urban environments and of special interest for the need of housing in the rural areas.

The main characteristic of the proposed system are:

a) Evolving Building System

Evolution of a building system in this thesis is define as the capacity of the system to progressively be tranformed. Most of the times building systems have fully conceived designs. For example the structure and its load capacity are determined in the beginning of the design and it is very unlikely that the structure could change.

What this system proposes is an initial and temporary shelter which offers an unfinished but habitable unit. The initial minimum conditions will gradually be improved through changes on the system such as the widening of the walls and finishing the walls and ceiling.

b) Flexibility and Expandibility

The system is conceived for dwellings which can be expanded and/or require a certain amount of flexibility. The system should allow two possible expansions: horizontal and vertical. The expansion is limited to the area where the dwelling is

located. It is important that in the initial stages of this type of construction the structure is not over overdesigned since it is expensive and it is not necessary.

The system can be transformed when the the family's needs, its configuration, and the change in the use of certain areas of the house demand it. In the first stages of the house a certain amount of flexibilty is possible until more definite improvements are made.

The system can also be dismounted in its first stages and assembled in another location before later modifications made the system permanent.

c) Staged Houses

The system should evolve and grow in stages. The small investment and savings capacity of low-income groups causes their dwellings to grow in stages. The system allows, not only what is commonly understood as staged housing in terms of space expandibility, but also the improvement or evolution of the system in stages. For example enlarging the width of the walls, strenghthening the structure, or using different finishings can be done in stages. There is no fixed order for accomplishing the possible stages. This property gives the user the freedom to invest in particular improvements to the dwelling that he considers the most necessary at a given time.

d) Flexible production and implementation

The system can be implemented by public or private enterprises. It can also be modified in a way that can be constructed by the owner with some assistance from construction workers. In either of the two cases the user participation is of significant importance and helps in the cost reduction.

The components and the dimensions proposed in the system are not fixed or unique . They are suggested mainly for two reasons: the dimmensions of the corrugated metal sheets available in the market and the basic module of 80 cm. proposed by Banco Obrero (1975) Venezuela. These two factors determined the basic system dimensions for use in this case.

It is important to choose components with dimensions that already exists in the market and to choose dimensions which are compatible with other existing market products (windows, doors, etc.) This strategy does not involve large investment or economic risk. This is part of what we have referred before as partial industrialization.

STRUCTURE

Richard Walker, the patentee of the corrugated iron declared: "(It is) a self-sustaining structure, with tie roads for lateral stability... A new property is given to the iron sheet by its being corrugated, or formed, by means of powerful machinery... a sheet of iron so thin that it will not sustain its own weight, will, after this process, bear 700 lbs." (Herbert, 1971)

The structure, both horizontally and vertically, is made out of corrugated metal sheets and steel frame members made out of thin metal sheets. Corrugated sheets are welded to a frame of thin steel members creating a panel. Panels are assembled by related industries or by public or private enterprises at the factory. The panels are bolted together by the frame elements to give the required stability. The roof panels are also bolted to the wall frames giving integrity to the whole structure. The total structure is light weight. The weight is carried through the frame members and corrugated metal sheets to the ground. Each component or panel is light enough that it can be lifted by one man and carried and assembled by two men.

Structure for Vertical Expansion

In this type of expansion certain parts of the lower walls will be casted with concrete for buildings of two levels. For three or four levels it will be necessary to fill most of the wall panels.

In order to expand vertically, the wall panels of the lower lever have to be made of two layers of corrugated sheets. These two layers serve as a form to cast concrete. This gives to the first floor the necessary strenght to support the floor above and also improves the thermal quality of the wall.

A concrete floor for a second floor will be poured on top of a steel deck. The rigidity of the system is achieved by: first, bolting or welding the steel deck to the lower steel framing members; second, reinforcing bars (which are protruding from the concrete that was cast in the lower level walls) go through the second level floor up to the second level walls.

SERVICES

In the first stage services (electricity and water) can be exposed along the interior side of the one corrugated layer panel. In subsequent stages the services will be covered by a second corrugated sheet lying between the panels.

For the first and the upper levels, services can be extented from existing installations and go through the circular voids of the horizontal frame members.

FINISHINGS

"If users are to take part in the building process it is crucial that the building system is capable of wearing different levels of finishings." (Dluhosch, 1985)

In order to change the character of the material from temporary to permanent different levels of finishings can be performed. There are no rules on the way the stages should be done to improve the dwelling surfaces. They are open the the users needs and their economical situation. The user should anyhow have in mind which are the changes that may occur.

The type of corrugated sheet used and the use of paint over it depend on the manufacturer or the user. The finishings can be done in the exterior or in the interior, on the initial single corrugated sheet panel or on the later doublesheet panel.

The general procedure for any of the sides of the panel is as follow: A metal mesh is welded or stapled to the corrugated sheet. Then different types of plaster or cement mixtures can be applied on top of the mesh. The type of covering should have a thickness between 1.5 cm. and 2.5 cm approximately. In the service areas plastic coat or ceramic tiles can be also be adhere to the plaster or to the mesh surface.

Finishings for the ceiling are divided in two clases:

- The case of a ceiling between two floors. In this case a corrugated but horizontal surface serve as a ceiling in a fist stage. Following a similar procedure than in the case of finishings for the walls, the ceiling can be covered with plaster or cement.

- The case of a ceiling in a sloped roof panel . In this case the roof frame elements could serve as the support for plywood sheets or another type of similar material. The air camera between the proposed ceiling and the roof will serve as thermal protection. This space can also be filled or covered with some type of insulation.

The roof can be covered with tiles as an example of what the low-income groups have spontaneously done. In this case the roof have to have the appropiate slope to place the tiles.

INTERIOR WALLS

Different widths of panels can be proposed as partitions:

- A first type will be those walls which serve a structural purpose. These panel should be of the same dimensions as the external walls panels (approximately 12 cm.)

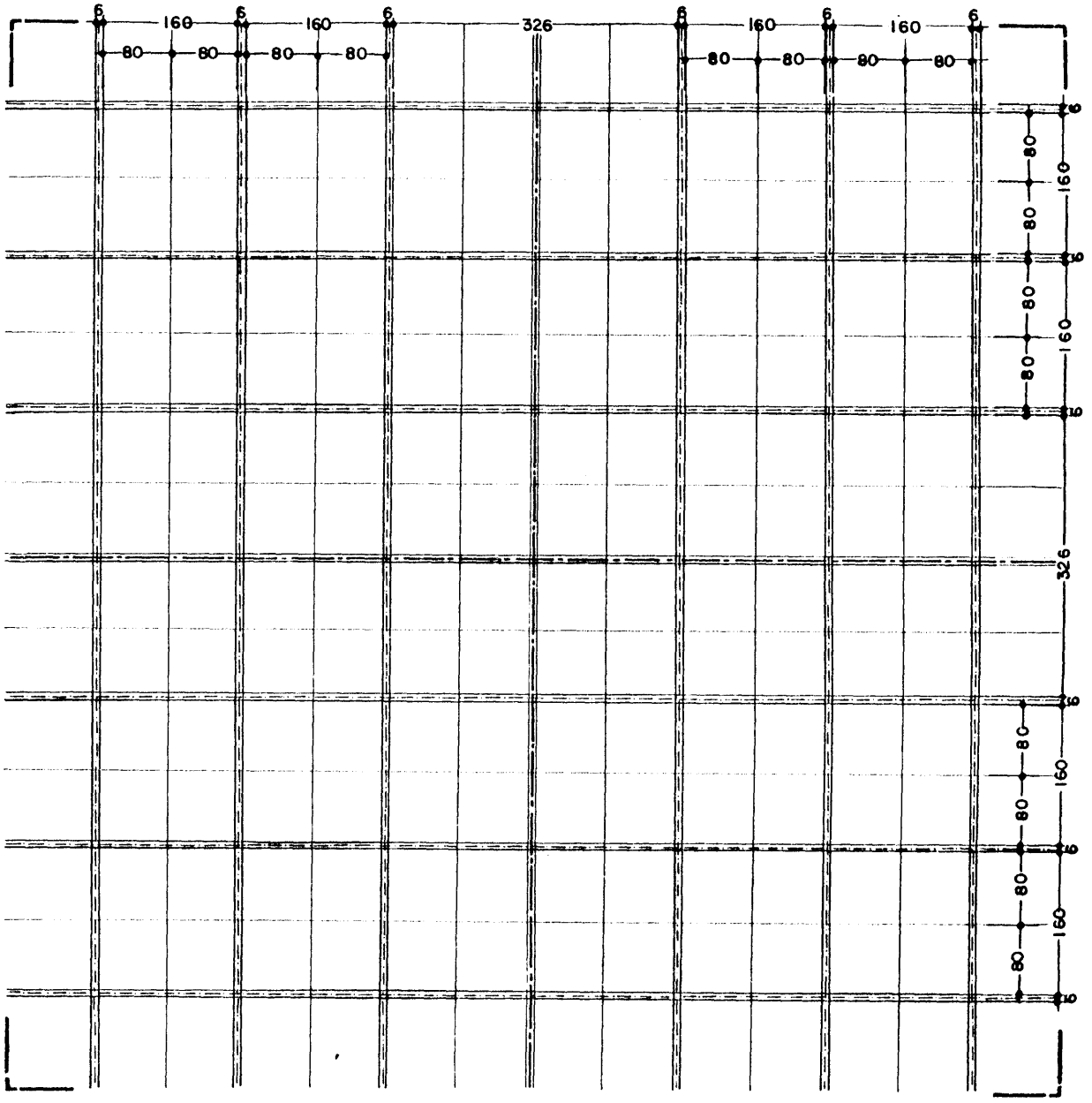
. It is convenient that these panels are connected to the frame joints in order to give continuity and stability to the system. This type of panel can be modified in order to be placed other points other than the frame joints.

- Thinner partitions or panels, with a width of aproximately 6 cm., can be placed on the frame joints or can be connected along the panels. The middle is a convinient place to connect them due to the vertical reinforcement there proposed.

In the next section the building system will be explained through the design proposal.

MODULAR COORDINATION DESIGN GRID

The system is based on a tartan grid with bands of 6 and 160 cm. The band of 6 cm indicate where the structural componets are recommeded to be placed. Panels can be moved along the 160 cm band. A basic module of 80 cm define the panel module due of the corrugated sheets and the opening components dimmensions.



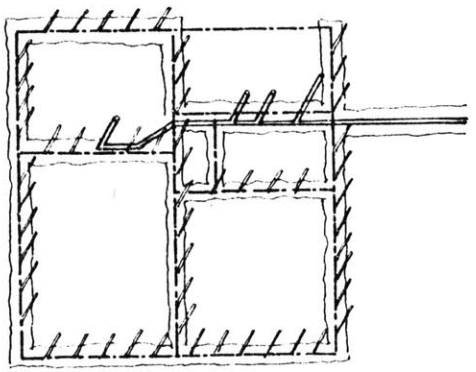
CONSTRUCTION STAGES FOR INITIAL UNIT

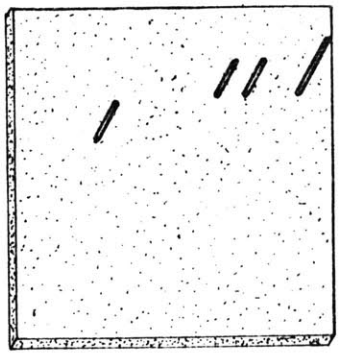
A- Site Preparation.

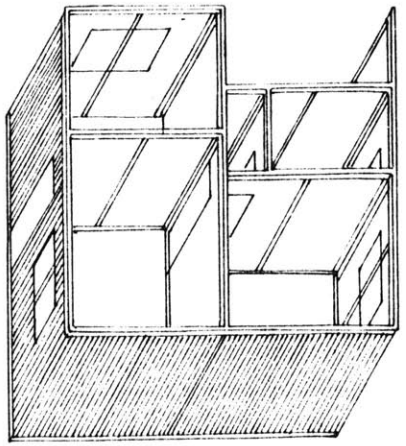
B- Foundation and concrete slab are casted.

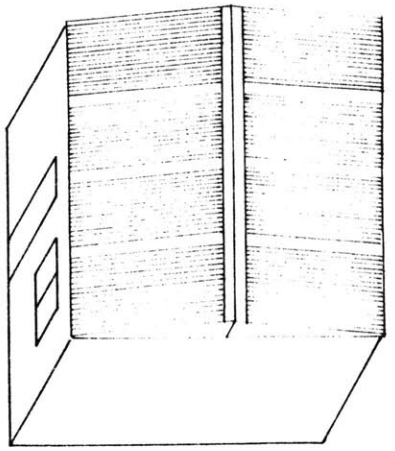
C- Wall panel assembly.

D- Roof panel assembly.









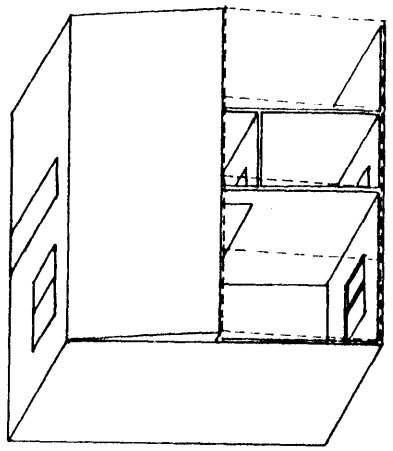
CONSTRUCTION STAGES FOR VERTICAL EXPANSION

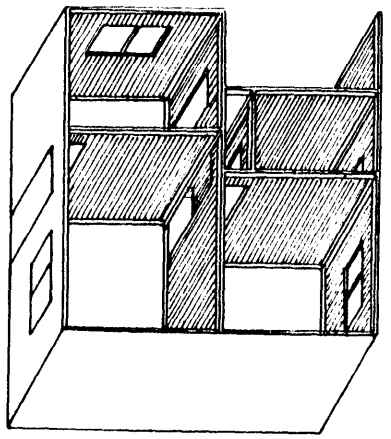
A- services are extended and vertical reinforcement is placed through the circular voids of the horizontal steel frame members.

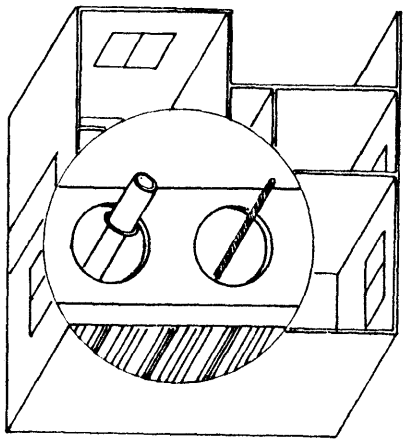
B- Second corrugated metal sheet layer is attached to the inside of the panel.

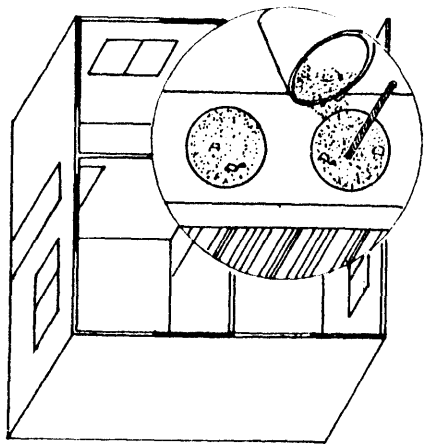
C- Roof is removed.

D- Concrete is casted inside of the wall panel through the circular void of the upper horizontal steel frame members. Corrugated sheets serve as casting forms and as reinforcement for the structure.









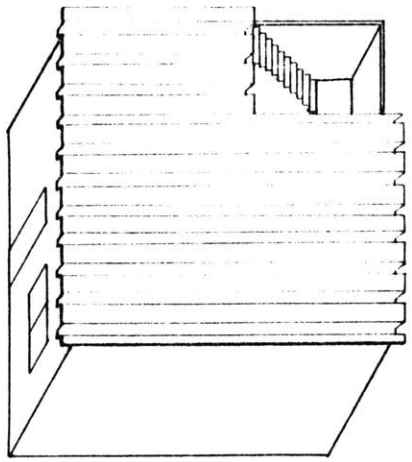
CONSTRUCTION STAGES FOR VERTICICAL EXPANSION

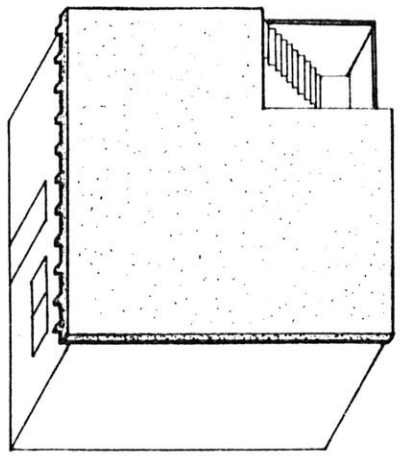
E- Metal deck is bolted or welded to the lower level wall panels. Previous definition where the services and the reinforcement are going to go through is necessary.

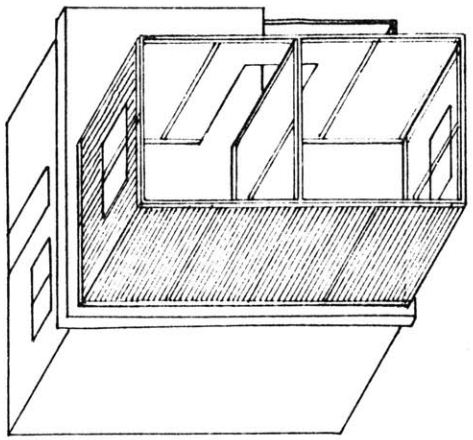
F- Concrete slab is poured on top of metal deck

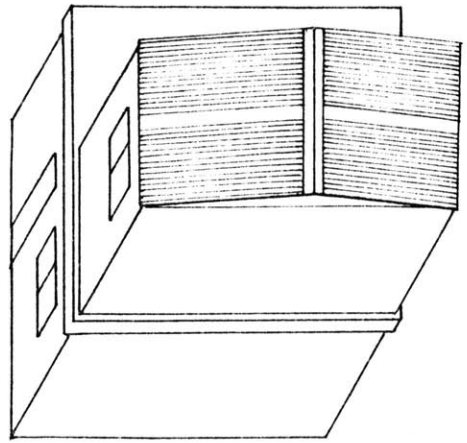
G- Wall panel assembly for the second level

H- Reassembly on top of the second level wall panels.





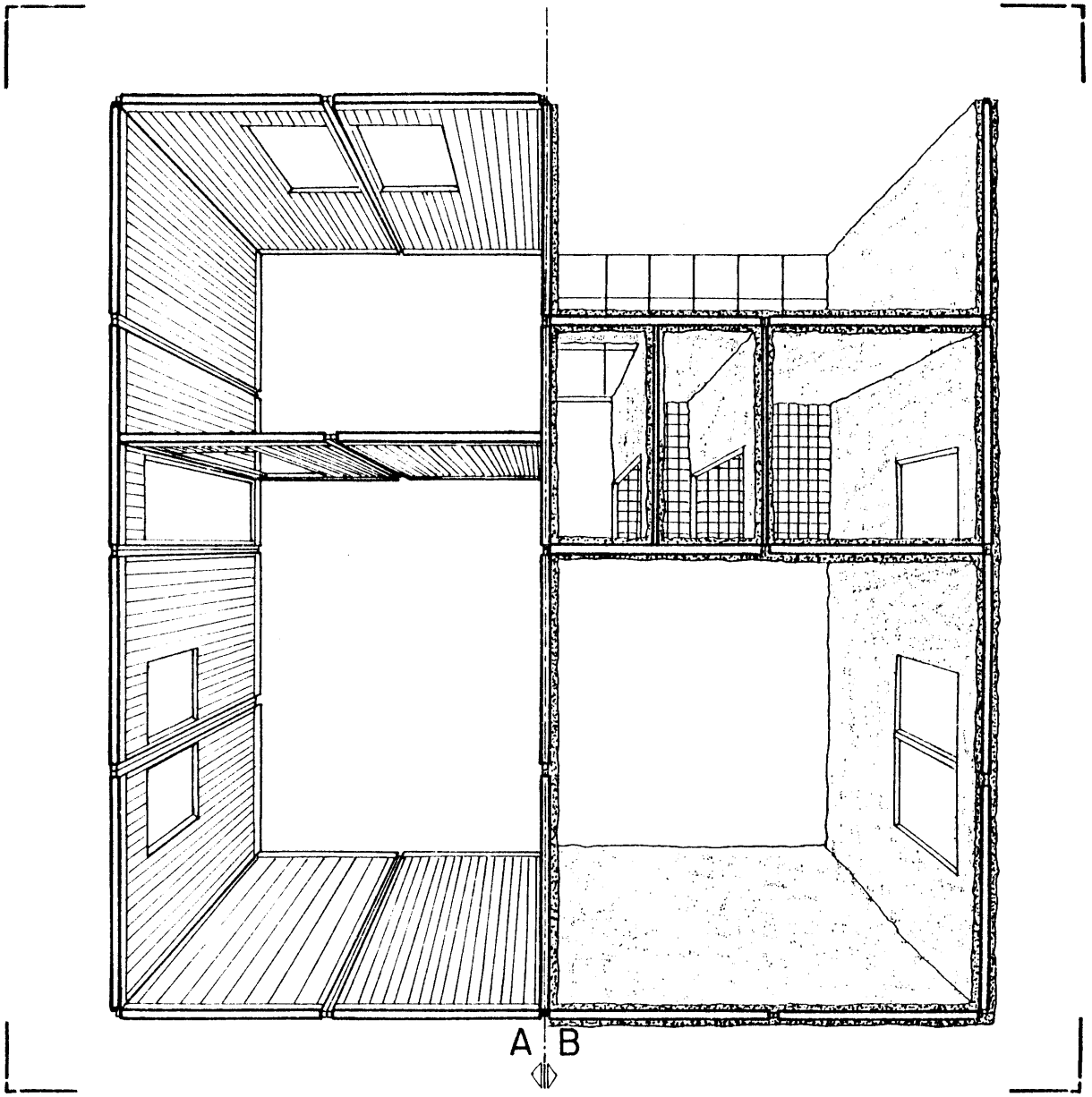




PLAN EXAMPLE
PERSPECTIVE

A- Initial stage. This side shows a part of the dwelling with corrugated metal sheet surfaces.

B- This side shows a part of the dwelling with plaster covering the wall surface.



PLAN EXAMPLE
JOINT CATALOGUE

A- Two Wall Panel Connection.

B- Corner Wall Panel Connection.

C- Three Wall Panel Connection.

D- Four Wall Panel Connection.

E- Door Panel Detail.

F- Window Panel Detail.

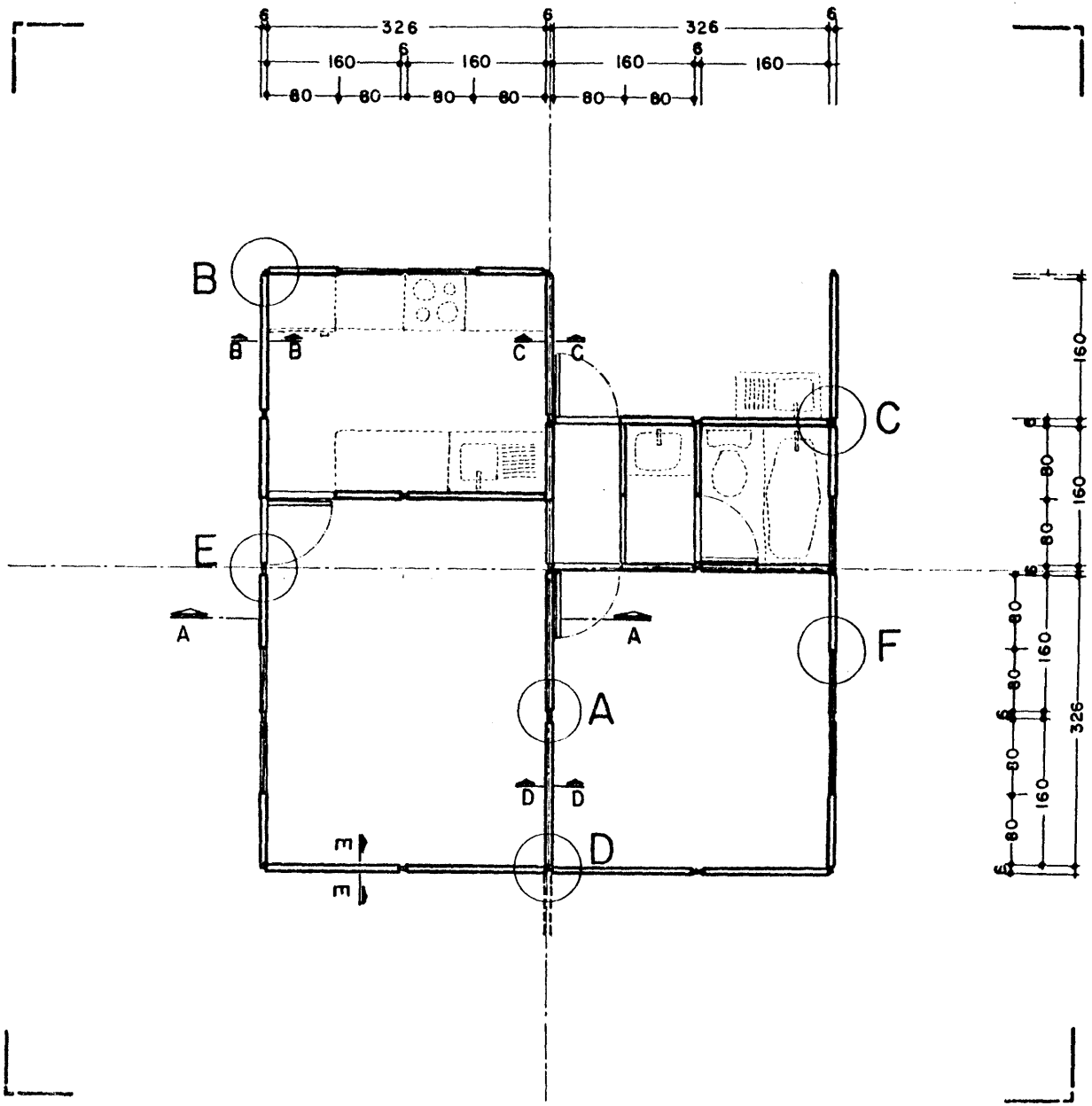
AA- Transversal Section.

BB- Wall Panel-Roof Panel Connection (Narrow Roof Panel End).

CC- Wall Panel-Roof Panel Connection (Wide Roof Panel End).

DD- Wall Panel-Two Roof Panels Ridge Connection.

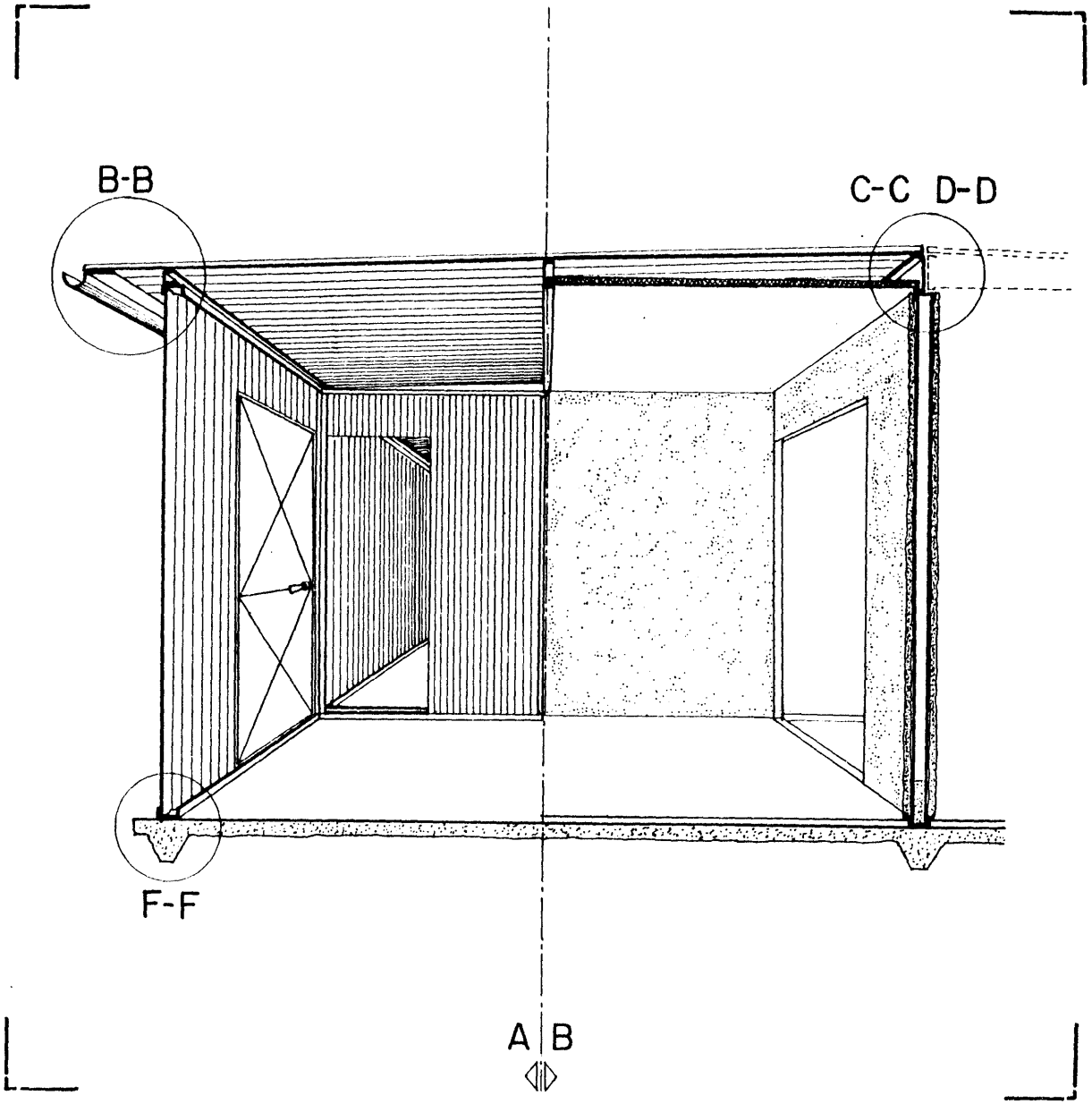
EE- Wall Panel-Roof Panel Connection (Longitudinal Section).

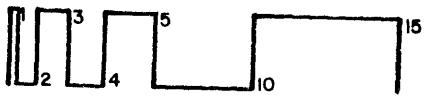


TRANSVERSAL SECTION PERSPECTIVE (A-A)

A- Initial stage. This side shows a part of the dwelling with corrugated metal sheet surfaces.

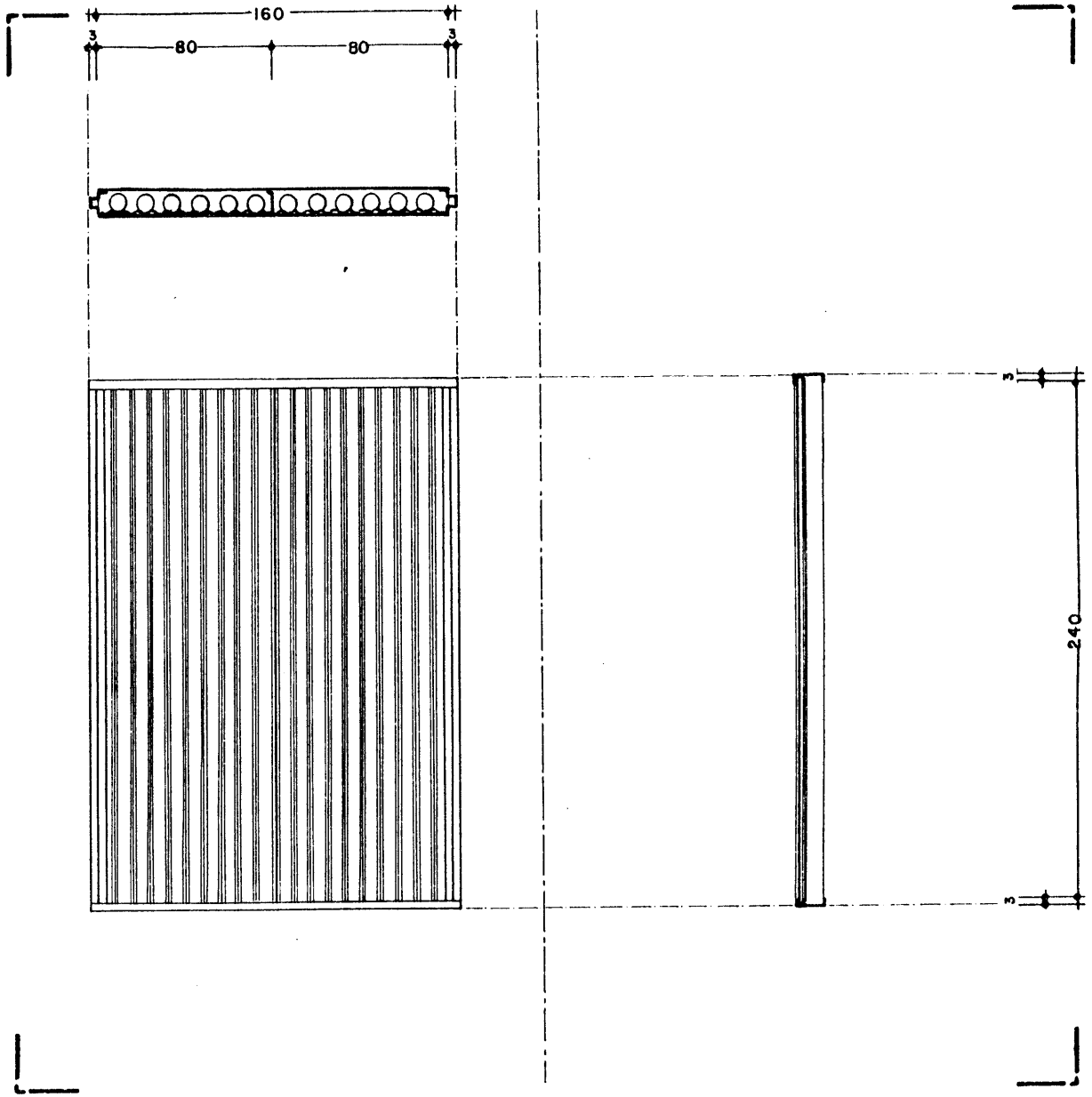
B- This side shows a part of the dwelling with plaster covering the wall surface and the roof with insulation panel.

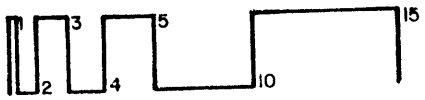




WALL PANEL

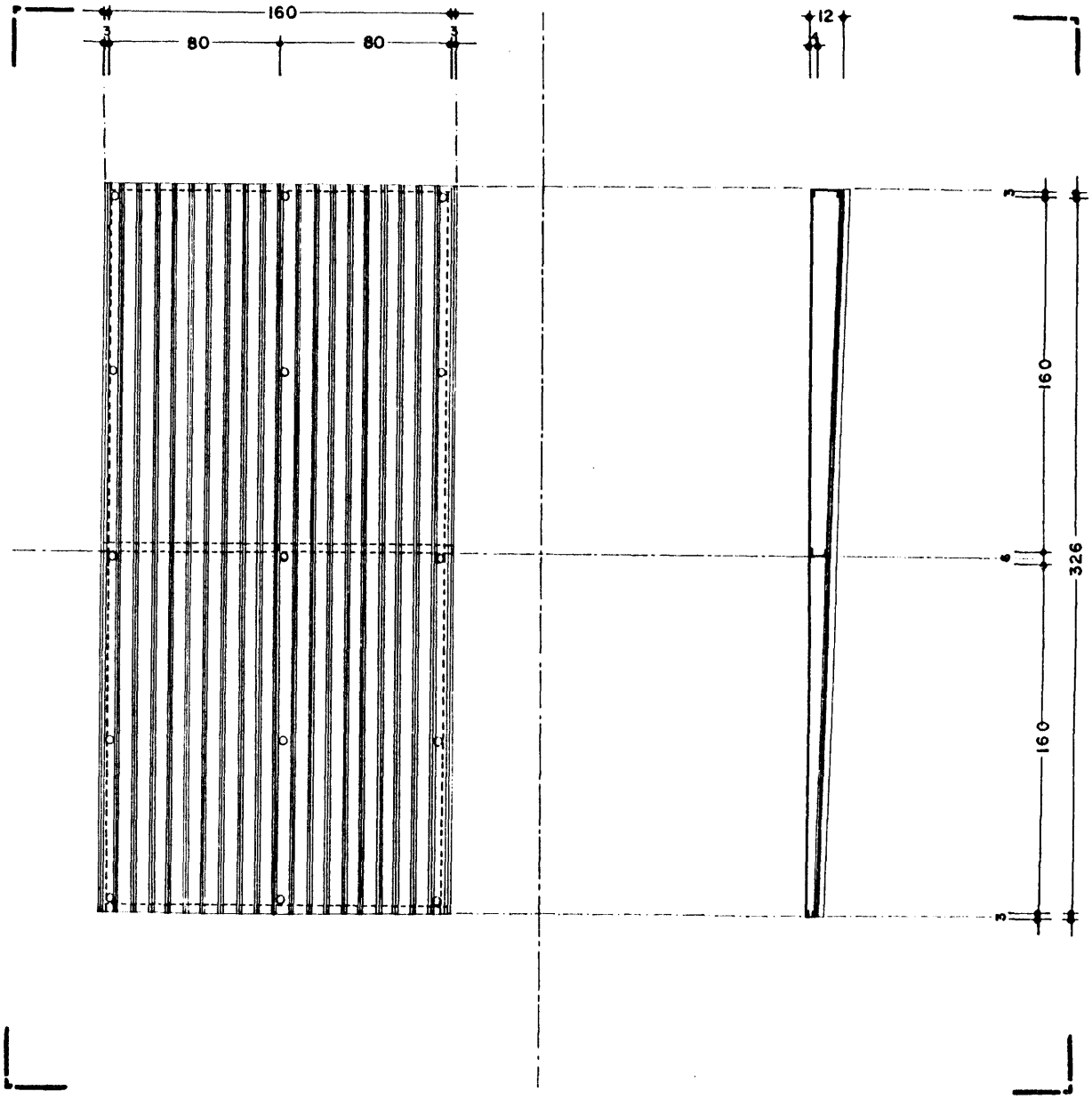
Wall panels are formed by steel members made out thin metal sheets. Horizontal members are U shaped and have 8 cm circular voids each 4cm. Vertical lateral members are shaped for wall panel connections and modular coordination purposes. A central U shaped vertical member is proposed in the middle of the panel to give rigidity and support to the structure.





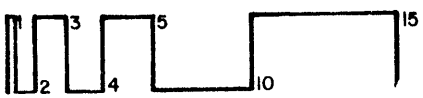
ROOF PANEL

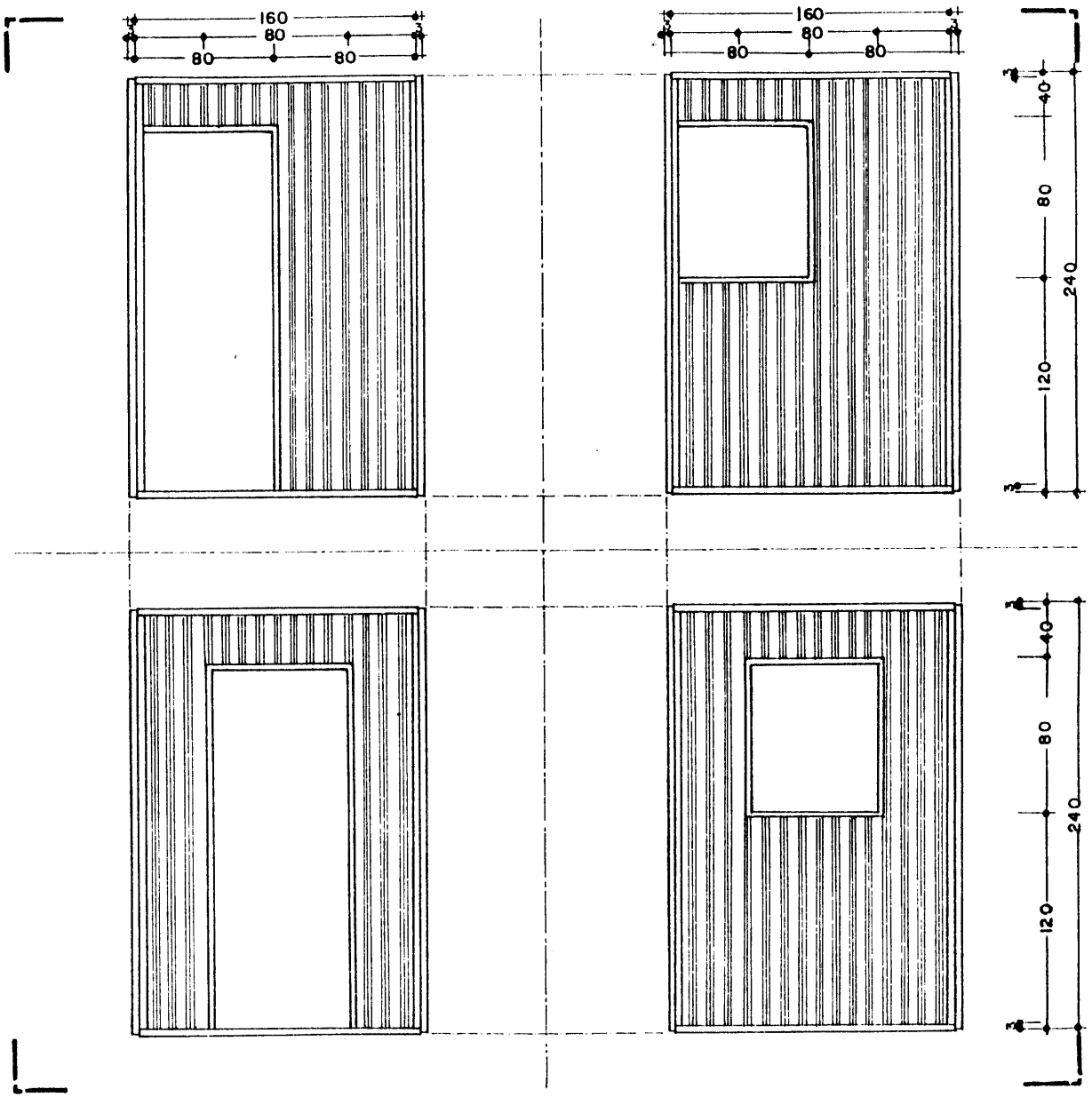
Roof panels are formed by to main U sloped thin metal members which works as the main beams. Tranversal U shaped thin steel members are connected the to sloped members. Corrugated sheets are welded or connected by drive screws on top of the frame.



TYPICAL OPENINGS

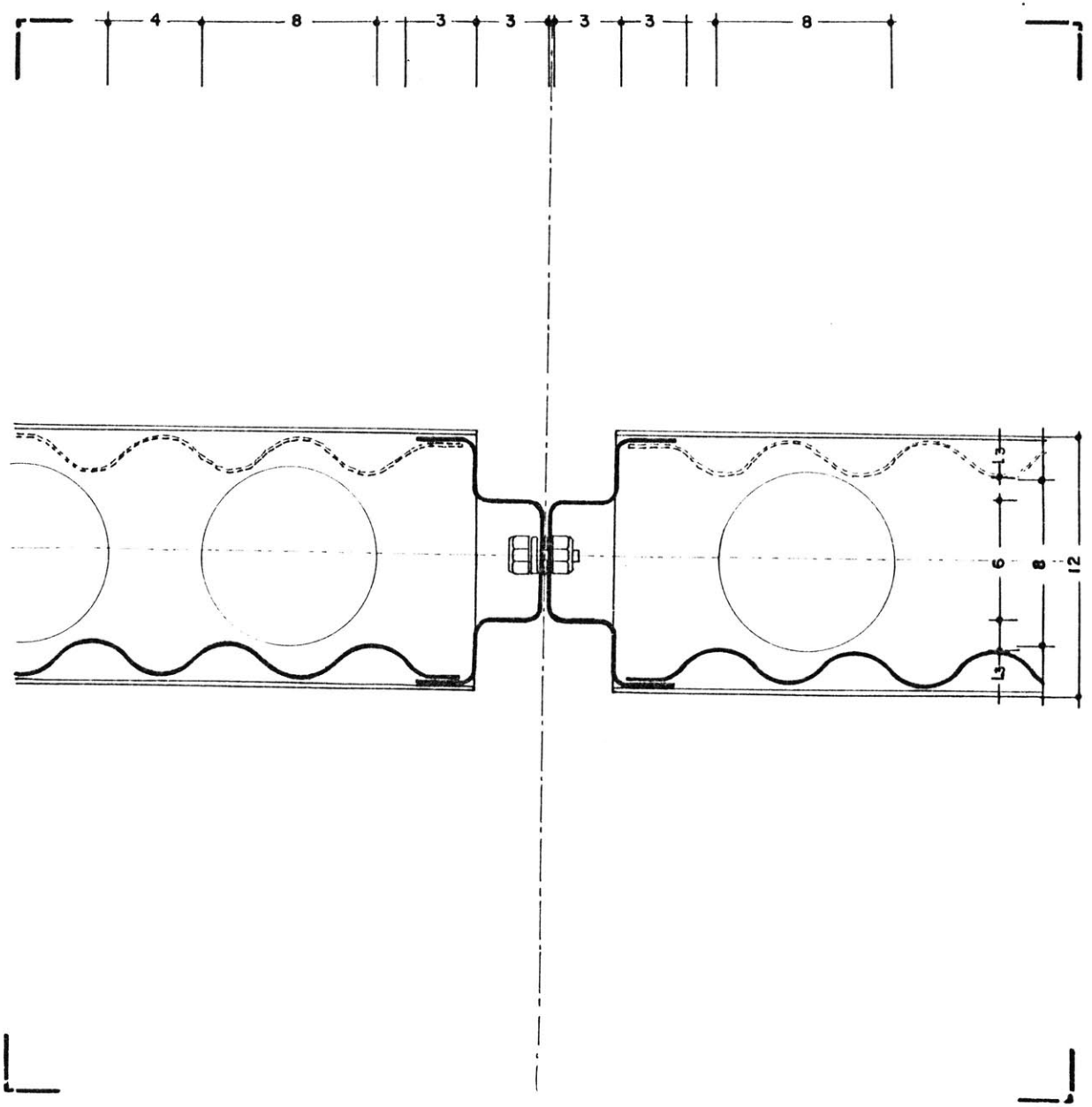
Doors and windows can be placed at the edge or in the center of the panel. In the first case, only one corrugated sheet needs to be cut to fit the openinng. In the second case, the central vertical frame member needs to be interrupted or eliminated in order to fit the opening.

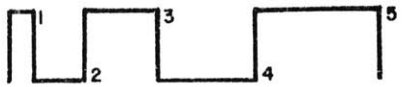




TWO PANEL JOINT (A)

Wall panels are bolted together along the vertical steel frame members. When tolerances or friction requieres bearing pads can be placed between frames.





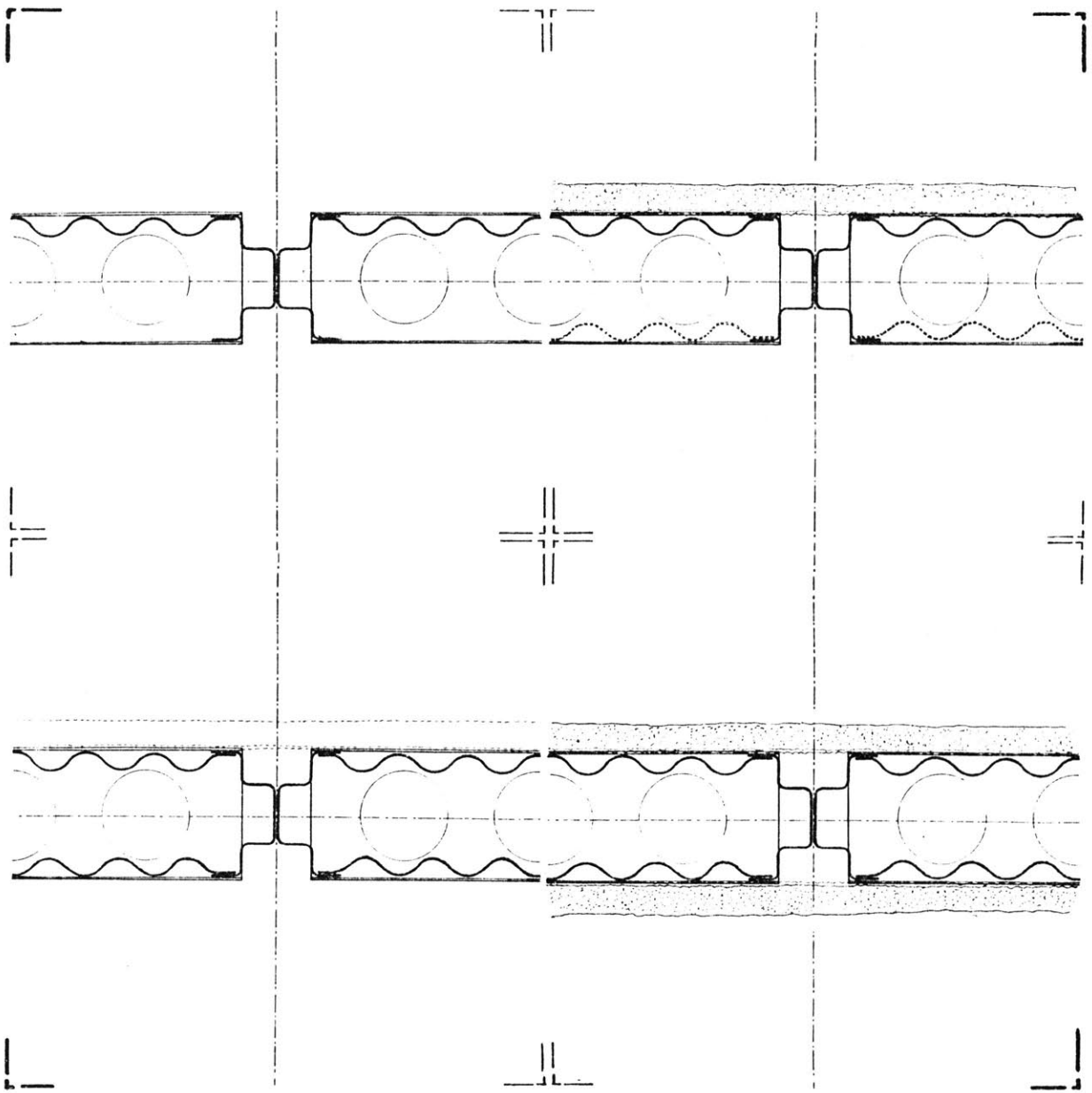
TWO WALL PANEL JOINT
TYPICAL STAGES

A- Inital Stage

B- Metal mesh is placed on top of the corrugated metal sheet and plaster is used to finished the exterior surface.

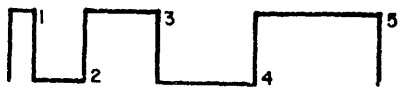
C- Two layer corrugated metal sheets. Finishing can happen in one of the two sides of the panel,exterior or interior.

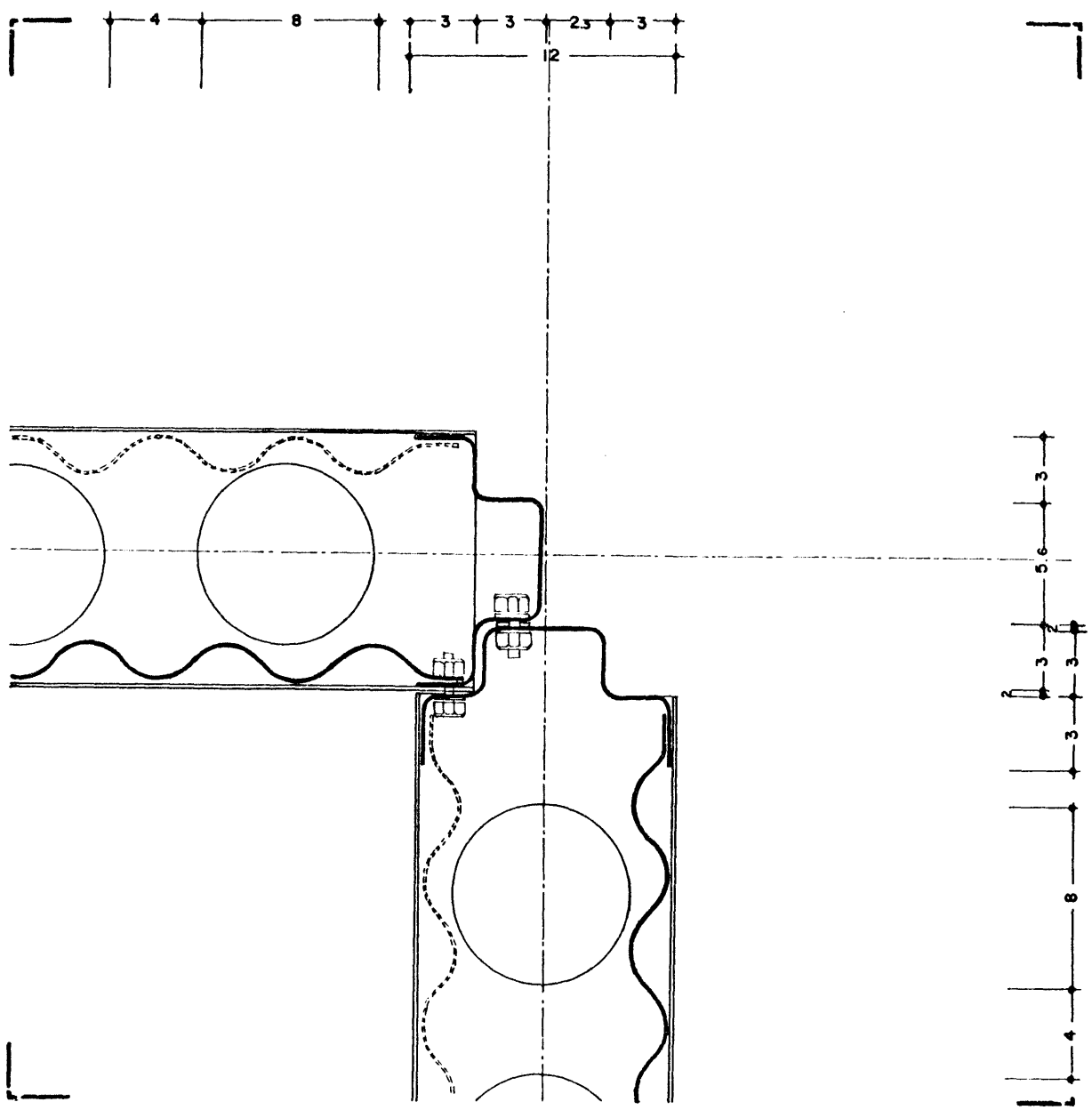
D- Two layer corrugated metal sheets finished on both sides.



CORNER PANEL JOINT (B)

Wall panels are bolted together along the vertical steel frame members. When tolerances or friction requieres bearing pads can be placed between frames.





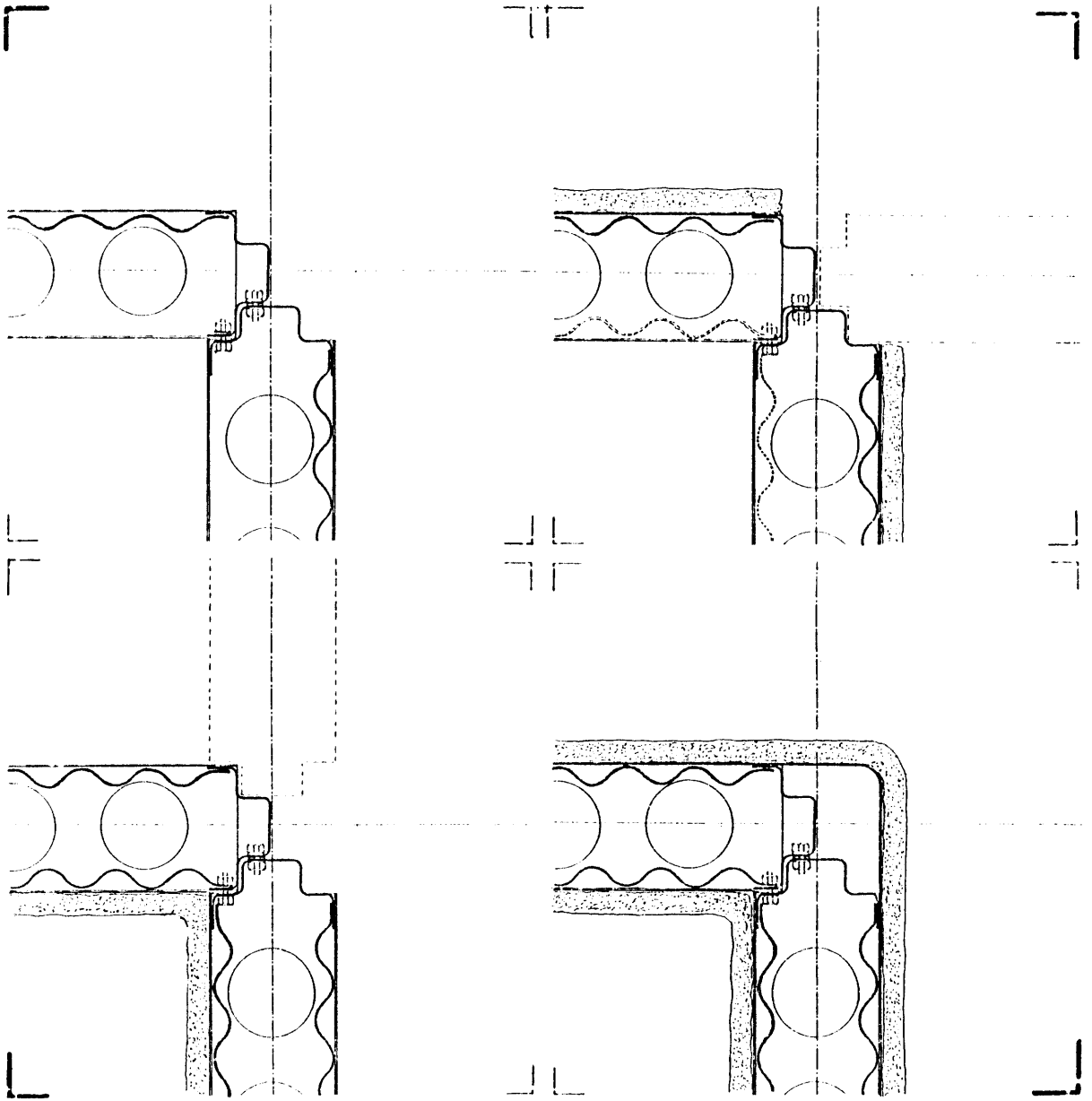
CORNER WALL PANEL JOINT TYPICAL STAGES

A- Inital Stage

B- Metal mesh is placed on top of the corrugated metal sheet and plaster is used to finish one side of the surface.

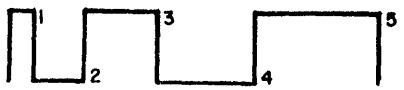
C- Two layer corrugated metal sheets. Finishings in some areas or rooms of the dwelling, exterior or interior.

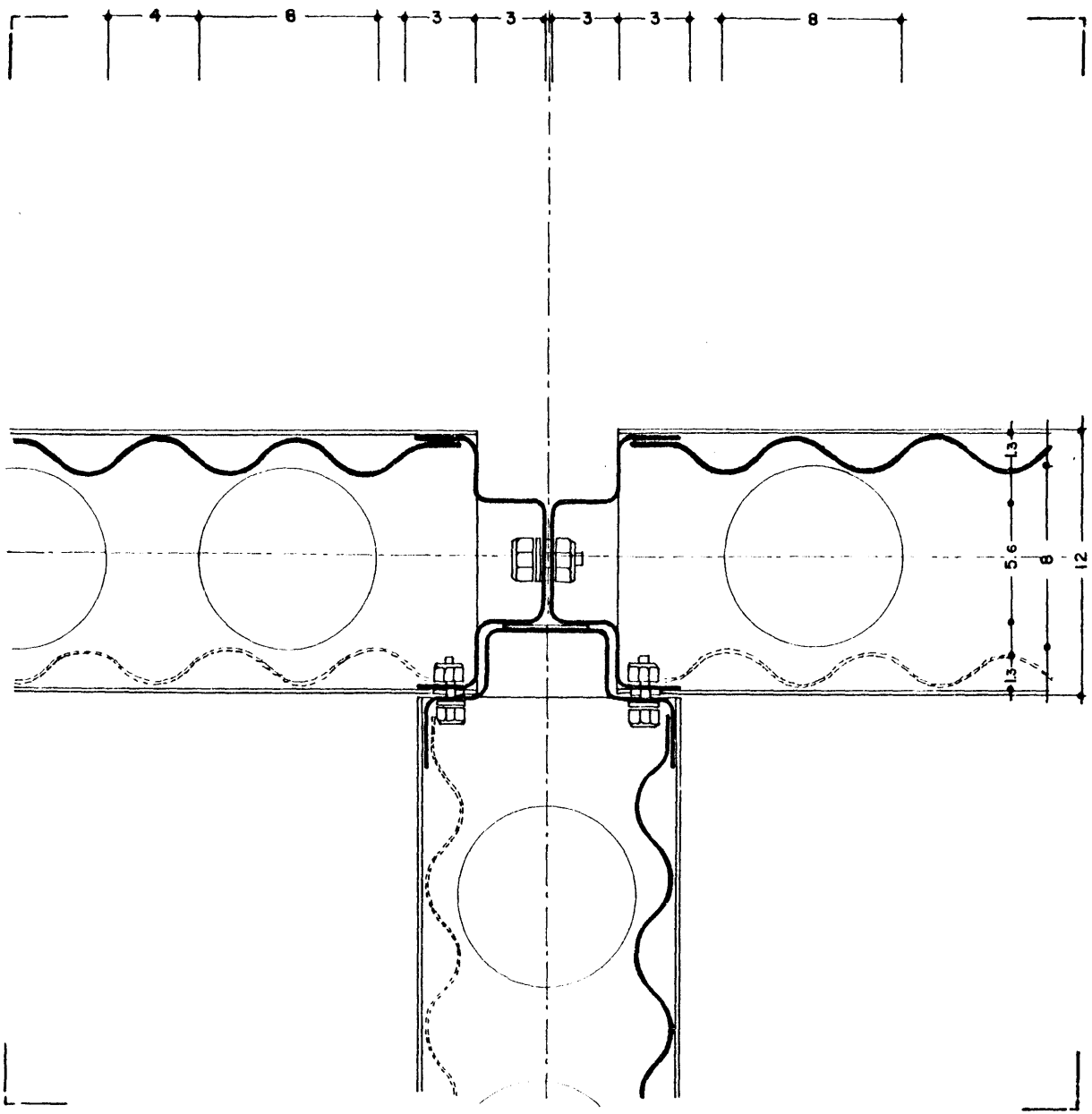
D- Two layer corrugated metal sheets finished on both sides.



THREE PANEL JOINT (C)

Wall panels are bolted together along the vertical steel frame members. When tolerances or friction requieres bearing pads can be placed between frames.





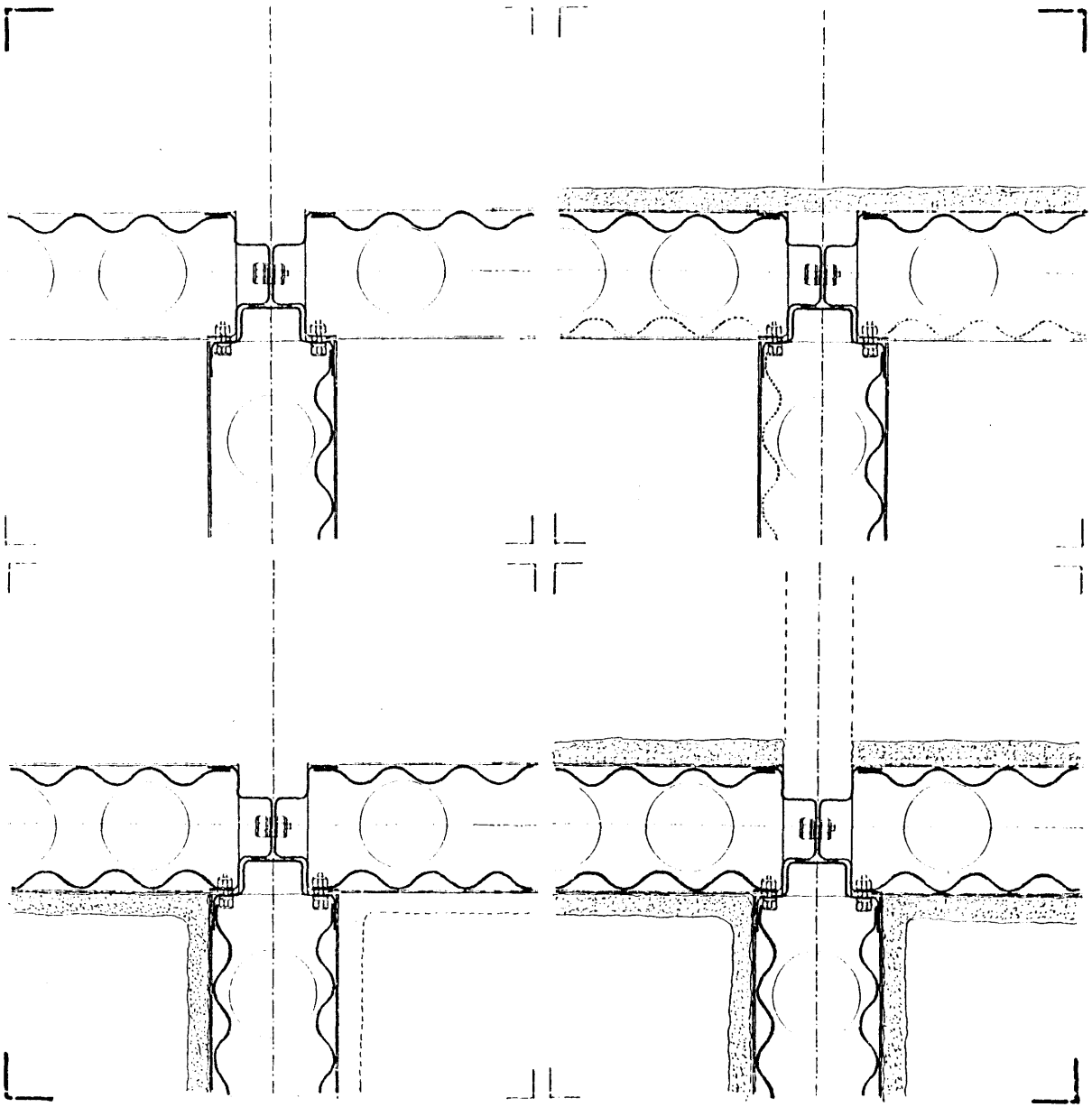
THREE WALL PANEL JOINT TYPICAL STAGES

A- Inital Stage

B- Metal mesh is placed on top of the corrugated metal sheet and plaster is used to finish one side of the surface.

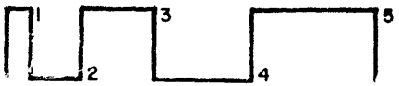
C- Two layer corrugated metal sheets. Finishings in some areas or rooms of the dwelling.

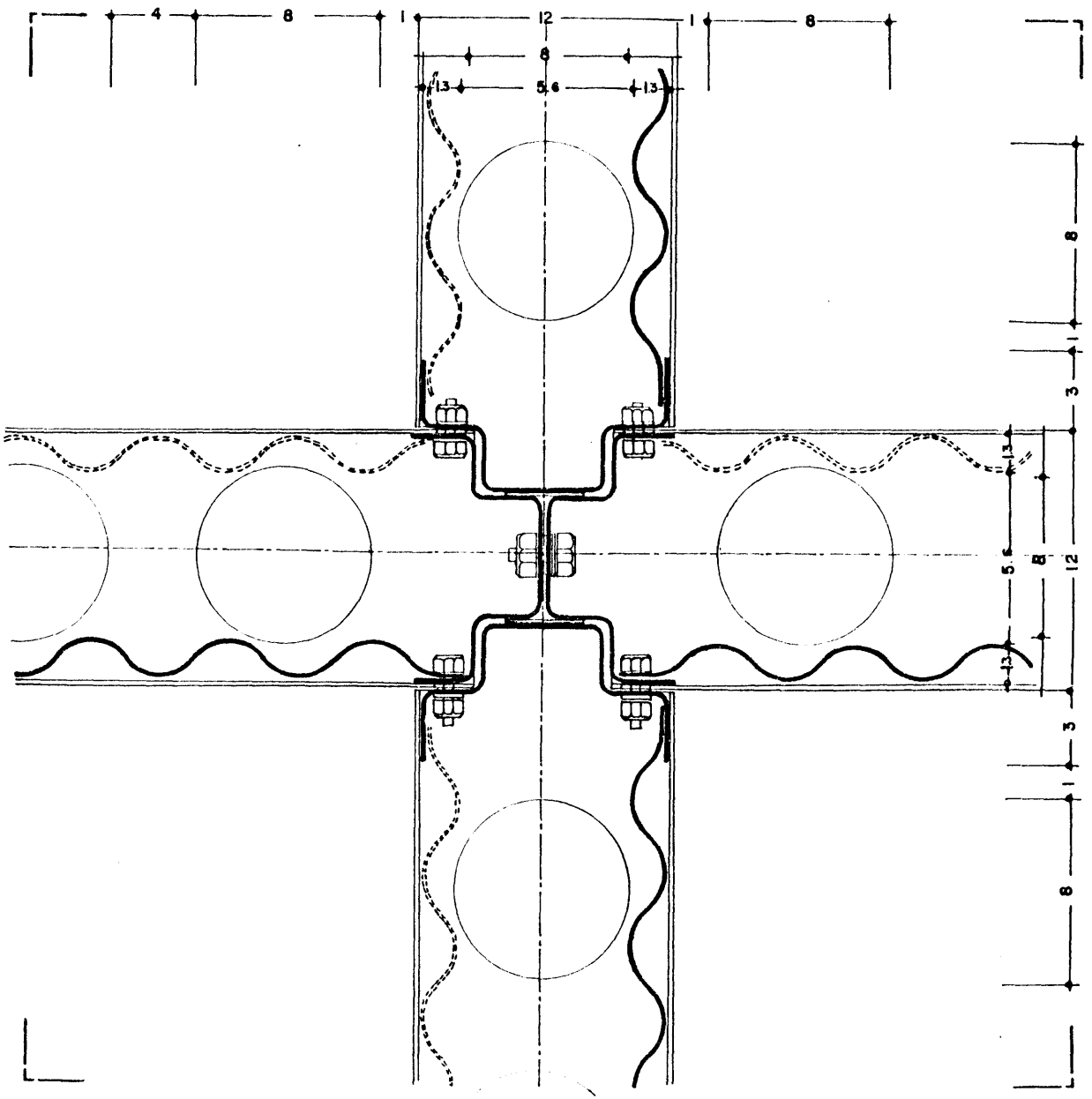
D- Two layer corrugated metal sheets finished on both sides.



FOUR PANEL JOINT (D)

Wall panels are bolted together along the vertical steel frame members. When tolerances or friction requieres bearing pads can be placed between frames.





FOUR WALL PANEL JOINT TYPICAL STAGES

A- Inital Stage.

B- Metal mesh is placed on top of the corrugated metal sheet and plaster is used to finish one side of the surface.

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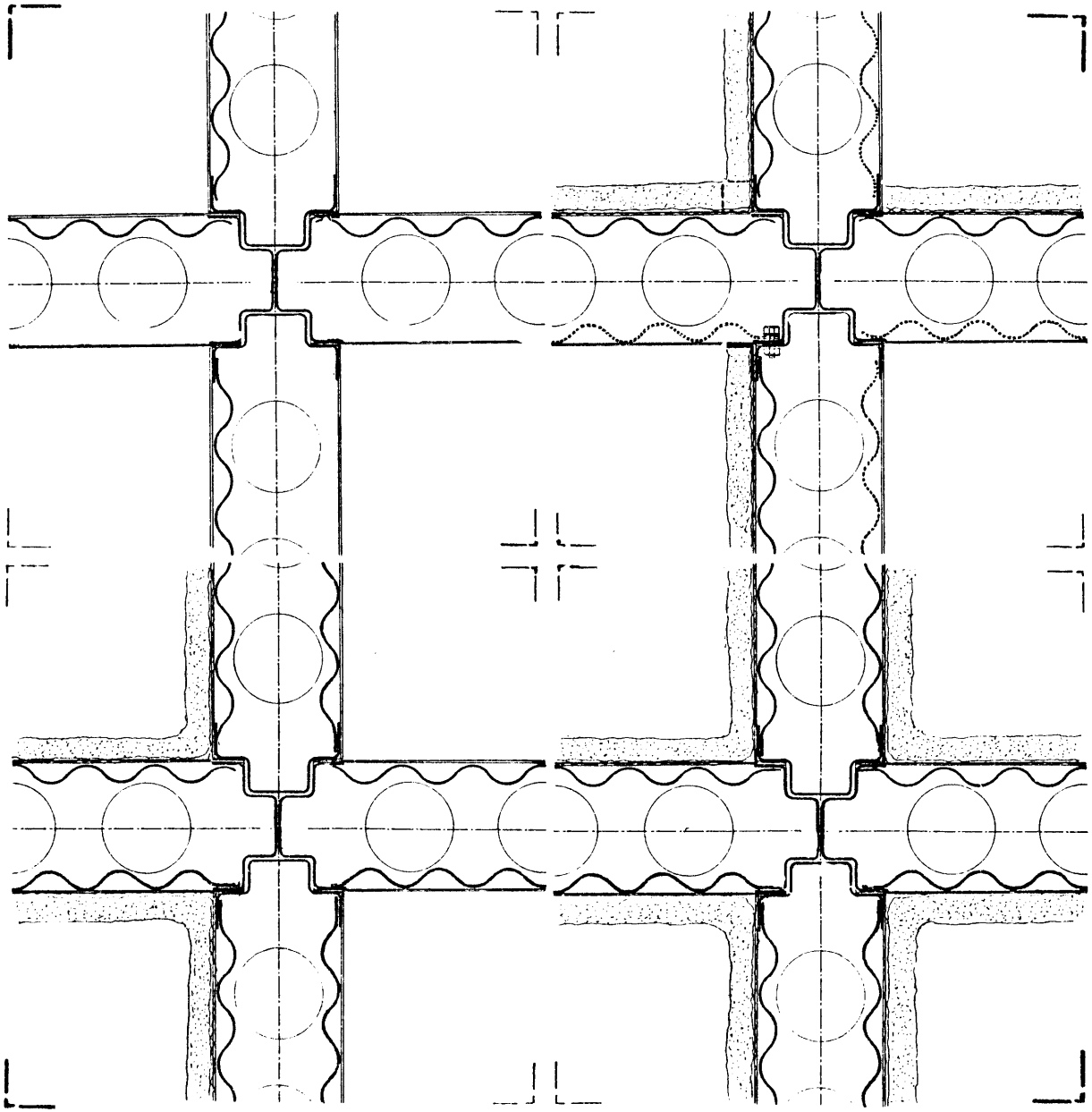
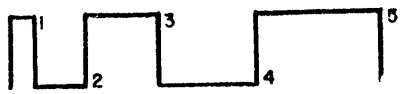
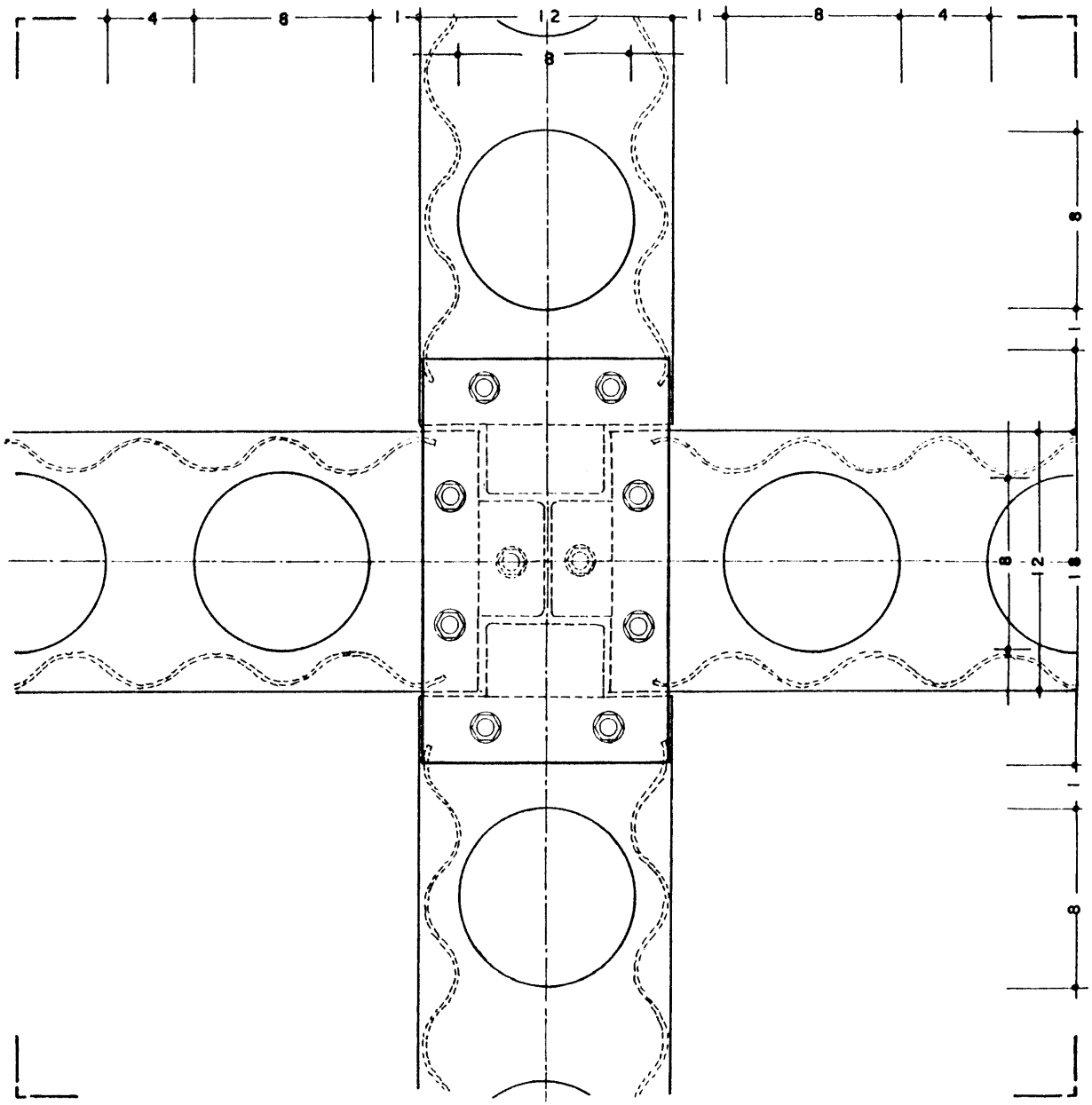
D- Two layer corrugated metal sheets finished on both sides.



WALL PANEL -
STEEL PLATE CONNECTION

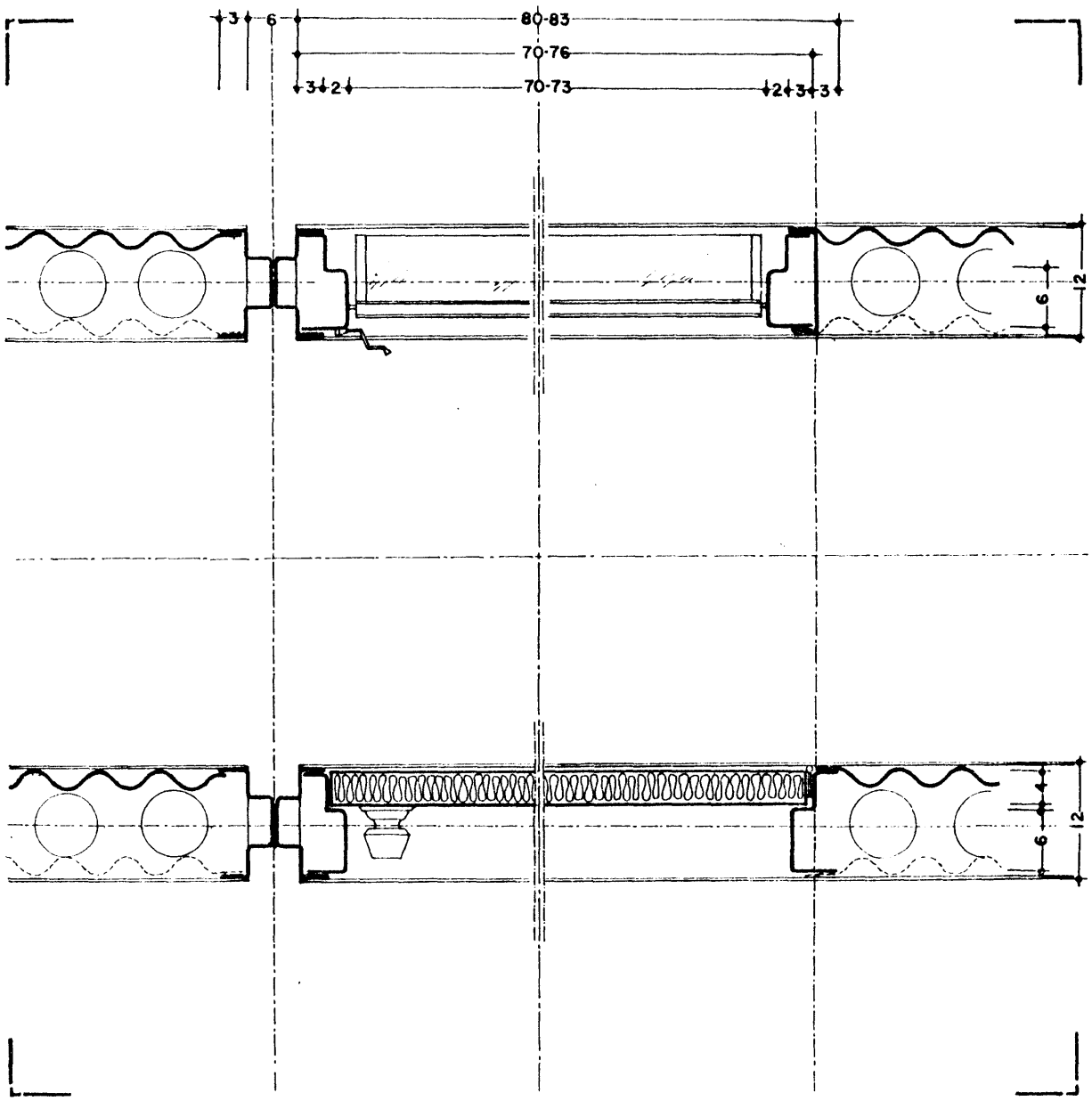
The steel plate is bolted to the wall frames giving rigidity to the joint. The roof panel is also bolted to the center of the steel plate.





OPENINGS (E AND F)

This case shows when openings are at the edge of the panel. The vertical frame members allow to insert the door or window frames. The right side of the detail (where the middle vertical frame member is located) can be displaced depending on the dimmensions of the opening choosed.

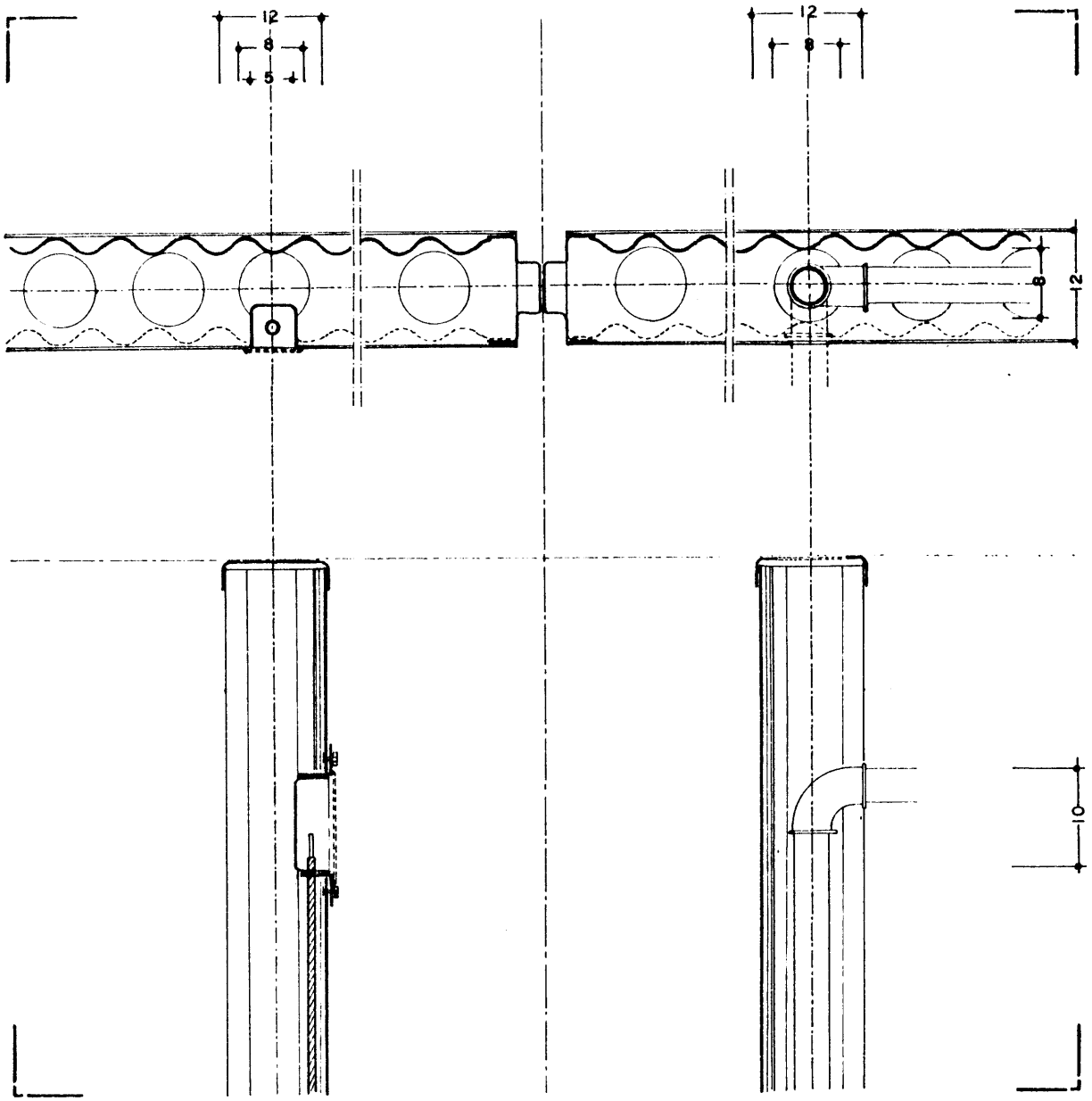


SERVICES

A- Electrical

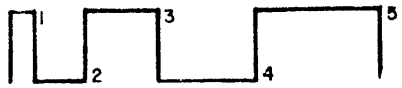
B- Plumbing

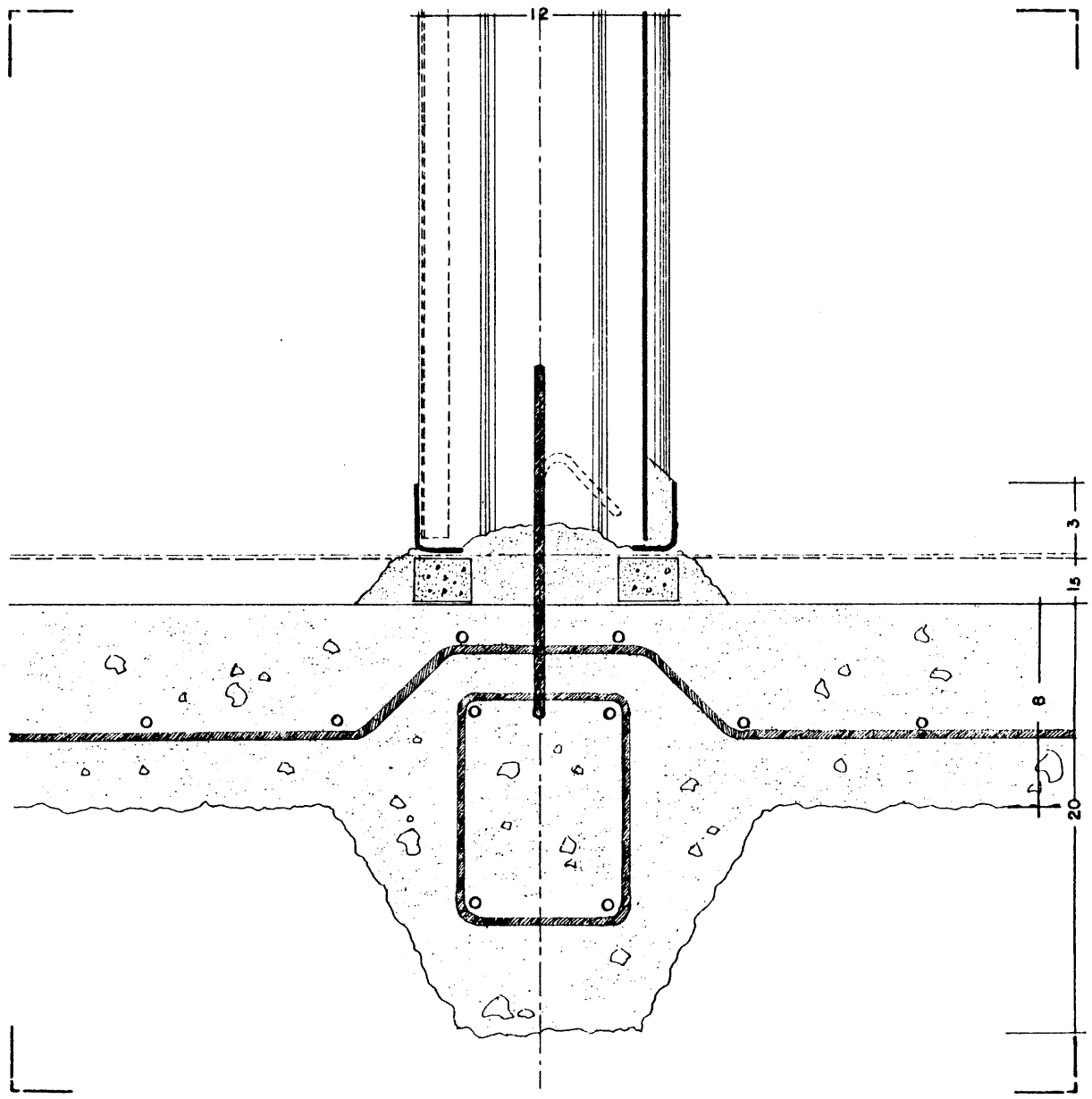
Pipes and electrical wiring are connected from the main supply through the circular voids on the horizontal members of the panels. Both types of services run along and inside the panel. Services can be extended to upper levels going through the circular voids on top of the horizontal frame member.



WALL PANEL-FLOOR-FOUNDATION CONNECTION

Vertical reinforcement connects the foundation with the wall panel. The reinforcement goes through the circular voids in the horizontal frame members and then is bended locking the movement of the wall panel. The panel is placed on top of concrete shimps and to a plaster mix to give horizontality to the system. Plaster is poured between the horizontal bottom frame member and the exterior corrugated sheets to avoid water inflitration.





WALL PANEL - FOUNDATION TYPICAL STAGES

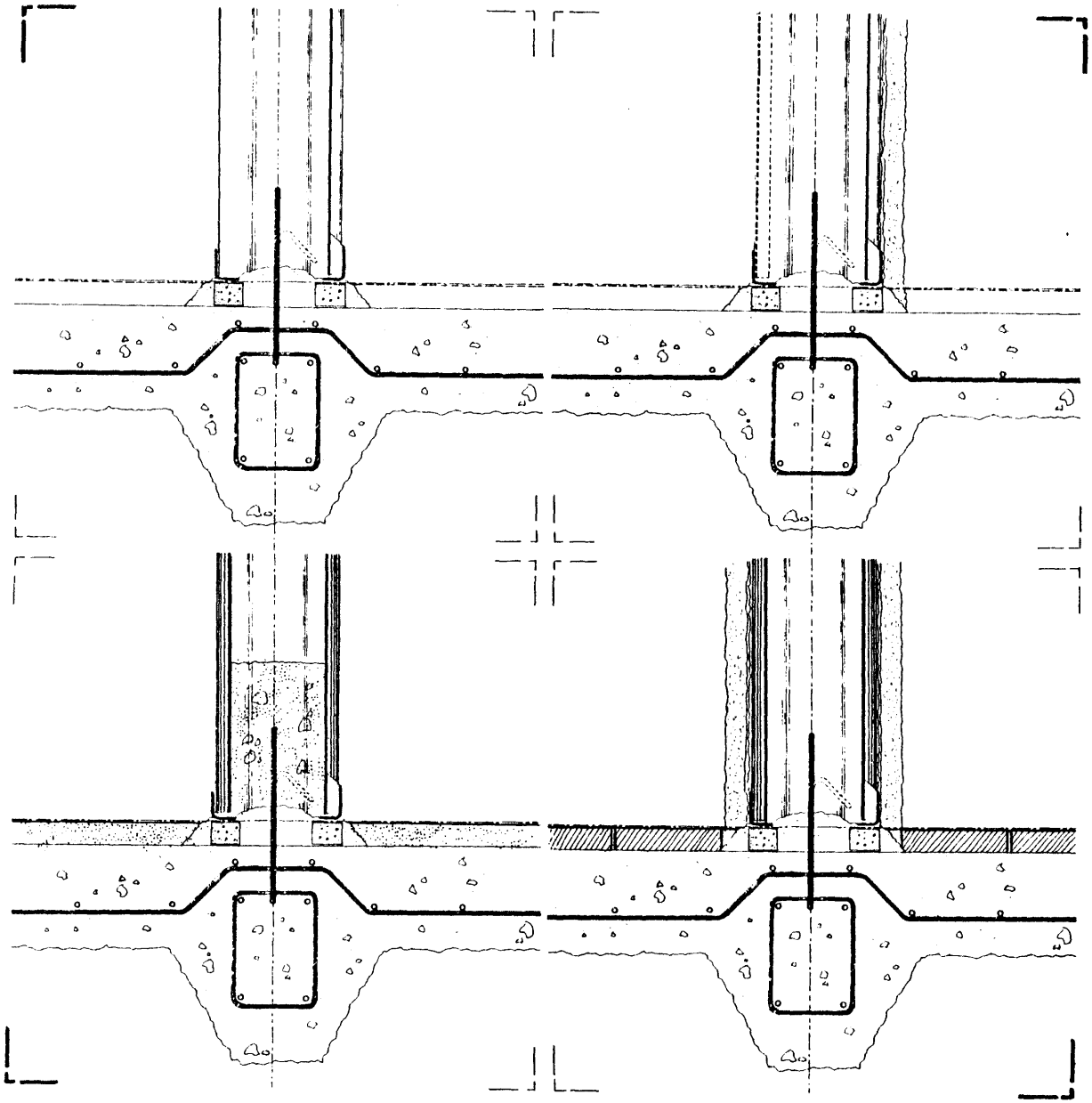
A- Inital Stage

B- Metal mesh is placed on top of the corrugated metal sheet and plaster is used to finished the surface.

C- Two layer corrugated metal sheets. A certain amount of concrete is poured to seal the wall-floor connection.

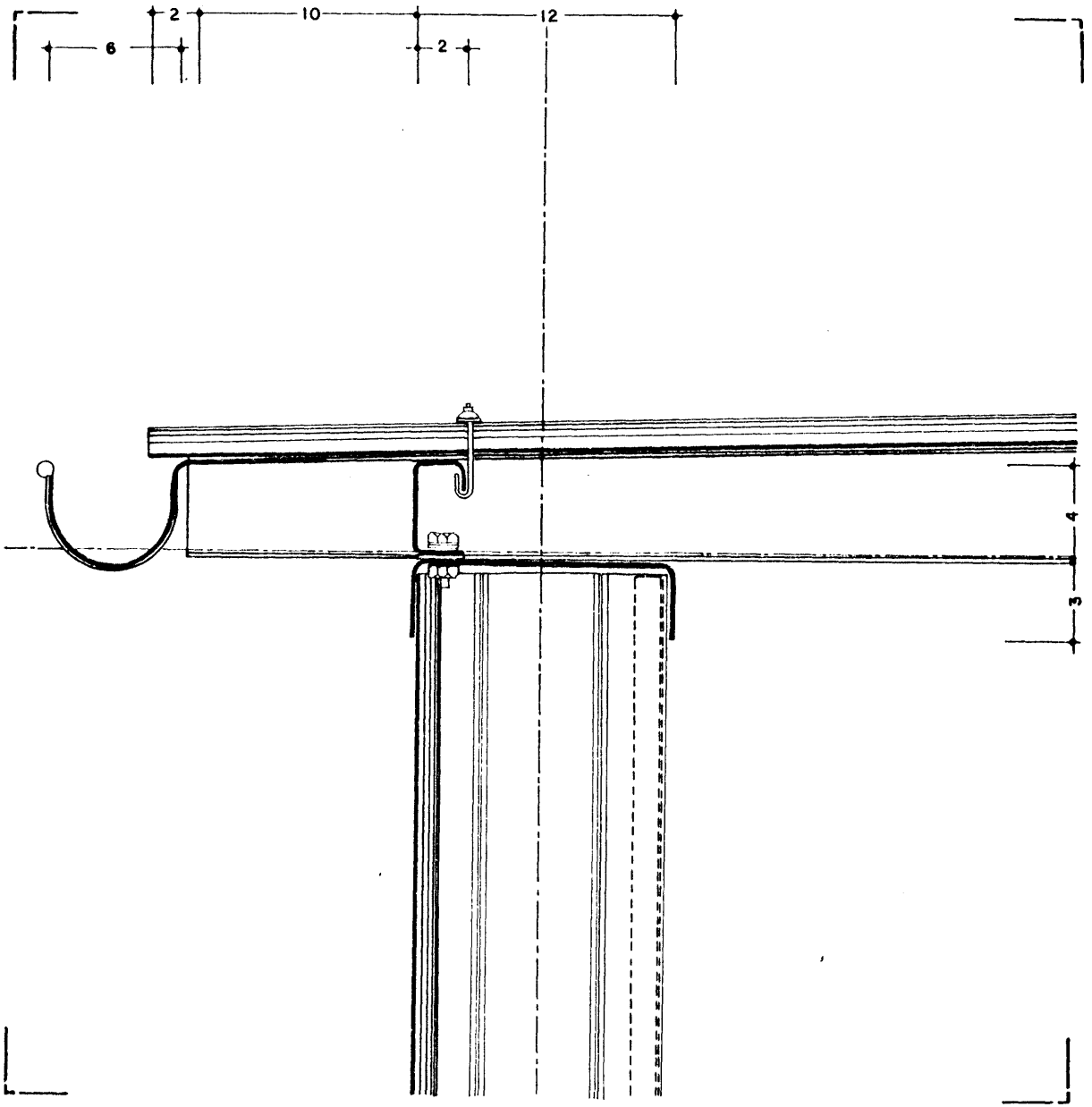
D- Two layer corrugated metal sheets finished on both sides. Tiles or other floor finishing is placed on top of the concrete slab.

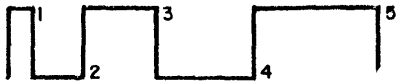
E- Concrete is poured between corrugated sheets when vertical expansion occurs.



WALL PANEL-
ROOF PANEL CONNECTION (BB)
(NARROW ROOF FRAME END)

This detail shows the case where the roof is in cantiliver. The sloped roof members are extended over the edge of the building. Corrugated sheets are extended over the sloped frame members and over the gutter. The gutter is connected to the sheeting by drive screws through the crown of the corrugation. The gutter prevents the corrugated sheets of bending and damaging.





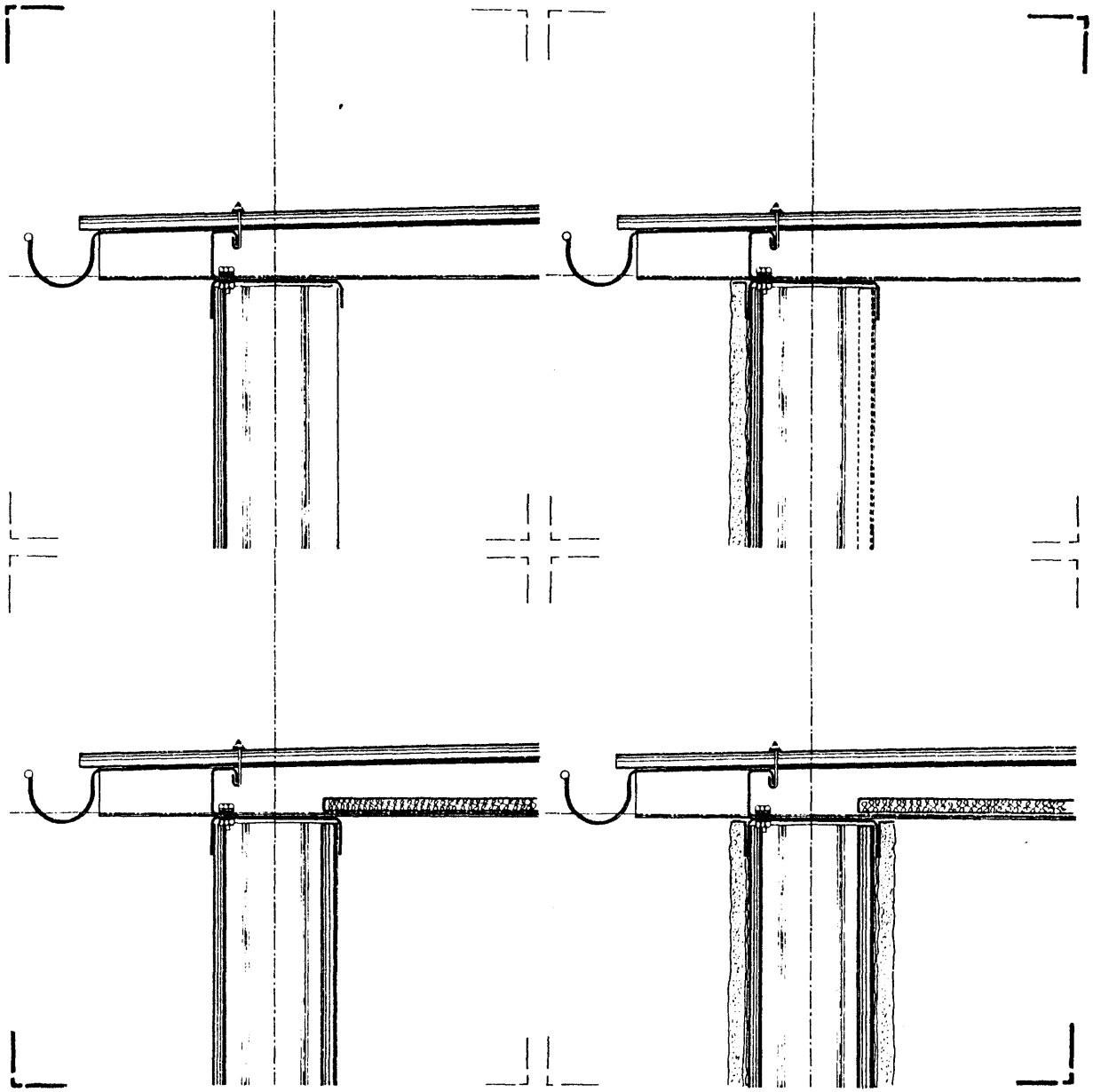
WALL PANEL - ROOF PANEL (NARROW END) TYPICAL STAGES

A- Initial Stage.

B- Finishings on the exterior surface. A small steel plate is placed on top of the edge of the surface to be finished.

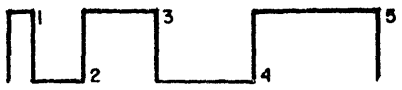
C- Two corrugated metal sheet. Insulation panels are placed between tranversal roof frame members.

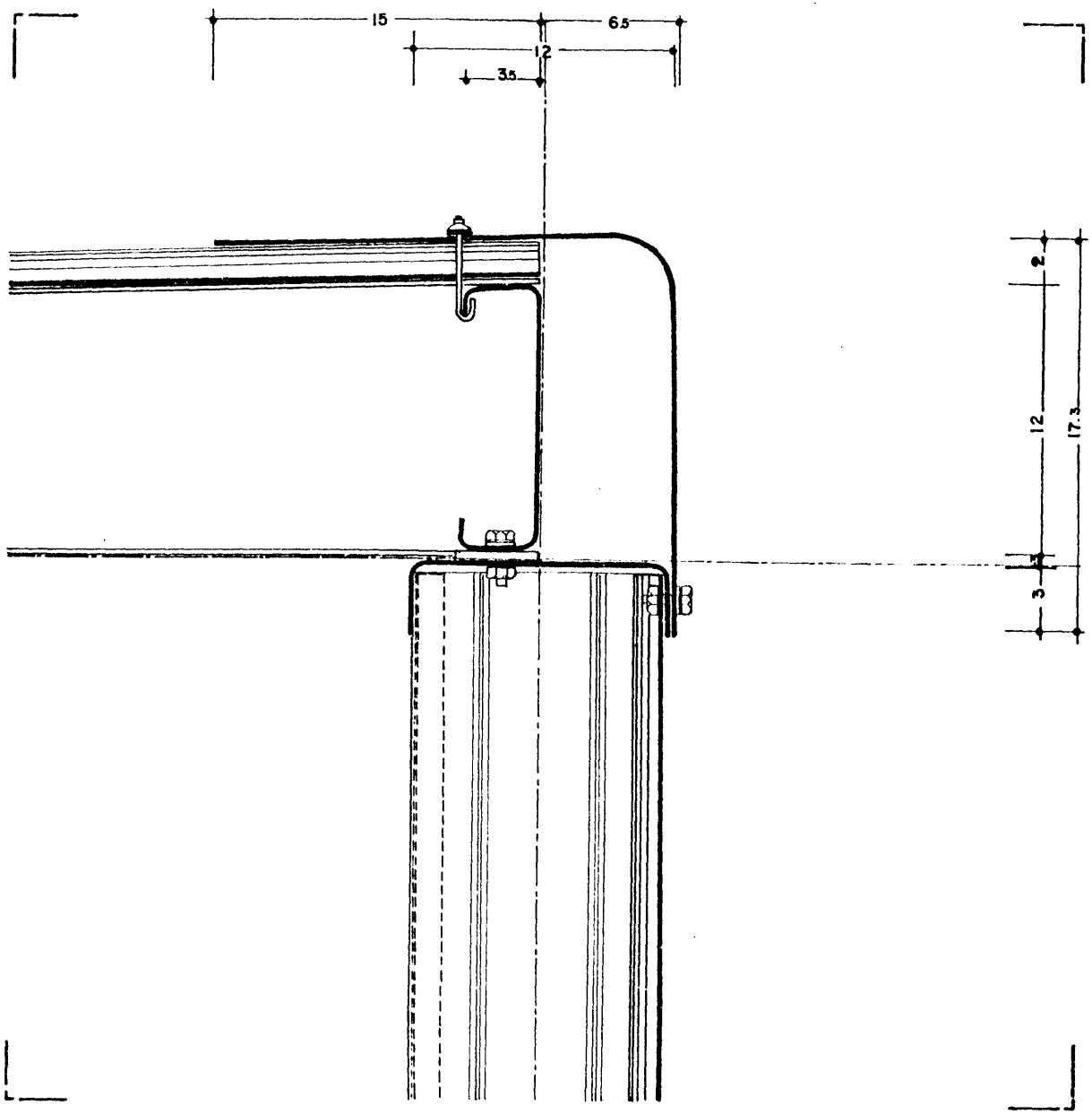
D- Finishings on both sides of the corrugated panel. Insulation panels are placed between tranversal roof frame members.



WALL PANEL-
ROOF PANEL CONNECTION (CC)
(WIDE ROOF FRAME END)

In this case the wide end of the roof panel coincide with the panel axis. This allows future horizontal expansion by connecting another roof element to this joint. A corner flashing is fastened to the sheeting by means of drive screws through the crow of the corrugation. The flashing is removable to allow expansions.





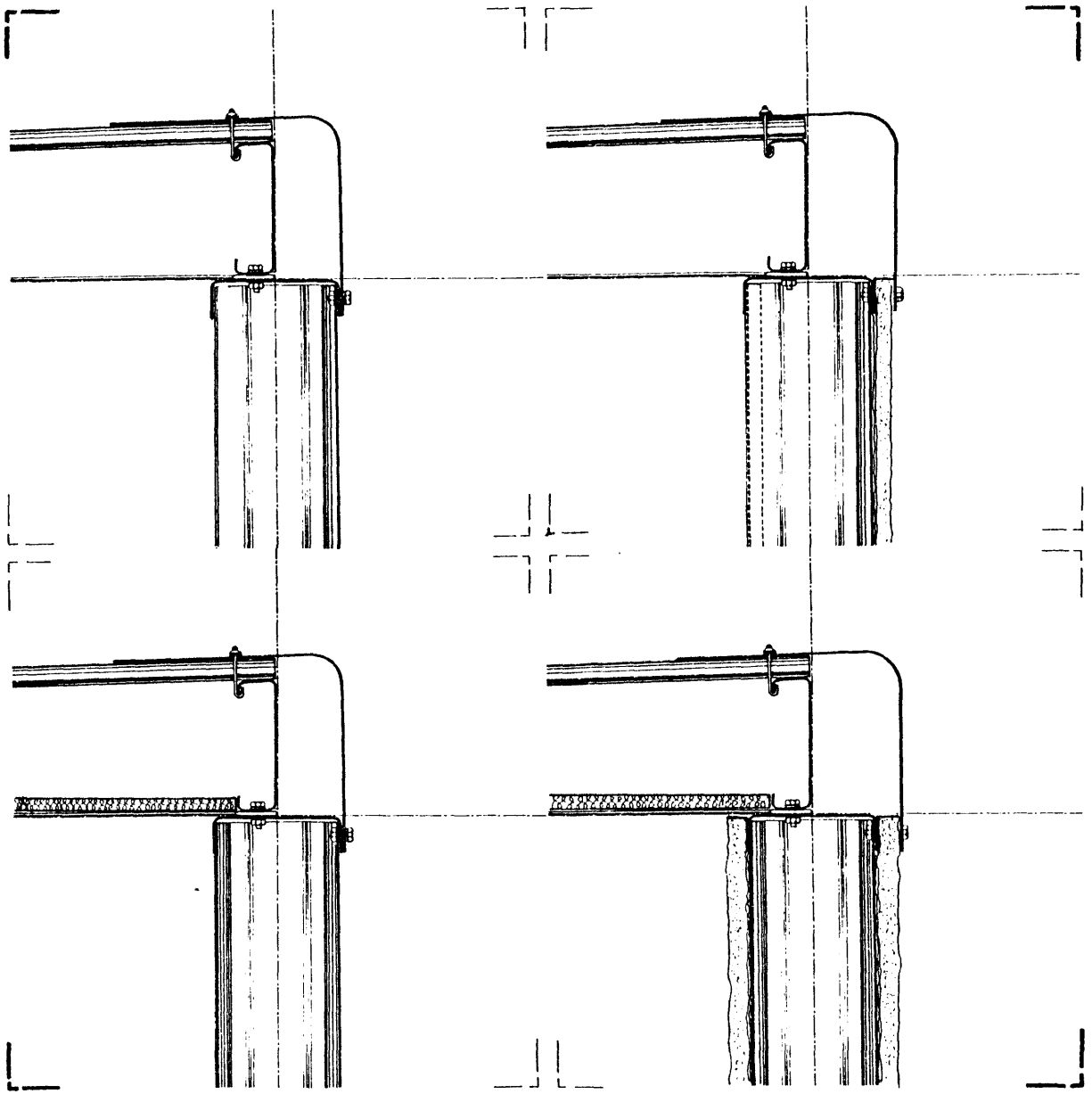
WALL PANEL-ROOF PANEL (WIDE END) TYPICAL STAGES

A- Initial Stage.

B- Finishings on the exterior surface. Corner flashing was removed and replaced after the finishing was applied.

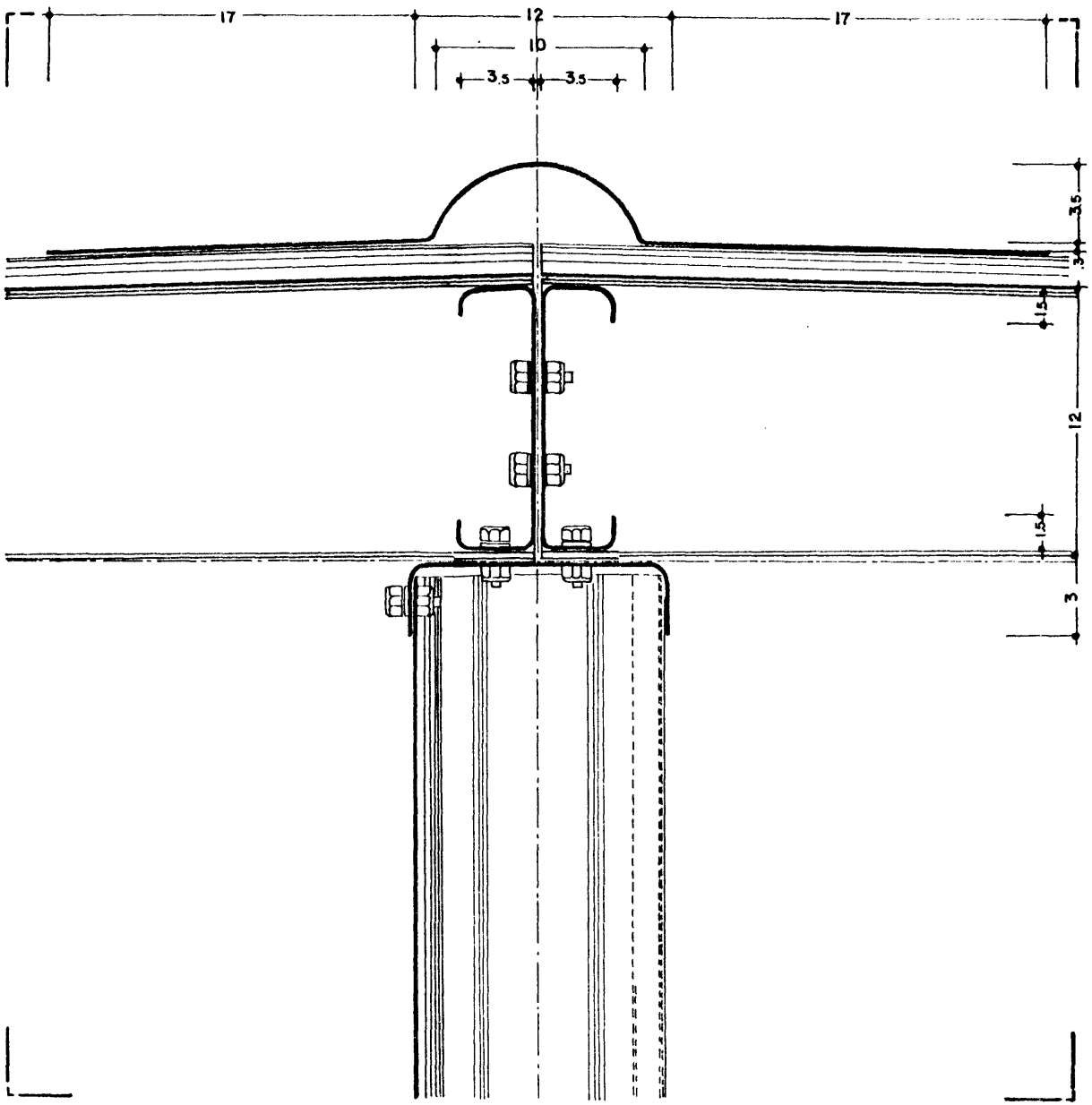
C- Two corrugated metal sheet. Insulation panels are placed between tranversal roof frame members.

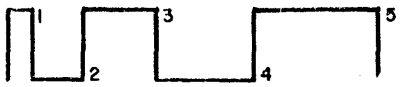
D- Finishings on both sides of the corrugated panel. Insulation panels are placed between tranversal roof frame members.



WALL PANEL-
TWO ROOF PANELS
RIDGE CONNECTION (DD)

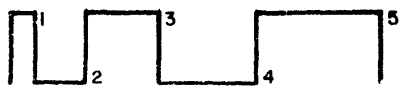
roof panels are bolted to the wall panel and betweem themselves. The joint at the ridge between the two sloped roof panels is made with a cover flashing with an overlap over 23 cm. On both sides the flashing is fixed with drive screws.

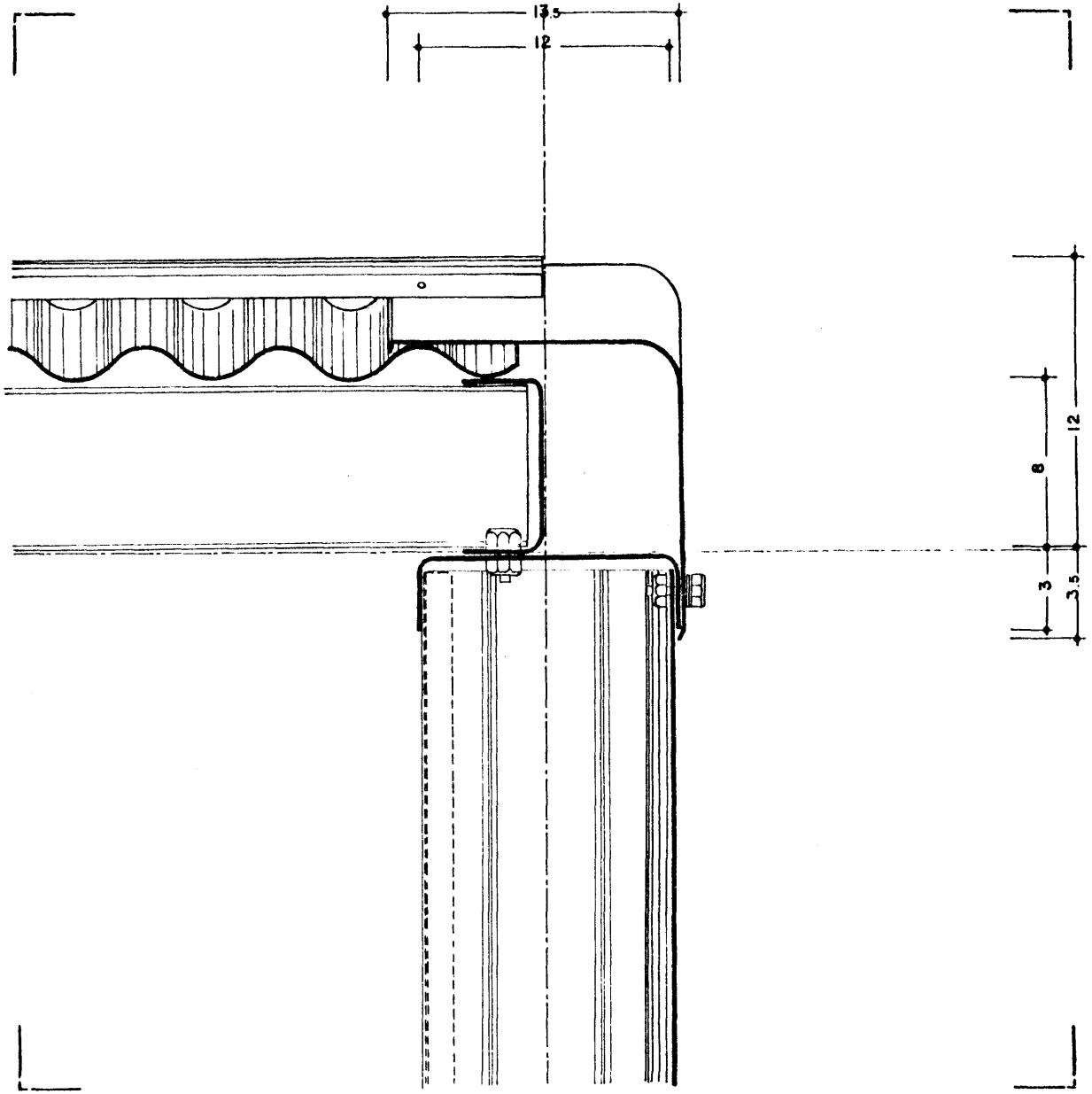




WALL PANEL- ROOF PANEL (LONGITUDINAL SECTION AT END OF THE BUILDING) (EE)

The roof frame is bolted to the wall panel. A corner flashing is fastened, together with the sheeting, by means of drive screws through the crown of the corrugation. This corner flashing is removable when a finishing is going to be applied to the sheeting surface or when the dwelling is going to be expanded.





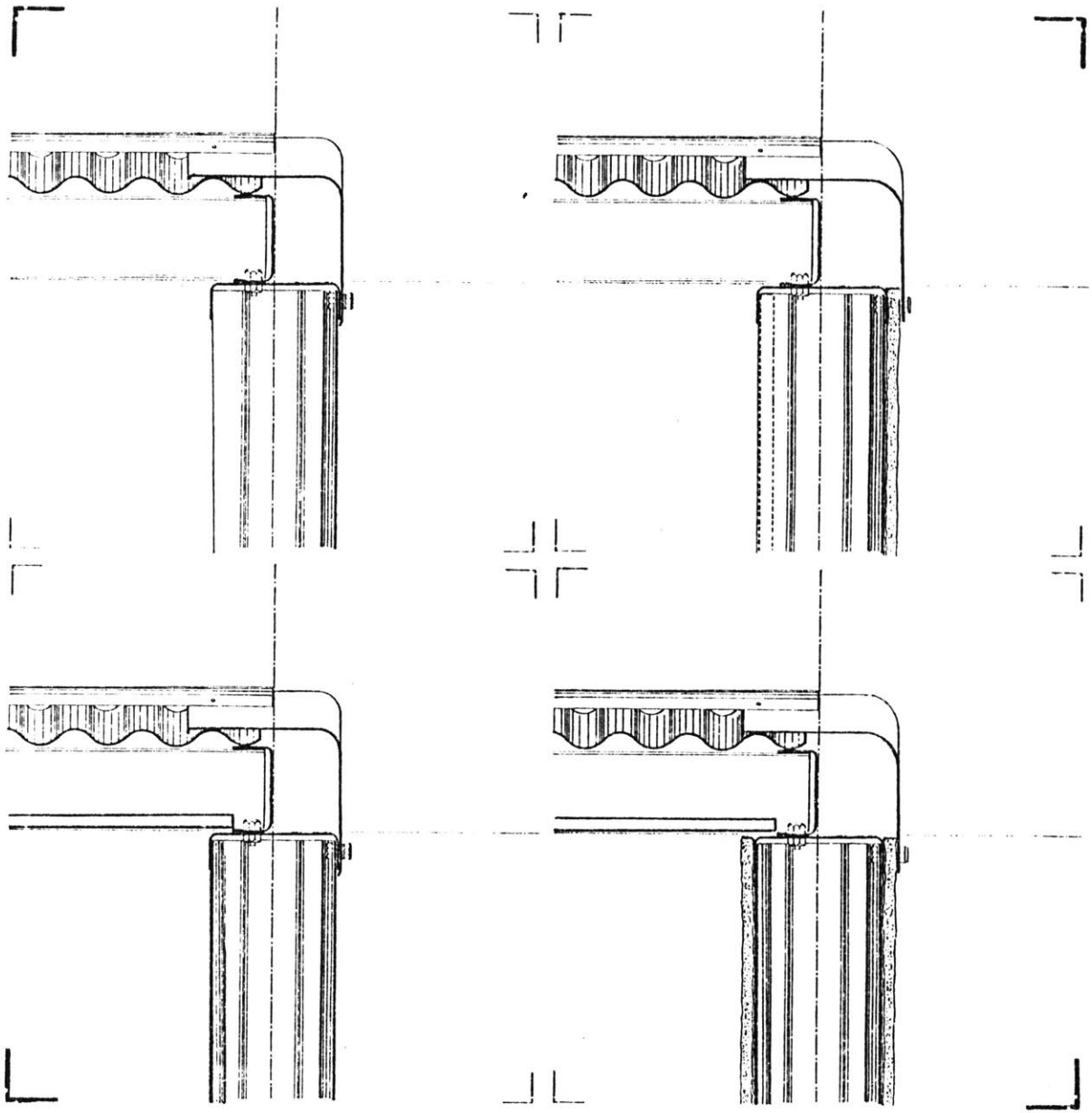
WALL PANEL- ROOF PANEL (LONGITUDINAL SECTION AT END OF THE BUILDING) (EE) TYPICAL STAGES

A- Initial Stage.

B- Finishings on the exterior surface. Corner flashing was removed and replaced after the finishing was applied.

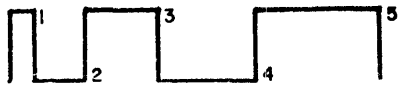
C- Two corrugated metal sheet. Insulation panels are placed between tranversal roof frame members.

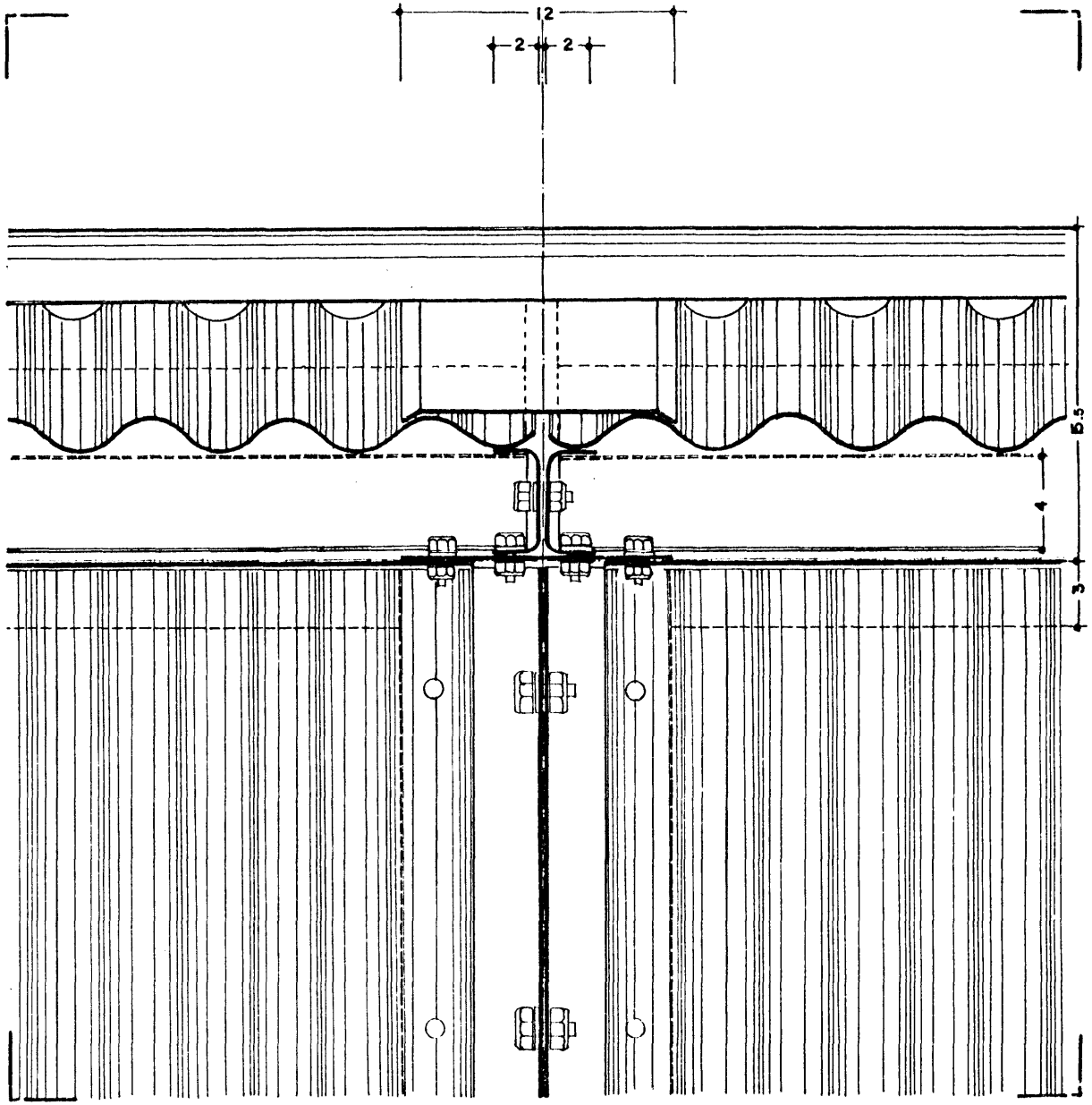
D- Finishings on both sides of the corrugated panel. Insulation panels are placed between tranversal roof frame members.



TWO WALL PANEL -
STEEL PLATE -
TWO ROOF PANELS
(ONNECTION
LONGITUDINAL SECTION
THROUGH
THE MIDDLE OF THE PANEL)

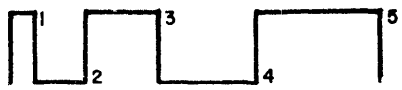
Wall panels are bolted together along the vertical frame members. A steel plate is placed on top on the joint to give more rigidity to the connection. Roof panels are bolted to the steel plate and between themselves. A cover flashing covers the end of both roofpanels at the place where they are connected. The flashing is fixed at the top of each sheeting with driver screws.

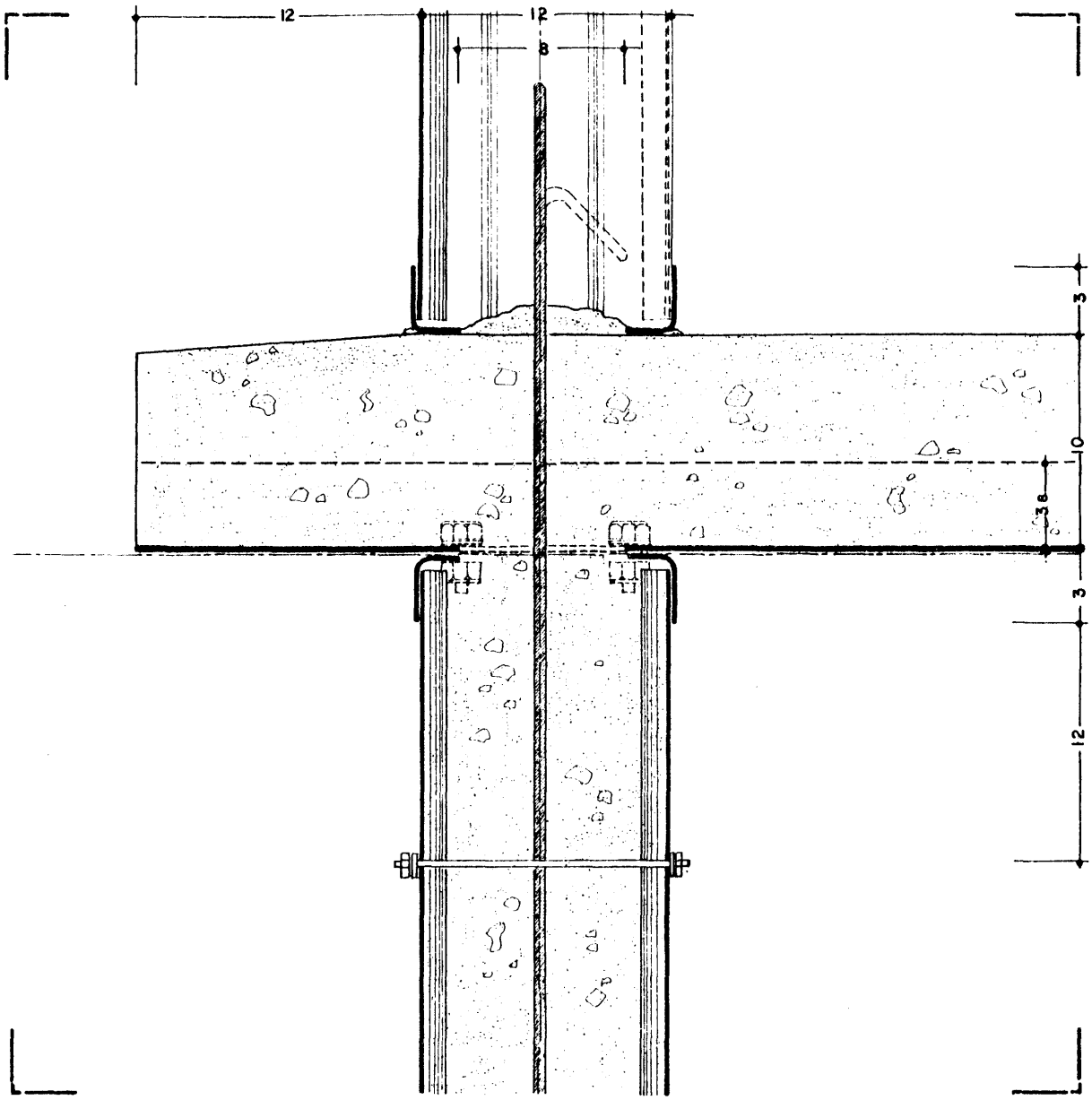




INTERMIDIATE FLOOR-WALL PANEL CONNECTION

In the lower level wall panel, corrugated metal sheets are tied with a long steel bolt. This bolt will prevent the sheeting to separate when the concrete is poured betweem them. The metal deck is bolted to the lower level wall frame and the reinforcement (which protudes from the lower level wall panel) go through the metal deck and the concrete floor to the upper level wall panel. This reinforcement once the floor is casted and the upper level wall panel is placed gives continuity to the structure and lock the upper level wall panel.





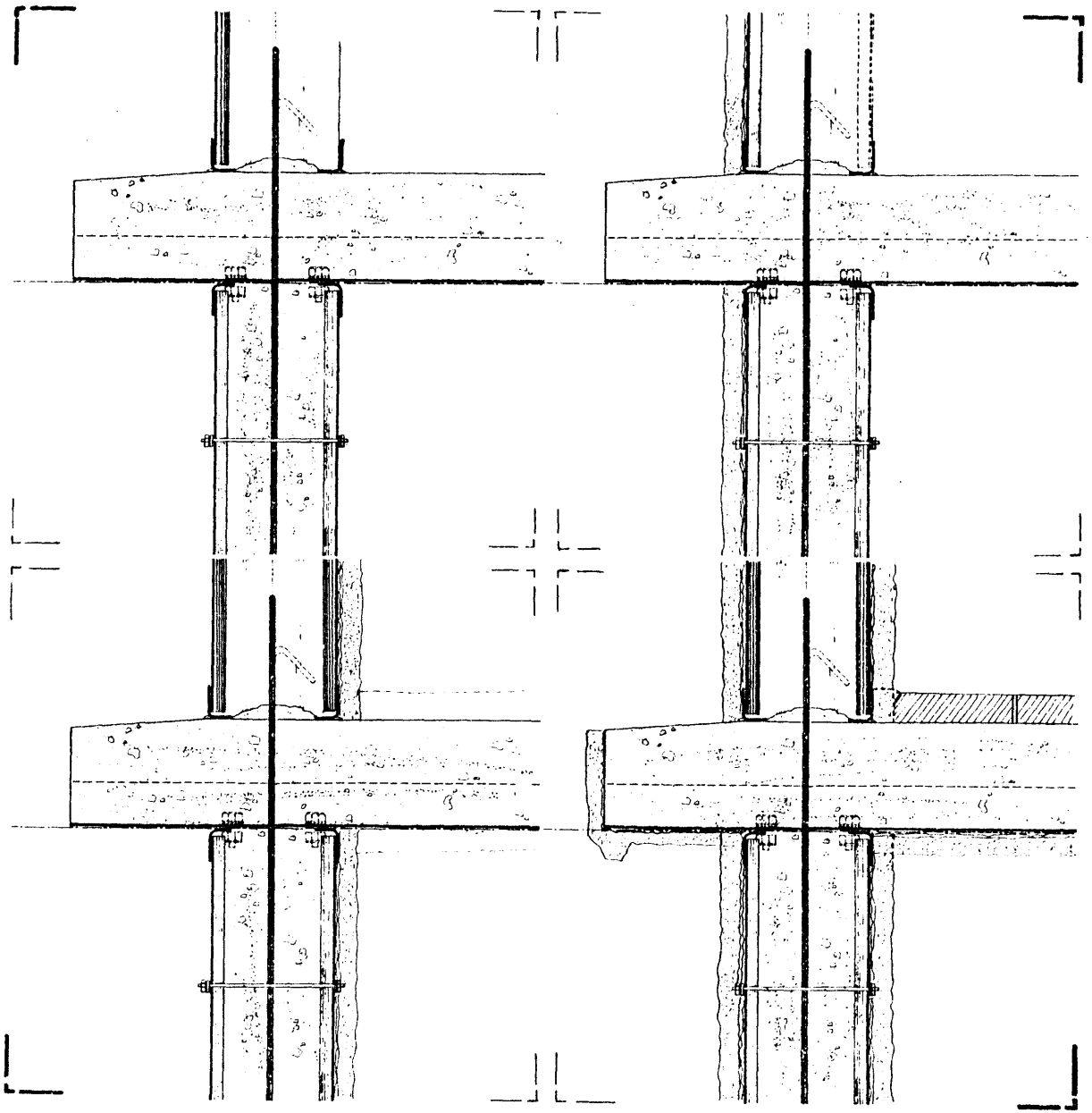
WALL PANEL-
INTERMIDIATE FLOOR
TYPICAL STAGES

A- Initial Stage

B- Finishings on the exterior surface.

C- Two corrugated metal sheet on upper level with finishing only in the interior surface.

D- Finishings on both sides of the corrugated panel. Ceiling with plaster finishing Upper floor with tiles or other type of floor finishing. Cantivilver is covered with metal mesh and plaster creating a gutter detail.



INTERMIDIATE FLOOR ASSEMBLY

A- Unfinished two layer corrugated sheet panel.

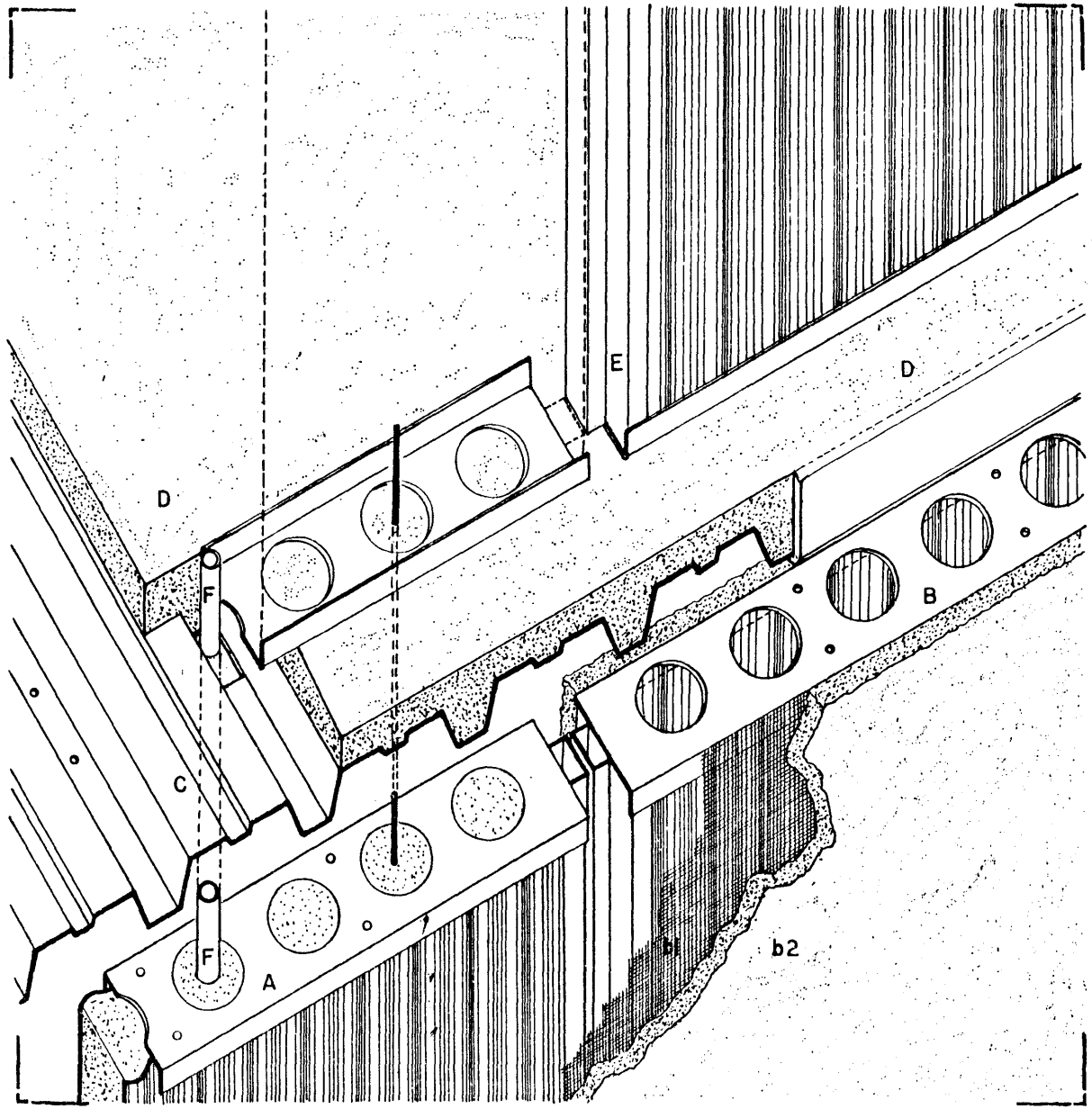
B- Finished two layer corrugated sheet panel. b1- Metal mesh. b2- Plaster.

C- Metal Deck.

D- Concrete floor is poured on top on metal deck.

E- One layer corrugated metal sheet panel.

F- Services and reinforcement go through the intermidiate floor from the lower level to the upper level.



ROOF PANEL ASSEMBLY

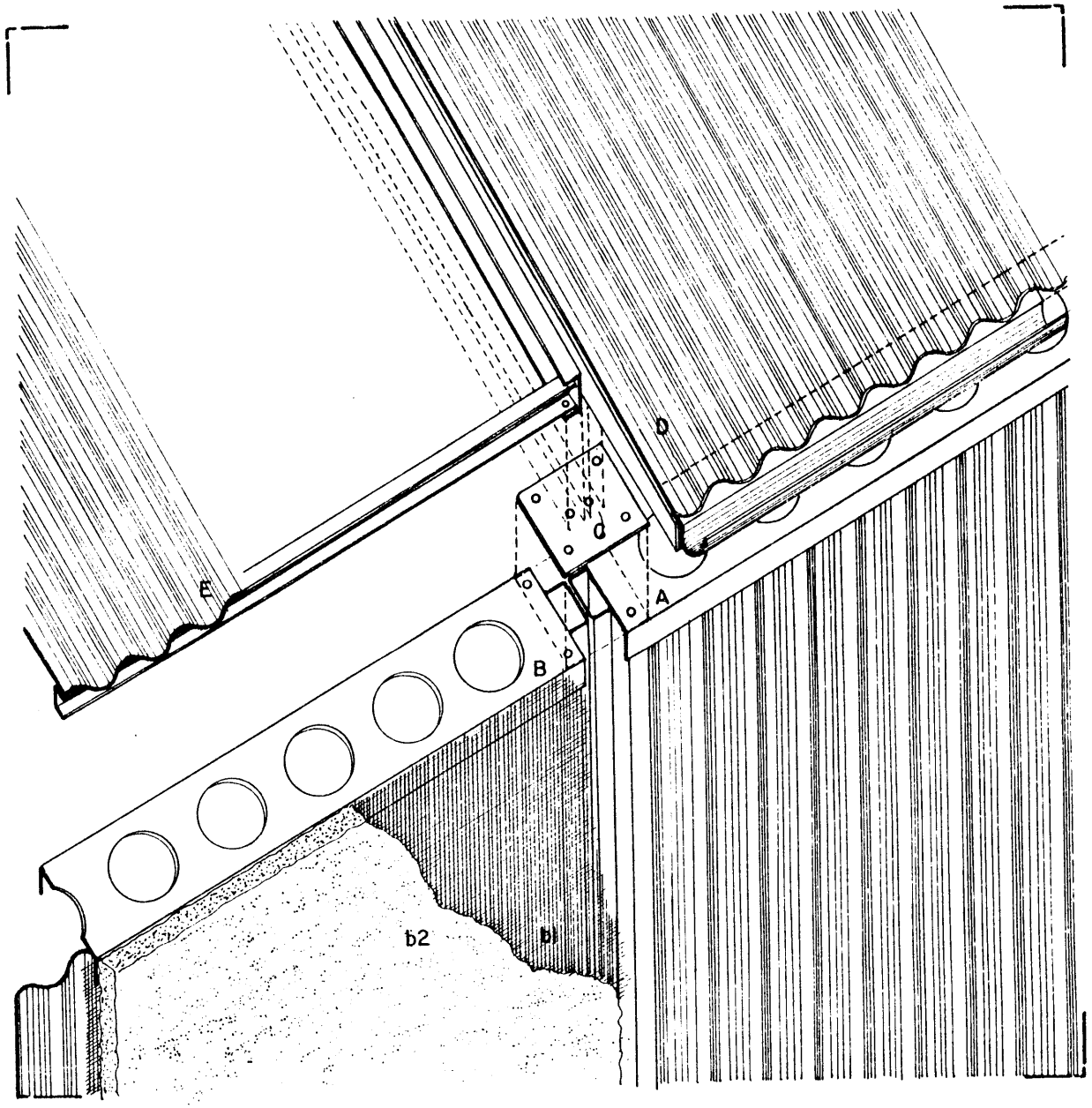
A- One layer corrugated metal sheet panel.

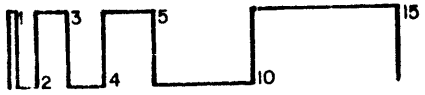
B- Finished one layer corrugated metal sheet panel. b1- Metal mesh. b2- Plaster.

C- Steel plate bolted between wall panel and roof panels.

D- Roof panel with cantiliver and gutter.

E- Roof panel.





OUTLOOK

"Subsequent observation, research and study of the methods and practices, developed by the millions of squatters, urban homesteaders, self-help communes, cooperatives and other so called marginal dwellers for providing their own housing, is gradually coalescing into a new theory of 'housing for the poor', and is inexorably influencing and modifing the attitudes of both public and private desicion makers through-out the development as well as the developing worlds". (Dlushosch, 1985)

Government and private housing agencies cannot supply of adequate housing to the low-income groups at the same rate low- income groups built their dwellings. The majority of these people have managed to provide themselves with a shelter and improve it step-by-step. What should be essential is to try to organize this spontaneous practice and create a discipline of their production process. This discipline should come from the understanding of the processes and the the materials used by the people involved with the cooperation of the market forces and public organisims and institutions.

The 'Ministerio de Sanidad' in Venezuela is actually using a system based on corrugated sheets for emergency housing (see pag. 33). This solution an other similar have been implemented in Venezuela without considering a possible improvement of the dweelings conditions. The problem is that in this alternative there have not been designed and provided the bases for upgrade such dwellings.

This proposal have taken from the people involved what has been useful for them and what can be transformed and improved: - From their materials: corrugated metal sheets that are cheap, easy and quick to assemble, and light to transport. -

From their processes: the idea of evolution of the dwelling finishings, the incremantal investments and the consequent staged construction.

This two areas, materials and processes, have been developed in the building system proposed to give and alternative which come from the understanding of the processes used by the low- income people. A technical alternative which is in between the formal and the informal construction processes and which try to get the most of each of the sectors involved.

But a housing problem of such magnitude cannot be solved by technical means alone. The problem is a whole world of production, financing and construction, which touches one of the most sensitive areas of the lives of the people involved: their house, their homes. Technique is just one part of the problem, not because there are not good technical solutions in the market, but because each alternative can not satisfy all the determinants of the problem: cost, construction time, user needs, etc. The problem is growing so fast that there is no physical solution that can cope with it at the same time , with the resources available.

The theories and the approaches to the problem have been changing over time: superblocks, housing mass production, self- help. The latest trend emphasizes the organization of the comunities and the use of self-managing and self-construction processes Self-help is very appealing as a solution. In essence it is what squatters in the 'informal sector' of construction have been doing all along. But it should be kept in mind that the important conditions must be met before this creative potential can be effectively utilized to develop communities in which construction and living conditions can be upgraded.

As Blake Hughes said in the First National Competition for Urban Enviroments in Developing Countries (Seelig, 1978), "We are not so naive as to believe that architecture is the solution to all the problems of the world, that good planing and design is a substitute for jobs that don't exist or food that doesn't exist or areto too dear. But housing and a sense of community are basic human needs and that is part of the problem that we know most about and can best do something about. So lets us try. "

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