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PLANNING AND DESIGNING OF INDUSTRIAL PLANTS 1/

by

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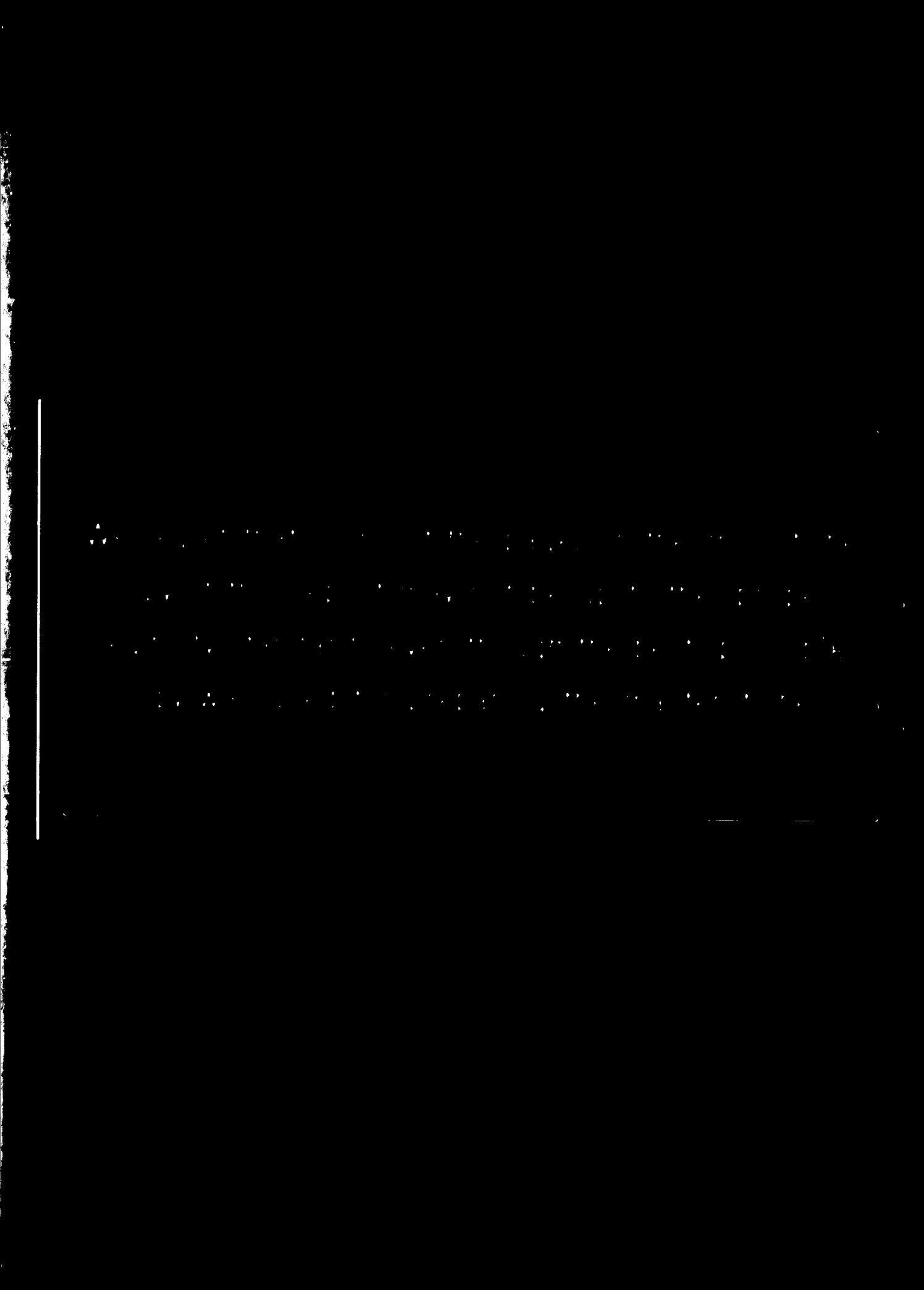

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SUMMARY

Socio-economical progress in developing and developed countries involves the construction of new as well as the improvement and extension of existing industrial plants. In post-war Poland a dynamical growth of industry and the urbanisation influenced by this growth, brought about the agglomeration of industry and settlements. These phenomena in Poland do not differ from those in other developing or even developed countries.

In every country some regions are unequally developed. The differences tend to grow and economical regions differentiate. Regionalisation and co-operation as well as the generally known depression of small towns are linked with the problems of the size of newly built industrial plants.

The location of a plant is defined by natural and economical conditions. Natural resources determine the location of mining industries and some manufacturing branches which are based on these resources. Their location is therefore geographically defined. All types of mech anical and textile industries and most branches of chemical industries constitute the group of free location. The location of industry becomes more free with the progress of technology in mining and manufacturing as well as in transport. With their development the transport systems and means become more flexible, less expensive and their influence on locations of industry is taken over by the sources of power supply. Rather new problem is the concentration of industry in so called industrial nodes with a comparatively high integration of all the industrial plants located there.

It was in England industrial revolution of 1760-1830 that manufacturing began to concentrate and first multistory factory buildings were built. At the end of XIX-th century the introduction of electricity, as power and light source, lead to construction of big one-floor structures. After the Second World War industrial building developed rapidly and particularly their roofing systems, their shape, and construction being affected by the demands of work conditions, technology and equipment. When new demands have appeared, and particularly in electronic industry, asking for constant humidity, temperature, light intensity and cleanliness they were answered by windowless buildings.

In recent years some new trends in designing for industry have appeared as well as new design methods. Among the new trends flexibility must be mentioned, the reduction of space enclosing machinery, the integration of work of various expert teams and the improvement of labour conditions.

Production processes constitute the most essential factors determining the shape of an industrial plant. The choice of technology and proper organization of production processes are vital decisions in the design of a plant. In the departmental oragnization of production processes, which prevail in many of existing plants, the machinery are grouped according to the type of operation they perform. In consequence the plant is devided into specialized departments which occupy separated spaces or even buildings. The arrangement of specialized units into a coherent system brings about line production. A line organization of production processes asks for a new shape of an industrial plant.

Successful transition from the departmental to line organisation of production processes depends, first of all, on the internal transport of manufactured products. The main requirements concerning the interior of an industrial building comprise a sufficient amount fo completely free floor space and suitable roofing. In line organization with a permanent flow of material and products the most important is a continous transport. Storage must come close to manufacturing. Methods of storing and ways of transportation within storages should allow the use of the same means of transport which are being used in the manufacturing processes.

All the elements involved in the process of working in an industrial plant must ensure the best process of production and also the best working conditions for all the employees. Working conditions are shaped by the co-relation of physical, economical and social factors. Man's action when dealing with machinery consists of three subsequent stages: first-information is received through senses - decision is taken, third - a proper action follows the decision. These three stages take place in a particular environment: the interior of an industrial plant. The most important physical features of working conditions are: light, sounds, temperature, humidity, air purity, colour and electromagnetic fields. Sight and hearing are those senses which are most frequently used to receive information and sight is onpable to bring more. That is why lighting conditions are of a particular importance.

The shape of an industrial plant and of its buildings, the type of external transport and its links with internal transport means, the environmental consequences - all these elements are determined by the general layout of a plant. The progress in technological processes, their integration with systems and means of transportation and growing care for employees have influenced the shape of industrial plants. Detached buildings in which particular production cycles are performed evolved into one space arrangement.

The types buildings to be constructed are generally determined when the layout of the plant is designed. Main factors which influence decisions are: technological processes, transport, physiographical and climatic conditions. The integration of various buildings and functions within particular zones becomes a transition stage to a full integration of a plant.

As the layout of an industrial plant seriously determines future shape, its elaboration requires full cooperation of all interested specialists. If an architect becomes familiar with other problems involved which are beyond his specialisation his participation in the layout elaboration becomes easier and more substantial. This is of great importance because that is when the future shape of a plant, its architecture and relation to environment are already determined.

I. INTRODUCTION

Socio-economical progress in developing and developed countries involves the construction of new as well as the improvement and extension of the existing industrial plants. Industrialization of a country and regions goes together with urbanization and is followed by a growth of social and economical services. The role of industrialization and urbanization increased particularly after the second industrial revolution prepared by a substantial progress in science and technology. They intensified even more before, during and after the Second World War. The War brought about a quick progress in technology, particularly in mechanical, electrical, electronic, carbo- and petro-chemical industries. Science and new processes of production rapidly advanced. After the War came a fast development of cybernetics - the science of control of complex processes and operations, and it essentially effected the progress in industry.

A quick collecting of possibly complete information, its segregation and analysis as well as its efficient use decide whether scientific, economical and social actions prove correct. The present stage of socio-economical evolution is sometimes called a revolution in information, because the amount and range of information needed to answer ever growing demand increase enormously. The population growth seriously influences these demands.

Not only the growth of population intensifies urbanization processes but also the quickly growing industry which requires new houses and accompaning services, both in old and new industrial concentrations. The extension of transportation network and the development of power supply must follow.

Hitherto independent towns and industrial plants merge in agglomerations which, in their turn, develop into conurbations, i.e. concentrations of industry with human settlements and services tied by transport and power supply systems.

Such a dynamic industrialization requires high capital expenditures and creates many new not only economical but also social and cultural problems because new labour force is permanently needed. A solution of these problems is very important to ensure a harmonious social progress. It is not easy and answers are being sought in social and political sciences.

The core of population of new towns and settlements is employed in industry and therefore the social and pedagogical role of an industrial plant becomes particularly important. Industry helps to shape social and cultural life of the society which is being urbanized and this role of industry is growing and becoming one of the strategic points of planning and social politics.

An architect and other specialists collaborating in designing of an industrial plant face many social, economical and technical questions. To ensure a final success, these questions must be answered in the process of programming and designing. While searching for answers some measurable and immeasurable factors have to be considered and therefore the processes are complex and difficult and require appropriate preparation.

In physical planning whenever industry is involved, and in designing of an industrial plant, out of many problems the following are the most important:

a) spatial relation of an industrial plant or a concentration of plants to human settlements and the problems of environmental protection;

b) requirements concerning the shape of an industrial plant, and in particular:

- to limit the area reserved for the development of industry,
- to ensure that a plant would not become obsolete too soon, since sciences and technology advance rapidly;
- to create proper conditions of work and social welfare, since production requirements are sometimes in conflict with these conditions as well as with social, pedagogical, or cultural role of a plant;
- to reduce investment and exploitation costs by rational solutions in technology, constructions and installations.

c) reduction and eventually complete elimination of industrial noxiousness and development of protection zones.

d) socially acceptable industrial architecture able to play its cultural role.

II. DISTRIBUTION OF INDUSTRY AND LOCATION OF INDUSTRIAL PLANTS

The growth of industry in Poland till the Second World War was determined by the socio-economical conditions of the country. Settlements had developed mostly in industrial concentrations and this effected the spatial conditions of the post-war development. The only exception was the Central Inudstrial Region where the river San joins the Vistula.

In post-war Poland a dynamical growth of industry and the urbanization influenced by this growth, brought about the agglomeration of industry and settlements. This agglomeration as well as an unequal distribution of industry have their deeper sources in the unequal distribution of raw materials, labour force and water supply, i.e. in the three essential conditions which determine the location of industry.

Underdeveloped regions are unequally industrialized. Investments there are more expensive than in the already industrialized regions. They are hampered by the shortage of labour force and suitable infrastructure.

As numerous problems in spatial development of the country had grown, the Law on Physical Planning was issued in 1961. This Law called for the elaboration of Development Plans of towns. The Committee for Spatial Development of the Country of the Polish Academy of Science has become active, national checkings of Local and Regional Physical Plans have been periodically arranged, seminars and meetings have been organized, sometimes under the U.N. sponsorship.

These numerous problems of the development of towns complicated mostly by a dynamic growth of industry gave birth to the theory of thresholds in urban growth. It says that the growth of a town meets various limitations caused by different physical conditions. They may be of a physiographical nature or may originate in infrastructure or in the necessity of redevelopment of an area. However, these limitations can be overstepped with additional high costs of investment or operative costs of urban functioning. Development threshold linse define the areas which may be covered by the growing town without especially high costs. These lines are overstepped when a particular investment -- for example sewerage system - opens new building areas.

These phenomena in Poland do not differ from those in other developing or even developed countries. In every country some regions are unequally developed because of their natural features, their socio-economical attractiveness, or their industrial traditions. These differences tend to grow and economical regions differentiate.

A guided economy controls the development of regions. It stimulates the growth of underdeveloped regions to increase the living standards of their inhabitants. On the other hand it tries to improve the living conditions in over-industrialized and over-urbanized regions. A guided economy should be based on an internal co-operation within particular regions or even subregions by construction of smaller plants in smaller towns to co-operate with key industry of a national importance. Thus a joint labour force pool and a joint disposition centre develop. They may even be of an over-regional character.

The division into economic regions, when introduced to planning and statistical reporting, has increased our knowledge of the structure of spatial activity and thus we can more effectively shape this structure in physical planning. Closer relations between the division into economic and administrative regions can increase their development, activize small towns, while the role of local government increases and local co-operation becomes easier.

Regionalisation and co-operation as well as the generally known depression of small towns are linked with the problems of the size of newly built industrial plants. It depends on the distribution of plants because of their need of labour force, their relation to other plants and infrastructure. If industrialisation programme provides for large plants it becomes one of the essential obstacles in the development of small towns. Such large plants are located in existing concentrations of industry and settlements. Migrations increase, people leave towns deprived of industry and move to big concentrations and number of commuters increases.

There are two different opinions concerning the optimal size of an industrial plant. One calls for large plants as both in the socialist and capitalist countries they have proved to be very efficient in mass production. These tendencies are characteristic in key industries of the USSR and the USA. Big plants are profitable in mining and key manufacturing industries, location of which depends on natural conditions

and infrastructure. Another opinion patronizes the construction and development of small and middle size plants arguing that such plants in Europe and even in the USA have achieved good results. Production management is easier as well as the control of quality. Small and middle size plants help to balance the development of regions.

In metallurgical industry, for instance, small plants prove to be efficient because of easy management. The efficiency drops in middle plants but it is increased again in large once because of a higher degree of mechanization and possible automation. In the textile industry, however, the efficiency directly depends upon the size of a plant: the bigger a plant, the higher efficiency. It also proves that metallurgical plants may easily be located anywhere to develop a region or to increase labour opportunities.

Whether a small plant may be constructed also depends on the assumed, by economical programmes, level of technology in particular industries. The choice of the best size of a plant demands that the effectiveness of the investment is examined, i.e. the production costs, income, output and labour efficiency.

The location of a plant is, therefore, defined by natural and economical conditions which include: organization of social forms of production, demographical conditions, the development of a region, marketing possibilities, transportation, power supply and technology.

Natural conditions such as the mineral resources, soil, climate, phyeiography, water resources were decisive in the first stage of development. Although their influence on the distribution of production has never been completely eliminated, it has been considerably reduced. Natural resources determine the location of mining industries and some manufacturing branches which are based on these resources. The location of mining industry is therefore geographically defined. According to some authors the manufacturing industries which particularly absort raw materials belong to those, whose location are geographically defined too. This concerns industries where final products are lighter than raw materials used and include the mineral industries and some branches of chemical and consumer industries. The site of mining and the costs of transport of materials are decisive in location of these industries.

All types of mechanical and textile industries and most branches of chemical industries constitute the group of free location. Transportation costs are here not essential, if compared to the costs of production, weight unit of their production is high and comparable to the material weight.

Distance from a plant to its market possibilities belongs to the economical limitations. It cannot be very great when products are not durable, fresh food, big and heavy, heavy machinery, structural building elements, and of a general use. If the industry consumes much power, its location is defined by the proximity of energy sources. The same concerns water which is particularly important for chemical, power and textile industries. The plants which need much water present also the problem of waste water. They must be located along rivers of great flow volume so that waste water might be absorbed and possible pollution diluted.

Locations are also limited by the distribution, quality and quantity of labour force which becomes decisive in labour absorbing industries and in those of highly specialised technology. From the various forms of production organisation specialisation and co-operation limit locations too. Co-operation can lead to the concentration of production and creation of industrial complexes. Agglomeration which is the possible final result prove to be economically effective but leads to many undesirable social effects.

Since the choice of location is limited by the above discussed factors the economical effectiveness of location may be calculated in a comparative way.

The location of industry becomes more free with the progress of technology in mining and manufacturing as well as in transport. With their development the transport systems and means become more flexible, less expensive and their influence on locations of industry is then taken over by the sources of power supply. Coal deposits attract power industry and may stimulate big concentrations of other industries. On the other hand oil, as being easily transported through pipe-lines allows for free locations of many industries.

The changes of technological processes may mean that other raw materials will be used and thus profitable locations of industries may change too. At the same time, the progress of technology causes an increase in the size of

industri[illegible] where raw materials, power [illegible] This leads to concentration and specialization of industries in particular regions.

The [illegible] is sometimes hindered by the fact that the [illegible] different than the [illegible]. The [illegible] investment and occurring various [illegible] needs must be examined. The number of [illegible] very great because the decision [illegible] country and regions. Some of these factors are frequently [illegible] natural resources may be discovered, transport [illegible] improved, migrations increase or decrease the volume of labour force, market possibilities fluctuate.

W. Isard, the author of new methods in modern regional research, has tried to find the economically effective methodology of location analysis. He investigates the relations between region or systems of regions and besides economical, he also examines the cultural and social factors that influence spatial decisions.

The location of a particular plant must therefore take into account: the technological needs of the plant, the fact that it must be linked with the transport network and technical infrastructure, the proximity of raw materials and water, the demands of a local physical plan, physiography and soil conditions, the direction of prevailing winds and noxiousness of the plant. In the same time the effects of the location must also be analysed. These effects may mean the need of: the construction of new transport routes, redevelopment of the existing or development of new technical infrastructure, demolition of the existing buildings, change in mass transport, social services, construction of new houses, and finally the development of protection zones.

The spatial relations between industry and a town demand that industry ought to be located in the direction of the natural development of the town. Nevertheless, all the tendencies in the location of industry linked with the existing towns and settlements demand that industry is isolated from other functions of the town. This leads to the removal of industry, and particularly of noxious industry, from the residential areas, while handicraft is concentrated in chosen locations within these areas.

The industry, removed from residential districts, is concentrated in the industrial district of a town and a local physical plan must reserve areas of proper size and location, well served by transport system and technical infrastructure, and isolated from its neighborhood by protection zones.

Such concentrations of industry enable to undertake joint solutions in technology and organization. That is why these concentrations are sometimes called industrial nodes, and if they directly serve the neighbouring settlements, they become industrial and settlement nodes. A modern industrial node differs from previous industrial concentrations or industrial districts by the fact of a comparatively high integration of all the industrial plants located there. This integration concerns the programme of the whole node, its design and construction, as well as, its management. Good co-operation of industrial and administrative units is then necessary, both vertical and horizontal, within the industries undertaking the investments and between them and the local government.

In the USSR, where recently the value of land occupied by industry has been carefully evaluated, 200-250 industrial nodes have to be designed. It has been calculated that about 5 industrial nodes will satisfy Moscow needs in industry and services. All these investigations were conducted by research and designing institutes. The most serious obstacles in the implementation of these plans were the difficulties in financing the investments, diversities in zoning, and the opposition of e management staff to the organisation of one joint management of the node and the reduction of personnel.

In the designing and implementation of industrial nodes the stages of construction are defined. Usually plants are put into service in periods no longer then 2-3 years. The extension of these periods may prove the whole project uneconomical. Since an industrial node is economically and physically planned as a whole, the area needed by industry is reduced, structures are standardized, transport routes, power supply lines shortened, and water and sewerage networks diminished. The nodes are economically and technologically more effective if some of their functions are concentrated. This particularly concerns the management, computer centres, fire protection, transport means, and social services like health service, educational facilities and catering.

[illegible] possibilities of standardization [illegible] and natural transport, the similarities in [illegible] processes and in raw materials they use, [illegible]. It is very profitable, if production wastes [illegible].

The [illegible] involves the problems of environment protection, which now days are strongly emphasized by communities, [illegible] organizations. Industrialization and urbanization result in the increase of air pollution which spread far beyond the industrial [illegible]. Development of industry, sometimes very spontaneous, also brings shortages and water pollution as well as the devastation of land.

The proper spatial arrangement of industry and settlements may mitigate environmental pollution and the investigations of the noxiousness of industry become socially necessary. Nevertheless, first of all, air and water pollution should be reduced by the elimination of pollutants at the sources of their origin. In chemical industry sometimes undesirable and even unknown by-products or wastes turn out to be very noxious and it is very difficult to control them. Only by very intensive research works and implementation of their results pollution may be held in check and pollutants recycled.

Regional planning must therefore define spatial relations between working, living and recreation sites, transport and other services, and it also must find out how the progress of technology may improve environmental conditions.

III. DEVELOPMENT TRENDS IN DESIGNING INDUSTRIAL PLANTS

It was in England during industrial revolution of 1760-1830, that manufacturing began to concentrate and first factories were built. Multistorey frame buildings responded to new demands. Water or steam supplied power and belts the transmission. Buildings were rather long and narrow, with three or four aisles and 9 to 12 feet spans.

At the end of the XIX-th century the introduction of electricity, as power and light source, lead to construction of big one-floor structures. They provided ample floorspace and were covered at first with gable roofs and later with saw-tooth roofs to let the natural light in.

After the Second World War, industrial buildings developed rapidly and particularly their roofing systems, their shape and construction being affected by the demands of work conditions, technology and equipment. New materials and structural solutions were applied to increase spans and to suspend installations. Then new demands have appeared, and particularly in electronic industry, asking for constant humidity, temperature, light intensity and cleanliness they were answered by windowless buildings.

This development of industrial buildings, analysed in here briefly, does not cover the whole industry. It concerns mostly light, metallurgical and consumer industries and emphasizes how an industrial building is influenced by production processes, power sources and equipment. Besides one-floor buildings, multi-storey buildings as well as special structures are still being constructed.

Nevertheless, one-floor building has become the most common type and its development is closely related to the progress of sciences and technology.

The evolution of industrial production which started with mechanization leads at various pace and intensity towards automation. Automation, however, is very complex and depends on many factors. Among others it is also conditioned by costs, stabilization of production processes and technology. It is being introduced slowly and gradually and its influence on future shapes of industrial plants is difficult to anticipate.

Automation [illegible] production, [illegible] and reduce the labour needs [illegible] productivity increases by half. So the change in [illegible] system [illegible] quite revolutionary. Considering economical, technical [illegible] relation of potential labour force to labour opportunities [illegible], one has to examine which stages of production or [illegible] [illegible]. To find correct answers they must collaborate with research institutes and the industries should carry out their own research works on [illegible].

In recent years the following new trends in designing for industry have appeared as well as [illegible] trends. Among the new trends flexibility must be mentioned, the reduction of space enclosing machinery, the integration of work of various [illegible] teams and the improvement of labour conditions. Flexibility is of a particular importance for modern industry. It enables to maintain the exploitation value of an industrial plant for as long as possible, because the plant can be adapted to changing demands. In practice it means the introduction of large spans, free floorspace, integration of production and additional spaces.

Good economical effects of a compact industrial plant measured in investment and exploitation costs are brought about by the reduction of the area, shortening of transportation routes, reduction of exterior walls, standardization of building solutions and easier management.

When the exploitation value of an industrial plant increases, economical, technical and organizational conditions improve. Working conditions improve too. The exploitation value of the plant may then last considerably long - what is nowadays important - because the time span between exploitation age of industrial buildings is permanently growing.

The progress in technology and the growth of industry demand that the possibilities of the extension of an industrial plant are ensured. Such an extension may concern the size of the plant, its area or its output.

Green spaces in industrial plants grow in importance and industrial buildings get new interesting solutions by the use of new materials and by new approach to structural, functional and visual problems. If buildings are more carefully finished in every detail and furnishing of interior is of a higher standard, employees become more attached to the plant and it is easier to get better qualified and more stabilized personnel. The growth

of industrial architecture in importance attracts now even best architects. Unfortunately, such a process is not universal. On the contrary, some industrial buildings are still badly designed and poorly constructed and the resulting social harm is irreversible.

It is not possible to analyse the factors which determine the shape of industrial plants in every type of industry. In some industries the technological processes are extremely complex and their analysis will not improve our knowledge of the subject under discussion. The division of production processes according to technological processes, into physical, chemical, and physico-chemical, is very theoretical and therefore not useful in the discussion of our problem too.

In some industries, and particularly in machine, metallurgical, and in some branches of consumer goods industries there is a trend towards uniformity in spatial solutions of the most typical production processes. That is why some factors of development in machine and metallurgical industries will be discussed. These industries in Poland and in many other countries are quickly developing because their products are not only needed in the country but are also exported. By and large, they are especially characteristic for modern changes in industrial production.

IV. FACTORS THAT DETERMINE THE SHAPE OF AN INDUSTRIAL PLANT

1. Production process

Production processes constitute the most essential factors determining the shape of an industrial plant. The choice of technology and proper organization of production processes are vital decisions in the design of a plant. In machine industry long series or even mass manufacture result in a stream like production. Modern organization of work and specialization require that universal machinery are replaced by highly specialized units which perform detailed operations. The arrangement of this type of machinery into a coherent system brings about line production. Transport of products become an integral element of this line production system.

Nevertheless, the departmental organization of production processes prevail in many of the existing plants. In this organization the machinery are grouped according to the type of operation they perform. In consequence the plant is divided into specialized departments which occupy separated spaces or even buildings. Departmental organization of production causes heavy multi-directional transport and waste of storage floor-space for products waiting their turn between different departments and operations.

When the amount and kind of production are stabilized in long series or mass production the technological processes can be improved and the departmental organization of production abandoned arranging the machinery in lines according to the processes of production. This line organization of production is characterized by one direction flow of products being manufactured. Production processes must be effectively assisted by all the additional operations to ensure smooth running.

A line organization of production processes asks for a new shape of an industrial plant. Subsequent stages of production as well as additional operations are arranged within one space and internal transport is curtailed. The costs of loading and unloading and of transport itself are reduced and the time of production is shortened. Since the area of production is integrated the area of a building can be more effectively used. From such a common area only dangerous operations are excluded: noxious, explosive, particularly

noisy or producing excessive vibrations as well as those which require special constructions. Excluded are also those operations which do not have to be performed inside a building. Nonetheless, some specific industries will not permit the introduction of the line organization of production processes or integration of production series.

While designing and constructing industrial plants one must consider the possibility of a permanent modernization of production and its evolution towards automation. Possible future alterations in the general lay-out and installations should be taken into account and the direction of possible changes of production processes must be analysed. The design of a production line and its spatial enclosure ought to consider these future developments so that the plant would not become obsolete too soon.

2. Internal transport and storage

Successful transition from the departmental to line organisation of production processes depends, first of all, on the internal transport of manufacturing means result in this organization of production.

The main requirements of line organisation concerning the interior of an industrial building comprise a sufficient amount of completely free floorspace and suitable roofing. Internal transport may then be suitably arranged to ensure an unobstructed flow of material and product.

As production processes become more manageable the means and systems of internal transport improve. Some sections of production processes in various industries are being standardized and the standardisation of manufacturing and transport equipment follows. Recently selfpropelling floor transport means have been developed and the most popular are lift trucks. Their efficiency improve with the use of containers or standardised pallets to carry materials. This raises the efficiency of overall internal transport, cuts down loading and unloading operations, reduces storage floorspace and allows for automation of storage operations. The use of containers in both internal and external transport substantially reduces the costs - from 50 to 75 %. Manual reloading of small elements takes from

half to one hour operation. Containers may mean reducing the time to one minute only.

The use of trucks poses extreme requirements for the construction of an industrial building because of their rather great weight up to over six tons. First of all, [illegible], ducts and pits must be avoided on the routes of transport means.

Integrated within one space, and particularly on one floor, industrial buildings are usually designed for light industry where elements to be transported, in general, do not exceed the weight of five tons and there is no need for other than suspended overhead transport means [illegible] well enough, and for many reasons they prove to be more economical. Moreover, each type of suspended transport means can also run beyond the width of factory aisle. Suspended transport means affect the shape of an industrial building by the fact that the ceilings must be lowered and structural elements lighter and simpler.

In line organization with a permanent flow of material and products the most important is a continuous transport which may be of a suspended type too. Most of the conveyors may be installed under the ceiling or roofing and thus the floorspace is free for manufacturing machines and floor transport equipment.

The discussed development of systems and means of transport leads to an increase in the smoothness of running of production processes and it clearly favours one space arrangement of the whole production. To obtain proper effects of production, to shorten its cycle, to increase efficiency and reduce employment, the internal transport and its links to the external transport means must be properly arranged and managed..

Storage must come close to manufacturing, and if possible, it should be put into the same building. Methods of storing and ways of transportation within storages should allow the use of the same means of transport which are being used in the manufacturing processes. The kind and size of a storage depends upon industry and upon storing methods. Its floorspace may be reduced when co-operation and distribution become more efficient; this may even lead to abandonment of some storages at all. If storage is closely linked with manufacturing the design of storage areas must follow the principles adopted in the design of manufacturing space: the same spans, height, structural solutions and free floor area. Flexibility

is thus secured and any future functional changes become possible.

Further improvement of internal transport consists in the introduction of automation as in manufacturing processes. Transport and manufacturing are then together automatically controlled. The type and quantity of every material to be stored, the stock of every item, the output of materials and products, the balance of stock and sale - all they controlled by computers, permit to avoid to frequent inventories and registering systems as well as enable an economical planning of storage floorspace and the production is not being obstructed.

3. Working conditions and social welfare and services

All the elements involved in the process of working in an industrial plant, described sometimes as the micro-climate of the plant, must ensure the best process of production and also the best working conditions for all the employees. The discussed trend towards automation affects irreversibly the shape of an industrial plant while the socio-economical conditions defining the share of a man in the production processes determine what the plant must offer him.

Working conditions cannot take into account only the requirements of production. Equally essential is the recognition of psychological and physiological needs of a man. This means that all machinery, tools and equipment as well as the microclimate of a plant ought to suit man's psychological and physical characteristics. To investigate these needs and to find out how to satisfy them now science has been created: human engineering. It, for instance, examines the relation between a man and machine, so that he might not get tired physically or psychologically. It also examines the reasons of satisfaction in working in various environmental conditions considering light, noise, climate and organization of work.

Not only the above named factors influence this feeling of satisfaction. equally important become human relations in a plant. These relations depend also on the competence of personnel department management, backed up by an ever increasing knowledge of sociology, social psychology, and social pedagogy. Human relations substantially inspire the morale of workers, their discipline, and their attachement to the employer. All these factors influence the quality and efficiency of production. Research works on human relations

are particularly [illegible] life.

Working conditions are shaped by the correlation of the following factors: physiological (energy [illegible]), economical (productivity, costs, amortization), [illegible] (satisfaction in work, psychological influence of the [illegible] relations to the type of work). All these factors [illegible] their relations are of great importance. As industry is constantly progressing, standards for every factor should be periodically refined to the novel working conditions.

It is not [illegible] such standards, and particularly those concerning social [illegible]. More principles science works to investigate human needs and [illegible] of scientific methods instead of intuition will reduce mistakes and improve solutions.

Man's action when dealing with machinery consists of three subsequent stages: first - information is received through senses, second - decision is taken, third - the proper action follows the decision. These three stages take place in a particular environment: the interior of an industrial plant. It affects man's work and the whole system: a man and machinery. Physical environment represents an integral part of working conditions which determine man's behaviour. And though a man can adopt himself comparatively easy to various environmental conditions, nevertheless, physical conditions of an industrial plant must tolerably suit a man despite the fact that automation replaces him. The most important physical features of working conditions are: light, sounds, temperature, humidity, air purity, colour and electromagnetic fields.

Sight and hearing are those senses which are most frequently used to receive information and sight is capable to bring more. That is why lighting conditions are of a particular importance in shaping working conditions. And their importance even increases in a one space plant where floor space is large and natural light altered.

Bad reception of sight impulses delays reactions, makes difficult the perception ofdetails and eventually reduces the efficiency of an employee. If appropriate lighting goes together with a rational use of colour, the perception is more acute and the comfort of employee better. The work is more precise and efficient, discipline better and accidents less frequent. However, the effects of physiological/psychological influence of colours should not be overestimated despite a substantial development of

science in this field. Influence of colours differ due to the physical and psychological features of an employee.

Another problem is how to reduce noise with proper acoustic solutions. Naturally, the source of excessive noise must be isolated by vertical acoustic screens or by location distant enough from the zones of less noisy work and from the concentrations of employment. This may even lead to the removal of such a focus of noise from a building.

As the floorspace of an industrial plant grows so does the distance between working places and the exterior. Direct visual contact with the exterior is broken and the way out becomes longer. Extra messures of fire protection are needed and fire escape must be secured as well as social services organized.

Another important item affecting working conditions is the solution and location of canteens, lounges, lockerrooms, ambulatories, menagement rooms and entrance halls. In general, they should be located along external walls so that visual contact with natural environment might be ensured. Their structures should offer a micro-climate different to that of a production space.

Menagement office may be located within or beyond an industrial building, since work there is different and more links with the world outside are needed (customers, for instance). Working conditions in an office change following the evolution in methods of menagement, although all these changes take place much slower than those of production prooesses. Hall type office premises present the same lighting and acoustic problems as one space industrial buildings.

Windowless buildings present separate and a very complicated problems. Artificial lighting, ventilation, air conditioning, and special building regulations, constituing their main problems, because of their complexity cannot be discussed here.

V. GENERAL LAYOUT OF AN INDUSTRIAL PLANT

The shape of an industrial plant and of its buildings - one floor one-space building, multi-storey building, a building enclosing production equipment - the type of external transport and its links with internal transport means, the environmental consequences - all these elements are determined by the general layout of the plant. Therefore, after having discussed the problems of distribution and location of industry and the factors which determine the shape of industrial buildings, the problems of the layout must be now considered.

The progress in technological processes, their integration with the systems and means of transportation and the growing care for employees have influenced the shape of industrial plants. Detached buildings in which particular production cycles are performed evolved into one space arrangement.

Present day industrial plant layout divides the whole area into various zones to perform different functions: management, social, production, additional, transport and the reserve for future expansion. To make the whole arrangement clear the whole zoning is applied even when dealing with one building only. If the future extension of a plant is ensured and building parameters unified, the future extension does not destroy the shape of the building or hamper the production.

The types of buildings to be constructed are generally determined when the layout of the plant is designed. Main factors which influence decisions are: technological processes, transport, physiographical and climatic conditions.

The integration of various buildings and functions within particular zones becomes a transition stage to a full integration of a plant. The implementation of such integration depends upon the degree of production complexity in particular industries. Under no circumstances this integration should be identified with the design of one common space for the whole plant. Technological processes and the above mentioned features of production opposing one another make this solution impossible. That is why when preparing the layout of a plant, one must segregate its functions according to criteria whether they go together or oppose one another.

A dynamical growth of industry requires that future extension of production and of a plant is ensured. Standardized building solutions and the principle of a free floor area ensure the possibilities to increase production by the modernization of its processes or the modernization of machinery and by improving its efficiency and not necessarily by the extension of a plant. However, sometimes it becomes necessary. The discussed principle of zoning makes possible to plan beforehand a future extension, its size and direction, and to reserve an adequate area for this purpose. One direction extension is the most convenient because it does not disturb the zoning. All the elements of the layout such as the roads, transport routes and power lines as well as green spaces must take into account the extension and not hamper it.

Industrial plants of a concentrated production and building programme result in a higher building density as well as in shorter transportation routes and power lines. Thus the extent and costs of infrastructure and other works to develop the area are considerably reduced, construction works are carried out faster and there is more free area for green spaces.

The concentrated production programmes increase the use of land, according to the Soviet sources:

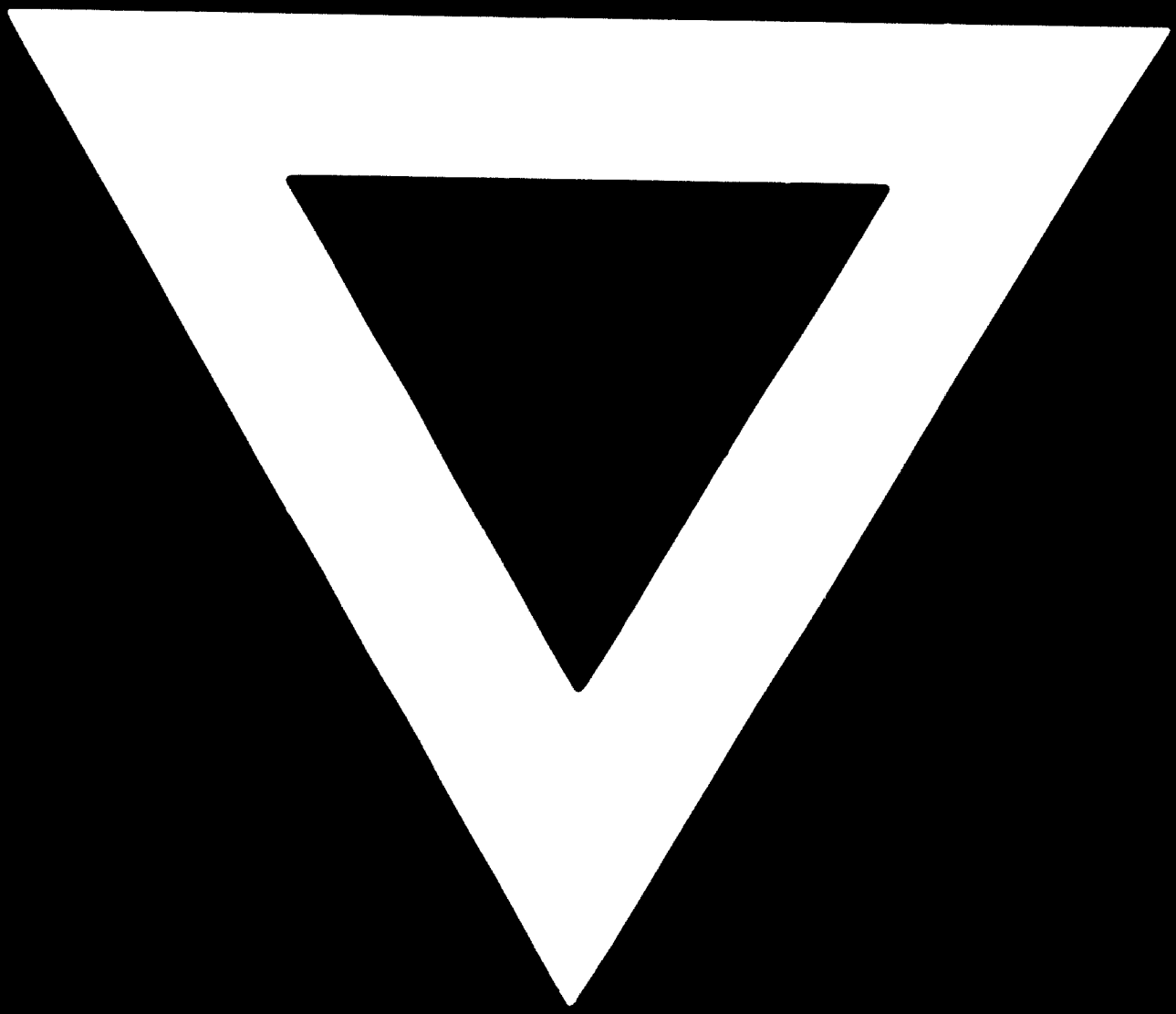
in metallurgical industry	from 10-20 %	to 30 %
machine	20-25 %	45 %
chemical	24 %	35 %
building	20 %	50 %

while some German sources report that the efficiency of land use may be raised from 15 to 60 %.

As the layout of an industrial plant seriously determines its future shape, its elaboration requires full co-operation of all interested specialists. Despite the fact that the standardization of production and building elements as well as equipment makes designing more feasible, such team work condition the final success. If an architect becomes familiar with other problems involved which are beyond his specialization his participation in the layout elaboration becomes easier and more substantial. This is of great importance because that is when the future shape of a plant, its architecture and relation to environment are already determined. As a matter of fact, the layout stage plays a decisive role in the industrial architecture

in general. And in its turn, this architecture, its character and quality and its relation to [illegible] plays an important role in the development of modern industry.

Since design is, first of all, the process of decision making, to make this task easier and more effective, the designers should use modern methods and systems theory in designing engineering. If fully used they help to produce quicker and more effective answers to measurable requirements so that more energy can be spent on creative work. Final results will undoubtedly prove to be much better than those produced in a routine way when answers do not consider scientific and technological processes or social demands.



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