vacuum filter installations, drying beds etc., have got to be designed and constructed along with the drainage scheme of the factory. Their subsequent insertion may be possible at a heavy extra cost and may result in complications being introduced in the efficient working of the system already planned and put up.

IX. Manufacturing sequence and its effect on the factory building plan.

Advice of the machinery manufacturers as to devise the best efficiency with a particular lay out of the machinery is the authoritative one. A given plant can be set out in more than one methods but for each lay out it will mean different arrangement of buildings, different arrangement for feeding the raw material and stocking the finished products. The economics of cost for buildings will differ ; the ease for future extensions may not be liberal in all the cases and the efficiency for flow of products from one section to the other will be different. Proper coordination between the planning agency and the manufacturers will result in an economical and efficient sequence for the manufacturing process. For a given industry and a known order of the process to be followed there may be a few alternative lay outs possible but there may be other instances where much of a flexibility is not permitted.

A detailed study of the lay out recomended by the manufacturers is necessary from the point of view of its suitability to our conditions. There have been instances where a particular lay out drawing prepared by machinery makers in a foreign country had to be materially altered to suit our requirements with certain fundamental differences. Appendix No. 7 shows lay out plan for a woollen textile mill prepared by the machinery Manufacturers M/s Toyo Menka Kaisha Ltd., of Japan. It had to be modified a great deal because of the following features :—

(*a*) From suitable framing scheme point of view a heterogeneous system of different spanned bays was not a desirable feature.

(*b*) Location of the office and the raw material stores within the main factory building is objectionable.

(*c*) No provision for future expansion is made even though demand for this was indicated in clear words.

(*d*) Construction features of the building do not cater for proper flow of products from one section to other.

(*e*) The lay out of the machines in some of the sections is crowded with inadequate provision of proper work space and space for flow of the material.

(*f*) The lay out could not be fitted in the lay out of the remaining industrial colony. North line direction did not suit. There was no face specifically designed to serve as the main entrance.

The modified plan which caters for different requirement as suited to our conditions in Pakistan and as suited to this site is exhibited on Appendix No. 8.

Good lay out of the plant will depend on the following points :—

(*a*) Right type of building single or multi-storey.

(*b*) Correct location of the buildings that comprise the factory.

(*c*) Preparation of the flow diagram showing the path of production.

(*d*) Location of stores at proper places.

(*e*) Judicious provision of traffic spacing between the buildings.

(*f*) Distance between processes to be reduced to minimum.

(*g*) Provision of balanced production units.

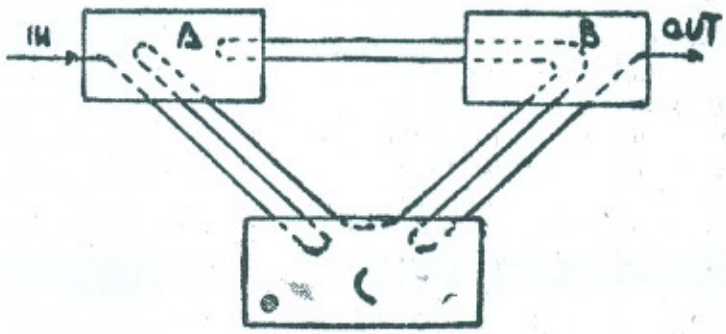
(*h*) Segregation of processes which will demand different units of buildings should only be done if necessitated by the industry or safety regulations.

(*i*) Key building should be fixed and then other buildings should be orientated around it.

Flow Diagrams :—

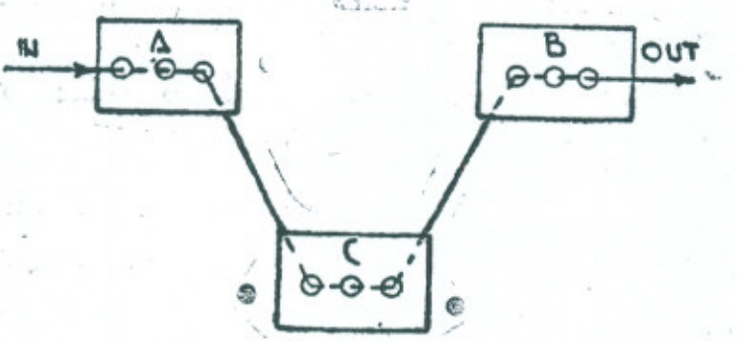
Characteristics of the diagrams :—

Diagram (i)



(*i*) Partly processed product enters A, is processed to be moved to C. It is further processed there and returned to A. It is once again sent to C from where after further processing it goes to B. It is routed to A once more, back to B and then after final finishing goes out. There are 8 lines of routing.

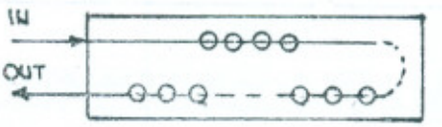
Diagram (ii)



(ii) The process line is unidirectional in this diagram. There is no undue length of the routing and only two route jonrneys as against 8 in diagram No.

(iii) Instead of 3 units of the buildings there is only one unit for the same line of process.

Diagram (iii)



Shape of the key Building :—

Some years back the main factory building was shaped to follow some of the English letters such as E, L, U, H, etc. However considering various aspects especially the plant lay out and flow diagram block type of construction is being preferred these days.

X. Building features to cater for fire insurance requirements :—

It is a wise step to seek the opinion of the insurance companies regarding design of such building units as doors, windows, partition walls stocking godowns for inflammable products, design and spacing of fuel oil handling structures. They have got their standard by laws to adopt suitable types of these building details which when incorporated will bring appreciable reduction in the insurance premia. In case of muitistorey buildings provision for fire escape stairs and other equipment for fire fighting will help reduce expenditure on the fire insurance policy. At time of putting up the internal fixtures and minute building details due care should be paid to this requirement, and as far as possible cooperation of the insurance agencies should be obtained.

Standard building regulations laid down under fire tariffs should be consulted before final design of the factory building is completed. The provisions change depending upon the class of construction (there are 4 classes) and type of the industry. The main items to be considered are walls, roofs and floors with different fastenings such as doors, windows ventilators, etc. Specifications for the reinforced concrete work as adopted by these tariff by laws should be followed. The adjoining or

communicating buildings from the purposes of assesing the risk are treated on the same basis as the main factory building itself.

Thickness and size of glass, wire netting, sashes and frames, setting of glass are the chief particulars to be considered for windows skylights and other openings. The doors and shutters should conform to the rules of the Fire Offices Committee (England) as adopted by Pakistan.

Fire Extinguishing Appliances :—

Hand appliance, hydrant installation and use of water hose and portable fire fighting equipment are gradually being replaced by a fully automatic sprinkler system. The last mentioned system claims the maximum discounts from the insurance societies and it will be advantageous to consult these societies before execution of any of these fire control systems. The minimum capacity of the pump of the source of water supply, storage and flow in the pipe system will be guided by these provisions. There are a number of firms in Pakistan representing standard makes of the sprinkler system and fire proof doors of well known foreign makessuch as M/s Buckwell & Co., Ltd., representing "Central Automatic Sprinkler System", M/s James Finlay & Co., Ltd., representing "The Grinell Automatic Sprinkler System" and Mathur and Platt Fire Proof doors. They can be called upon to work and put up a detailed proposal for these anti-fire appliances to suit a definite lay out.

The automatic sprinkler system will ensure that as soon as fire breaks out in any vulnerable parts of the factory where the sprinkler heads are installed there will be automatic burst of forceful spray of water from a number of points bringing the fire under control in no time. With the rise in temperature beyond a stipulated limit these sprinklers start functioning, the pumping plant is automatically brought into commission and the fire alarm starts sounding. It is found that by these devices the fire damage has been cut down to 70 to 80% of the previous figures when manual operations used to be employed for fire fighting.

The technique of making fire proof and fire control doors has also developed considerably. There are automatically worked doors which will not only guard against the spreading of fire from one building to an other but even from one section of the same factory to an other. The thermal drop on the two faces of such doors has been found from 1960°F without wharping.

Extra cost of these installations is fully justified especially in textile, oil and other industries processing inflammable products.

XI. Main Factory Building (Specific design).

In the new industrial projects the structures should be studied simultaneously with the mechanical lay out and operating procedures. The manufacturing order, general type of construction depending upon the material available, working of any special equipment like overhead cranes, facilities for provision of lighting and land available are some of

the controlling factors which determine the broad outlines for type of buildings to be constructed. Specific problems affecting the type of construction are given below :—

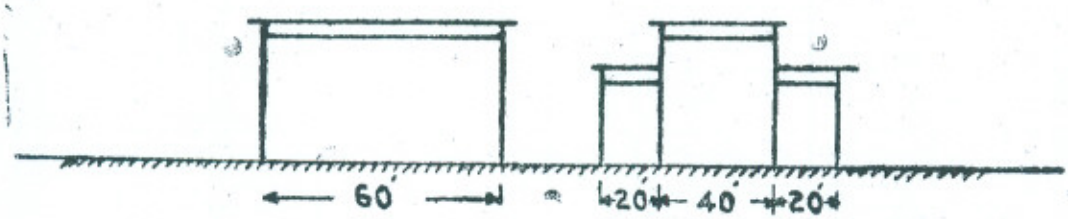
1. The maximum stress limit allowed in different members and fabricated out of different materials provided all are available with the same convenience. It will be seen that sometimes at a slightly extra cost it is possible to design a structure having a functional value many times more than another structure built out of a slightly cheaper material.

2. Reduction in number of structures like intermediate columns etc., which cause interference to the free working space. If there are no other limitations it may be advantageous to do away with side aisles and increase span of the central aisles to the maximum possible limit. Economics of cost of different arrangements should be considered before accepting a particular type. Considering the two arrangements shown in the sections given below it will be observed :—

(*a*) Roof and floor areas are practically the same in both the cases.

(*b*) Foundation cost is more in (*b*) than (*a*).

(*c*) Cost of beams for supporting side walls is more in (*b*) than (*a*).



(*a*) (*b*)

(*d*) Cost of drains, eaves flashing etc., is less in (*a*) than (*b*).

(*e*) Cost of construction if proportional to wall area and window area is more in (*a*) than (*b*).

(*f*) Floors of (*a*) are fully usable while of (*b*) are not. This is a great point in favour of (*a*) considering the efficiency of operation,

(*g*) If overhead cranes or hoists are needed in all the aisles of (*b*) cost will be much more than having a single crane in (*a*).

Sucklike comparisons will enable selection of a particular type of construction. It will be seen that there may not be much variation in the cost of different alternatives but the difference in economy of operation is really pronounced. Appendix No. 9 shows a lay out embodying these principles.

(3) Planning to secure the most open and least obstructed working space :—

(a) General framing scheme :—

Planning of the framing scheme should be done considering the construction material available, lay out of the machinery, services such as air conditioning lighting and ventilation. A few of the points important for framing distribution are jotted below :—

(*i*) An economical span of the trusses or the aisle span for any other type of construction should be selected so as to reduce the number of supporting columns.

(*ii*) Similarly the bay span selected should be appropriate. This length will be greatly controlled by the dimensions of the machinery. Generally 20 ft. bays are selected.

(*iii*) Every effort should be made to equalise spans under (*a*), (*b*) above so as to standardise the structural units for even distribution of the working space.

(*iv*) Accommodation of the roof lighting or ventilation arrangement should fit in with the framing scheme well.

(*v*) Location of doors, windows in the outside walls should be done based on the external column spacing.

(*vi*) Provision of bracing, crane girders and columns hoists etc., if required should also be made.

(b) Individual positioning :—

Less important units like sanitary fittings, locker rooms, control rooms etc., may be placed in small extensions to the main buildings rather than the main building itself. Offices of Foremen and production staff may be placed in the contral sections where due to shady area the working space is not so valuable as close to the walls.

(4) Type of Costruction Materials :—

It should be decided in the first instance about the type of materials which are available and which are going to be most suitable for the construction. There may be difficulty in getting cement due to which concrete roofing may not be possible. The usual saw tooth roof with asbestos cement sheeting may have to be adopted. There may be a particular locality like Karachi where extreme dampness may not permit any other type of useful construction than concrete both for the walls and the roof. There may be soils which may have deficient bearing pressures and there may be possibility of cracks developing in concrete structures due to uneven settlements. In such cases steel framed structures will have to be used. Speed of construction, durability, kind of

process involved, fire risks etc., are some of other factors determining the type of material to be used.

(5) **Appearance :**

The architectural features do not control the style of construction normally but sometimes where a new unit is to be harmonised with existing ones perhaps a definite style of construction will be followed to have uniformity in the outward appearance. It is important to consider that architectural features of industrial buildings should be functional and should not exhibit the structures what they are not.

General factors affecting type of construction :—

Besides a few specific points dictating the type of construction as mentioned above there are some general points influencing the style of building :—

(*a*) Amount of land and its cost. In certain cases double storey buildings are put up bringing in certain difficulties to operation just to save the floor space occupied.

(*b*) Character of the soil especially if it is poor may determine the type of construction.

(*c*) Local building codes, fire protection requirements and safety regulations may restrict the choice in type of construction.

(*d*) Type of equipment and machinery may be too heavy and their installation except for the ground floor may not be possible.

(*e*) General services like ventilation, lighting, roof drainage and other utilities may have a strong influence on the basic style of construction.

(*f*) Local climate and requirement of partial air conditioning or complete weather control may affect the design of construction for efficient results.

It is not possible to lay down conclusive regulations and guiding points which may enable definite selection of a particular type of construction. These points are mentioned so that while selecting a suitable design they may not be ignored completely. For a particular industry in given environments the local conditions may be absolutely different and the system of construction may have to be adopted on considerations much varying. It is possible that the controlling factors for adoption of a particular type of construction may be other than all the items listed above. However it may be expected that perhaps choice of a particular type of construction may be guided by a number of items considered above if not all. It is useful therefore that before making a final choice it must be tested on the anvil of all possible aspects which contribute towards a successful design.

Multi-storey buildings :—

Most of the factory buildings being built up in Pakistan are single storeyed. However there may be occasions where a multi-storied building may be more advantageous and economical for a particular industry. For planning such a building following things should be kept in view :—

(*a*) The system of construction should be so adopted that ceilings of different floors present one even flat surface for permitting fixtures like-pipes and suspended shaftings.

(*b*) Spans selected should be of economical length as demanded by the machinery lay out. If the latter can be adjusted for any length then it should not by increased beyond reasonable proportions because the cost goes up as square of the span increment beyond a certain distance and not indirectly proptional to it.

(*c*) Fire escapes must be provided in all the storeys.

(*d*) Even though a multi-storeyed building is more compact and better from the point of view of distributing of motive power, heating, ventilation supervision, air conditioning and humidification yet every effort is to be made to minimise the disadvantages of limitation in the un-usable space due to system of stair cases, extra columns needed, lifts and hoisting arrangements for inter floor communication.

(*e*) It is possible to have top light on the upper most storey only and light for the lower floors will have to be arranged by side glazing. While providing continuous glazing due consideration should be given to climatising effects.

(*f*) Keeping in view the high fire resisting qualities of a building as the controlling factor it is found that concrete construction is the cheapest among a number of systems like encased steel framing, steel construction etc.

(*g*) The system of construction should be such as not necessitating construction of supports on the external walls which will not permit continuous glazing or insertion of window extending in height from about 8 ft. above the floor level to the ceiling level. It is generally specified to provide a window area about 35 to 40% of the floor area, to cater for which construction of external walls in the multi-storeyed buildings must be planned on proper lines.

(*h*) Height of different storeys should be determined by the process to be carried out in them. It generally varies from 10 to 15 feet. With complete air conditioning it may be possible to keep down the heights on the lower range.

(*i*) In cantilevered extensions the floors should be continuous so that due to stepping the efficiency of operation is not cut down.

Planning for comfort of the worker :—

It is in the interest of any organisation to cater for maximum facilities and ease of operation for a worker when he is engaged with his daily routine job. Any extra investment for proper lay out of the machinery and provision of services like air conditioning, proper illumination of the work place, heating, purification of the internal air etc., will result in increasing both physical and mental efficiency of the workers with reduced sick-man days and with more efficiency increassd and better outputs can be expected. Most of the other facilities and their significance have already been discussed. A particular study of the lay out of work place is only made here :—

(*a*) The space allotted to an operative (may be around the work bench or in between a group of machines) should be adequate and well thought out. It should be neither excessive nor too little because the former will result in wastage of time and the latter put limitations on freedom to work causing encroachment on safety.

(*b*) The minimum and maximum working areas for an operation should be studied and provision made accordingly, based on assessment of the arm movement.

(*c*) Space should be provided considering the safety of the worker.

(*d*) Concentration of work in the alloted space should be studied.

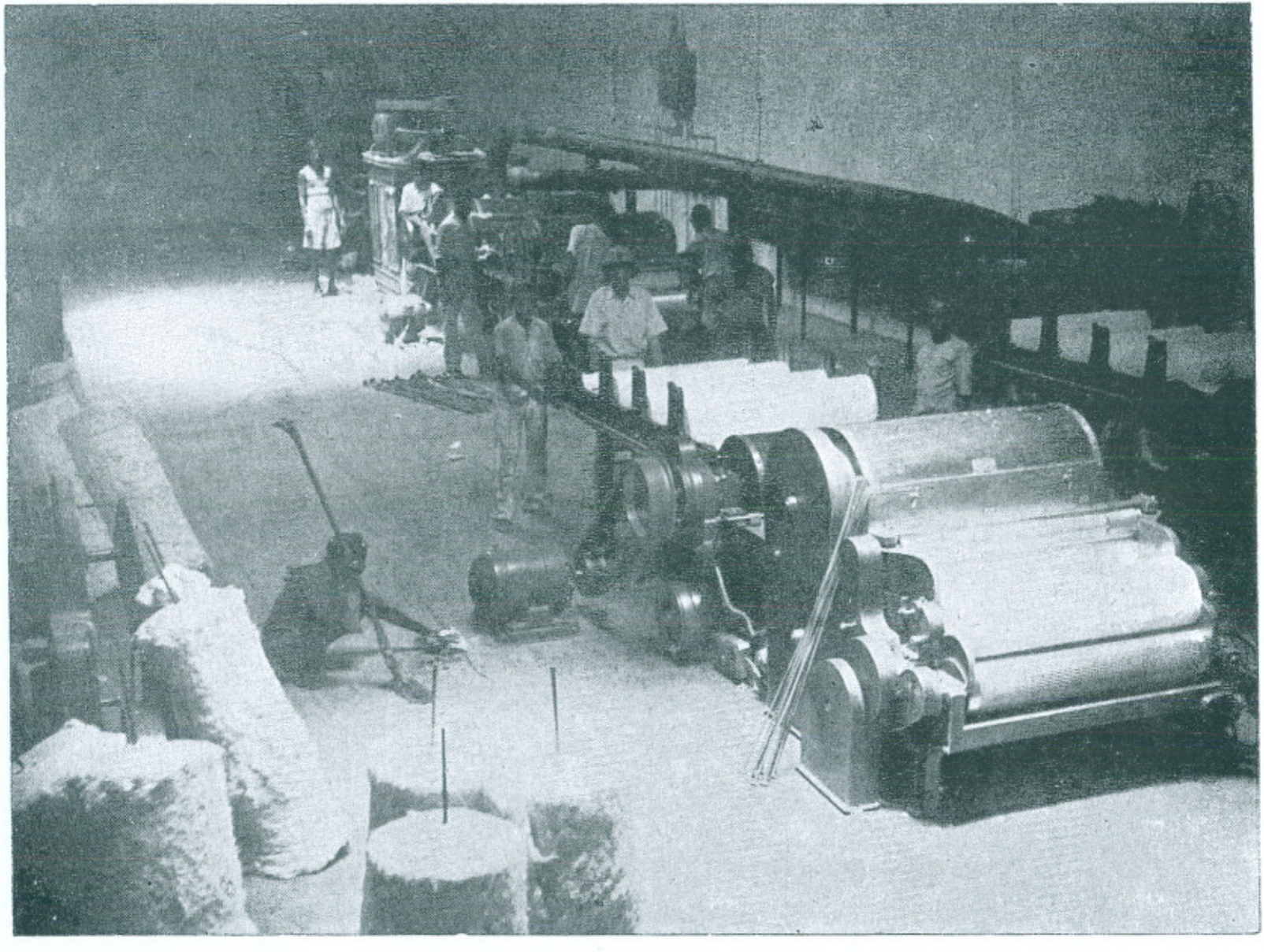
(*e*) Maintenance, cleaning etc., of the machines should be done with minimum of effort.

(*f*) Individual arrangements for vacuum sockets or vacuum filters should be provided rather than a central system where the process is going to foul the breathing air too heavily.

(*g*) Effect of the machine heights on efficicency of the worker should be given consideration. Generally waist level height is considered to be the best.

(*h*) Facility for provision of tool space should be so located that it is within easy reach.

(*i*) If the worker has to attend more than one machines at a time it should be seen that fixtures such as columns do not interfere with his movements. The machines should be erected in consecutive order depending upon the sequence of the operation.



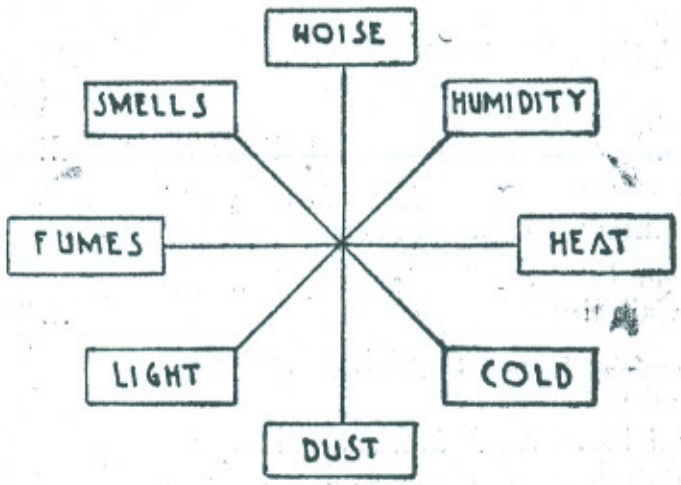
A blowing room in a Textile Mill shows defective system of day lighting. There are moving shadows and patches of intense light glare on the floor and on the machines.

(*j*) The workers employed in transportation of the material from one section to an other should have levelled space to negotiate. Terraces and steps should be avoided in their path of work.

(*k*) Drive machanism such as belting, couplings, shaftings and gearing should be suitably installed so that safety of the workers is not infringed.

Physical environments :—

Study of the physical environments as exhibited in the sketch below



will enable proper siting of the machinery and installation of remedial measures for comfort of the worker. Noises should be located, eliminated or damped down. Gentle movement of air around a worker is necessary to undo the " stuffy " atmosphere created by humidity and for body heat transference to the atmosphere. For elimination of fumes and smells they should be combated by provision of exhaust ducts at the point of generation. The remaining aspects have been considered separately with the adjustment in planning for their best provision.

Provision of Lighting :—

A factory can have day lighting or electric lighting as the major provision but generally arrangement have to be made for both considering that the machines will operate on a number of shifts. To ensure the least possible strain on eyes of the workers, to have smooth and efficient processing with the least breakdowns it is necessary that light arrangements in a factory should be well planned. The objective to be achieved is as follows :—

(*a*) Distribution of intensity of lighting should be optimum at different points for different type of operations.

(*b*) It should be uniform.

(*c*) It should not cause eyestrain.

(*d*) Excessive high lights and shadows should not exist.

(*e*) There should be sufficient contrast with the background and objects to be seen.

(*f*) There should be control of lighting to avoid dimness at one time and glare at another.

(*g*) There should be no sun spot or moving shadows across the floor.

Amount of light required for adequate visibility for the varying nature of industrial processes is indicated below :—

Description of works	*Amount of light in foot candles*
(1) Rough work, furnace rooms, Godowns ...	5
(2) General manufacturing of large objects and offices requiring moderate visibility ...	10
(3) General work and offices requiring fairly good visibility ...	15
(4) Process, work requiring really good visibility ...	20 .
(5) Special fine work of manufacturing and inspection fine drafting and things requiring excellent visibility ...	20—25 or more

For good planning of a structure for the day lighting system the following things should be kept in view :—

(1) Lay out plan for different type of machinery should be carefully studied and adequate provision of lighting for each process especially through side windows should then be decided. No shadows should be cast on the machinery.

(2) The area of windows should be at least 25 to 30 per cent of the floor area and area for the north light roof glazing, high and low bay system or of through monitors should be 10 to 15 per cent of the floor area.

(3) To improve the lighting and efficiency of workers the internal painting of structures should be properly thought out.

(4) While determining the intensity of light needed the influence of adjoining structures trees etc., should be carefully studied especially for the light planning in multiple storeyed buildings.

(5) The shape of the building itself should be studied to determine the effect of one wing on the other.

(6) Operating and cleaning system of windows should be studied, and then design of the external columns and bracings decided. Type of windows should also be decided in advance so that if required any modifications in the design can be incorporated at the proper time.

(7) Type of roof should be decided depending upon the availability of building material.

(8) Type of glass should be selected to give the best results. At those places where direct sunlight is not objectionable clear glass should be used but at other points where direct sunlight is objectionable transluscent glass should be used.

(9) Size of the window pane to be used should as far as possible be standard and uniform. The fitting in of the windows or proof lighting should be co-ordinated with the architectural planning of the building.

Type of roofs and their light intensity value :—

There are different types of roofs adopted for the industrial buildings. The tooth saw arrangement is adopted for the north light. It is very economical but no so convenient from the point of view of drainage, ventilation etc. The high and low bay arrangement will not limit the lay out to be spread out East-West wards only but even East and West light can be utilized in this case. The other type of roof is with single monitor or with multiple monitors. Effect of light through windows should also be considered for determining the light intensity curve. It is found that from the consideration of the light intensity curve the first two types of roof are better. Shell type of roofs are more expensive but advantageous to achieve bigger spans. Flat type of roofs are uneconomical and provide deficient lighting.

Electric lighting and power installations :—

A number of experiments have been conducted to find out the varying trends of output of different processes as related to the amount of lighting in a concern. It is found that during the period when day light is more out put is also more but it is comparatively reduced under artificial illumination. Every effort is therefore necessary to make artificial lighting approach as close to the day light conditions as possible. Keeping in view a number of shifts on which the industry has to operate it is essential that planning for electric illumination should be as efficient as with day light. Following are some of the considerations to be kept in view for proper electrification of a factory :—

1. Due importance should be given to physiological considera-

tions for proper placing the light points for convenience of the workers.

2. Different systems of lighting such as direct. indirect, semi-direct, semi-indirect, cove installation and florescent lighting, should be considered to find out which one will suit best and at which point,

3. At the time of planning the main factory building the planning for electric installations should be simultaneously considered so that different structures such as control room, switchboards, location of conduits etc., and their effect on structural members especially in case of multi-storey buildings should be studied.

4. Maintenance and cleaning problems in connection with the luminaires should not be ignored because it may have influence on some of the important structural fittings.

5. Electrical control rooms should be sited at proper points. The fire proof control room should also be located at a convenient point.

Ventilation :—

The technique of replacement of heated and fouled air with fresh air by means of natural circulation or mechanical means is called ventilation. Important data to be considered in connection with this facility is detailed below :—

(*a*) Number of air changes required per hour for health of workers and needs of mechinery should be determined. Basis should be the hottest season and a calm weather. It is found that minimum of 6 changes per hour and minimum in coming air velocity of 250 ft./minute are adequate.

(*b*) It is generally estimated that 5 sqft, ventilation area for every 100 sq. ft of floor area *i.e.*, 6 per cent provision is adequate.

(*c*) Ventilation system should consider the localised points producing heat. System of windows and monitors besides catering for light should also keep requirements for ventilation in view.

(*d*) Question of wind action on the factory building and problem of ventilation should be studied.

(*e*) The mechanical ventilation system should be planned jointly with humidification and air conditioning facilities because they are very closely interconnected. In those areas where for most parts of summer months there is drifting sand and storms, mechanical ventilation will have to be utilised generally.

(*f*) Position of inlet and outlet ducts should be suitably planned so that strong cross currents are not set up. Dampers should be provided on all the ducts to control the variable openings.

(g) Position of ducts in roofs for all such services as ventilation, fume and gas extraction, humidification, air conditioning etc.. should be properly planned in early stages before the construction is taken in hand. This will obviate subsequent fitting in at increased costs when even after best efforts the results achieved may not reach the correct standard.

Roofs :—

There are different types of roofs adopted with different requirements in view. A particular choice may be essentially based on the type of material available, machinery lay out, climatic considerations, question of day lighting the plant or to harmonise the architectural features of the entire project as one unit. The general desirable qualities of roofs are as follows :—

(a) Lightness.

(b) Strength.

(c) Water-proofness.

(d) Fire resistance.

(e) Cost.

(f) Durability.

(g) Low maintenance charges.

(h) Suitability to the mechanical lay-out.

(i) Best utilization of the material available in the local market.

(j) Ease of drainage and flashing.

(k) Provision of the required amount of lighting.

The roofs which are now being constructed in Pakistan for different industrial projects are :—

(a) Steel trusses with asbestos corrugated cement sheeting.

(b) Steel trusses with G. I. Corrugated sheeting.

(c) Concrete roofs with shell type of construction.

(d) Concrete roofs with monolithic columns and arches.

(e) Flat concrete roofs with beams and slabs.

All the above types are mostly constructed to cater for provision of north light arrangement. Details of different types of roofing essentially from the lighting consideration have already been discussed under the heading of provision of lighting.

Floors and Machinery Foundation :—

The guiding principle for construction of floors is more or less on similar lines as for roofs. However there are a few requirements quite typical for construction of floors such as the style of framing, effect of floors on the foundation design, supporing framework for multi-storey buildings, which deserve attention in particular.

The problem of drainage both soil and surface, various ducts, electrical conduits and planning of the machinery foundations should be properly considered while designing the ground floor basement. Any floors carried below the ground level have to be properly designed against the subsoil water pressures and for water tightness. Provision of expansion joints should never be ignored.

The floors of certain buildings such as warehouses machinery rooms have to withstand shock from heavy consignments or machinery parts, tools etc., dropping very often on them. They should be adequately strengthened to take up this arduous duty.

Machine Foundations :—

Machinery foundation drawings have to be supplied by the manufacturers sufficiently in advance so that they are ready for erection as soon as the machines are received. It is necessary that they should be given some idea of design of floor so that the machinery foundations can best be fitted into the general lay out, In case of light machines with practically no vibration effect their foundations are cast monolithic with the floor but where heavy loads are involved the foundations should never have rigid connection with the basement. Otherwise the floor and the entire superstructure may be set in resonance. At the junction joints where the foundations pierce through the floor slab bitumastic or other suitable filler should be used. Following points deserve merit for planning of the machine foundations :—

(*a*) The foundations should be constructed on firm soil and should be wide and deep enough to withstand different forces to which they are subjected.

(*b*) They should be strong enough to take up the effect of vibrations in case of the machinery with marked vibration setting effect.

(*c*) As far as practicable they should be isolated from the basement floor.

(*d*) To keep the foundations ready in advance their heights should be kept 1″ to 2″ below the final finished height and the difference should be made up by means of grouting.

(*e*) Anchor or foundation bolts should be of proper type and strength depending upon the type of machinery they have to hold.



This textile mill has put up a flat type concrete slab roof with system of beams. The cost as compared with other type of roofs has been too high and only 8½% north light has been accomplished which is very inadequate.

They are supplied by makers with the machinery but their particulars should be known in advance so as to make provision for them while casting the foundations.

Some people keep casting of the foundations pending till actual receipt of the machinery so that by measurements of actual baseplates they can be more exact about their casting. If the foundation drawings are available and advance planning can be done there is no reason why this time should not be saved.

XII. Air conditioning :—

Air conditioning technique consists of processing enclosed air to regulate its moisture content, temperature, circulation and purity. It is an established fact that whatever expenditure is incurred on provision of this facility in an industrial concern it repays itself in a number of ways. Human efficiency, capacity and mental alertness is best at a particular temperature and relative humidity. Fibres for processing variety of raw materials on the synthetic system require a controlled humidification and temperature range to check frequent breaks and interruptions. There is a tendency to increase speed of modern industrial machines more and more with new developments in metallurgy. Fluctuations in temperature should be checked ; dust and trade waste particles in the factory air should be removed for efficient working of delicate parts of these machines. Only then will it be possible to do away with the faults in the articles manufactured and achieve the best output. Air conditioning has thus become a necessity in the modern industrial concerns.

It is a wise step to obtain the opinion of machine manufacturers as to which operations in a factory require installation of air conditioning. The final opinion will of course be of the air conditioning expert who is entrusted with the job of planning this facility. It is however necessary to have some basic knowledge of this requirement in different sections of a mill at time of supplying data to such an expert so that everything is not left to him. Opinion of medical authorities should be obtained to find out the best suited temperature and humidification for human efficiency because a combination of both will determine the effective temperature. It is generally accepted that 68°F and 65°F are ideal temperatures during summer and winter mouths respectively and a relative humidity of 65%. It should be decided which of the processes comprising the air conditioning system have to be installed. For example it should be seen whether refrigeration with humidification or the latter alone is required ; whether dust and fume control is necessary and whether special provision for ventilation regulation is to be arranged.

Data to be supplied for obtaining quotations for the air conditioning contract :—

Before referring the air conditioning problem to any experts it should be known what type of information has to be made available to them so that they can put up their proposals on definite lines.

(i) The lay out plan showing the most suitable site for erection of the central or combination air conditioning system.

(ii) Detailed sectional drawings of the main factory building showing graphically as much information covered in the questionnaire form as possible.

(iii) A questionnaire form duly anwered should be supplied. A typical form may be somewhat on the following lines :—

(1) *General* :—

(a) Name of the place where factory is being put up ....

(b) Brief description of the main factory building *i.e.* whether showing single storey with concrete roofing, multi-storey with steel trusses and asbestos roofing, new or existing and so on...

(c) Description of the surroundings.....

(d) Altitude of the site above mean sea-level..... .....

2. Meteorogical observations :—

(a) Maximum and minimum temperature variations both outside and inside rooms in Summer and Winter if record available ....

(b) Wet, dry bulb readings, dew point and relative humidity in different seasons.....

(c) Characteristics of rainfall.....

(d) Any special breezes affecting the temperature conditions ..

3. Drawings :—

(a) Processes to be air-conditioned and description of rooms in which to be installed with their position on the drawing... .....

(b) Lay-out drawing position of power house in relation to the factory building, boiler house, cooling towers, water supply system and the site for central or combination system of air conditioning.

(c) Mechanical lay-out drawings.

(d) Drawings showings details of flooring and roofing system, ventilation, lighting arrangements, passage of steam pipes, type of walls, windows, doors etc.,

4. Electric supply :—

Details of the electric supply like A.C./D.C. voltage, phase, cycles, etc.

Details of electric motors and other sources of power consumption like electric lighting with the maximum consumption figure.

5. Steam Supply :—

Giving consumption figure, quantity and pressuse in lbs. per square inch....

6. Machinery :—

(*a*) Any heat radiating machinery or apparatus...

(*b*) Number of workers who occupy the room at a time...

(*c*) Any heating equipment which exists.

(*d*) System of forced draught ventilation.

7. Detail of the building :—

(*a*) *Exterior walls* :—
(*b*) *Partition or interior walls* — Their direction of facing length height area both gross and net surrounding temperatures for (*b*) should be known with details of construction.

(*c*) *Exterior windows, doors and glass* :— .. Here again information on lines shown above should be collected.

(*e*) *Floors* :— .. Their areas with temperature variation and details of construction should be known.

(*f*) *Ceiling, roof and roof glass* :— .. Information as to their areas, temperature variation and details of construction should be known.

8. General remarks and details of any special demands.

Incorporation of the air conditioning installation in the building plan.

Planning for the air conditioning installation should be coordinated with the building plan at the proper time. It may be possible to reduce total height of the factory after installation of the air conditioning equipment. If the ducts for air diffusers are planned at the right moment and at the right place they may not ruin the architectural attraction of building besides adoption of the correct type of ceiling. If it is possible to achieve some reduction in height of a factory building without interfering with working efficiency of machines by installation of the air conditioning, the saving may itself justify this facility besides the other advantages of increasing the output and improving quality of the products.

Dust, Fume and Gas Extraction :—

Elimination of dust, fumes and obnoxious gases in a factory is necessary not only from the point of health of the workers but also demage to the machinery. Besides dust from the outside atmosphere there are a number of operations which give rise to industrial dirt within a factory. Some of these are listed below :—

Grinding, Crushing, Milling, Conveying, Mixing, Refining, Smelting, Drying, Mining and Carding.

Dust and other waste particles from the trade can be efficiently removed by means of vacuum extractors, air washers, oil filters, cloth filters and electric purifiers.

To keep out easy entry of dust particles through window and door crevices it is desirable to maintain an internal pressure of the air in a process room above the atmospheric pressure. This can be easily achieved by means of regulation of the ventilation system through air conditioning.

There are electric filters and precipitators which can be installed for this service. Whereas the air filters can be installed at different points of the factory the precipitators are generally installed to purify the exhaust gases. In case of certain industries like the viscose art silk, tanneries, obnoxious and injurious gases are emanated which are treated by means of ozonizers combined with scrubber towers.

The location of different types of purification devices are based on the type of industry and useful for some of the sections in a particular mill and not the entire chain of process. Their location and erection should be done as recommended by the makers of such an equipment.

XIII. Construction Planning :—

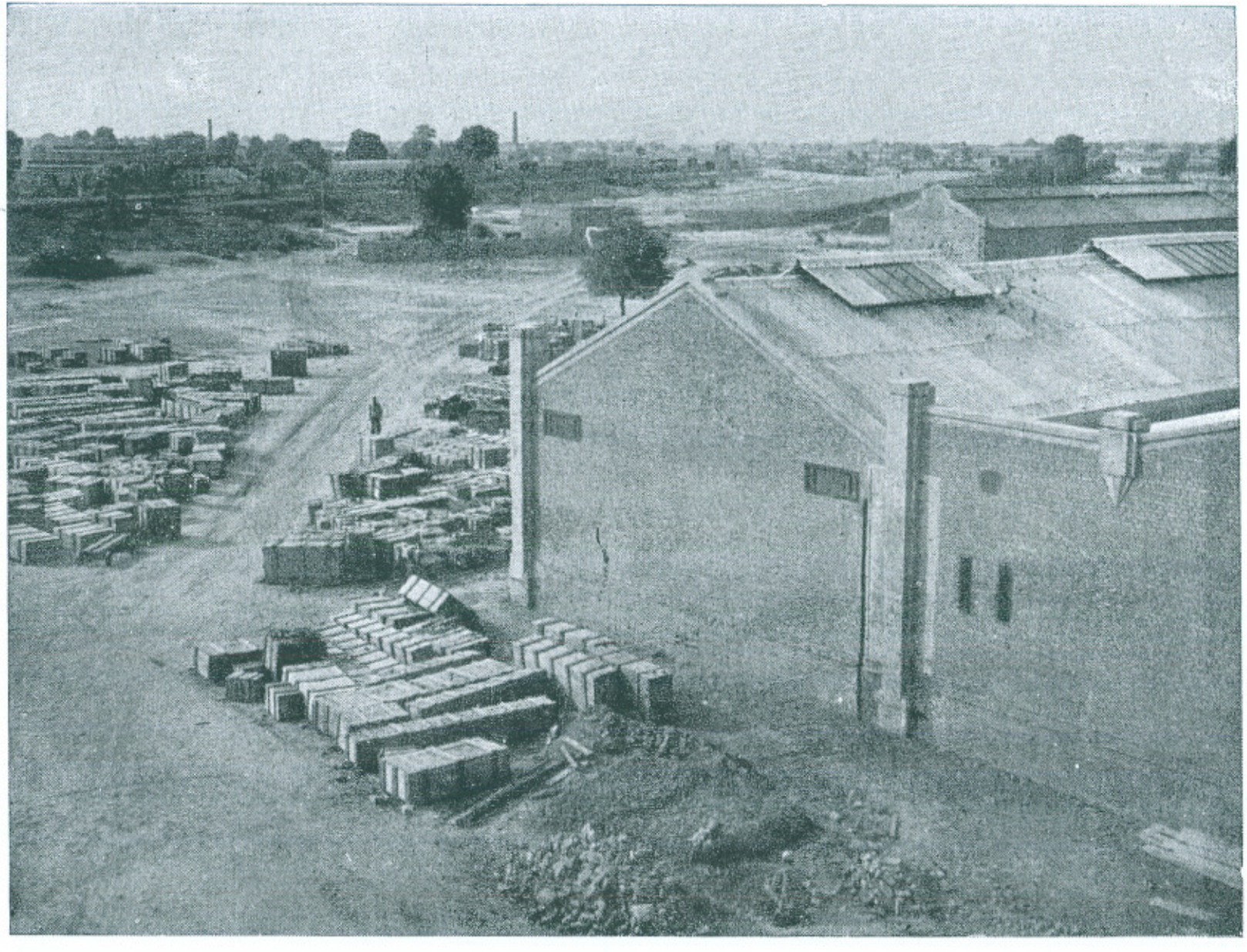
It is a very wise step to plan out the construction of an industrial project after its detailed lay out and design has been prepared. This will check a haphazard approach to the job and units with first priorty will be built up first using the right type of equipment and material. The things which count are somewhat on the following lines :—

Building Material :—

(*a*) Arrangements to procure the material should be taken in hand immediately after the building blue prints are ready and quantity estimation is finalised. The fact should not be ignored that there is scarcity of most of the essential building items such as cement, timber, steel, etc., in Pakistan.

Construction of staff quarters :—

(*b*) The first buildings which go up should be temporary shelters for the supervisory staff.



Machinery packages have been lying in the open exposed to rigours of the weather. Factory building has been completed yet valuable machinery parts have not been stored properly. A wrong planning has been done to do the machinery erection by picking it up from the open, after the foundations are laid. Raw material godown has been constructed without considering the lay out of the railway siding. As a consequence the siding when it is laid out will pass away from the warehouse and about 8 ft. higher than the ground floor level of the building.

(c) *Storage of Machinery and Material:--*

Machinery :—Machinery must be protected against weather effects immediately after its receipt. This will warrant construction of proper storage sheds on temporary basis. Electrical goods such as motors, transformers, generators, switch boards etc., require extra care against moisture damages. Similarly dust storms may be another nuisance against which delicate parts of the machinery must be protected. These storage sheds should be properly sited so that heavy machinery can be easily transported to them from the unloading point.

Material :—Some items of material cement and lime in particular require special precautions for bulk storage. Very often it so happens that lack of the storing facilities stands in the way of advance purchase of such items of the material, when they are easily available. Procurement of cement and steel should be planned at the correct juncture keeping in view the demand of these items for big development projects afoot. After completion of these schemes there is a good opportunity to purchase these commodities prior to commencement of the new priority projects by the Government. As soon as a deal is negotiated the storage facility should not stand in the way of its final settlement and lifting up the full quantity of the material.

Even though the store godowns are temporarily constructed yet they must ensure a leak proof construction to save the items such as cement against effect of rains, floods etc. Their siting should be correctly done so that they do not interfere with construction of the main buildings in any way. They should, as far as possible cot down the frequency of handling and lead distances to the minimum possible.

(d) *Electric Power* :—

If electricity is available close to the site and a temporary connection for the period of construction is possible this must be arranged.

(e) *Access Roads* :—

Kacha access roads should be built for purposes of prompt delivery of different building materials at the site.

(f) *Water Supply* :—

There may be sites where tube wells have to encounter hard rocky strata and take long time to finalise. Even for supply of nominal quantity of water for moulding of bricks, precasting cement concrete blocks or for the main construction itself the tube well must be started sufficiently ahead otherwise in the absence of water at the site no progress is possible. There may be sites where open wells exist with potable water and can adequately meet with the initial water supply demand. Steps should be taken to work them with a proper type of machinery which is not only economical in first cost but also is re-usable. This point has been taken up under the heading of construction plant.

be able to give a sound guidance in different matters it is seen that various undertakings are delayed. The managing directors have to run about tackling technical matters absolutely beyond their prowess.

Confidence of share holders if it is joint or co-operative concern is shaken, due to delays. There is no body to prepare details for calling the building tenders or to achieve co-ordinantion between the machanical lay out and the building design. Schedule of requirement for the machinery cannot be accurately prepared and best mechinery is not arranged. This is attributable to the present tendency to postpone the engagement of the technical officer to the last so that administration can utilise his services when actual construction is to be taken in hand. Experience will show it is false economy.

Drawbacks in this system :—

(*a*) Fixture of the site may not be best.

(*b*) Advice from the manufactures cannot be taken for the planning.

(*c*) Proper set of drawings cannot be prepared.

(*d*) Exact schedule of requirement is not known.

(*e*) It is not possible to get the most economical and best machinery.

(*f*) Delays in delivery period may not be cut down.

(*g*) There is no single technical officer who is in touch with the development of the concern from beginning to end and thus have mastery over the organisation.

System being adopted in other countries :—

In other countries services of consulting engineers are generally obtained for the engineering planning and erection of the industrial concerns. They perform the following functions :—

(*a*) Preparation of project report including the economic apparisal.

(*b*) Planning.

(*c*) Design of construction.

(*d*) Estimation of cost.

(*e*) Testing of materials and supervision of construction.

(*f*) Specialised plant and mechinery inspection during manufacture.

(*g*) Co-ordination between the manufacturers and the contractors.

(*h*) They should invite quotations, scrutinize them and place before the organisation directors for their approval.

(*i*) They should invite building tenders with design.

(*j*) They should get the architectural rendering done to the building after the design has been accepted.

(*k*) Air conditioning services will be incorporated in the design and water supply arrangements will be made.

Special advantages of this system are as follows:—

(*a*) Delays in the manufacture ; any deficiency of the fabrication and supply of machinery will be eliminated.

(*b*) Time in writing tenders and checking will be saved.

(*c*) Economics of construction will be in hands of experienced consulting engineers.

(*d*) Contractors of repute with proper tools and plant will be selected to undertake the job.

(*e*) Materials employed for the construction will be of the highest order.

Consortium of Administration :—

Planning, design and execution will all be done by one single agency. It is difficult to get such a firm in Pakistan but there are quite a number available in foreign countries. It is expected that not in the distant future such organisations will be available in our own country as well. Till such facilities are available every effort is to be made to secure the best engineer who possesses wide experience not only in the preliminary planning, construction of the factory but can also serve as a mill engineer so that his interests with building up of a concern are not on temporary basis. He should have the confidence that he is setting up a show which he has to run tomorrow. It is very difficult to get such qualified men in industry in Pakistan and naturally foreign countries will have to be explored.

Securing services of a foreign engineer :—

There may be a number of industries for which it may be advantageous to get technicians from the country of manufacture of the machinery. The correspondence to secure the machinery and a planning as well as the operational engineer should proceed simultaneously. The concern whose interest has been created for supply of the machinery will naturally give the best possible advice for the technician to handle it from the erection stage to the operational stage.

After doing some preliminary correspondence and getting the relevant papers in hand it is profitable if final settlement for purchase of the machinery or for selection of the engineer is done on the spot in the manufacturing country. The money spent in visiting a number of countries where from the offers have been received is definitely worth

(*a*) *Taking stock of the past experience* :—

As a first step it is necessay to take stock of all the development to which different industries have progressed, under the existing conditions and what are special points from which we can learn. It is not an easy job to compile this information spread over the last 5 years. However the easiest way of doing so is to make questionnaire forms indicating the points against which information is sought and issue to different proprietors of the factories for filling up. They shonld be guided about filling up these forms and directors of industries in the provinces should chase up this problem.

History of Construction :—

(*b*) The new industrial concerns being set up from now onwards must maintain this historical records right from the first day to finish. In particular they should keep an account of their difficulties, omissions and suggestions for others. They have to be told the specific points and aspects touching planning, construction and operational stages which should be covered in such a write up. In fact these are the same points about which it is well known that the industrilists are facing difficulties at the moment.

(*c*) A survey should be conducted on the availability of different types of building raw materials at different places of the country ; what is their utility for industrial construction and which particular item will suit specific industries. It is difficult for private agencies to get such site resource surveys conducted so as to benefit most from the site of setting up an industry. For instance there may be a locality where both bricks and cement concrete blocks can be used with success. However considering good quality sand, shingle available locally cost of concrete blocks may be less than bricks.

(*d*) *Price fluctuation and building activity survey* :—

The corporation should publish a review for the price fluctuations of different building materials in both the wings of Pakistan and also fluctuations in price index of different types of machinery in the foreign countries. The activity for building of different types of idnustrial concerns should be published for information of the public. A sample form on which it can be done is shown on Appendix No. 9.

(*e*) *Standardisation of Blue Prints* :—

The entire area earmarked for industrial development should be divided into zones keeping in view different characteristics such as the climatic conditions, special type of construction to be adopted, and handling of both raw and finished products. Considering different types of industries that can be set up in these zones their typical lay outs should be prepared. Blue prints for economical type of factory buildings should also be prepared. As regards the general lay out planning it cannot be enforced at all sites and material changes depending upon local conditions have to be introduced. However such type

plans will afford guidance for the public on what lines to approach and what requirements to cater for. Final adjustments are not difficult to make.

(*f*) *Building certificates* :—

It may appear a little premature to enforce issuing of building certificates by P. I. D. C. to anybody interested in setting up an industrial concern after approval of the plans. This will result in gagging industrialisation at its infancy. However in some form or other Government must be sure that the plans according to which these concerns are being set up are properly drawn up which will not spoil the quality and quantity of a product. This should be more with a view to give voluntary guidance rather than centralisation of this activity. After some years of the industrial growth this practice will become a necessity and will have to be enforced with rigidity.

(*g*) *Approved list of Engineers and Contractors* :—

There is dearth of engineers and contractors who are experienced in building up industrial concerns. Most of the technical people claim to possess sufficient knowledge and experience but actually responsibility for a considerable bad planning and construction of un-economical structures is attributable to their half baked knowledge. In order to encourage specialisation of the industrial planning and building and to eliminate in-experienced people claiming a virtue which they do not possess it is necessary for P. I. D. C. to maintain a list of approved engineers and contractors who by dint of their attainments can be recommended to public for setting up the industrial structures. At the moment they are finding it extremely hard to get hold of reliable agencies to undertake their jobs. This list is particularly necessary for those building contractors who tender for contracts with their own designs. Such selected lists should be revised from time to time and published for the information of public.

(*h*) *Selected Engineering Designs* :—

It is necessary for P. I. D. C. to publish selected engineering designs concerning industry from time to time. They may be local designs as being followed in Pakistan or from other countries as applicable to our requirements and should bear constructive criticism. Models and designs of some of the selected industrial projects should be exhibited in the industrial exhibitions and prizes awarded to the best offered designs of given projects. Members of different engineering associations should be encouraged to write technical papers on the industrial develpoment subjects.

(*i*) *Purchase Missions abroad* :—

Government of Pakistan do send purchase missions in foreign countries for procurement of machinery from time to time. Besides arranging the machinery they should also aim at the most efficient plann-

provoking problem. Others will offer their crticism and constructive suggestions. They will be lead then to divulge their experience.

These sentiments have been responsible for presentation of this pepar dealing with a very intricate subject where each aspect demands wide experience for one to say something with authority whieh the author lacks. It will have served its mission if it serves as an appeal, inviting men with experience to explore further this problem facing the building up of our nation by chopping and pruning it to a stage approaching maturity.

The ideas expressed in the paper are strictly the author's own and in no way associated with his official capacity.

Acknowledgement :—Mr. A. D. Azhar Financial Adviser Development Government of Pakistan very kindly spared time to correct the entire draft. I cannot find words to express my thanks he deserves.

The author contacted the following gentlemen and discussed with them different problems covered in the text. They offered valuable suggestions and encouragement for writing of the Paper for which the author is indebted to them all :—

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Mr. M. I. Haquani	...	Chief Development Officer P.I.D.C.
Mr. Dreyer	...	Engineer M/s Volkart Brothers.
Mr. Zafarul Ahsan	...	Chairman Thal Development Authority
Mr. Gallagher	...	Air Conditioning Engineer M/s Volkart Brothers.

Following concerns provided all the facilities including their design plans to study their factories for which the author is indebted to their management.

(1) M/s The Pakistan Cooperative Woollen Textile Mills, Lawrencepur.

(2) M/s The Abbasi Textile Mills Ltd., Rahim Yar Khan.

(3) M/s The Sadiq Soap and Allied Vegetable Products Ltd., Rahim Yar Khan.

(4) M/s The Kohi Noor Textile Mills, Ltd., Rawalpindi.

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(1) Planning—by E. and O. E.

(2) Planning Industrial Structures—by C.W. Dunham.

(3) Industrial Waste Treatment—by Eldredge E. F.

(4) Textile Electrification—by Dr. Ing. Wilhelm Steel.

(5) Civil Engineering Data Book—by Seclyc Elwyn Egglestore

(6) Publication on air conditioning—by :—

(*a*) H. Krautz Bad Pyrmont Germany, (*b*) Hall and Kay Ltd., England. (*c*) Carrier Corporation U.S.A.

(7) Construction Planning and Plant—by Ackerman & Locker.

(8) Textile Organisation Production—by A.E. Clifford.

(9) Steel Survey of Pakistan (2 Vols.)—by United States Steel Export Co.

(10) Report of the United Kingdom Industrial Mission to Pakistan 1950.

(11) Railway Steel Topics—by United Steel Companies Ltd., England.

(12) American Builder—(Magazine)

(13) Fire Tarrifs issued by the Insurance Association of Pakistan.

(14) Publications of M/s Mather and Platt Ltd., London, on "Grinnel" Automatic Sprinkler and Fire Alarm System and Fire Control doors.

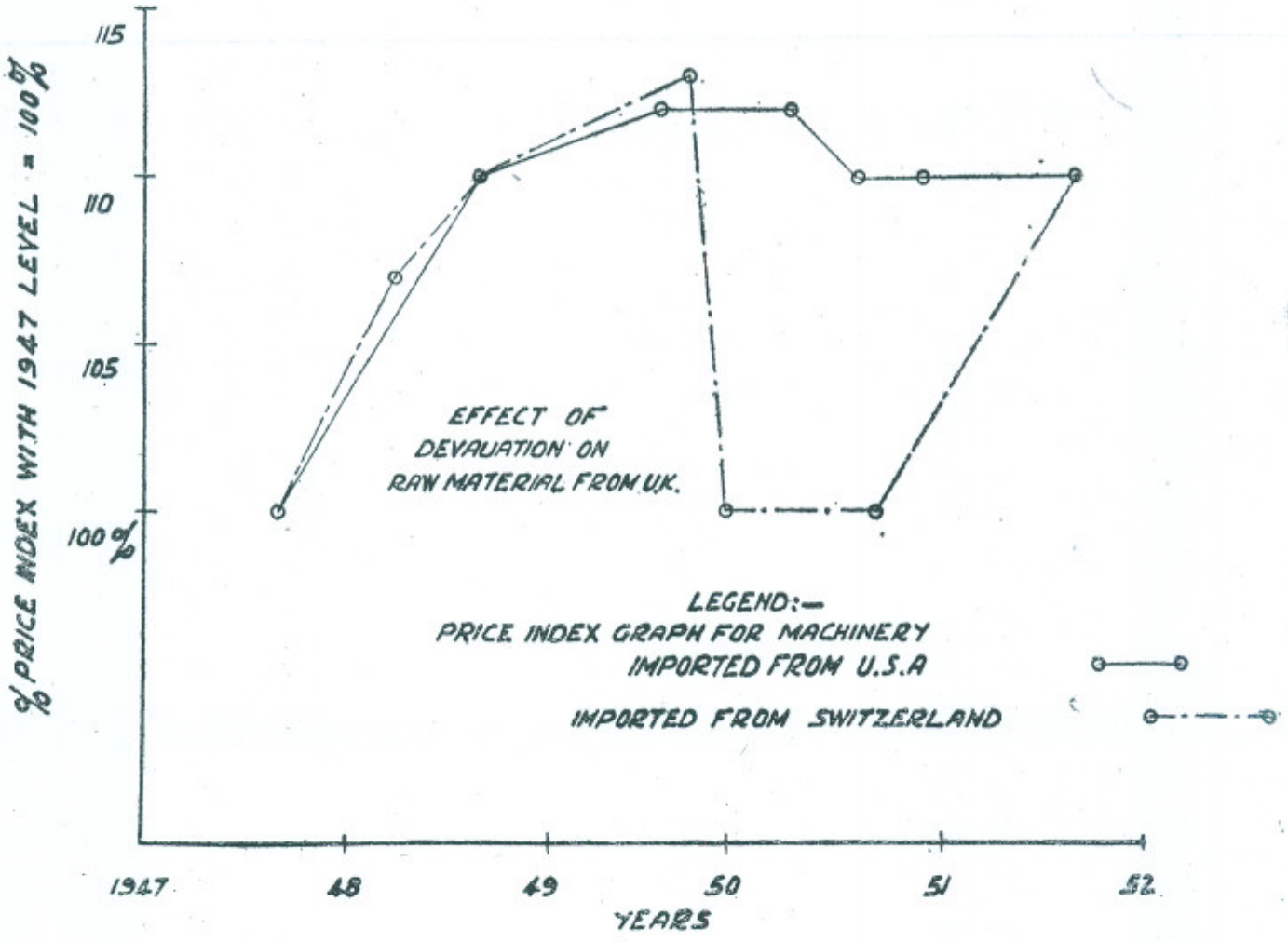
(15) Economic appraisal of development projects (2 Vols.) United Nations.

PAPER N&300

APPENDIX No I

MACHINERY

PRICE INDEX GRAPH

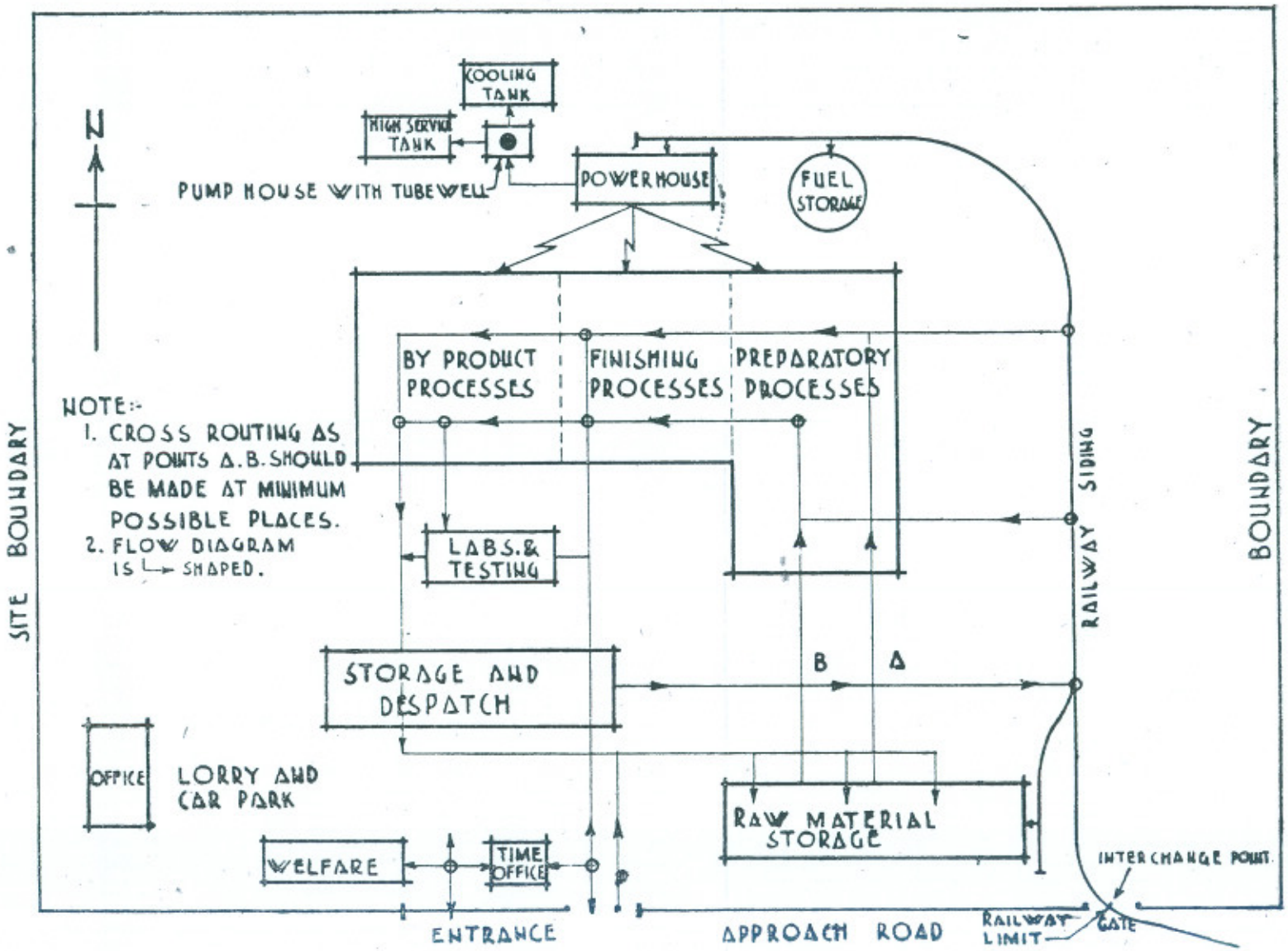


PAPER NO. 300

TYPICAL PLAN ANALYSIS OF A FACTORY

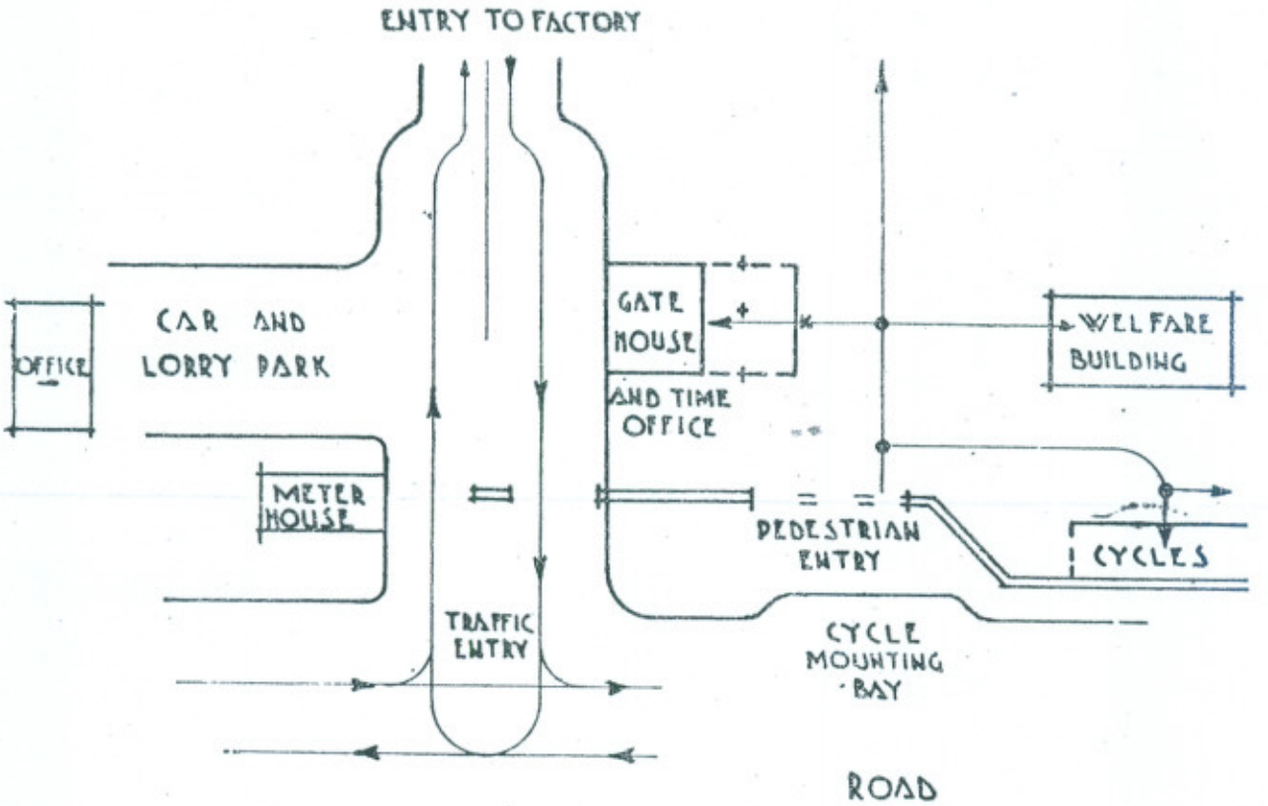
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APPENDIX NO. 2

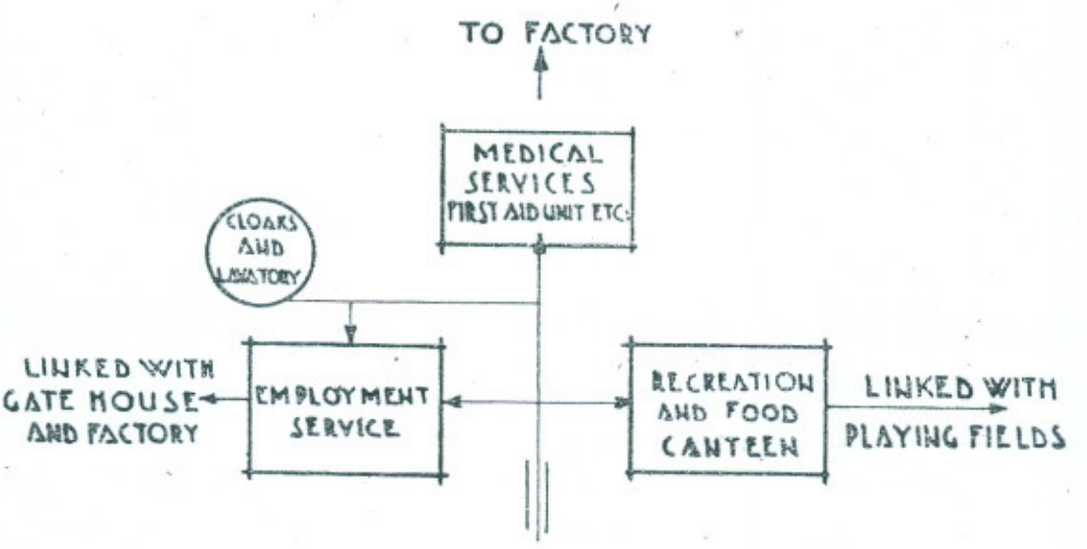


PLAN SHOWING A TYPICAL ENTRANCE

(NOT TO SCALE)

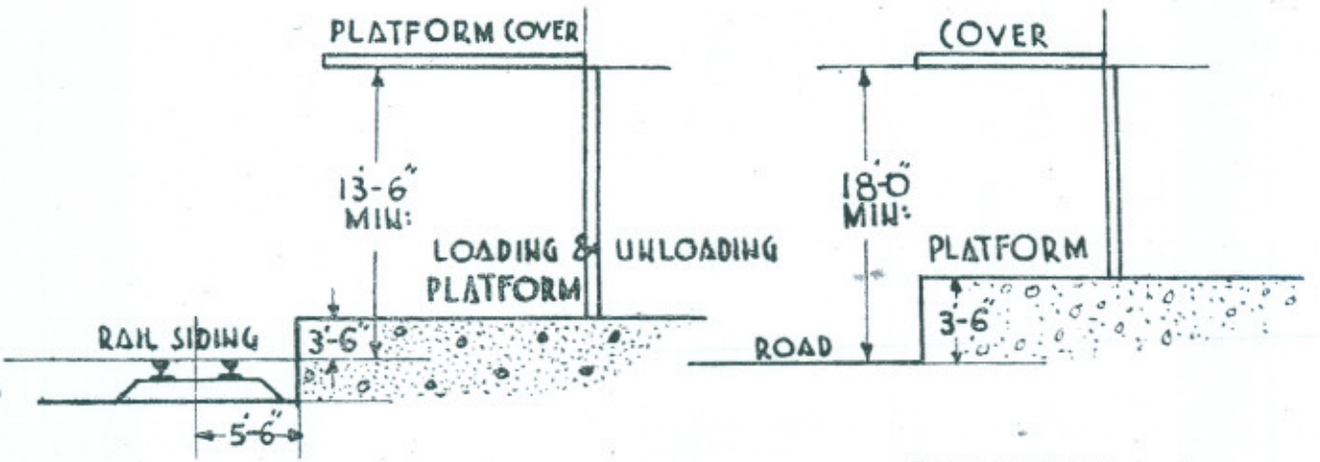


DETAILS OF WELFARE UNIT



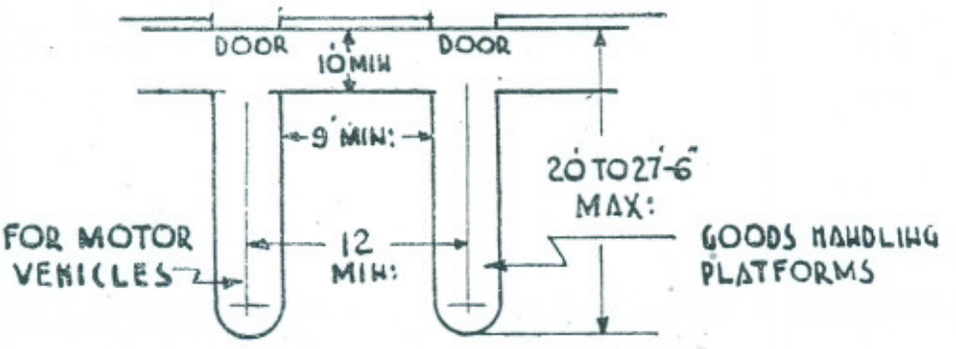
GOODS HANDLING PLATFORMS

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ELEVATION (RAIL FACILITY)

ELEVATION (ROAD FACILITY)



PLAN (ROAD SERVICE)

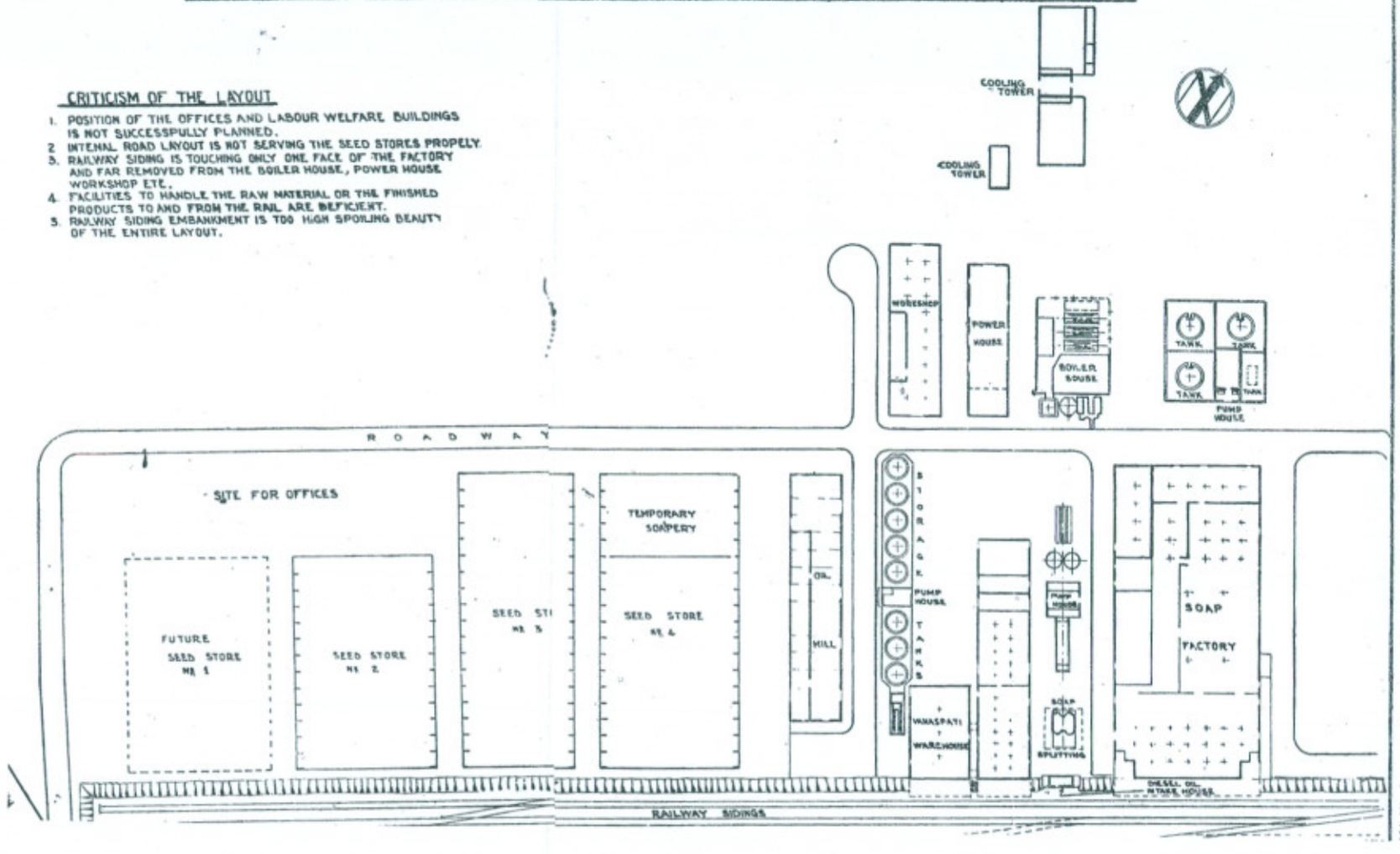
12 300

VEGETABLE OIL AND ALLIED PRODUCTS FACTORY

APPENDIX No. 5

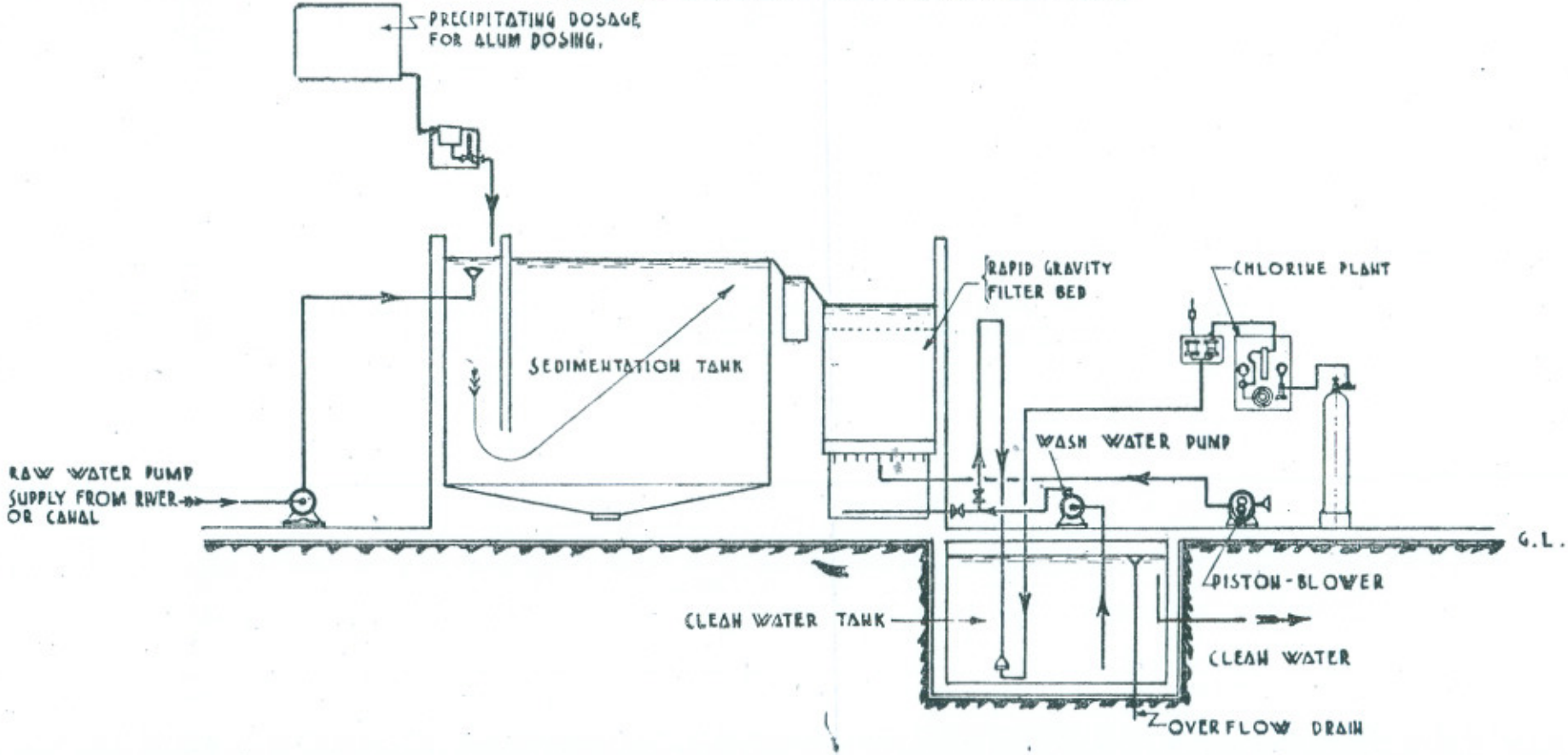
CRITICISM OF THE LAYOUT

1. POSITION OF THE OFFICES AND LABOUR WELFARE BUILDINGS IS NOT SUCCESSFULLY PLANNED.
2. INTERNAL ROAD LAYOUT IS NOT SERVING THE SEED STORES PROPERLY.
3. RAILWAY SIDING IS TOUCHING ONLY ONE FACE OF THE FACTORY AND FAR REMOVED FROM THE BOILER HOUSE, POWER HOUSE WORKSHOP ETC.,
4. FACILITIES TO HANDLE THE RAW MATERIAL OR THE FINISHED PRODUCTS TO AND FROM THE RAIL ARE DEFICIENT.
5. RAILWAY SIDING EMBANKMENT IS TOO HIGH SPOILING BEAUTY OF THE ENTIRE LAYOUT.



TYPICAL LAY OUT FOR RAPID GRAVITY SAND FILTRATION AND CHLORINATION PLANT

(CAPACITY :- 0·1 TO 0·2 MILLION GALLONS/DAY)



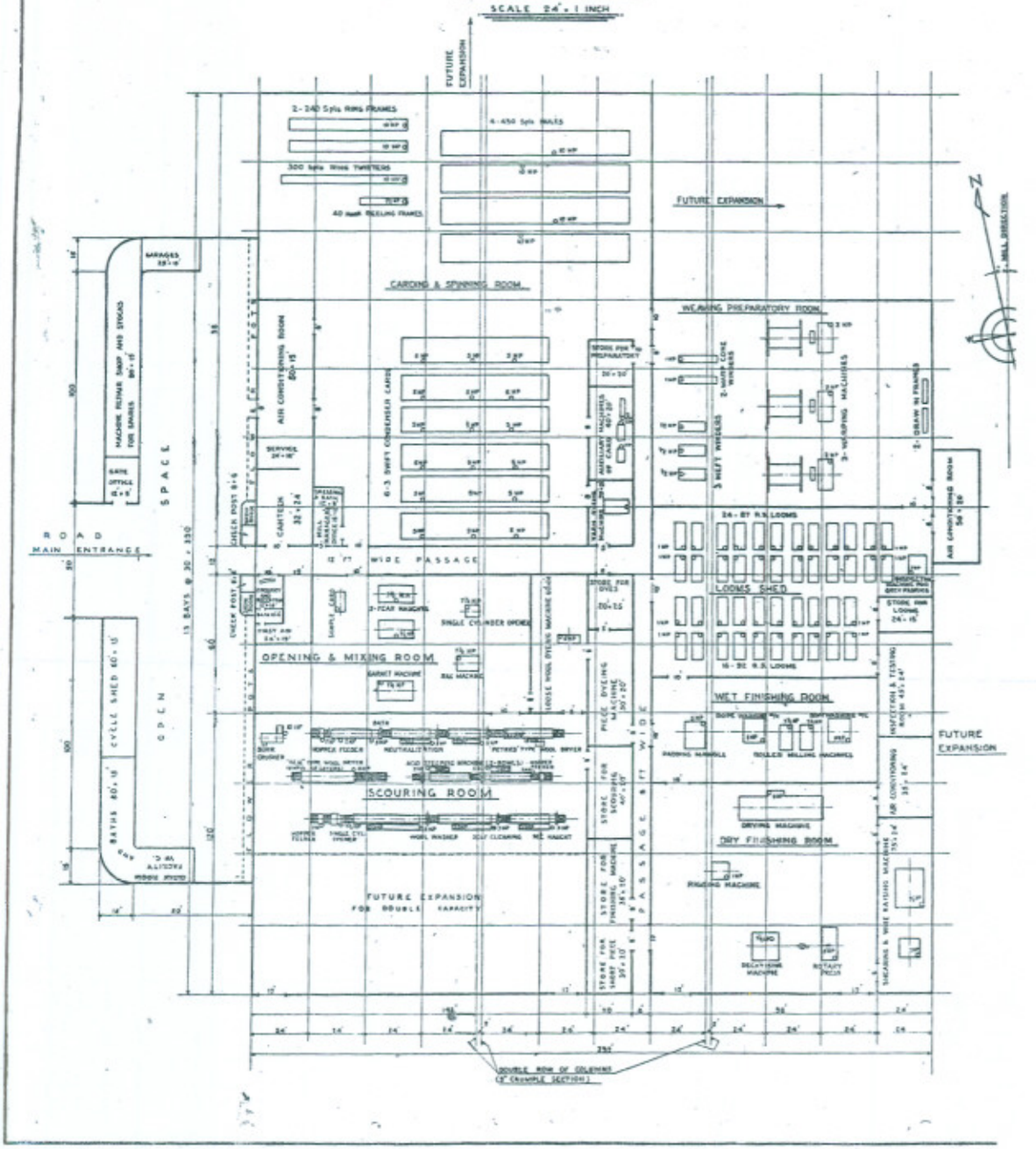
THE PAKISTAN CO-OPERATIVE WOOLLEN TEXTILE MILLS LTD

LAWRENCEPORE

MAIN FACTORY.

LAYOUT PLAN

SCALE 24' = 1 INCH



LAY OUT PLAN OF WOOLLEN TEXTILE MILL at LAWRENCEPUR (PAKISTAN)

SCALE 20FT = 1 INCH.

