ARCHITECTURAL QUALITIES OF HYDRO-ELECTRIC POWER HOUSES OF NORTHERN INDIA

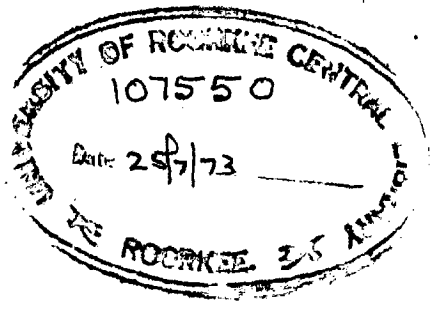
A DISSERTATION

submitted in partial fulfilment
of the requirements for the
award of the Degree of

MASTER OF ARCHITECTURE

By

V. B. VADNERE



DEPARTMENT OF ARCHITECTURE
UNIVERSITY OF ROORKEE
ROORKEE, (U. P.)
October, 1972

C E R T I F I C A T E

Certified that the dissertation entitled "ARCHITECTURAL QUALITIES OF HYDROELECTRIC POWER HOUSES OF NORTHERN INDIA", which is being submitted by Sri V.B.Vadnere, in partial fulfilment for the award of the degree of MASTER OF ARCHITECTURE, Department of Architecture, University of Roorkee, Roorkee,India, is a record of the student's own work carried out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other degree or diploma.

This is further to certify that he has worked for a period of 8 months from 1st January,1972 to 31st Aug.,1972 for preparing this dissertation at this University.

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Roorkee:
Dated Oct.10,1972.

A C K N O W L E D G E M E N T

I take this opportunity to extend my sincere and heartfelt thanks to all those whosoever provided me with valuable information, material and suggestions pertaining to this dissertation without which it would have not been possible to present this work in the form.

I earnestly express my gratitude to Professor G.M.Mandalia, Head of Architecture Department, U.O.R., for kindly giving me invaluable guidance and timely encouragements to proceed further with this work.

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Roorkee:
Dated: 15th Oct.1972. [V. B. VADNERE]

C O N T E N T S

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I N T R O D U C T I O N

The construction of the major Hydro-electrical projects, already built during, successive Five Year Plans, almost inevitably introduced very considerable changes in the appearance of the Rural Project areas, because of their predominant form in the landscape. However little attention is paid to the Architectural design and related aesthetics of these projects.

PowerHouses, transmission lines and substations etc. because of their size and nature have considerable impact on the surrounding country and resultant change in the landscape. They are appreciated or criticized according to their forms and features. The good communications have brought many forwarding remote power-houses, within an easy visiting distance of the public. It is probable that it may be visited by considerable number of people; It always pays to develop attention to securing a pleasing architectural effects, to harmonise with the landscape, and use these minimum investment to secure a recreational and working benefits, beyond and above those benefits for which they are being designed at present.

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Dams are the most magnificient of all organic engineering structures. In their finest expression they grow out of the land and landscape around with the grandeur of the out-crop of rock; but the related structures of the hydro - electric works, their switchyeards, wires, transformers can both, bring the sense of industrialisation to a scene and take away from the grandeur of the dam. Therefore the rationalization of architectural qualities have been suggested to limit its zone of influence so that it can fit quitely into the background.

Humanizing proportions are needed within the precincts of these buildings, so that the workers may feel that they are in a human world, within the framework of - machines.

The work of an Architect in general includes building design (inside and out); design of internal and external environments of power-houses after considering form, colour, proportions, materials and finishes.

This is an age of specialists and a hydro-electric scheme is a complex structure of applied specialists knowledge, requiring the full cooperation of the civil,mechanical and electrical engineers. An architect can play his due role at the project stage, to the execution of the project until its completion.

In Switzerland there is a Federal law passed in 1954, that before a water resources scheme is taken up, it must be submitted to experts on landscape and nature protection. In case it is thought that the structure will make the landscape ugly, one has to make it underground[1]. Similar lagislation in India shall pave the long way to protect the serenic beauty of the country site and improve the ecology of the region.

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1. MOSNYI EMIL., 'Water Power Development', Vol.2. Publishing house of the Hungarian Academy of Sciences, Budapest, 1960.

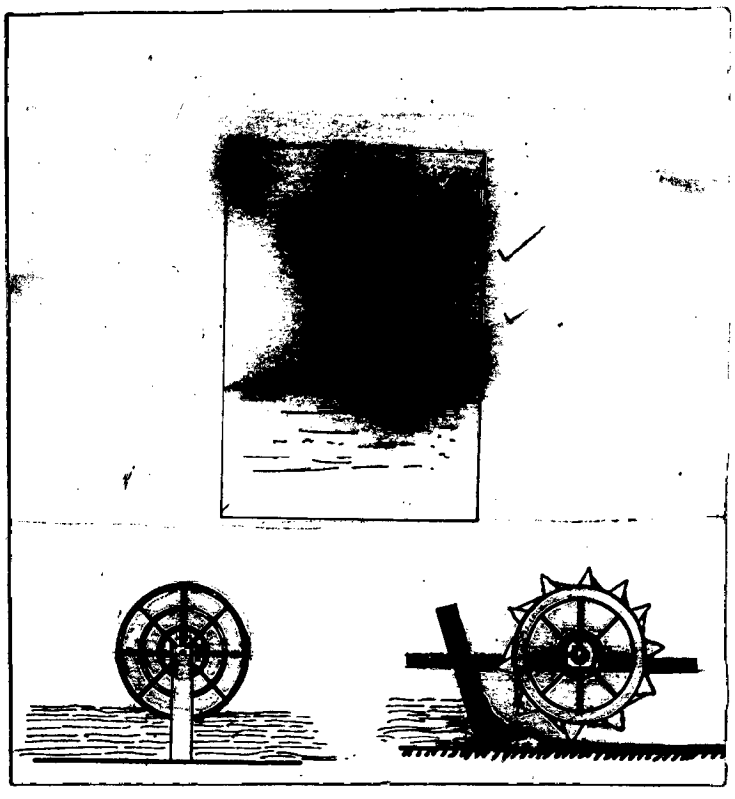
CHAPTER - I

B A S I C S T U D I E S

I.1 Brief Historical Survey

The primitive and the ancient forms of water power houses are the water wheels. The first traces of their several years ago, can be found on the 'H' Wang 'Ho' river China; on the Nile in Egypt and on the Eupharates river, where bamboos and wooden wheels of great diameter were used for elevating water and grinding grains. Mills operating by water wheels can be found all the world over. It was only later that the energy of an artificial fall, created by diverting the water in a conduit (Power canal) was utilized by Mills, operating not only with undershaft but also breast-shot and over-shot wheels[Plate-].

The invention of turbines in the nineteenth century meant a great leap forward in water power development. A rapid development in the construction of reaction wheel was brought about by discovery made by J.B. Francis, in 1849, while the first pelton wheel produced, in 1890 gave an impetus to the development of impulse wheels. These types were the direct fore-runners of



1.

2 2

3 3

EARLY FORMS OF WATER WHEELS.

Ref:- MEAD., 'Water Power Engineering', Chap. 1

modern turbines and were produced and improved in many variations during the past century [2].

I.2 Indian scene and the present day Programme

Hydro-power generation came to India in 1898, with the installation of tiny Hydroset of 20 K.W. at Darjeeling. This was followed in 1902 by a 4200 KW station at Sivasamndram on the Cauvery, in Mysore state and in 1909 by the 4500 KW station at Mohora on the banks of the river Jhelum in Jammu and Kashmir.

Today we have other efficient sources of energy - thermal and nuclear for generating electric power. Yet the importance of harnessing water is hardly reduced in the expanding complex of our power stations because wherever water resources are abundant they are the cheapest and water control has more than one good effect in irrigation and flood control, besides power generation.

The following table gives the changing pattern of power generation after independence [3].

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3. A Times of India "Science today", 'Power in India! Publication.]

2. MOSNYI EMIL., 'Water Power Development'.Vol.1, Publishing House of Hungarian Academy of Sciences, Budapest.

Changing pattern of Power generation

[Figures are in Million KW]

Year	Steam	Disel	Hydel	Nuclear
1947	757	98	508	-
1951	1097	103	575	-
1956	1598	228	1061	-
1961	2436	300	1917	-
1966	4417	486	4124	12
			4000 (Projected capacity at the end of IVth Plan.)	

From the foregoing descriptions from paragraphs I.1 and I.2, it can be concluded that the machines of power houses have been changed from most rudimentary construction to light technical and scientific nature in an atomic age ——for which a due didnity and respect is required for the aesthetics and environment in and around the structure, as a landmark and for boosting the national economic growth through power.

	NUCLEAR
SITE	Ne load centres, near the source of water, and on ne transportation routes. ca
SOURCE OF POWER	Wum um
FUNCTION	Th eat generated in the core of the reactors is used to el rt the water passing through them into steam. The la saturated steam is then used to drive the electricity be ating turbines in the same manner as in any thermal Power a . The fuel used in the reactors is enriched Uranium. The se nsor in which the steam is condensed after passing through at urbine is kept cool by the use of water drawn by means fr mps, through the intake channel extending deep in the a e of water. Generators are used to control the Nuclear is Stations. (3) wa a lo en mu wa th tu fr fo up
ARCHITECTURAL EXPRESSIONS	Wi ent elements of expressions are the hall, reactors, se ng towers and ~~xxxxxxx~~ the smoke stacks. vi ma ngineering function of each plant is expressed outside. Ha nole complex creates an image, capable of excieting of oving the imagination thereby attaining visual harmony a eaning. di Po ex fo

HYDRO	THERMAL	NUCLEAR
Common feature and one which leads to the high proportions characteristics of such halls lies in the fact that heavy equipment requires some kind of overhead lifting device in the form of a beam crane, moving on rails, running the length of the hall. Therefore the hall is column free. It is high, wide, and spacious of very large proportions. Overall visual character of the form does not look severe, because of its setting into the country site, and its siting near the source of water. Surrounding area don't have extensive handling and space, for the storage of materials as in the thermal power houses.	Inside there is no feeling of spaciousness, the great oblong stacks, the boilers, are crowded, as close to one another, as operating convenience permits, and the height of the room is broken at numerous and irregularly spaced levels by the galleries required for inspection and operation. Overall impact is much more striking because of its gigantic dimensions of its different parts such as cooling towers, and smoke stacks. This can form a eyesore if, not architecturally treated.	

CONCLUSIONS :

Planning and Design of Hydro-Electric Power Houses is relatively straight-forward than the planning of thermal and Nuclear Power-houses and over all site layout is simple in nature. Fitness of form and environment from the layout of machines, is the great challange for an Architect to attain a desired Architectural qualities. Attempts has been made to explore these qualities through the chapters that follow.

CHAPTER - II

E N G I N E E R I N G F E A T U R E S

II.1 Types of Hydro-electric power-houses

a). Surface

b). Submergible

c). Under-ground

a). Surface Power-house:

A surface power-house is one which is built on earth's surface, may be near the dam or canal or away from the canal, depending upon the Hydraulic requirements of the site.[Plate -]

b). Submergible power-house:

Submergible power-houses are built at the toe of the spillway or dam, so as to allow a water to flow over the power-house in times of flood. [Plate -].

c). Under-ground Power-house:

This type of power-houses are hollowed out and built within a rock or a mountain.

1.3 COMPARATIVE STUDIES OF POWER HOUSES - HYDRO, THERMAL, NUCLEAR

	HYDRO	THERMAL	NUCLEAR
SITE	Near the water head resources, i.e. near the lake, river, reservoirs; canal or under-ground.	Near, load centres, coal mines, near sources of water and on major transportation routes.	Near, load centres, near the source of water, and on major transportation routes.
SOURCE OF POWER	Water	Fuel	Uranium Thorium
FUNCTION	The basic requirements of Hydro-electric Power Houses is water in, large quantities. The reservoir can be built by building a dam, across a river or by bringing water from several distant sources, to collect at one point. A forebay draws water from the main storage reservoir by a canal or a tunnel. The power house is placed at a much lower level and water is brought down to it through a penstock or pipe line. At the lowest level is turbine. The water enters through the inlet valve, much can be operated to turn the water on and off at will. Inside the turbine, the force of water turns the generator. Current flows from the generator to the trans-formers where the Voltage is stepped up, to be transmitted by huge pylons.(3)	The basic function of a Thermal Power House is to convert the stored thermal energy of fuels into a consumable electricity. This is done by first burning fuels in suitably designed steam generating units, to produce steam. This steam is then made to motivate the steam turbine driven turbo generator to produce electricity. Power thus generated is stepped upto high voltage transmission lines to the load consumtion centre. (3)	The heat generated in the core of the reactors is used to convert the water passing through them into steam. The dried saturated steam is then used to drive the electricity generating turbines in the same manner as in any thermal Power house. The fuel used in the reactors is enriched Uranium. The condensor in which the steam is condensed after passing through the turbine is kept cool by the use of water drawn by means of pumps, through the intake channel extending deep in the source of water. Generators are used to control the Nuclear Power Stations. (3)
ARCHITECTURAL EXPRESSIONS	Wild natural landscape forms a perfect setting for a Power House for it provides a striking contrast.with the large machine hall. Hall is largely rectangular, because of the turbine units are, placed in a row, approximately normal to the direction of the flow through the Power-house. Layout of Machines are expressed outside into a rectangular form.	Boiler halls and the tall smoke stacks are the features of eye shore if not properly designed. For the designers it is an object of pride, and challange. With vertical boilers, the boiler room is likely to be heigher than the machine hall. It will gain more height because of the bunkers, super-imposed, on the boilers and topped intern by the coal conveyors feeding them.	Dominent elements of expressions are the hall, reactors, cooling towers and ~~xxxxxxx~~ the smoke stacks. The engineering function of each plant is expressed outside. The whole complex creates an image, capable of excieting and moving the imagination thereby attaining visual harmony and meaning.

(3) A Times of India in 'Science Today' Publication. "Power in India". p.

II.2 General design features common to surface and submergible power-houses.

II.2.1 Site Characteristics :

One of the ideal features which makes the planning of hydro-electric development, comparatively economical is a good system of natural storage lakes, at high altitudes, with substantial catchment areas, high average rainfall, steep gradiants and favourable sites for impounding reservoirs.

II.2.2 Classification of Power-houses :

There are broadly two divisions -

i). Powerhouses depending primarily on flow, canal, river etc.

ii). Powerhouses depending primarily on storage, i.e. reservoirs, near the dam site etc.

According to A.Ludin and others authors, there are three types of plant with respect to head conditions, namely [1]

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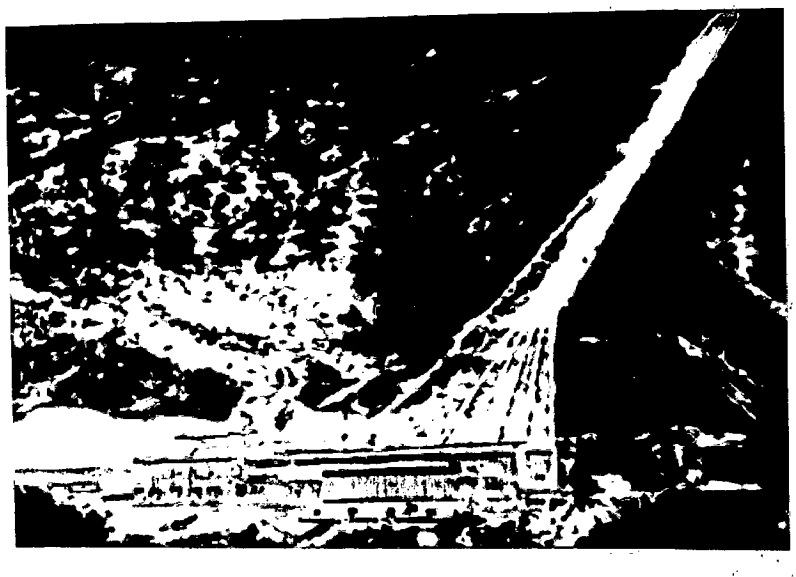
1. MOSONYI EMIL, "Water Power Development", Vol.2.

PLATE

TOBIQUE NARROWS, CANADA

Ref:- BROWN GUTHRIE, J. 'Hydro-Electric Engineering Practice'. Vol.1



TYPICAL HIGH HEAD POWER HOUSE

Ref:- 'Science Today', Power of India, Journal.

i). Low head plants with

$$H < 15 \text{ M.}$$

ii). Medium head plants with

$$H = 15 \text{ to } 50 \text{ M}$$

iii). High-head plants with

$$H \geq 50 \text{ M.}$$

These types of powerhouses presents a different visual effect in the landscape, in relation to the surrounding engineering structures, as seen from their locations [Plates -].

II.2.3 Planning Features :

Powerhouses comprising largely a rectangular building remains a basic answer to the problem of housing, the generating sets and ancilliary equipments. Units are usually always placed in a single row approximately normal to the direction of the flow. From the operational consideration, it not only avoids greater complications in the water passage-ways, but also facilitates the handling of the equipment by a travelling crane. The overall layout is determined by the practical, economic and operational consideration. It can broadly be divided into two parts[4].

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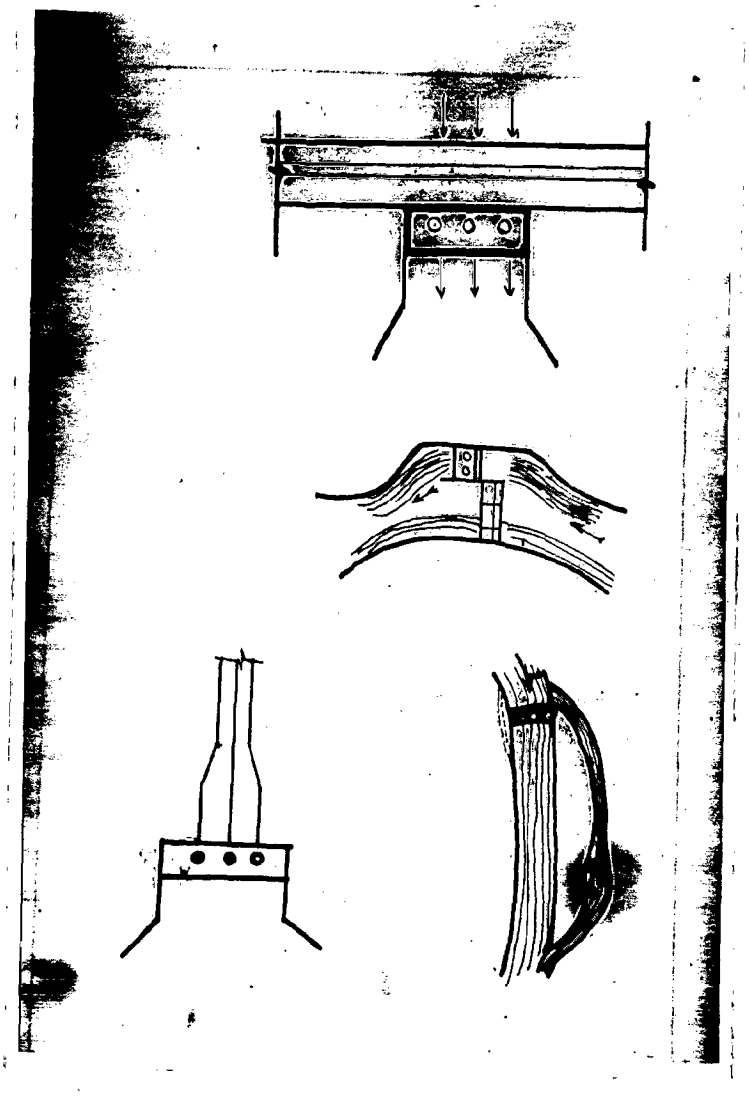
4. CREAGER WILLIAM P. and JUSTIN, D. JOHN. "Hydro-electric Hand-book".



SITE CHARACTERISTICS OF POWER HOUSES

Ref:- MOSONYI EMIL, 'Water Power Development', Vol.1

i) The 'substructure' to support the equipment and to provide the necessary waterways.

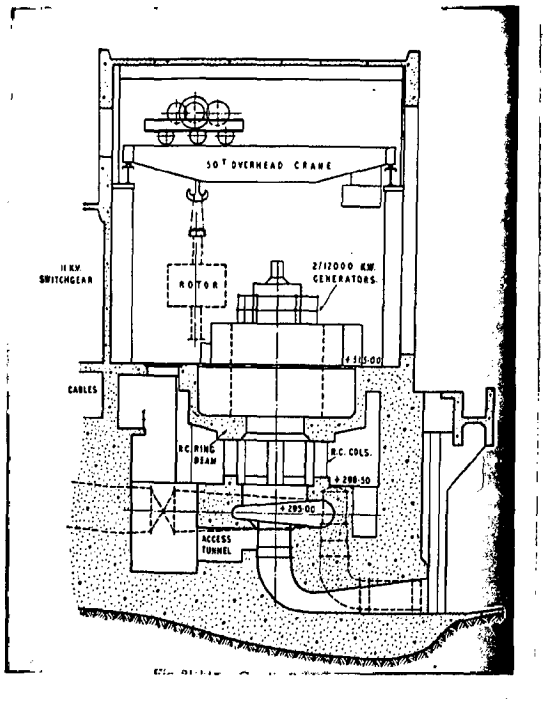
ii) The super-structure or building to house and protect the equipment. It must also create a good working condition, by way of internal aesthetics, environment and amenities.[Plate -].

The sub-structure is entirely a complex engineering part on which the operational efficiency rests. It contains the turbine, shaft, coupling, scroll-case, etc., comprehensible only to the powerhouse engineers, and technical staff. There is practically no scope for the Architectural treatment of this structure.

The architectural qualities can be explored in super-structure or building with the coordination of the power house, and structural engineers. These qualities have been explored through the chapters that follow.

II.3 Features of under-ground power-houses

Increased attention has recently been turned towards underground powerhouses in India, wherever suitable geological and topographical conditions prevail. Large underground power house became possible when the technique of tunneling and of



TYPICAL SECTION

Ref:- BROWN GUTHRIE. J. 'Hydro-Electric Power Houses'. Vol.1

steel-lined pressure shafts was sufficiently developed. Underground power houses are also preferred from defence point of view, over and above various techno-economic reasons.

The powerhouse usually has a semi-circular or elliptical roof and vertical walls. The roof arch supports the full rock load, in the case of poor rock. The roof arch abuts into the recesses in the rock, thus stabilizing, the walls. In some cases inverted T-beams are used. This arrangement provides a space between the rock and the ceiling, which was used for catching any infiltration of water. Usually the roof area is of monolithic concrete, placed against the rock and pressure grouted. In this case a second inner arch is provided, usually very thin, and with a water proof layer on top.

In case of some power houses, no protection to the roof is provided other than a layer of cement mortar " guinited " on to a mesh of reinforcement, which in turn was fixed to steel rods, securely drilled and grouted into the rock [5].

Generally three types of linings are used:

i). reinforced concrete

ii). steel lining embedded in concrete

iii). prestressed concrete lining of precast elements.

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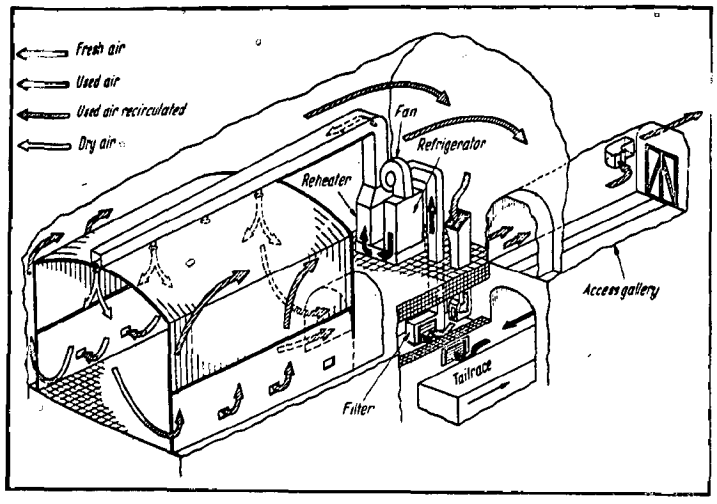
5. BROWN J. GUTHRIE., "Hydro-electric Engineering Practice" Vol.1, Chapter XXII. P-1054, Blackie and Son Ltd.,1958.



2.3 Features of Underground Power House

Fig.

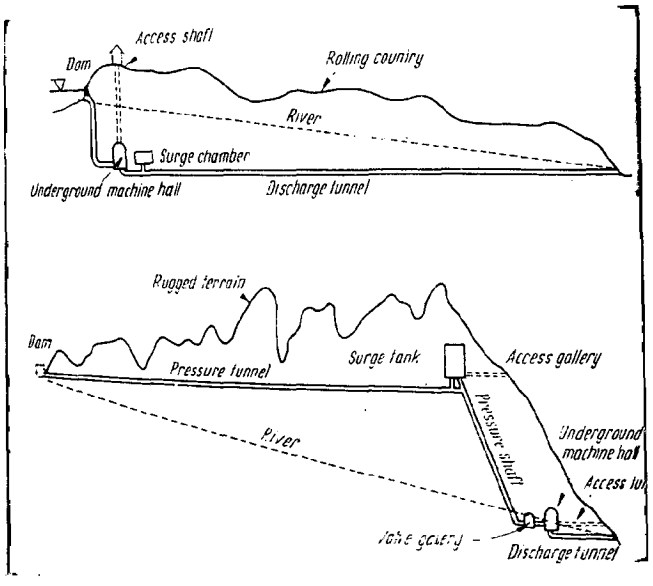
1

2

Ref:- 1. MOSONYI EmIL, "water Power Development", Vol.2
2. BROWN GUTHRIE. J. "Hydro-electric Engineering Practice", V.2

2.3 Features of Underground Power House

1



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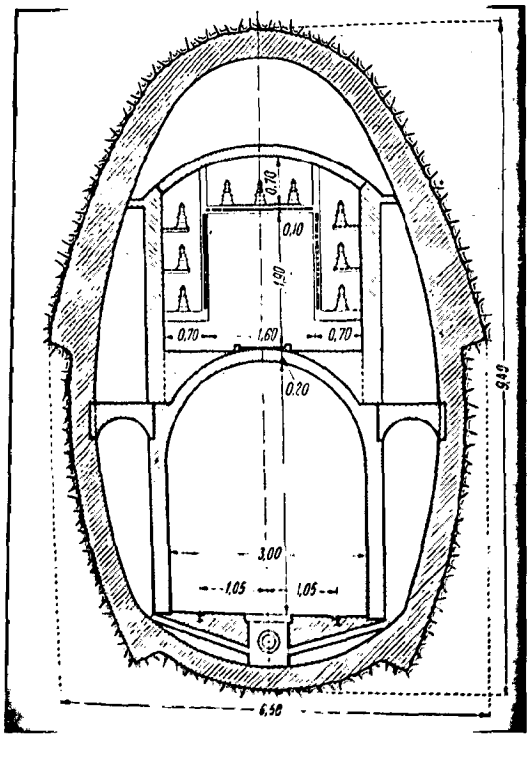

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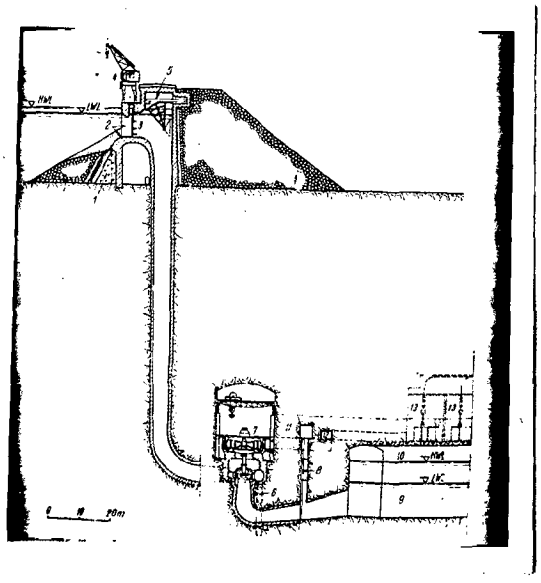
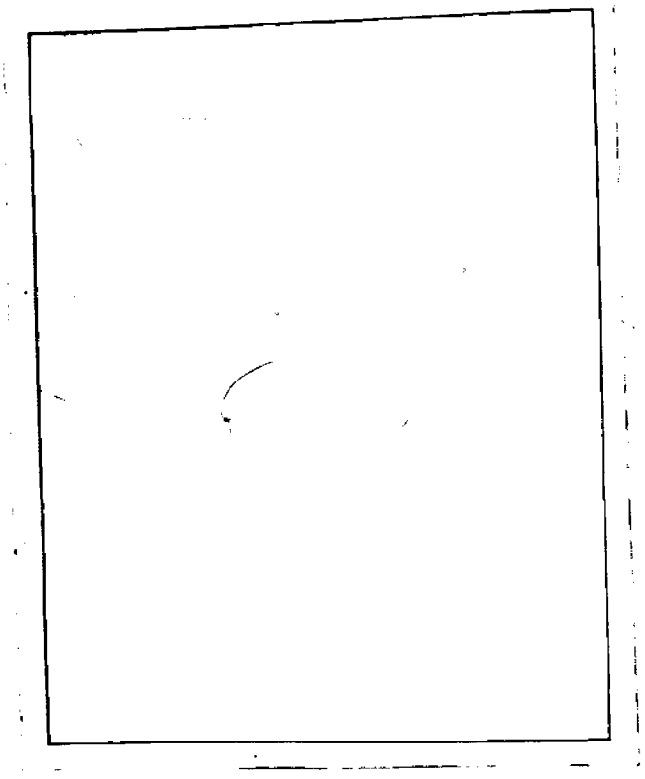


Ref:- MOSONYI EMIL, 'Water Power Development', Vol.2

Plate



ACCESS ENTRANCE TO UNDER GROUND POWER HOUSE

Ref:- MOSONYI EMIL. 'Water Power Development' Vol.2

Those linings can also help to prevant the seepage of water.

Over and above the requirements and other items of equipments, the additional items, that are needed, are the separate air-conditioning plant, adequate air ducts, further cooling water tanks for generators, and sometimes for the transformers as well.

Communication gallaries are provided between the power house and the surface as well as between individual connections.

i). For the personal

ii). For the transportation of machines and their parts.

iii). For admitting the fresh air.

iv). For discharging the water (waste water)

v). For accomodating cables and buses.

Passages required for the above purposes are united as far as possible, in order to reduce the number of separate tunnels or shafts.

Fresh air is supplied to the power house, usually through the main access tunnel or shaft itself, warmed up waste air is exhausted along the same tunnel or shaft, through a separate duct.

II.4 Major space requirements of Power houses

The essential space requirements of an indoor hydro-electric power house are:

a). A main turbine room in which the machines are usually arranged in a single row, approximately at right angles to the direction of the flow.

b). A loading bay adjoining the turbine room on which plant can be assembled or dismantled.

c). Annexes or extensions to the main turbine room to house electrical equipment.

d). Passages or ducts for cables.

In addition, some or all of the following may be required according to the function of the station.

e). Operating or control room

f). Repair shop with machine tools.

g). Store room for spare equipment and maintenance materials.

h). Offices and administrative accomodation.

The length, width, and height of the turbine room are determined by the hydraulic and mechanical characteristics of the turbo-generators. The purely electrical plant, such as switchgear, batteries, and transformers, is accommodated in

PLATE

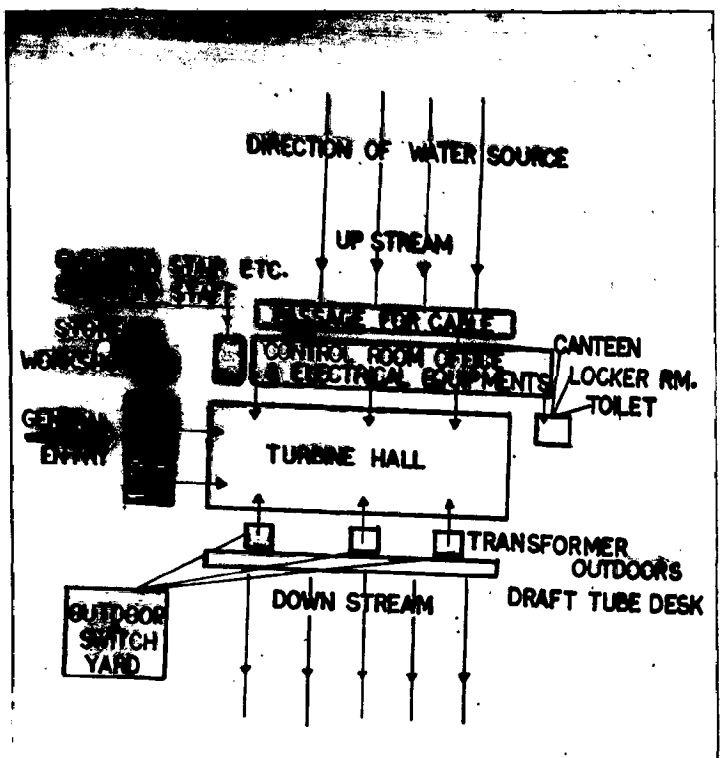
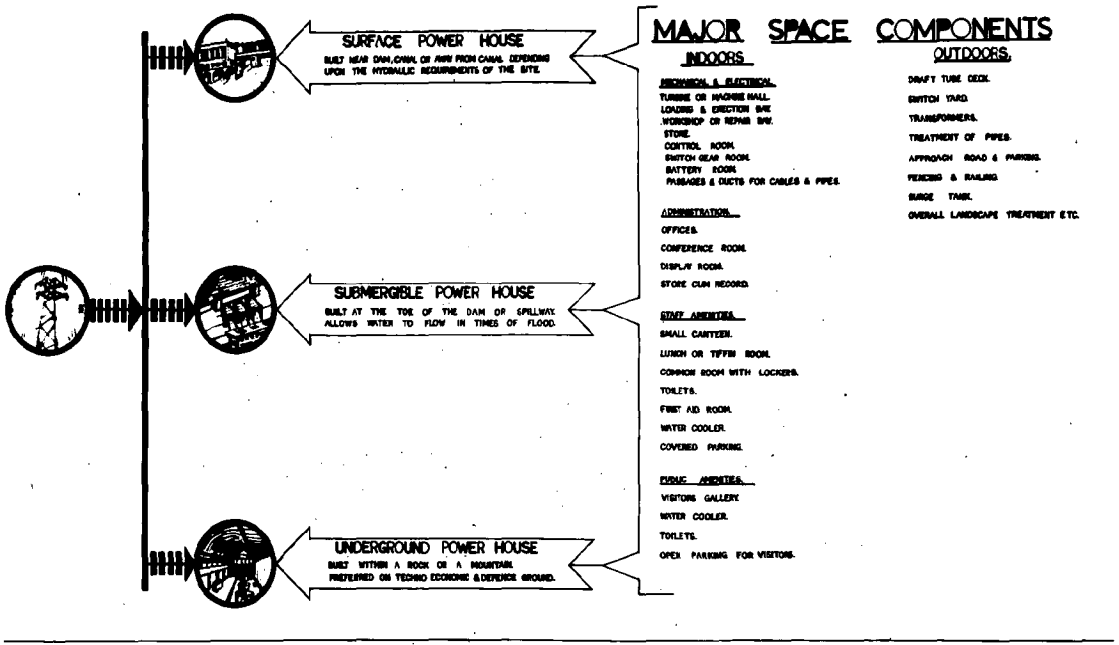


FIG. SHOWS THE TYPICAL SCHEMATRIC DIAGRAM & INTER RELATIONSHIP FOR SURFACE & SUBMERGIBLE POWER HOUSES

PLATE



TYPES OF POWER HOUSES & THEIR MAJOR COMPONENTS

annexes or extensions of the main building as found most suitable The floor is largely determined by relation to access road levels and the flood levels likely to be experienced.[6].

For the major space requirements and their scope of architectural qualities. Refer Appendix(1)2.4.

II.5 Turbines and their effects on volumetric visual form

There are two shaft arrangements of turbo-generators.

i). The horizontal shaft arrangements

ii). The vertical shaft arrangements.

i). In the horizontal shaft arrangement, shafts of the turbines are parallel to the longitudinal axies of the power house. Hence the generators and the turbines are supported at the main floor level, longitudinal spacing of machines and length of power-houses are determined by the overall length of each machine, and minimum convenient space in between. Overall length required is greater than the vertical shaft arrangement [Plate -].

ii). In the vertical shaft arrangement, the turbines, and the generators, are housed on a vertical axis, machine supports

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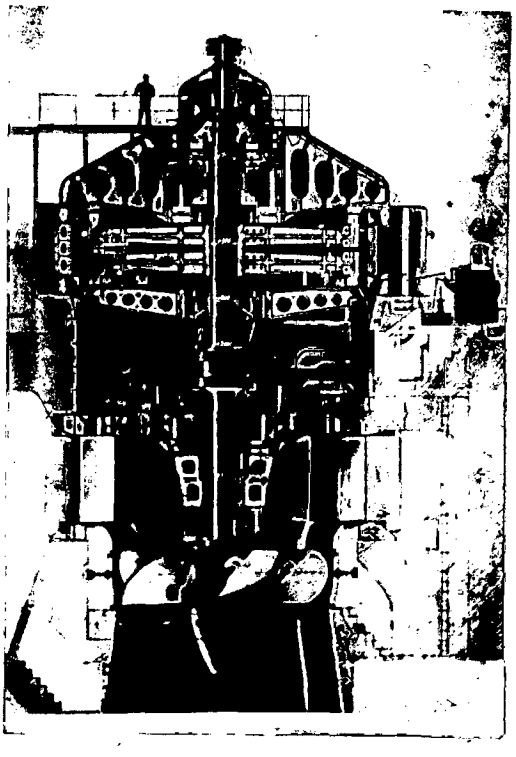
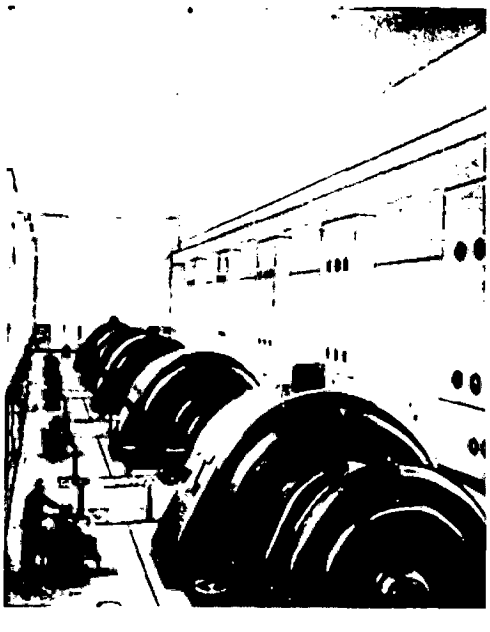
~~6. CARR., "Electric power station", Vol.1.~~

6. BROWN. GUTHRIE. J. "Hydro-electric Engineering Practice" Vol.II, Pp-599 -606. Blackie and Son Ltd. London,1964.

Fig.





Ref:- MOSONYI EMIL, 'Water Power Development', V.1

are relativelymore complicated as the wheel and the generator require substantial additional structure. Vertical shaft arrangements are predominently used in all major power houses. This type of arrangement requires the minimum spaces for the installation and therefore permits the smallest area of the power house. It is not only practical solution for large machines, especially the topographical nature of the site limits the size of the powerhouse.

A comparison of horizontal and vertical turbines with respect to building volume is given in the following table No.1, which shows the vertical machine to advantages in regard to compactness of lay-out.[7].

Table-1.

Type	Turbine		Turbine house			
	MW	r.p.m.	Area sft.	Volume cft.	Sft. per KW	Cft. per KW
Horizontal	15	360	16000	6,80,000	1.06	45.2
Vertical	15	300	7000	3,22,000	.47	21.4

From the foregoing studies following, observation emergo on the volumetric visual form by the horizontal and vertical arrangements of turbine.

7. CARR, "Electric Power Station" Vol. I.

i). Horizontal shaft arrangement:

- Overall length required is greater than the vertical shaft arrangement, overall height required is less.
- This can create a feeling of restlessness because of the greater length of the hall.
- Length of the general circulation is increased.
- In the modern practice, this type of turbines are not installed.

ii). Vertical shaft arrangements :

- Overall height of thehall is greater than the horizontal shaft arrangement.
- Overall length is considerably reduced.
- The interior looks much more neat and spacious, because of its great width and lesser length of the hall.

design of few typical foreign examples have been studied, to explore the contemporary modern architecture as applied to this type of most functional buildings. This has been revealed with the aid of visual design principles such as unity, form, space, texture, colour and harmony. The fact remains that certain qualities do possess by all buildings, as in painting and sculpture which in the concensus of opinion of mankind, has judged beautiful. It is evaluated on the basis of authors own observation and experience, from the photographs, that follow,

CHAPTER - III

AESTHETIC DESIGN : EVALUATIONS OF FEW FOREIGN EXAMPLES

III. 1 Introduction

It is now recognized that the areas of common ground between architecture and engineering are more important than the demarcated territories. This realization helps to dispose off some conceptions. One is that, applied decoration, a cosmetic intended to brighten an otherwise drab appearance. Another is that engineering is solely concerned with functional efficiency and has no room for elegance. Both conceptions are travesties of truth.[8]

Engineer is constantly searching for the most economical solutions to problems of layout and plant assembly the architect is looking to see how the whole complex, can be satisfactorily relatedtto its environment and be given an expression form as an indication of its function and in human terms.

III.2 Scope

In order to understand pros and cons of aesthetics of Hydro-electric powerhouses studies of exterior and interior

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(8) HOLFORD LORD AND SHEPHEARD H MITCHEL - Paper entitled "Architect and Power Engineering", Journal "Electronics and Power" December 1970.

design of few typical foreign examples have been studied, to explore the contemporary modern architecture as applied to this type of most functional buildings. This has been revealed with the aid of visual design principles such as unity, form, space, texture, colour and harmony. The fact remains that certain qualities do possess by all buildings, as in painting and sculpture which in the concensus of opinion of mankind, has judged beautiful. It is evaluated on the basis of authors own observation and experience, from the photographs, that follow.

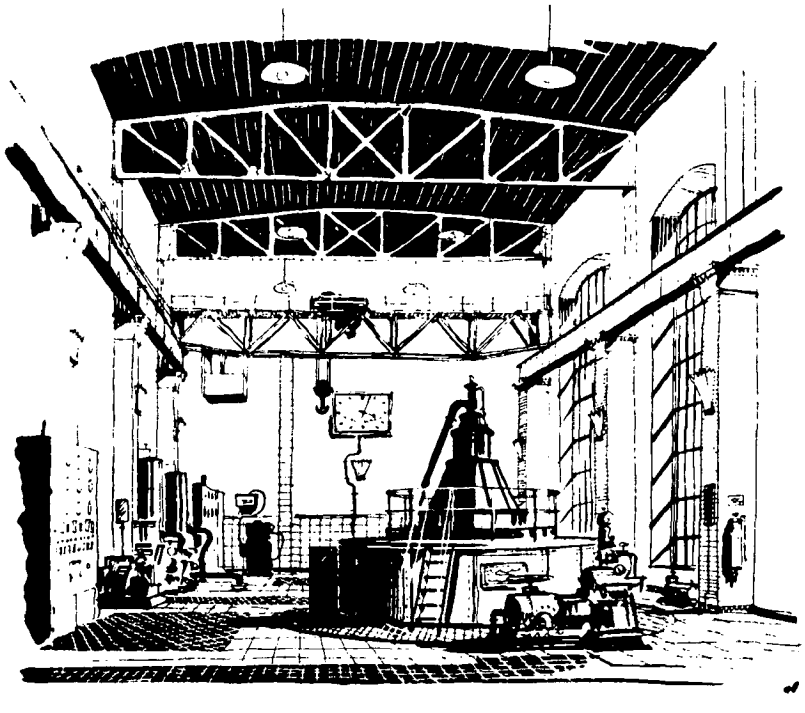
3.3 Internal Design

E X A M P L E S

3.3.1 Typical Example -

There is typical of many of the older stations; no attempt has been made either to design the various items of equipment or to relate them to the structure. The interior has been treated with the confused elements, which reflects the drab and untidy appearance. The colour scheme would almost certainly be dull greens and buffs. [Plate -]

Plate



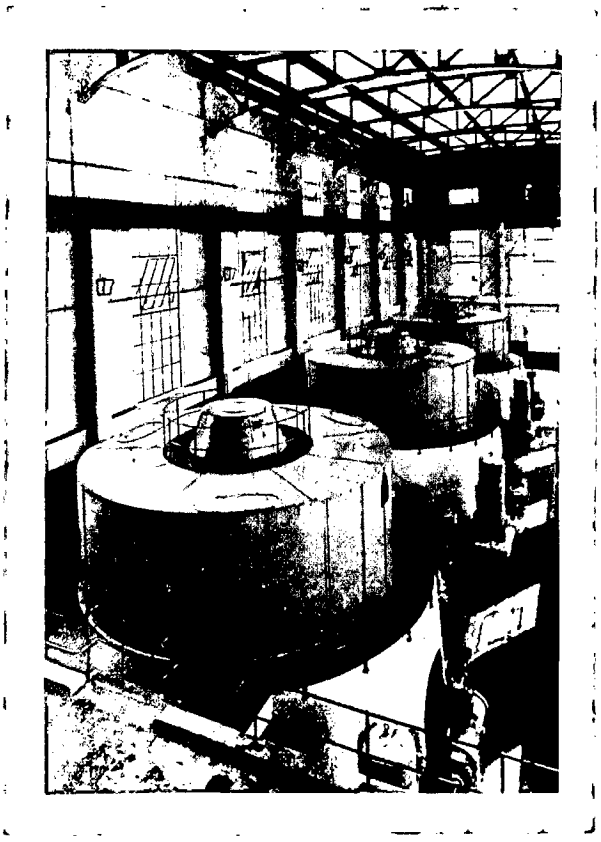
TYPICAL EXAMPLE

Ref:- BROWN GUTHRIE, J., "Hydro-Electric Engineering Practice", Vol.1 Chap. XXIII. p. 1117

III.3.2 Tongland Powerhouse (South of Scotland)

- The most practical layout of the generators, its shape and size is directly proportional to the volumetric form of the interior.
- Height and clearances for the crane, is reflected to the honest expressions of beauty.
- The neat and clean shape of the generators, harmonize with the clean and graceful treatment of its interior.
- Generators and turbines are reached by different levels, so as to bring within the reach of man, and this characteristic of planning, bring forth the visual perception of machine, which is subordinated and made a servant of man, to achieve maximum power.
- Vertical windows located at a equal distances, distribute the beam of light evenly over the hall, which creates an interesting effect of light and shade contrast in the interior.

PLATE



TONGLAND POWER HOUSE (South of Scotland)

Ref:- BROWN GUTHRIE, J. 'Hydro-electric Engineering Practice' Vol.2
pp. 681

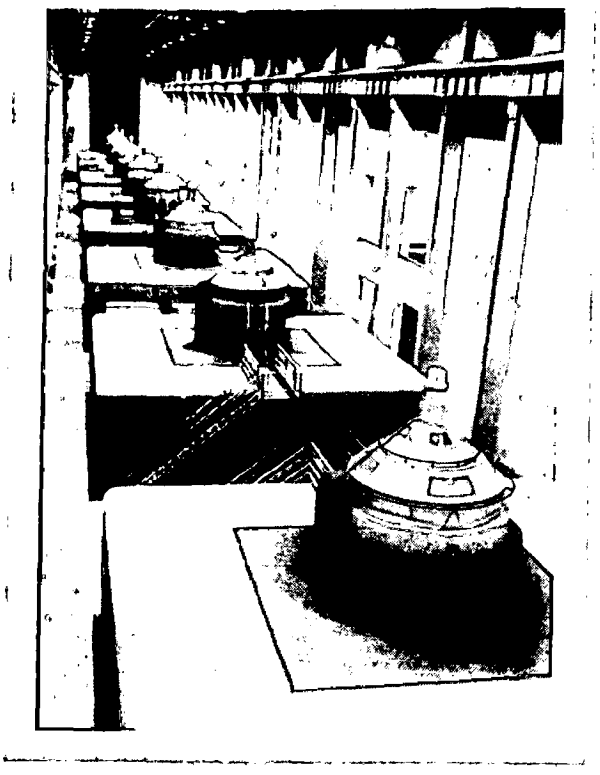
- The crane beam, of neat shape and size divides the vertical space visually bringing the scale of the hall, at a pleasing proportion.
- The tubular railing around the gallery and machines, creates a smooth enclosure, without disturbing the graceful form of the machines.
- The placing of the auxiliary equipments near the each generator, adds to the unity of design, and thus provide a clear access on the corridor side. [Plate -].

-:-

III.3.3 Des Joachims, Power House (Canada)

- The interior of this power house looks visually very narrow, because of the greater number of units, installed and lesser height provided.
- The structural columns to support the crane beam and roof are placed at a closer distance, which forms a rhythmic interior and gives a feeling of strength and permanance.
- The square casing around the generators, with a well designed exciters on the top, and of white finish of its floor gives a neat and clean appearance in contrast with the patterned texture of the floor.
- The railing has excessive details than necessary, which unduly attracts the eye, for this practical nature of the hall.
- The flat ceiling with rows of hanging lights gives uniform illumination, over the whole area, which brings the intrinsic value of each component and their finish.
- The glazed opening at the end of the hall, defines the area, it creates a spâtial effect, to link the interior with the exterior and vice-versa. [Plate -]

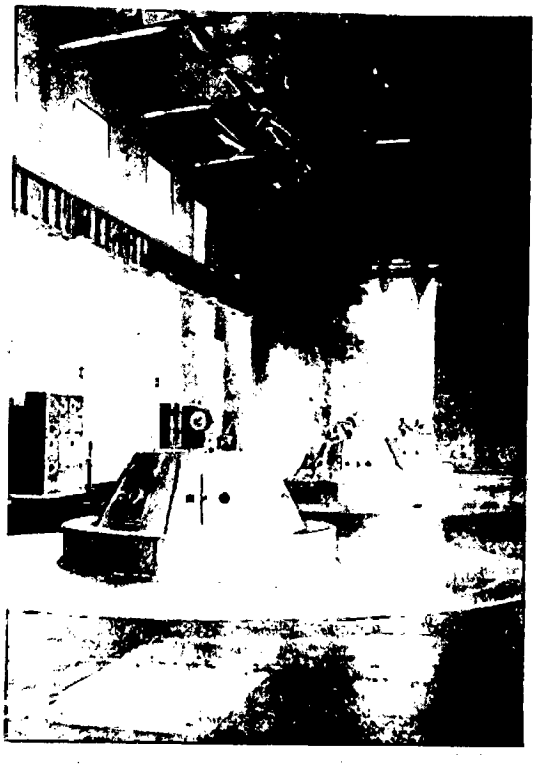
PLATE



DES JOACHIMS, POWER HOUSE CANADA

Ref :- BROWN GUTHRIE, J. 'Hydro-electric Engineering Practice' V.1

PLATE



GLENIG POWER HOUSE, SCOTLAND

Ref :- BROWN GUTHRIE,J. 'Hydro-electric Engineering Practice', V.1

III.3.4 Clunie Powerhouse (Scotland)

- The overall interior is lofty and spacious, because of its greater width, low installations of turbines and the clear space created all-around the machines.
- Light lattice girders of roof harmonizes with the smooth finish of walls and machines.
- The functional crane beam, devides the vertical space, and helps to create an intimate scale.
- The reflective qualities of floor and machine finish, provides subdued feeling and thereby can boost the morale of the operators.
- A clean and simple interior, which has been enhanced by the use of bright colours. [Plate -]

III.3.5 HoJum Station (Sweden)

- This is the most interesting example of underground power house. Here the hewn rock face is left exposed between the columns, which support the overhead crane.
- The natural organic rock, enframes the smooth outline of the concrete, and creates a vividity in the interior.
- The spaces between the side columns and the rockface wall is well utilized for locating the auxiliary equipments thereby creating a spacious interior, undisturbed for the circulation.
- The heavy R.C.C. columns with heavy crane beams provides a feeling of safety to the underground enclosure.
- The smooth patterned floor, contrasts well with the natural concrete finish and rock, and gives a feeling of intimacy.
- Here the honest expression of design, is the result of the common understanding of the design team work, which is in keeping with the spirit of contemporary architecture. [Plate -]

PLATE

HOJUM STATION, SWEDEN

Ref :- BROWN, GUTHRIE J., 'Hydro-electrical Engineering Practice' Vol. 1

PLATE

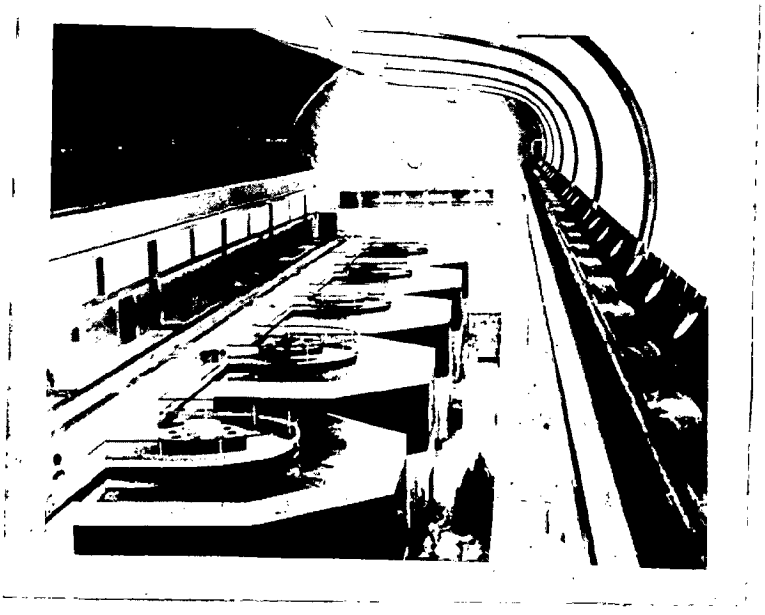
SOVERZENE UNDER GROUND
POWER STATION ITALY

Ref:- BROWN GUTHRIE, J. "Hydro-Electric Engineering Practice"
Vol.1

III.3.6 Soverzene Underground Power Station (Italy)

- This is the most interesting example of underground power house. The interior effect of this powerhouse is most unusual and striking, is similar to Banquet hall or a Foyer of a cinema.
- It projects an idea that what can be thought and imagined to create, an elegant and cozy interior, for this type of practical project.
- Such project can enhance the pride and dignity of a Welfare state.
- The extensive use of local marble gives an impression almost of opulence.
- The arched concrete false ceiling has been executed in plaster of Paris and contains Italion form of painting, so clearly suggests the three dimensional form.
- The lighting scheme shows the great originality of thought.
- The introduction of artificial windows, creates a most effective illusion of a surface building, the imagination shown by the designer should not have been directed to a most original form of wall treatment. [Plate -]

PLATE



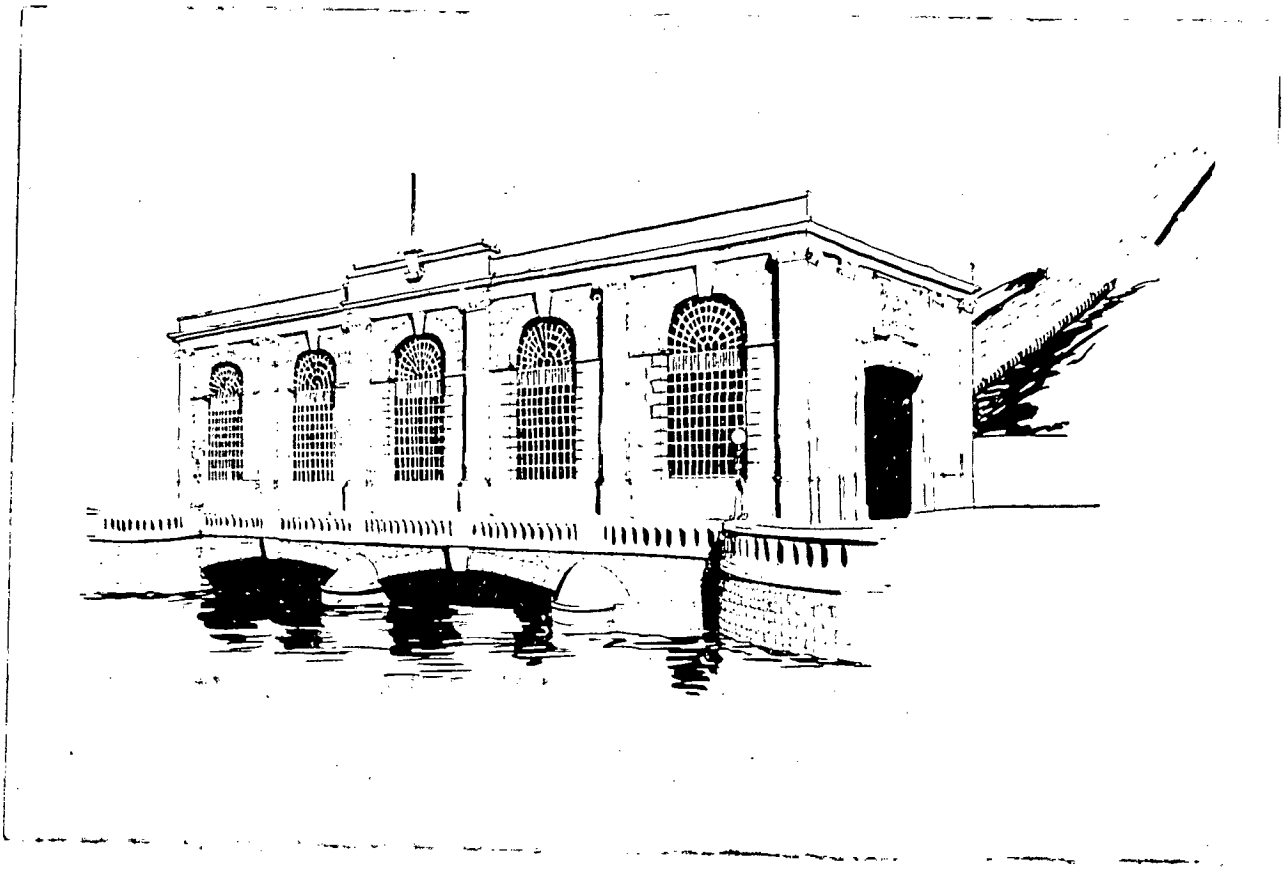
KARIBA UNDER-GROUND POWER HOUSE, ITALY

Ref :- BROWN GUTHRIE, J. 'Hydro-electric Engineering Practice', Vol.2

III.3.7 Kariba Underground Powerhouse (Italy)

- With the design and shape of the false ceiling, the volumetric impression of the interior is greatly enhanced and creates vividity.
- It is in the form of a double curve and provides protection to the machine.
- Concealed services and ducting acts as a reflector panel to flood lights, which provide general lighting and assists in some measure to improve the acoustic of the powerhouse.
- The vault is close lined with profile plastic sheeting.
- The generators are approached directly from a gallery, which unites the whole interior.
- The pentagonal shaped pedestal for the generators, creates a striking effect, and a rhythmic form, to the interior.
- To avoid the feeling of confinement the treatment given to the powerhouse contains a recessed lighting feature along each side of the turbine hall, which avoids the usual surface condition by giving artificial window treatment. [Plate -]

PLATE



TYPICAL EXAMPLE

Ref :- BROWN GUTHRIE, J. 'Hydro-electric Engineering Practice' Vol.1

III.4 EXTERIOR DESIGN

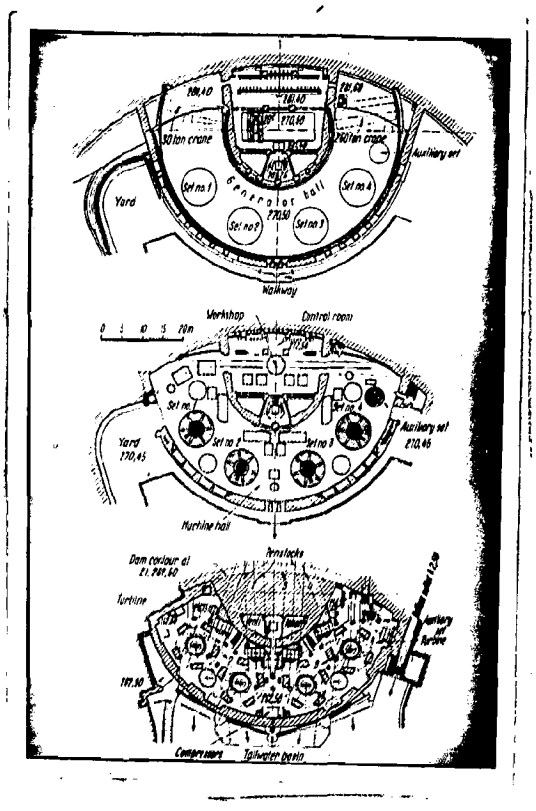
E X A M P L E S

III.4.1 A typical exterior of a powerhouse.

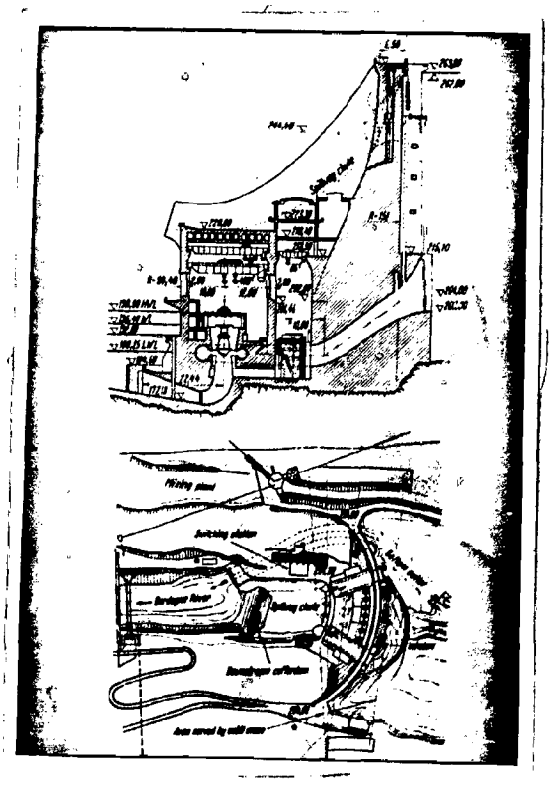
- The traditional approach to powerhouse design.
- This introduction of pseudo-classic detail is completely insincere.
- The structure is clothed with detail borrowed from classical styles more normally associated with civic building.
- Even in case of dams, the capping and upper portion of the structures were enriched with classical ornaments.

[Plate -]

PLATE

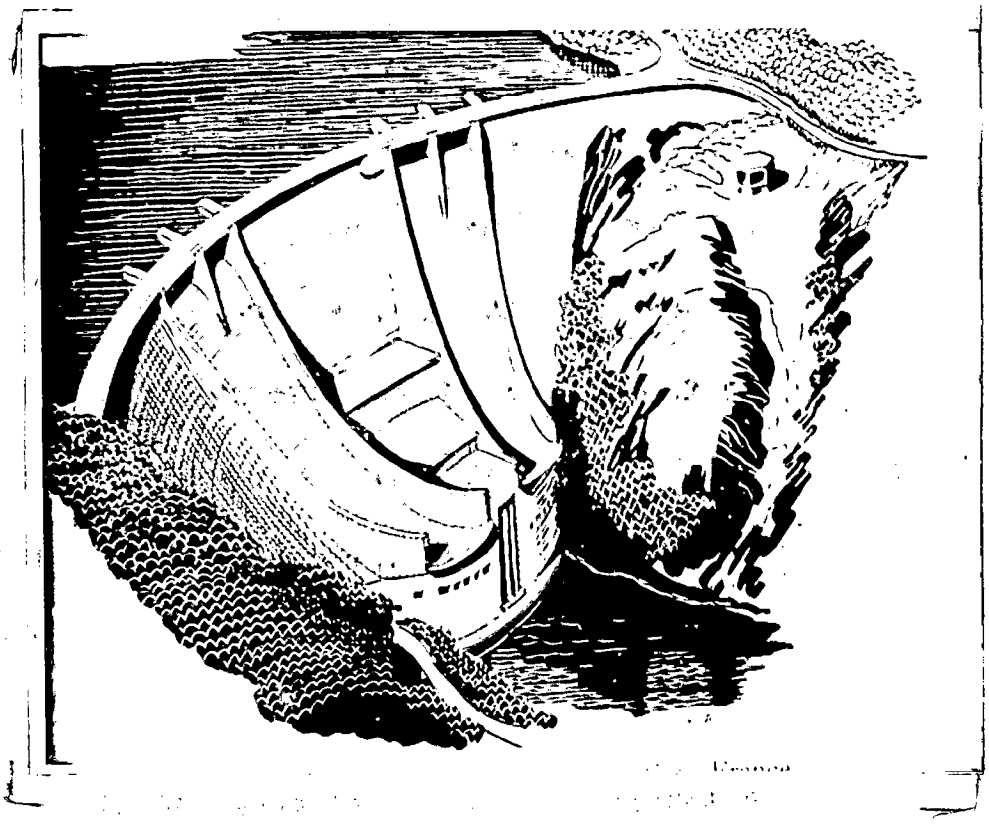


L'AIGLE DAM AND POWER STATION, FRANCE.



Ref:- BROWN GUTHRIE, J. 'Hydro-Electric Engineering Practice' Vol.1

PLATE



L'AIGLE DAM AND POWER STATION, FRANCE

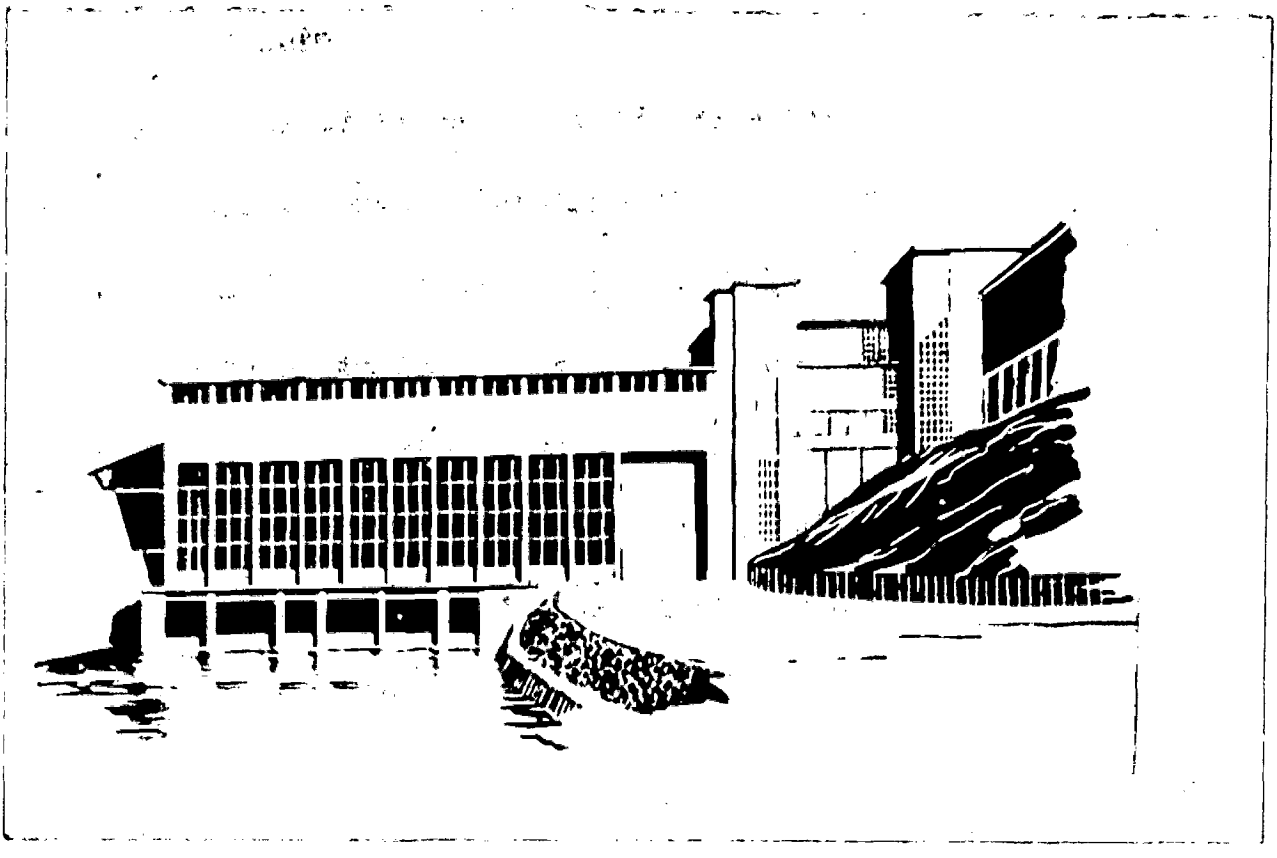
Ref :- BROWN GUTHRIE, J. 'Hydro-electric Engineering Practice' V.1

III.4.2 L'Aigle Dam And Power Station,(France)

- Placing of generators on a circular arc, is a departure from a long tried rectangular building in which the machines are placed in a single row.
- Here topography of the site necessitated a cramped layout spacial tracks with curved tracks were provided.
- The blending of the powerhouse into the dam structure exhibits gery close clerity and harmony between the form of the dam and the powerhouse.
- The terraced roof treatments, add to the three-dimensional vertical movement and reduces the scale to the perception of man.
- The road on the top of the dam, provides a linkage with the organic growth of the surrounding country.
- The waterbody and the natural landscapes surrounding the structure emphasized the total effect of the project.

[Plate -]

PLATE



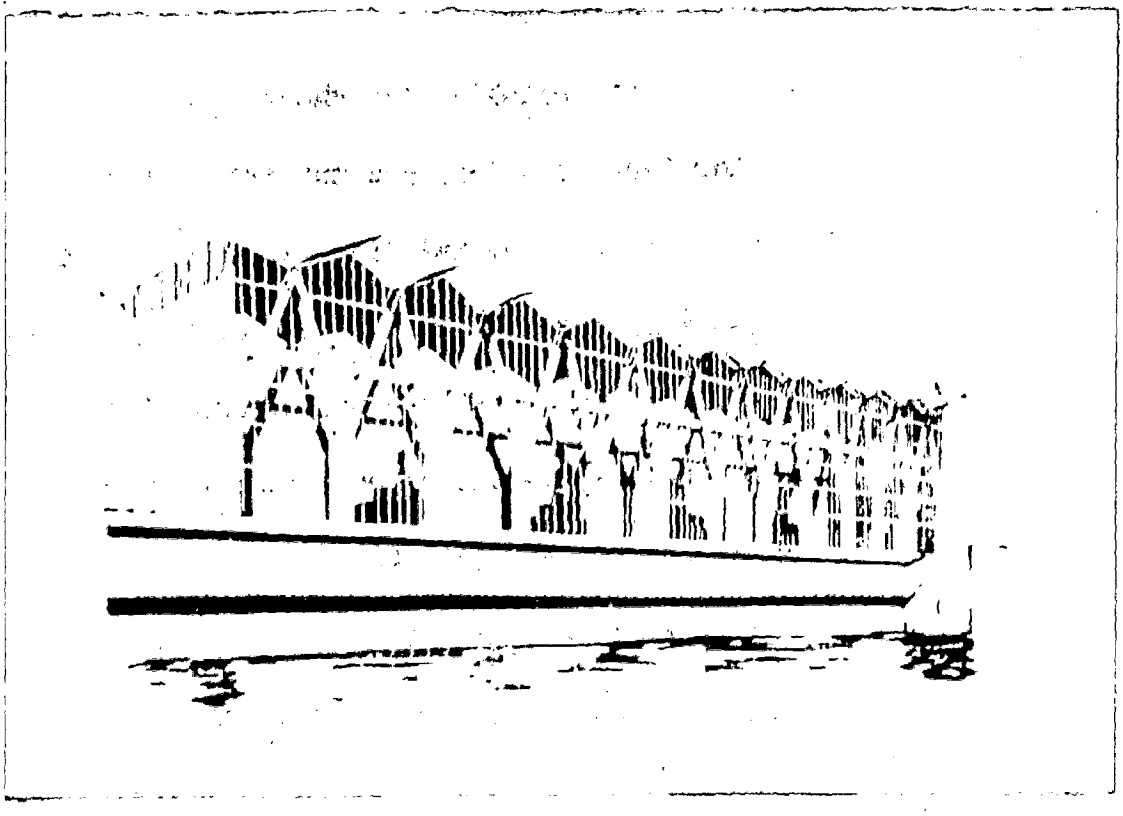
CATHALEEN'S FALLS, EIRE

Ref :- BROWN GUTHRIE, J. 'Hydro-electric Engineering Practice' Vol.1

III.4.3 Cathaleen's Falls, (Eire)

- This example is in strong contrast with the foregoing example, where relation of solidity of dam structure is maintained in the overall form of the powerhouse.
- From the treatment of large size fenestrations , it seems that the power house is fed by the runoff river water, in its natural course, without adjacent dam or a spill-way. It is much more of a free standing bldg.
- Glazing is much more dominating than the solids. The spirit of heavy and complicated machinery is not reflected in its external message.
- The facade is too light by introducing large size glazing.
- It gives an character of civic building.
- The vertical masses for offices and control room on the right hand side create a balanced form, but its design is not visually pleasing.
- Large glazing areas in turbine hall may cause blast damage.

PLATE



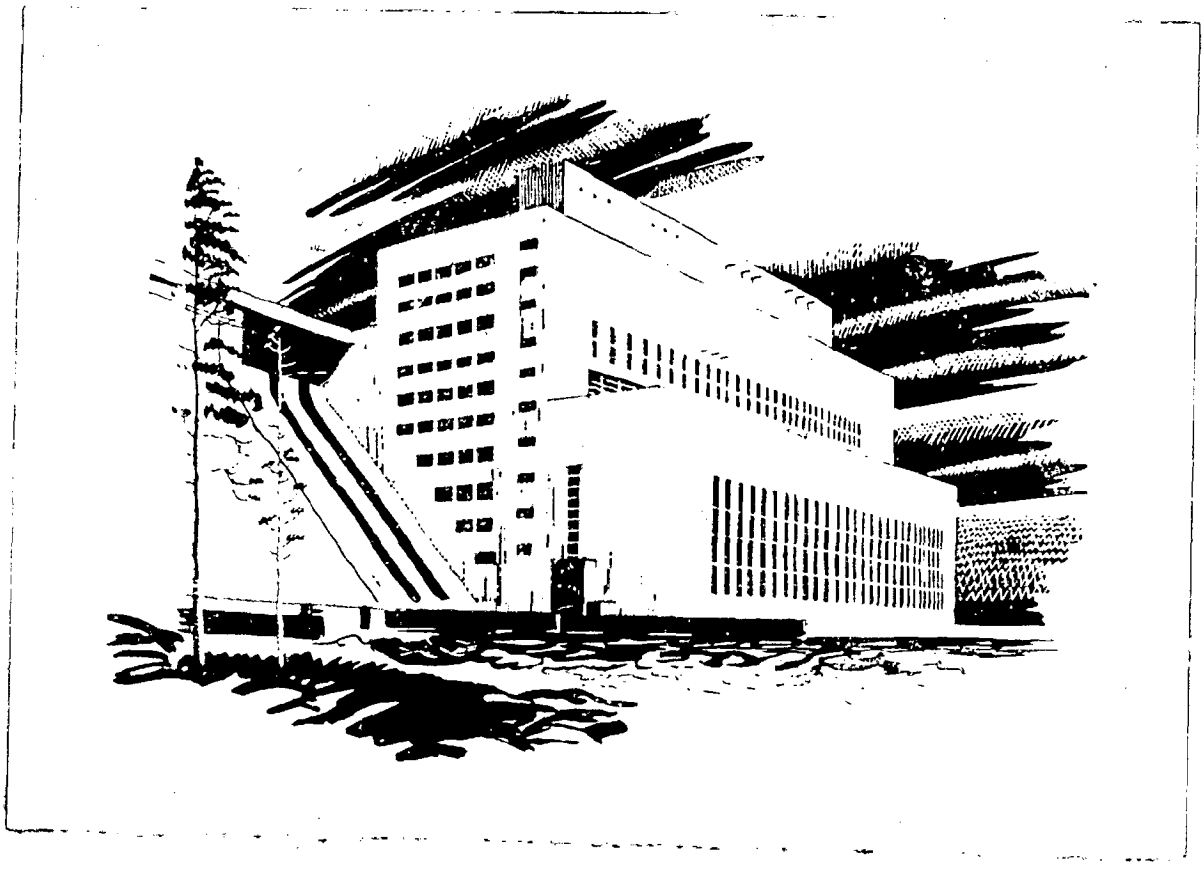
BIRSFELDEN POWER HOUSE, SWITZERLAND

Ref :- BROWN GUTHRIE, J. 'Hydro-electric Engineering Practice' Vol.I

III.4.4 Birsfelden Powerhouse (Switserland)

- Powerhouse is built on the side of the weir, which has a light design. It also blends with the site and the environment.
- Glazed walls catching the changing moods of the sky, reflections of water, and the exciting skyline which the lighted building will offer at night.
- A new reinforced concrete construction, the series 'Y' shaped columns which has the effect of reducing the crane beam space and consequently reducing the dimensions of the beam itself.
- The feature of light appearance by the use of large sheet of glass area, seems suitable because of its siting in the open surrounding landscape without the backdrop of dam, etc. [Plate -]

PLATE



PYHAKOSKI POWER HOUSE, FINLAND

Ref :- BROWN GUTHRIE J. 'Hydro-Electric Engineering Practice', V.1

III.4.5 Pyhakoski , (Finland).

- Scale and masses gives an impression of a thermal powerhouse.
- The monumental effect is produced by the grouping, and its general treatments.
- The small windows given on the shorter side of the block, adjoining the dam structure, weakens the mass, and abruptly detract the eye.
- Supreme suitability of concrete as structural material is well expressed in the treatment of the dam and the powerhouse. [Plate -].

CHAPTER - IV

EVALUATIONS OF ARCHITECTURAL QUALITIES OF SELECTED POWERHOUSES OF NORTHERN INDIA.

Introduction and Scope

For the sake of expediency, the examples, reviewed in this chapter, are restricted to four powerhouses in Northern India. These include Pathri, Rihand, Bhakra and Chibro Power houses. They are fairly representatives of categories, such as surface, submergible and underground types.

This line has been chosen to ensure that nothing important is left out and at the same time, the review remains manageable, within the time and resources, at the disposal of the author.

The review has been done under the parameters, which are included in the text of each example.

1. PATHRI POWER HOUSE

1.1 General Information and Features

- Location : Bahadrabad village, Roorkee-Hardwar Road; District Saharanpur, U.P.
- Type : Surface; built on the Ganga Canal
- Generation of Power : 18.4 MW.
- No. of Units : Three
- General Architectural treatment by Sri S.R. Yardi, Senior Architect, C.P.W.D., New Delhi.

1.2. DESIGN AND LAY-OUT

i). It is a rectangular, R.C.C. framed structure, and is located on the Ganga canal, the machine hall is 183'-0 long ; 41'-6" wide, and a 40'-0 high. It has principally three floors. The basement floor (R.L. 903.5) houses the turbine room; the ground floor (R.L 913.5), the main access floor level, houses the - turbo-generators, cable room and superintendent and his staff; control room, Switchgear room, offices and

rest room are located at the third floor level, overlooking the machine hall.

1.3 Space evaluations

i).	Electrical and Mechanical operation area.	Area adequate and fulfills all requirements.
ii).	Circulation	Sufficient clearances provided around the machines and its auxilia ies. Circulat other parts is and rooms are tly located.
iii).	Staff Unit	Area provided is adeq

1.4 Welfare facilities

Amenities like, drinking water, toilets, rest-room; common room, first aid, parking etc. are provided.	Conveniently loc and the area pro is not adequate the requirements.

1.5	Structure, Construction materials etc.	Walls: R.C.C. framed structure. Floors: R.C.C. Roof: Steel truss, truss with a.c. sheet roofing with false ceiling.
1.6	Environmental - Engineering requirements	
i).	Illumination:	
	Natural :	By way of vertically - designed windows.
	Artificial:	Fluorescent tubes and hanging lamp points.
ii).	Ventilation:	
	Natural :	By way of small ventilators at the top levels.
	Artificial:	By way of exhaust fans.
iii).	Noise control:	In control room, by providing double glazing. No accoustic treatment in offices and rest room.

iv) Thermal comfort : Control room, offices, and machine hall is fairly warm, as there is no sufficient free circulation of air by way of exhaust fans and cross openings etc.

v) Maintenance and sanitation: The powerhouse is not well maintained, there is underground drainage system provided.

vi) Fire Protection : Fire extinguishers, and sprinklersystem.

1.7 vii) Finishes, on walls, floors etc. Walls plastered and distempered.

Floors:

Machine hall : mosaic

Control room and offices: Terrazzo finish.

1.8 Architectural qualities:

A) Internal environment

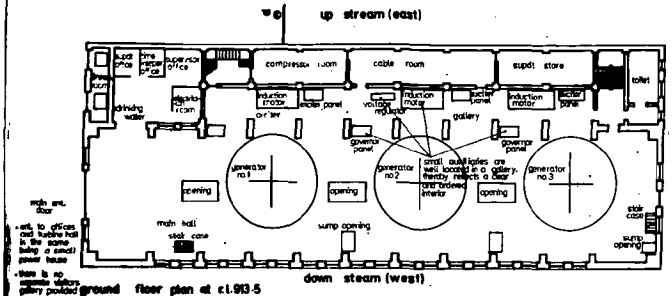
Machine hall

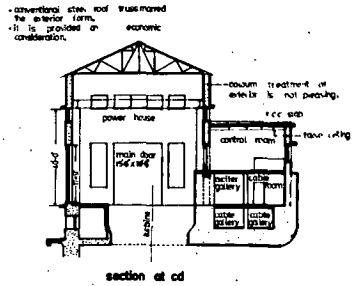
i) Volumetric scale of the interior is based on the size of the machine and the height of the travelling crane.

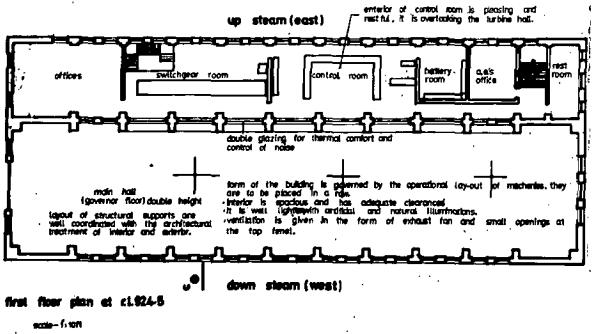
ii) Interior is clean and tidy and is well related to the scale of machines.

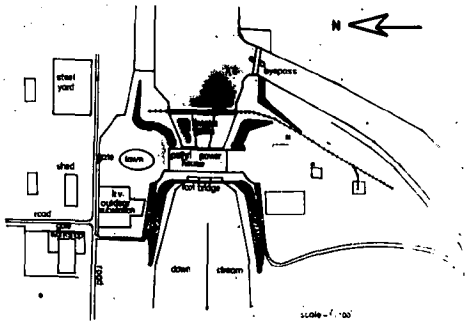
iii) The hall is well lighted with natural and artificial illumination. But the colour scheme of machines, walls and floors are not pleasing.

PLATE





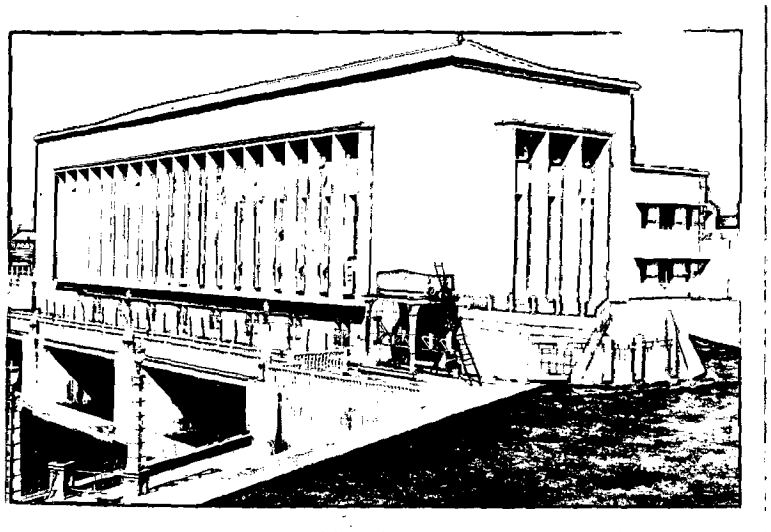




PATHRI POWER HOUSE AT BAHADRABAD, DISTT. SAHARANPUR U.P.

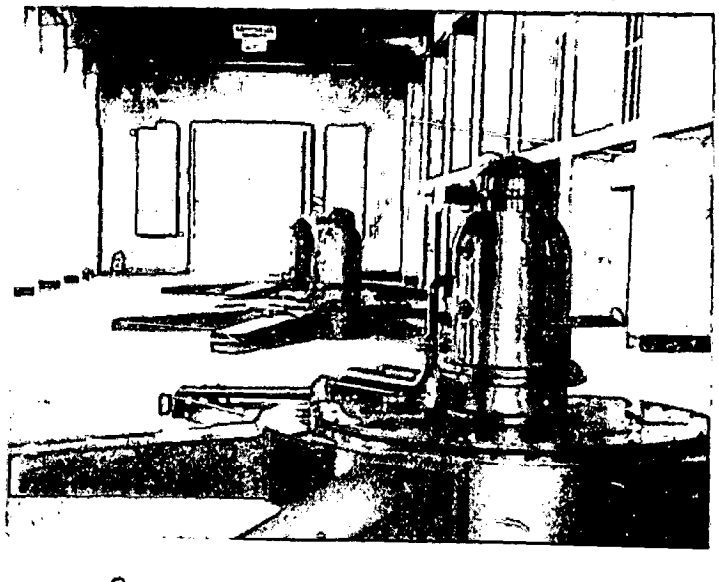
lay out plan

Plate



Pathri Power House
Bahadrabad U.P.

1



2

Source : S.E. Central Design Directorate Irrigation Department, Lucknow. U.P.

iv) The shape and size of the fenestrations, are in proportion with the volume of the hall.

v) Spatial effect is achieved by locating the control room, and offices at a mazzanine floor level, overlooking the machine hall and on the other side, the windows are placed at a lower level thereby the linking of exterior and interior spaces is achieved.

vi) There is a free circulation of space around the machines.

Control room

i) The controlled panels are arranged in 'C' type shape, and are 4'-0" away from the walls, for the maintenance and repairs.

ii) The interior looks pleasing, because of good colour scheme, and well lighted interior with artificial illumination, flush with the false ceiling.

iii) However in summer, the room is thermally uncomfortable because of absence of good circulation of air, and ventilation.

Offices

The offices of the engineers are well furnished but that of the lower staff are not provided with the condusive environment.

B) External Environments:

i) Exterior design is straightforward and simple, reflects the characteristic expression of a utility building, except the sloping form of a steel roof truss, does not harmonize with the scale of thebuilding and it looks too severe with the straight forward outline of the bldg.

ii) Auxilliary equipments such as gantry crane, switchyard and transformers are well located and properly maintained, to reflect a clean sight from outside.

iii) Pitching of side slopes at different levels looks too dull and monotonous, in absence of proper landscape design and related aesthetics.

iv) Overall form of the building, looks graceful and empowering in a flatted country site. [Plate -]

2. RIHAND POWER HOUSE

2.1 General information and features

Location:	On the Rihand river at the foot of Rihand dam. Distt. Mirzapur.
Type:	Submergible type
Installed capacity:	250,000 KW.
No. of units	Five
Architectural Design	Sri I.G.Verma,Architect Irrigation Department, U.P.

2.2 Design and layout

Machine hall and control room with offices are housed in separate blocks. They are connected at the erection bay of the machine hall. The hall is very lengthy and houses five units. It is 420 feet long and 85'-6" wide, located just down stream of the toe of the dam and at the east of the spillway. The machine hall is directly entered through a large entrance doorway.

The control room block has two floors, the ground floor consists of control room, switchgear room ,cable gallery, retiring room, toilets, and stircase etc. The upper floor houses the offices, and electrical rooms.

2.3 Space Requirements

i) Electrical and Mechanical Plant area: Adequate area provided, it fulfills all the requirements.

ii) Circulation: Sufficient clearances provided around machines and auxiliaries.

iii) Staff offices: Area adequate.

2.4 Welfare Facilities

i) Amenities like drinking water, toilets, lockers, common room, retiring rooms, tiffen room, canteen, first aid, and parking are provided. — Area adequate, and conveniently located.

2.5 Structure, construction and material etc. — Welded structural steel framework, with concrete panel-walls.

Floors: R.C.C.

Roofs: Steel trusses of welded construction, supporting, flat RCC slab.

2.6 Environmental Engineering Requirements

i) Illumination: Natural : By way of windows operated mechanically.

Artificial: By flourescent tubes at equal spacing.

ii) Ventilation: Natural: By way of top ventilators.

Artificial: Exhaust fans.

iii) Noise control — Main offices and control room are located in a separate block. Therefore no acoustic measure is provided.

iv) Thermal comfort: Machine hall is fairly warm in summer, but comfortable in winter.
Control room and offices are air-conditioned.

v) Maintenance and sanitation. Powerhouse is well maintained and there is underground drainage system.

vi) Fire protection Fire extinguishers and automatic sprinkler and fire alarm system around working areas.

2.7 Finishes on walls and floors

Walls smooth plaster with distemper colour paints.

Floors:	Machine Hall:	Mosaic.
	Offices and control room:	Terrazzo finish.

2.8 Architectural qualities

A) Internal environments :

i) Machine hall

1. Volumetric scale of the interior is long and lofty, because of the machine requirements of the hall.
2. There is a clerity of expression between structural and non-structural members. This is being enhanced by the clean and rounded shape of the generator.

3. The crane beam is well finished with the vertical pairs, thereby its design is well coordinated with the design of fenestrations on long wall.

4. The outside view of the tailrace side is marred by the high level sill windows, thereby there is no free circulation of air at the working level.

Control Room

i) It is a very spacious room, and furnished with good colour scheme, illumination and curtains etc. It is a nurve centre of the powerhouse.

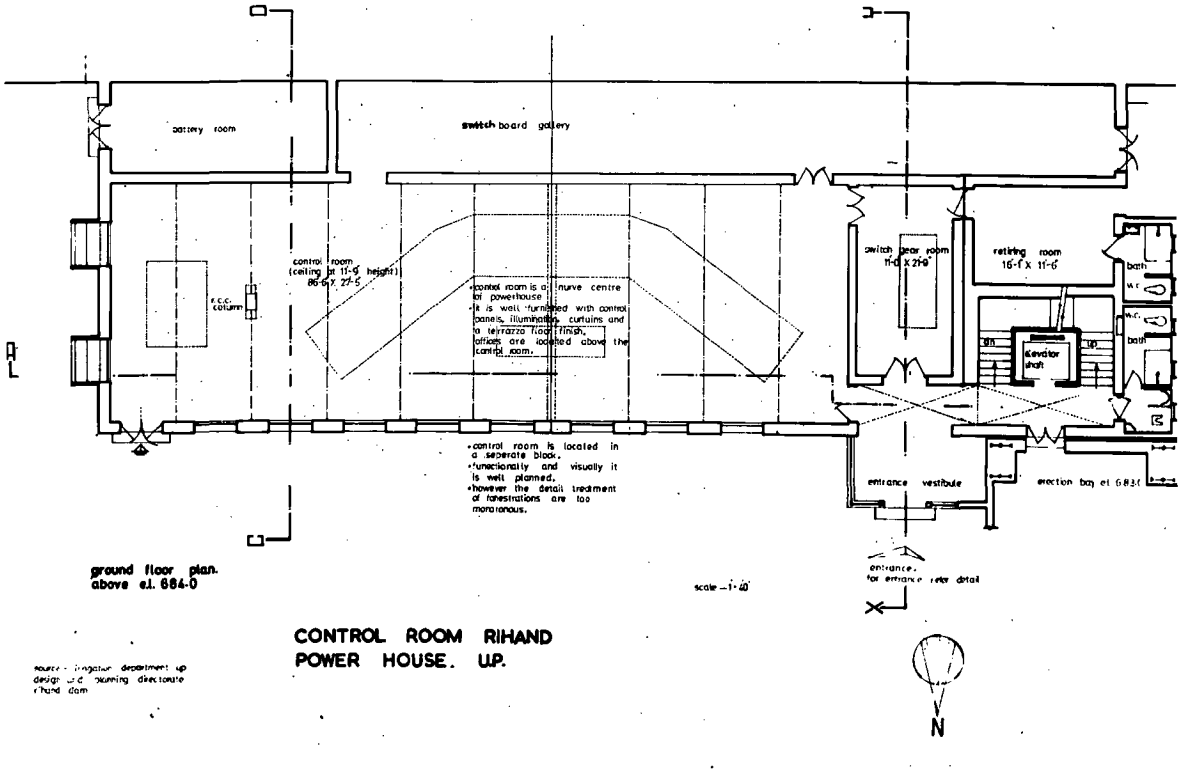
ii) Control panels are placed in a centre, away from the walls, on all four sides.

iii) The light greenish colour of the control panels, harmonizes with the shade of the curtains.

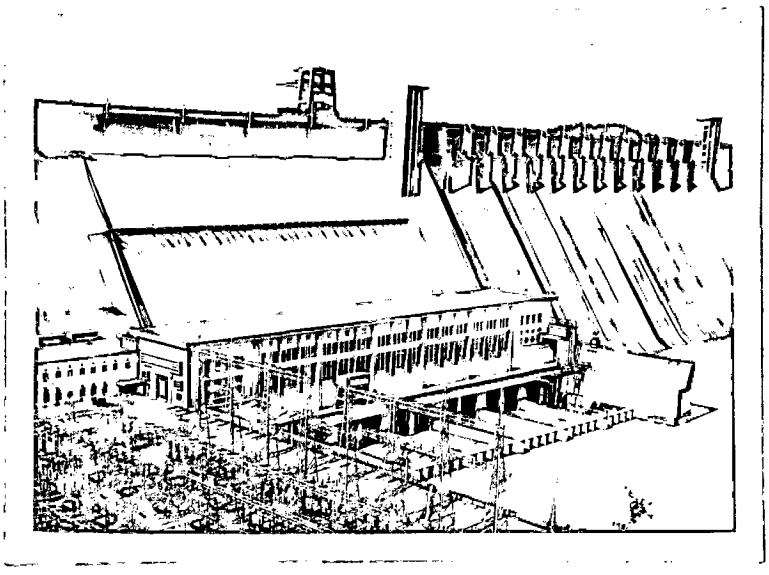
Offices

Offices are located above the control room in a separate block. They are of suitable dimensions and are well lighted. However, the colour scheme of the offices is dull and not cheerful.

PLATE


battery room
switch board gallery
control room (ceiling at 11-6 height) 86-6 X 27-5
r.c.c. column
switch gear room 11-6 X 21-9
retiring room 16-1 X 11-6
bath
W.C.
bath
elevator shaft
entrance vestibule
erection bay el 683-0
entrance for entrance refer detail
•control room is located in a seperate block.
•functionally and visually it is well planned.
•however the detail treatment of fenestrations are too monotonous.
ground floor plan. above el. 684-0
scale — 1-40
CONTROL ROOM RIHAND POWER HOUSE. UP.
source - irrigation department up design w.c running directorate rihand dam
N

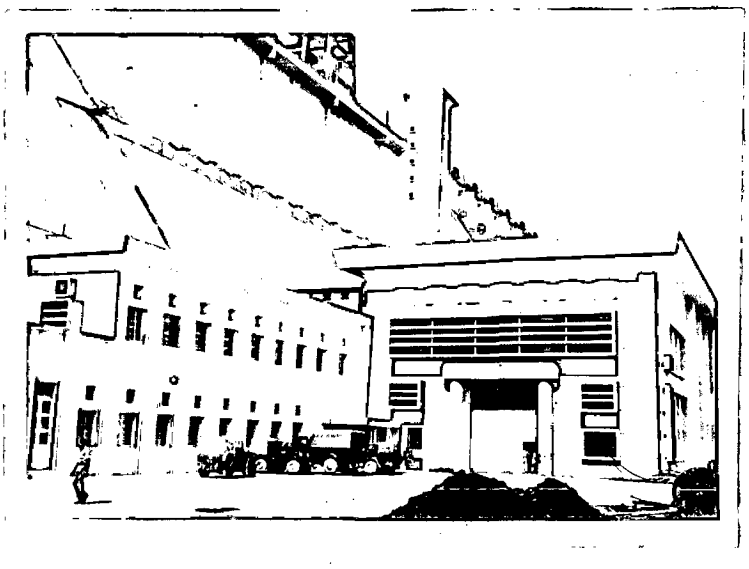
PLATE



Rihand Power House

Distt. Mirzapur, U.P.

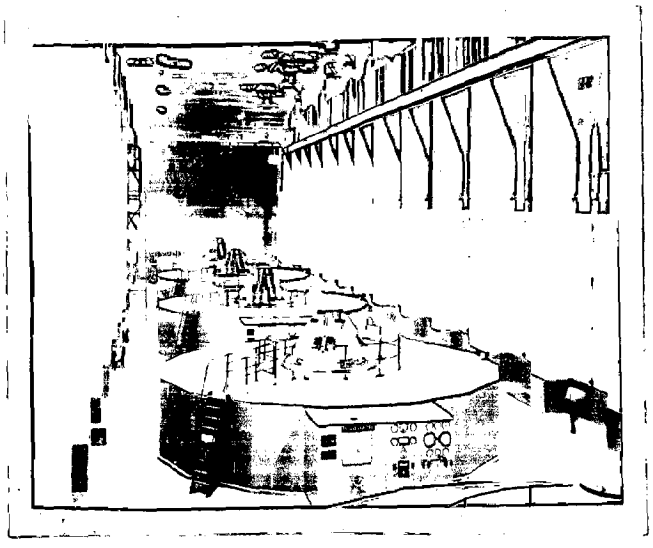
1



2

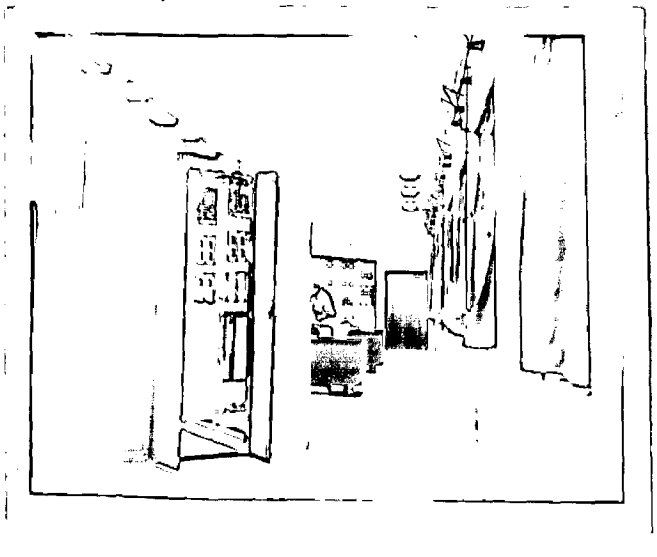
Souree :- S.E. Central Design Directorate, Irrigation Department, Lucknow, U.P.

PLATE



Rihand Power House

Distt. Mirzapur U.P.



Source :- S.E. Central Design Directorate, Irrigation Department, Lucknow, U.P.

B) Exterior Design and Environments :

i) Overall horizontal form and finishes of the building, harmonizes with the solid background of a dam-structure. But the fenestration design of the powerhouse, reflects the characteristic expression of a stereotyped office building.

ii) The complex busbar lines of the switchyard visually screens the view of the power house, and creates a dynamic tension in the environment.

iii) Some introduction of landscape features and recreational facilities can bring to the whole environment, a touch of geityness and delight. [Plate -]

4.3 BHAKRA LEFT BANK POWER HOUSE

3.1. General features :

- Location: At the foot of the Bhakra Dam, at a distance of about 7 miles away from Nangal.
- Type : Submergible
- Installed Capacity 4,50,000 KW
- No. of Units. Five
- Architectural Design Le-Corbusier

3.2 Design and Layout:

i) It is a massive multistoreyed reinforced concrete bldg. and is located on the left bank of Sutlej river. It is 371 ft. long, 104 ft. 6 in. wide and 161 ft. high.

ii) The building comprises six major floors, which have been designated according to their reduced levels. The top floor is in level of adjacent ground, and is at E.L. 1207!

iii) The main bays have been designated as Bay No.1,2,3,4,5. Bay No. 1 is 73 ft. wide and bays no.2,3,4 and 5 are each 60',while width of service bay is 58'-6" .

iv) Laterally each floor except, E.L.1207', and E.L.1225'. Floors, consist of two portions one on the upstream side accommodates the generating units and the other on the

downstream side, houses various facilities, located at different galleries at all elevations.

v) E.L. 1225', Floor.

The deck portion of this floor accommodates the five unit set-up transformers, and their cooling equipment and gantry crane for handling the draft tube gates. The rest of the floor within the powerhouse, covers service bay, landing place for powerhouse lift, reception room, balcony, which runs throughout the length of the power house, along downstream wall connecting the approach way to the rear exit of the powerhouse.

vi) E.L.1207' floor.

Main control room, battery room, test laboratory, air conditioning equipment, blowers, battery charging equipment, carrier communication equipment and main offices have been located.

vii) E.L. 1192' Floor.

Mainly divided into two portions:

a) Machine hall : installed with five generators.

b) Cable gallery : steel racks fixed on supports, carry the control and auxilliary supply cables.

c) Near the service bay floor, first aid dispensary and power-house workshop have been located.

3.3 Space Evaluations

i) Electrical and Mechanical plant area: Adequate area provided. It fulfills all the requirements.

ii) Circulations: Sufficient clearances provided around the machin and the auxiliaries.

iii) Staff offices: Fulfills all requirements of office planning and design.

3.4 Welfare Facilities

Amenities like drinking water, toilets, retiring rooms, lunch-rooms, canteen, first aid room, lockers, showers and parking are provided. Area adequate and meets all the requirements.

3.5 Structure, Construction and materials etc.

Massive reinforced concrete construction. Side end wall 8.5 ft. thick R.C.C. and 11 ft. thick Roof. Light weight concrete fills is used in all floors, in which a large quantity of pipe and electrical conduit is embeded.

3.6 Environmental Engineering Requirements

i)	Illumination	Major artificial light
ii)	Ventilation	Mechanical
iii)	Noise control	Provided in control room and offices.
iv)	Thermal comfort	Fairly comfortable, being air conditioned.
v)	Maintenance and Sanitation	The powerhouse is very well maintained, and there is an underground drainage system.
vi)	Fire protection	Fire extinguishers, and automatic alarm system on turbine, switchgear and transformer area.

3.7 Finishes on Walls and Floors

Smooth plaster finish on walls with dado finish at the lower level.

Floors :

Offices	-	Linoleum
Control room	-	Rubber tiles
Turbine hall	-	Mosaic.
Retiring room	-	Linoleum.

3.8 Architectural qualities:

A) Internal environments :

Machine Hall

i) The hall is spacious, clean and orderly - planned, reflects the functional expression of purpose for which it is designed and commissioned.

ii) The visual effect of the turbo-generators, is pleasing, because of its clean shape, and variation in colours.

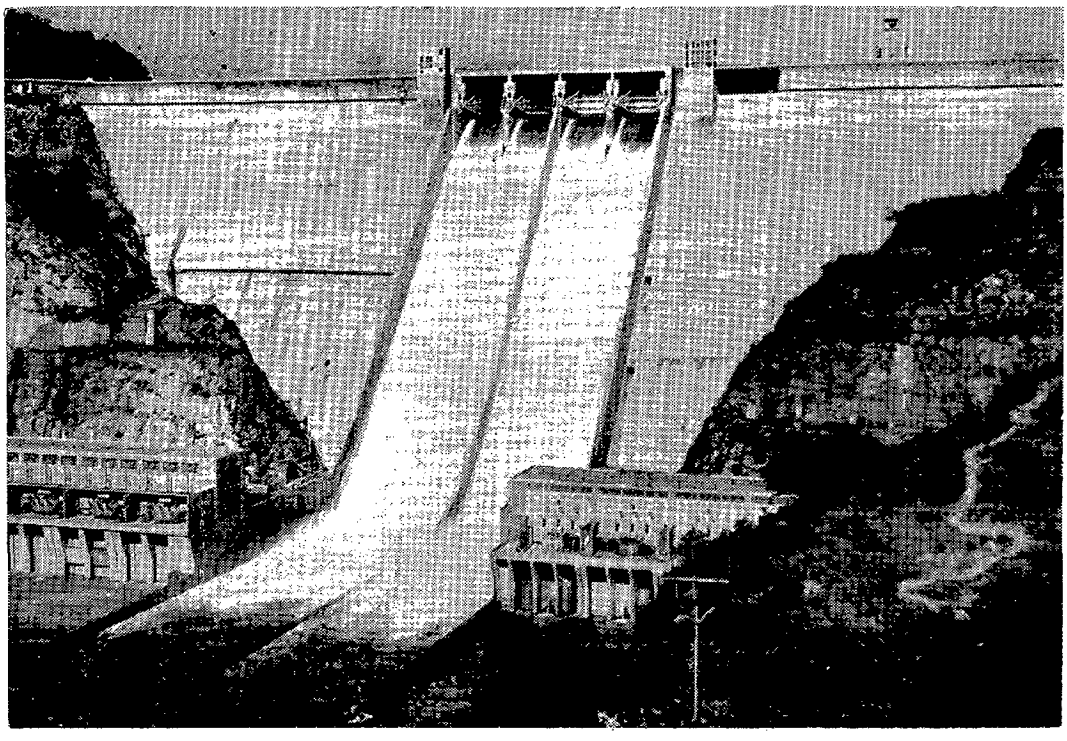
iii) The auxiliary equipments are well and orderly located so as to get a sufficient clearances around the equipments and it also helps to plan, a neat and clean interior.

iv) The various parts of machines are approached by a simple and grafeful designed staircases, which are most functional and aesthetically pleasing.

Control Room

i) It is a nerve centre of the powerhouse,and richly furnished with control panels, rubber tile flooring, flush ceiling lighting , curtains and a pleasing colour scheme.

PLATE



Ref:- W.R.D.T.C. Magazine, University of Roorkee

PLATE

BHAKRA POWER HOUSE, MACHINE HALL

Ref:- BROCHURE., 'Water and Power Development India', Govt. of India. Ministry of Irrigation and Power.

- Offices

i) Offices are furnished with a well designed furniture, illuminations, colour schemes, etc. It is airconditioned.

ii) It is appreached by a separate entry with the help of elevators and staircases.

3.9. Exterior Design and Environment

i) The harmonious form of the powerhouse is organically tied down with the grandeur of the Dam structure and balances with the rock moulds on either side.

ii) The visual sight of the transformers, located on a deck, are not well located and treated with in between walls and as such presents an unpleasing view from the exterior.

iii) Expreession of concrete as an exposed form work is well expressed with the backdrop of the dam structure.

[Plate -]

4. CHIBRO UNDERGROUND POWERHOUSE

4.1 General Features

- Location: Yamuna Hydel Project II, near Dakpathar. Distt. Dehradun.
- Type : Underground Power house
- No. of Units: Four
- General Aesthetic Design by: Sri K.M.Bhargava, Architect, Irrigation Department, Lucknow.

4.2 Design and layout:

Yamuna Hydro-electric scheme stage II, envisages development of 340 MW of electrical power by utilising the drops available in the river Tons between Ichari (near proposed Kishan Dam Site), and its out fall in river Yamuna near Dakpathar. Along this reach, the Tons river flows in a double loop and the valley is very narrow with steep hill sides rising upto about 1000 m. above the river bed level.

4.3. Size and the shape of Powerhouse Cavity.

1) Four machines of 63.MW spacings of 14.5 m are located in a row, in order to keep the size of the machine hall minimum.

ii) Main busbars for each machine, will be carried along the down-stream face of the cavity, and they will be hung from the roof arch.

iii) Control room: The control room has been located on the opposite side of the execution bay of the power house cavity. This was done with a view to keep the length of control cables to a minimum .

iv) Access Tunnel: The access tunnel offtakes from the main Haripur Koti road itself at 9.1 km along east of the Chibro hill. The access tunnel is 7 m. dia 'D'shaped and about 350 m. long.

v) Cable tunnel: The cables from the transformers will be carried through a cable tunnel leading to a switch-yard to be located on the terrace available along the river bank.

vi) Archor Gallery: A 4 m. wide and 6 m. high gallery has been provided on the upstream side of the powerhouse cavity, at a distance of 18.475 m. It has been provided solely to accommodate the other end of the prestressed anchors provided on the upstream wall of the powerhouse cavity.

4.4 Space Evaluations

i) Electrical and Mechanical operation area: Just adequate, to meet the all requirements.

ii) Circulation: Minimum clearances provided around equipments.

iii) Staff offices: Area provided is adequate.

4.5 Welfare Facilities:

Amenities like, drinking water , rest room, first aid room, toilets, are provided. Conveniently located

4.6 Structure, construction and materials :

Rockfall has been retained with the help of huge anchors by providing anchor gallery.Gauntry columns are steel frame structure. These columns are encased in concrete.

4.7 Environmental Engineering Requirements:

i) Illumination: Applie Artificial with fluorescent tube lights and hanging lamps.

ii) Ventilation: Mechanical

iii) Thermal comfort: The hall, control room, and offices are air-conditioned.

iv) Maintenance and Sanitation : Powerhouse is well maintained, and there is underground drainage system.

v) Fire protection : Fire extinguishers and automatic sprinkler and fire alarm system.

4.8 ~~xx~~) Finishes on Walls, Floors: Rockfall has been treated with 3" shot creating on both faces, to prevent seepage.

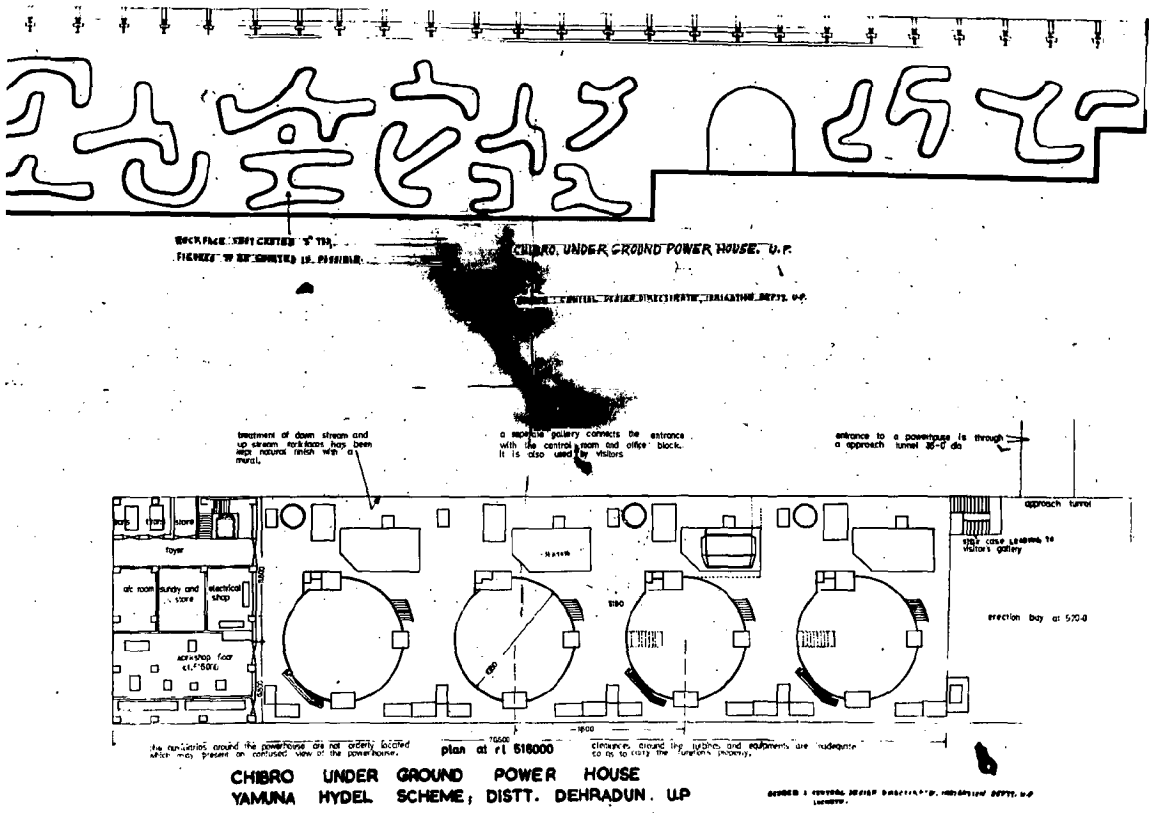
Floors : Mosaic.

4.9 Arbhitectural qualities

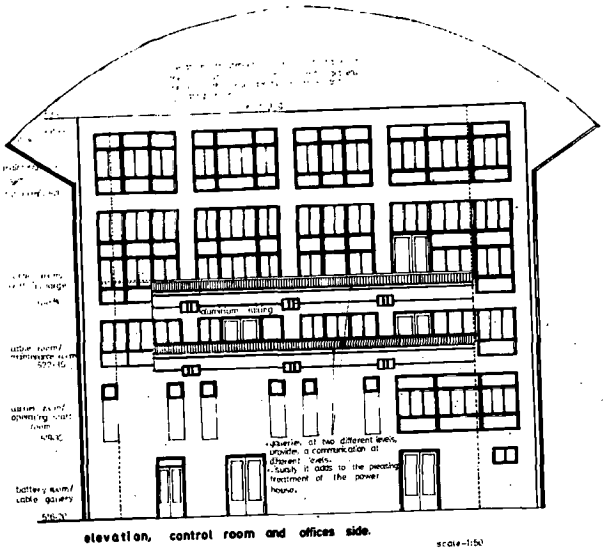
A) Environments:

- Machine Hall - Machine hall gives an impression of long tunnel and is very narrow. The total effect

PLATE


CHIBRO UNDER GROUND POWER HOUSE. U.P.
treatment of down stream and up stream rock faces has been kept natural finish with a mural.
a special gallery connects the entrance with the control room and office block. It is also used by visitors
entrance to a powerpuse is through a approach tunnel 25'-0" dia
approach tunnel
store
foyer
air room
sundry and store
electrical shop
workshop floor el.+598.0
erection bay at 570.0
plan at rl 618000
CHIBRO UNDER GROUND POWER HOUSE
YAMUNA HYDEL SCHEME; DISTT. DEHRADUN. U.P

PLATE



CHIBRO UNDER GROUND POWER HOUSE,
YAMUNA HYDEL SCHEME DISTT. DEHRADUN UP

Refi- S.E. Central Design Directorate Irrigation Department Lucknow, U.P.

is calm and quite, A visitors gallery has been provided at higher elevation. It also connects control room. Heavy types of false ceiling to be provided as cable gallery. It will be treated with lighting fixtures and colour scheme.

Control room and office block

It has been provided on the other end of the power house. It is well treated with full glazing, and a balcony overlooking the power house. It relieves the severe effect of the interior by good illumination and the general aesthetics.on wall. [Plate -]

CHAPTER - V

CONCEPTULIZING THE ARCHITECTURAL QUALITIES OF POWER HOUSES.

INTRODUCTION AND SCOPE :

In conceptulizing the Architectural qualities of Power Houses, it is imperative that the form and the environment of the Power house must be developed on the practical and economic nature of the plant. This will increase the efficiency and boost the morale of the personal.

Scope of the Architect is to design the Hydro-electric Schemes, as part of Regional pattern and there are great opportunities for integration of Engineering, Landscape design and Architecture. A favorite modern theme, the natural computability of contemporary Architecture and Engineering can find expression in an enormous electric generating power houses.

5.1. Interior Design :

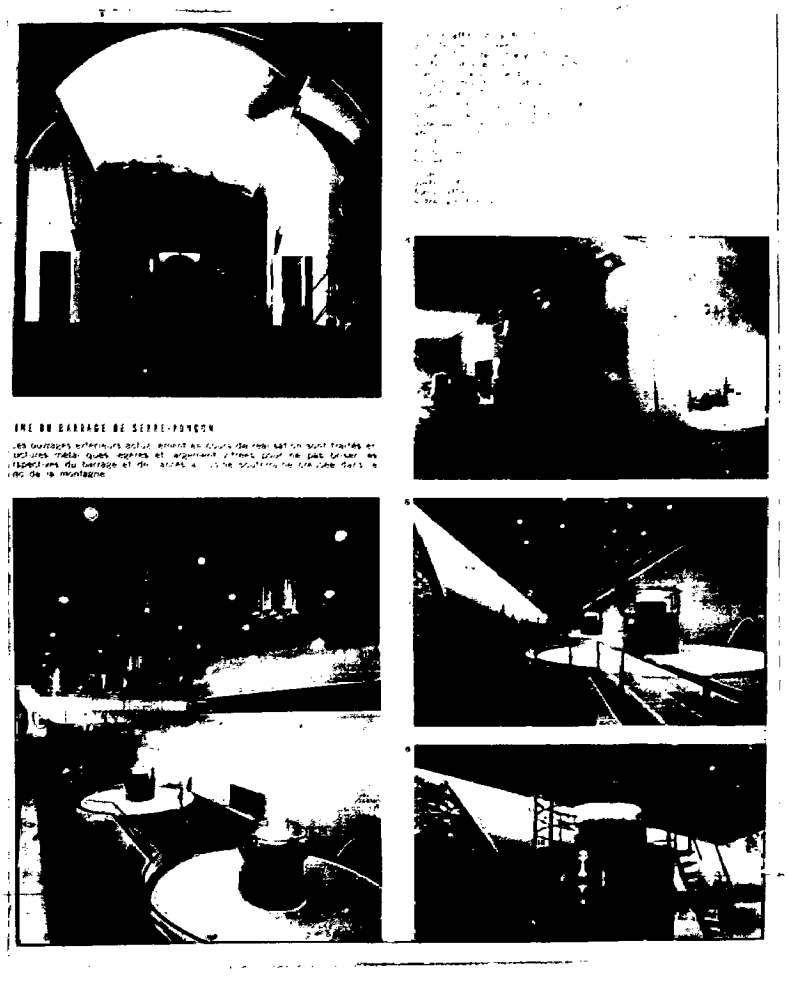
5.1.1. Generator halls :

Conceptual Example 1.

Under-ground Power House.

- Design and related desthetics of the interior is based on the creative power of the designer, who has been successful in solving the biological and psychological working conditions of the personal.

PLATE



USINE DU POWER HOUSE GERMANY

Ref:- D'Architecture, Vol.25, Sept.62

Ref :

Plate

- The interior is sophisticated to attain the highest of efficiency and comfort.

- The interior is lively by unifying all forces of design elements.

- The exposed rock cut given on the face of the wall reduces the effect of severity of machines, and links the interior with the surrounding land forms.

- Entrance to the access tunnel for the underground power house, welcoming with the arch canopy and links the exterior with the interior and vice versa, giving a sense of direction and movements. (Plate)

Conceptual Example 2.

- Structural fabric of the power house is well conceived to create a pleasing and spatial volumatric interior.

- The well finished crane beams, visually, brings a sense of human scale, and relieves the Loftiness of the interior.

- The clean shape of the machines, harmonize with the clean finishes of the floor and wall and the general illumination effect adds to the total sprit of the interior (Plate).

Conceptual example 3.

- Lay out and the pedestal platform for the machines, unites, the whole interior composition and contrasts well with the vertical planes.

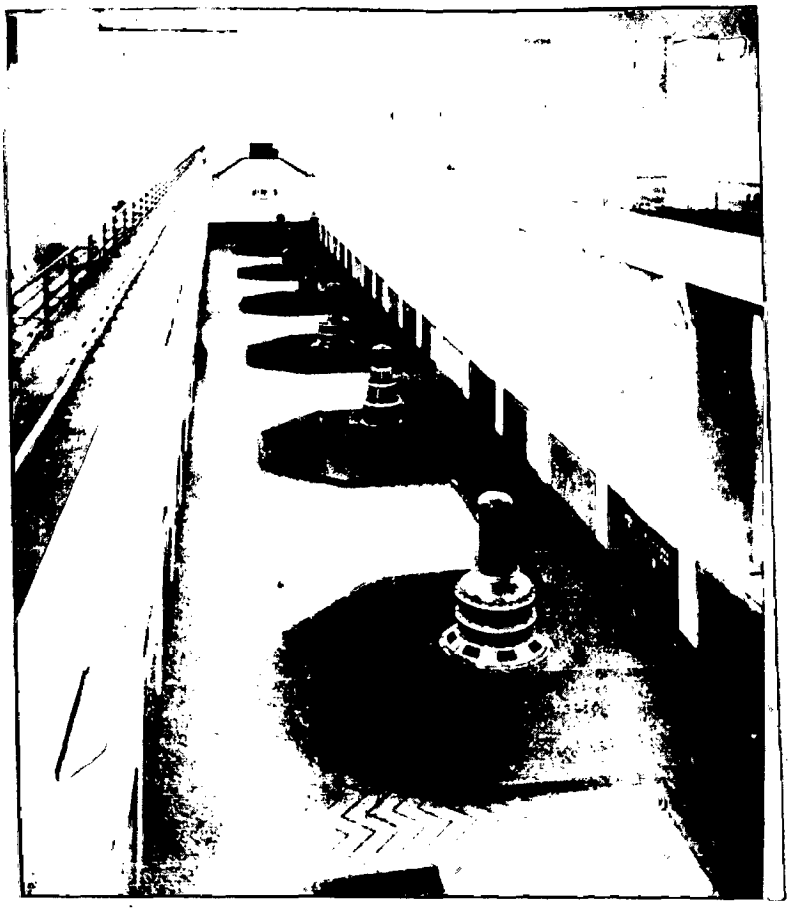
- The rhythmic lines of the vertical piers, harmonize with

PLATE

INTERIOR, CINEGO STATION, AUSTRALIA

Ref:- 'Water Power' Journal, Sept.57

PLATE



MACHINE HALL OF HENRI POINCARE STATION,
AUSTRALIA

Ref:- 'Water Power' Journal, June 1960

PLATE

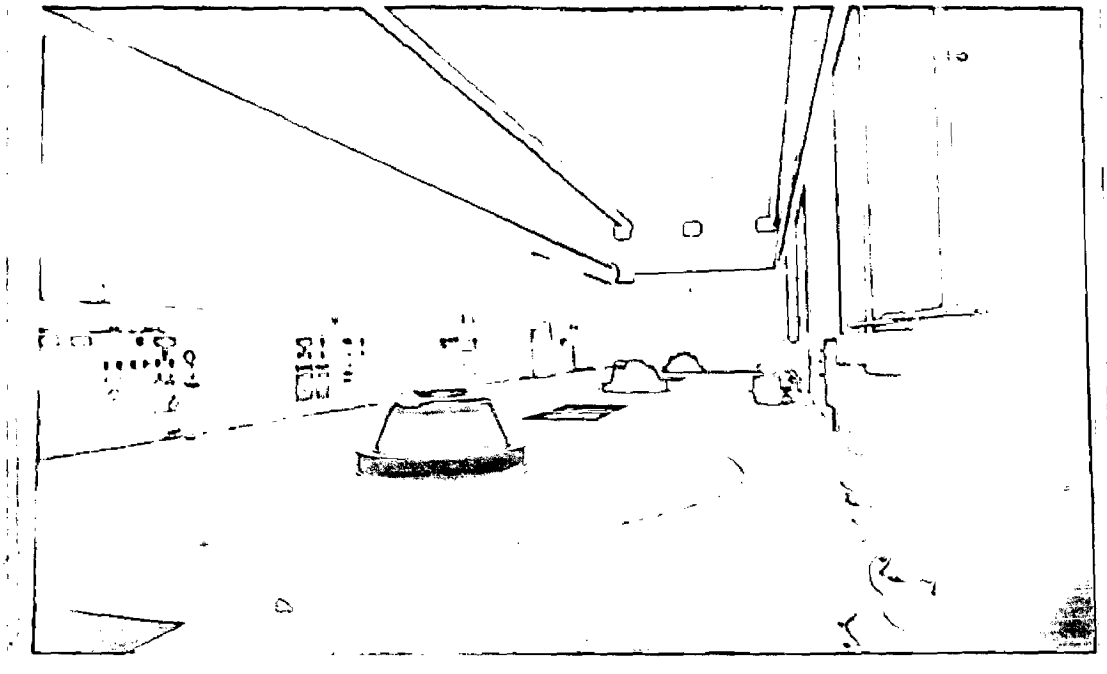


Fig. 17. Picote underground machine hall in service

Ref:- Water Power May, 1959

the railing of the gallery on the opposite side, and gives a dynamic sense of value.

- Aesthetics of Industrial design is well expressed in the pleasing appearance of the turbo-generators.

- Softness of the illumination relieve the monotony and enriches the transparancy of the interior (Pplate).

Conceptual Example 4.

- Clerity and orderliness of the machine and its auxiliaries adds to the total spatial effect.

- The sweeping lines of the illumination harmonizes with the fabric of the interior and reflects a rich interior environment.

- Aesthetics of the shape of the turbo-generators is simple but graceful and gives a clean outline (Plate).

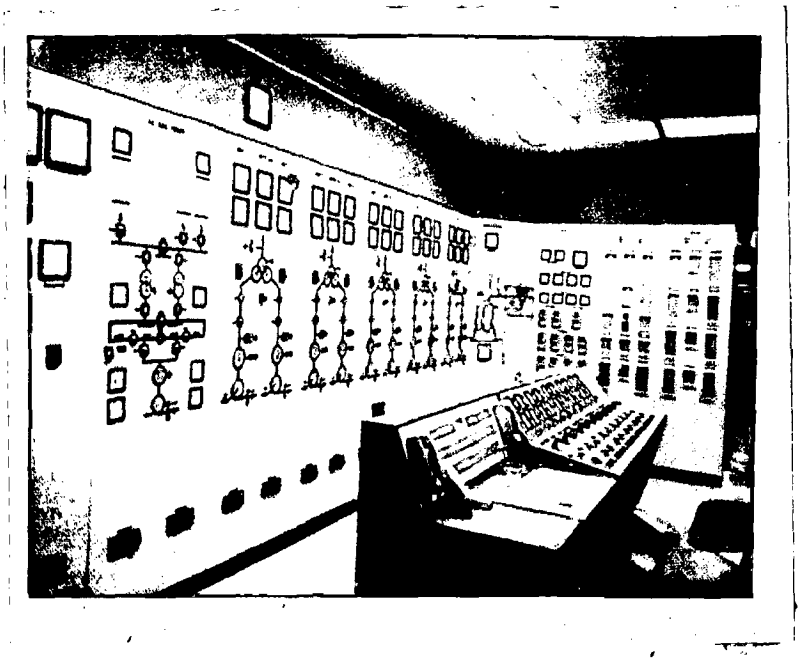
5.1.2. Control Rooms:

Control room is a nerve centre of the Power house a fundamental design is based on the pleasing interior the layout of panels and the luminous ceiling dominates the room and reflects the richness of design.

- They are mostly air-conditioned, the environment inside the room is cozy and comfortable.

- The good finishes on wall and floors helps to design neat and clean interior (Plate).

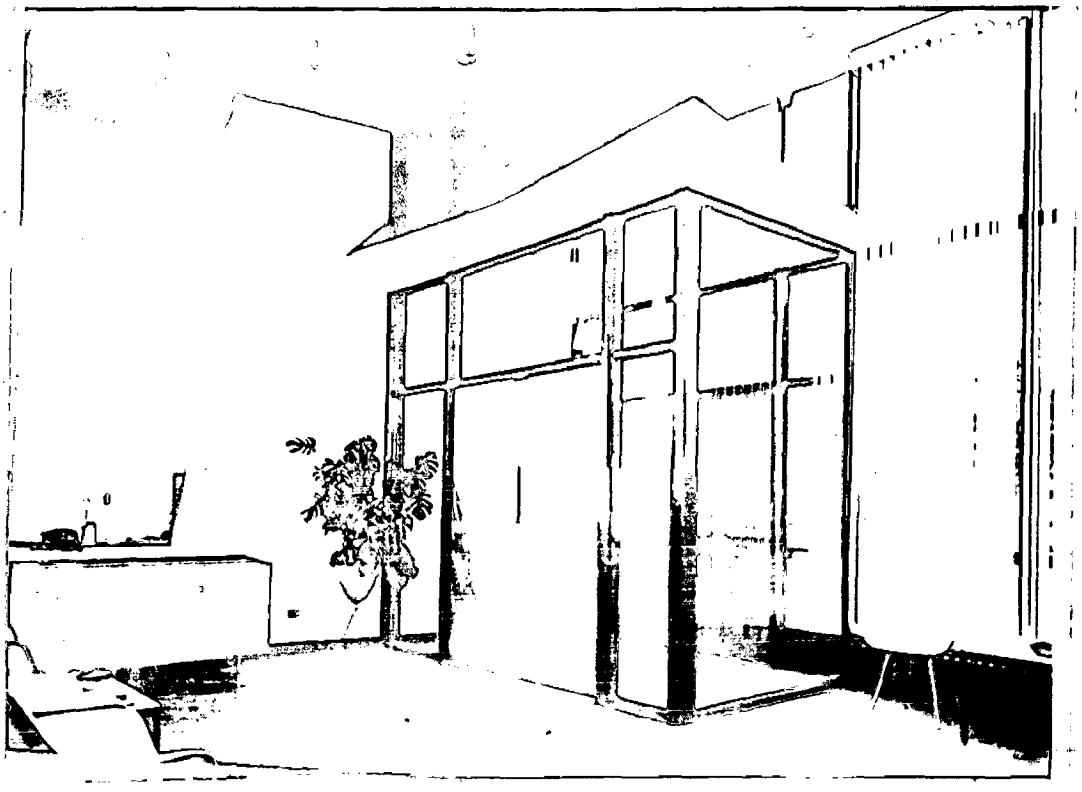
Plate



Control Rooms

Ref:- BROWN GUTHRIE, J. "Hydro-electric Engineering Practice", V.2

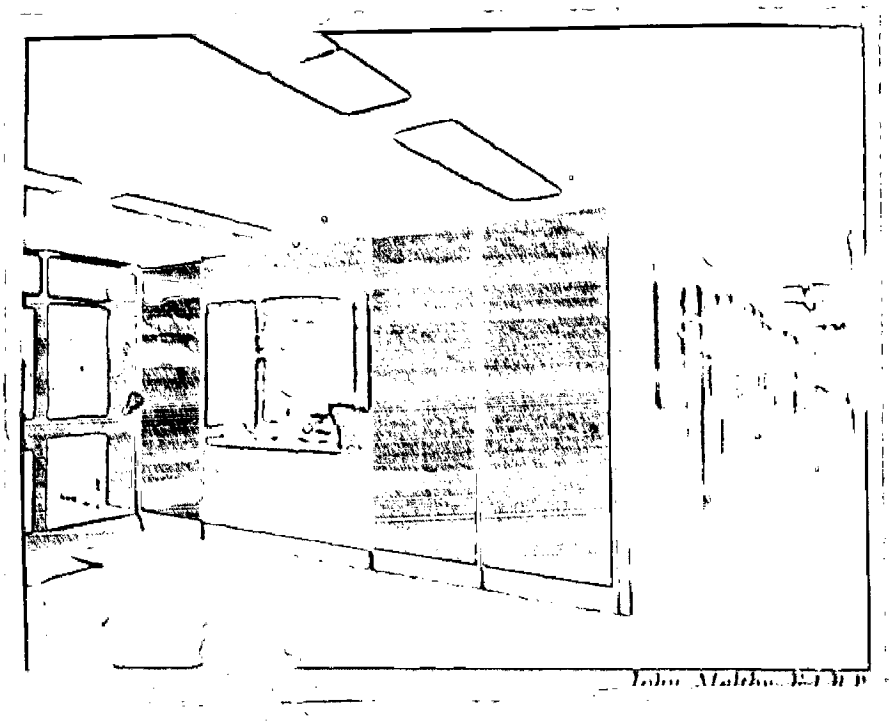
PLATE



TYPICAL RECEPTION ROOM

Ref:- MUNOE F. JAMES. 'Industrial Architecture'.

PLATE



TYPICAL EXAMPLE OF OFFICE

Ref:- MUNCE F. JAMES., 'Industrial Architecture'.

5.1.3. Typical Reception hall and Offices :

- Design and related aesthetics of a reception hall is welcoming and cozy.
- The expression of different materials are well co-ordinated to achieve a total effect of pleasing interior. (Fig.1) Plate ( )
- A typical interior of a power house, Office, with demountable partitioning, helps to achieve a spatial effect and control the noise from the machine hall (Plate).

5.2. Exterior design when Power Houses are Located:

5.2.1. At the toe of the dam.

Conceptual Example 1.

- It is a submergible power house where the Power house is built in the body of the dam, so as to allow water to flow in times of flood.
- This is a conception of flowing unbroken landscape viewed as a whole, is the background against which the design of the arch dam and the power house, their siting, and zone of influence is considered.
- The dam and power house form, is organically merged into a surrounding landscape, without loosing its own identity.

PLATE

E.D.F. BARRAGE DE MONTEYNARD, ISÈRE, FR

CONCEPTION : A. COYNE ET J. BELLIER.
ARCHITECTES : CHOMEL, FONTERME, POURADIER, DUTEIL
PHOTOS BRIGAUD, BARANGER, ERRMANN ET VERDTS.

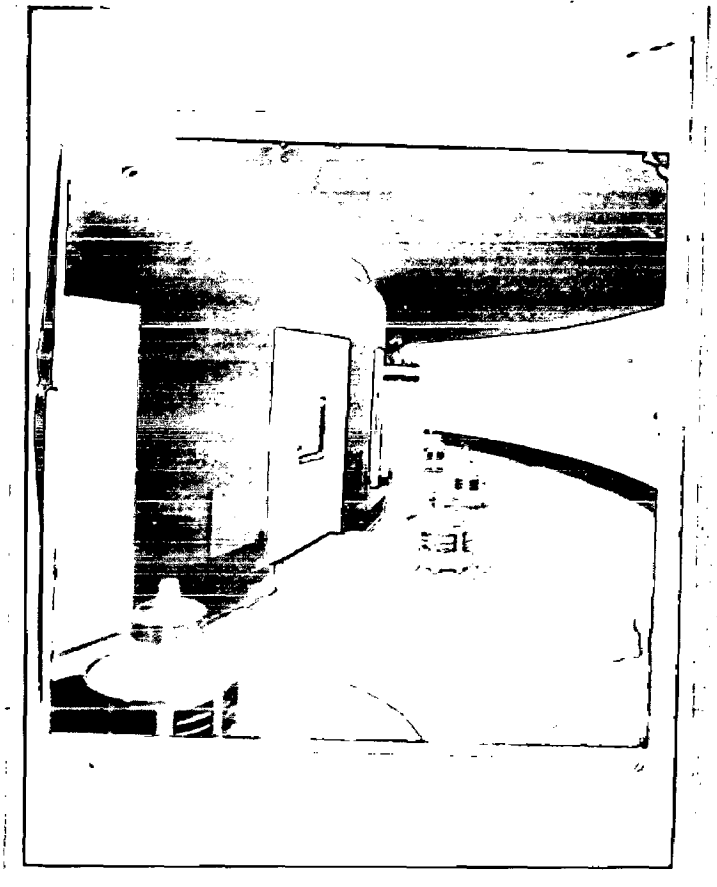
ABORDS

Ref:- D'ARCHITECTURE - Vol.25. Sept.1967

POWER HOUSE, De MONTEYNARE

Ref:- De 'Architecture'. Vol.25. Sept.1960.

PLATE



INTERIOR. DeMONTEYRARD. POWER HOUSE

Ref:- D'Architecture. Vol.25. Sept.60.

- Here it is realized that a good landscape is part of nations standard of living. Every possible has been done to preserve it.

- Here the machines are set on a arc where special crane with curved track is provided.

- The interior is dynamic and there is a vividity in design (Plate).

Conceptual Example 2.

- In a countryside, it is intended to keep the nature dominant, the aesthetics of power house, and related structures are designed to limit its zone of influence.

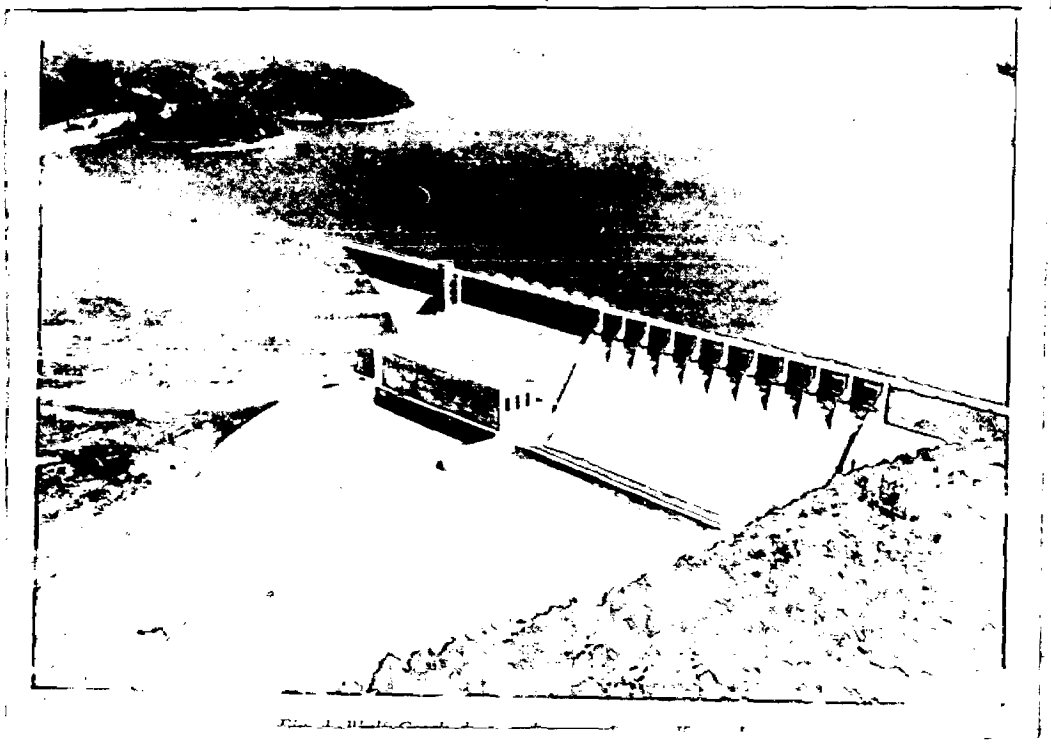
- The sight of the structures is made to look part of landscape composition. It is well disruptive than an effort to conceal it.

- Fitness of material with the fitness of structures is well expressed outside, with strong force-full use of modern materials.

- Form is developed to guard against successive obsolescence. (Plate).

5.2.1. At the side of the dam or spillway:

PLATE



WOLF CRACK DAM AND POWER HOUSE,
KENTUCKY

Ref:- 'Water Power', Journal Feb.58.

Conceptual Example :

- In this case the solid design of the exterior is dictated by the need to provide strong water holding retaining wall against the possibility of extreme rise in the level of flood water.

- Here the harmonious grouping of the dam and the power house is achieved by the natural topography of the site.

- Fitness to function is well expressed in the exterior form.

- The material and the finishes of the two structures reflects an impression of an comprehensive irrigation and power development schemes.

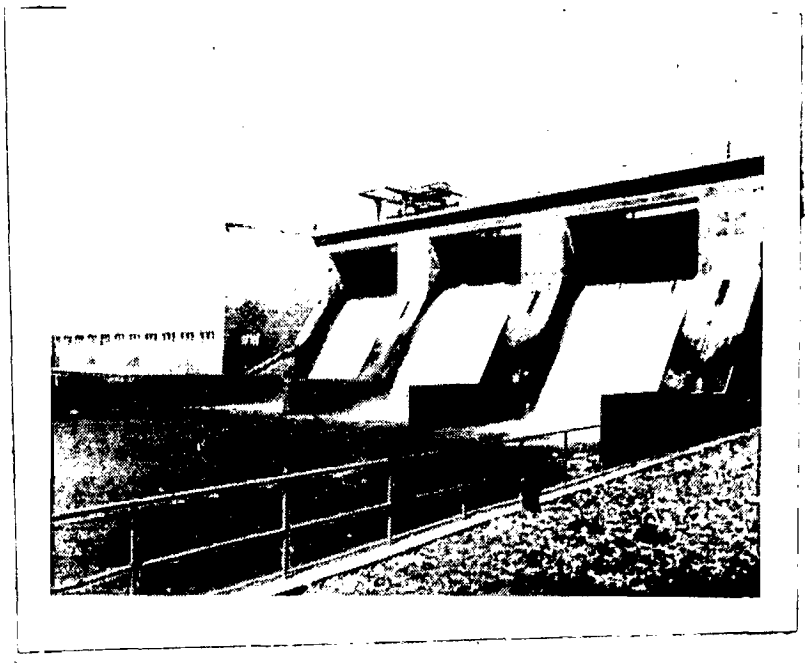
- The simple and graceful railing of an tabular pipe is much more subordinated with the form of the two structures, and thereby adds to unity the total enclosing of the scheme.

- The natural sheet of water on the fore-ground of the dam, and the power-house, increases the value of the structures for which it is designed. (Plate).

5.3. <u>On the Power Canal away from the weir or the Spillway</u>:

- The siting of the power house is free standing and open in character where there is scope of design on all four sides.

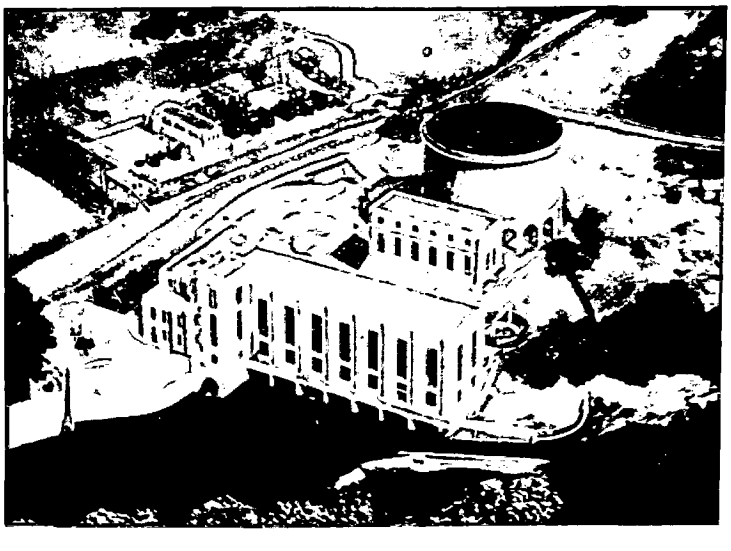
PLATE



VERBOIS POWER HOUSE, GENEVA

Ref:- BROWN GUTHRIE, J. 'Hydro-electric Engineering Practice' V.2

PLATE



Conceptular Example 5.2.3. On the Power Canal Away or Weir

Tongland Power Station

Ref:- BROWN GUTHRIE, J. 'Hydro-electric Engineering Practice' Vol.1

- Here the wild landscape forms a back drop to the powerhouse.

- Power house should have zone of influence with the immediate surroundings.

- It's form should be subservient to the open landscape. (Plate)

5.4. Switch yards :

- Visually exposed busbar arrangements, can well balanced with the masses, of the power house.

- The orderly layout and clean design of R.C.C. posts serve to harmonize with the powerhouse structure. (Plate).

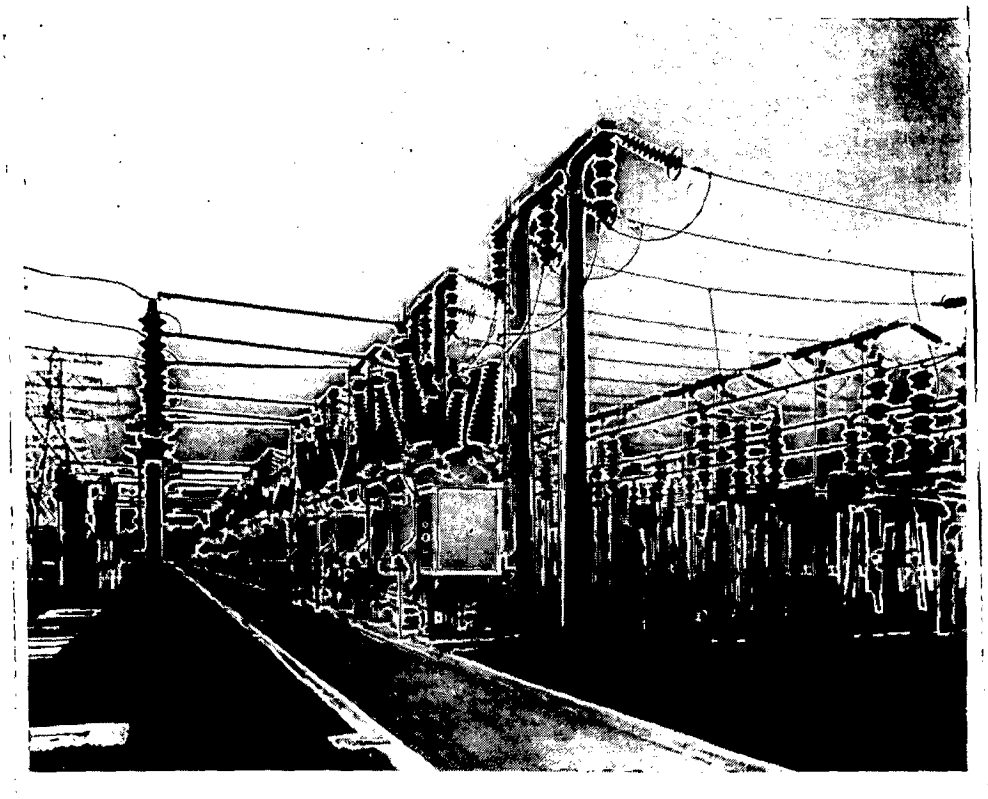
5.5. Total landscape expression :

Conceptural Example :

Hydro-electricity is the only source of power which has so far made a positive contribution to the landscape. Whether the contribution out weighs the damage which it may also cause, depends, on its siting and the sympathy towards the landscape with which the construction is carried out.

Dams are perhaps the most magnificient of all organic engineering structures. In their finest expression they grow out of the landscape with the impersonal grandeur of a out

PLATE



Ref: 1. BROWN GUTHRIE, J. 'Hydro-Electric Engineering Practice', V.1
2. CROWE SYLVIA. 'The Land Scape of Power'

PLATE

THE BORTOLOUGHRY POWER HOUSE.

Ref:- SYLVIA CROWE, 'The Land Scape of Power'.

crop of rock. But the related structures of hydro-electric works, their towers, wires, and transformers can both bring a sence of Industrialization to the scene and take away from the grandeur of the dam.

The new Echtolochry power station (Plate) is equally satisfactory;every thing possible has been done to limit its zone of influence and it fits quitely into the back-ground.

Built with great similicity in local stone, it is recessed into the hill side,so that from no direction,does it stand up as a silhouetted block. The rock of the excavated hill side is left as a rough framework, binding the building to the hill. The slopes at the side have been carefully shaped to accord with the natural land form and the boundary at the sides is formed by the wall of local stone, not enclosing a rigid rectangle but changing direction to fit in,with the shape of the ground,in exactly the same way as the traditional farm boundary walls.

CHAPTER - VI

CONCLUSIONS AND RECOMMENDATIONS

6.1 Background

It is now recognized that the areas of common ground between architecture and civil engineering has expanded in the realm of Industiral, Mechanical, Electrical and other specialized engineering projects. Their importance is all the more in collaboration rather than the demarcated works in seclusion or unrelated compartmentization , modernization, of this vital inter discipline lead to superior result in its all encompassing aspects.

Further the later part of 20th centuary, architecture has made a specialized contribution in respect of cost dynamics by new rational that any structure infused with aesthetic qualities of merit, need not cost more than a similar structures, less pleasing or drab in its environmental coordination of the interiors and exteriors.

6.2 Conclusions

Based on the studies presented in this dissertation, the following conclusions are made:-

i) · The most significant conclusion to be drawn from the study, is that the architect with certain personalized studies, is the only specialist capable of providing appropriate envelope for the power stations.

ii) · Architecture of power stations should be vivid enough.

iii) · Architecture of the power station should enhance the landscape.

iv) · Power station building should not upset the ecological balance.

v) · Power station should be functional in every inch of its space.

6.3 Recommendations

6.3.1 Interior Design - Inspite of limitations and restrictions, imposed by requirements of space, head room, Gantry crane clearance, expansion joints, dimensions of openings etc., the methods and means to secure

a pleasing architectural effects are based on the following aspects :-

i)· The power station building design should be inside out and not vice versa.

ii)· Design of internal environment should get preference over external environments.

iii)· Integration of all engineering functions, should have preference over frevolious embelishments.

iv) · Creation of spatial effect by presence of machines and its auxiliaries should be attained by aid of their layout, colours, shapes and envelopes.

v) · Creation of spatial effects by the design of fanestrations, finishes, texture, colour and illumination on walls, floors, and ceiling.

6.4 . Design - Exteriors

i) · The appearance of the building should express its local or national significance.

ii) · Major power houses, should be buildings of prestige, fulfilling its functions as heritage of our times.

iii) · The architectural design of the powerhouse, should harmonize further with appurtenant and even with non-appurtenant buildings and structures of the environment e.g. office bldgs.,bridges,dams,barrage, weir, living quarters etc.

iv) • The architectural design of power houses should be in consonance with the natural surroundings.

v) • The man made landscape by organic (trees, shrubs and greens), inorganic(rockeries, pavements, rails), engineering assemblage (switchyard and high tension lines illumination should accord an appearance of oneness.

6.5 Fabric of the Power Houses

i) • The proper selection of structure, materials, walls, cladding etc.

ii) • The structure should be strong to withstand, water pressures, wind forces and seismic forces if any.

iii) • Water proof treatment of walls and roofs.

iv) • Reduction of noise factors.

v) • Safety of workers.

6.6 Psychological considerations for work

i) • Bright, cheerful, attractive colour schemes should be provided to increase the efficiency of the workers.

ii) • Airconditioning or forced ventilation, number of air changes.

iii) • Illumination for work and environments

iv) • Fenestrations where not possible, feelings should be created.

v) • Neatness and cleanliness of power houses.

-:-

B I B L I O G R A P H Y

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APPENDIX -I (2.4)

MACHINE ARCHITECTURAL QUALITIES

S.No.	Requi	ideration	Scope for Architectural Qualities
1			6
1	TURBINE MAC :	idth and height he hall is - y the overall hensions and arr- generating sets. are finalised by t suppliers and se engineers. Doland the gene- er unit may be ta- times the area the outside Shell ator. $\frac{4 \times 3.15 \times \pi \times 10^2}{4}$ 990 Sq. Meter Guthrie Brown, stance between chine centre lines. ax. runner discharge lameter. 9 x 5.2 = 15 meters n further States that full proof formula t 'Space' required ines.	**Interior** a) Spatial effects. b) Finishes on walls and floors c) Proper selection of roof structure and its aesthetics from the interior. d) Colour scheme on the body of the machine and its auxiliaries. e) Harmonious scale and proportion of fenestrations. f) Art of illumination of the hall. g) Aesthetics of general details. **Exterior** a) Exterior form with its relation to its function, the exterior Engineerin Structures and the landscape. b) Aesthetics of exterior design c) Aesthetics of roof structure. **Environmental Engineering Factors:** a) Thermal comfort b) Illumination-Natural and Artificial c) Ventilation-Natural and Artificial

1	2	3	4	5	6
2	Loading and Erection bay (also known as assembly bay)	a) The Plant and its parts are dismentled and reassembled for erection and repairs etc. b) It is the part and parcel of the machine hall	Kept on one end or on two ends, depending upon the layout.	It is usually extends the full width between the crane rails, As a rough guide, it is equal to the distance between the machine centres or dependent on the largest items of the machine. According to Doland the space requirements of the erection bay and operating area varies from 75 to 150 percent of the area of the generator room.	Same as above
3.	Workshop or repair bay	For the general repair of the machine parts.	It can be in a seperate block, or near the erection bay with seperate entry from the outside.	Minimum half the area of the working bay as a rough guide.	Finishes on walls and floors. Type of roof structure. Harmonious proportions of fenestrations. Illumination natural and artificial. Colour scheme of the machines.
4	Store	For storing the equipments, Space parts, and tools etc.	Near the working bay and the workshop.	Area same as above as a rough guide.	Finishes on walls and floors. General illumination.
5	Control Room	Remote automatic control of the machines are carried out together with, switching of the main and auxiliary switch gear. Control panels are placed flush maker with the wall or arranged to stand clear of the walls. Control desk with telephones are also located in the room.	Over looking the turbine room. or on the down stream side. Near the entrance on the upper floor. It can be in a seperate block.	Diamensions are decided by the control panner - suppliers and the Power House Engineers.	Layout of the Control Panels, and furniture. Colour scheme of the room. Illumination. Floor and wall finishes. Air conditioning.
6	Switch gear room	It covers apparatus and switches for making and breaking circuit continuity.	Near the control room	Same as above	same as above
7	Battery room	Small reliable sources of power is available as stand by at all times for control alarms, indications, communications, and emergency lighting.	Near the control room	The space required, depend upon the number of cells. Size is decided by an Power House Engineer.	-do-

MAJOR SPACE REQUIREMENT STUDIES OF HYDRO-ELECTRICAL POWER HOUSE, FOR THE FINDINGS OF ARCHITECTURAL QUALITIES

(Common to Surface, Submergible and Underground Power Houses).

S.No.	Requirements	Functional Features	General Location	Dimension Consideration	Scope for Architectural Qualities
1	2	3	4	5	6
1	TURBINE HALL OR MACHINE HALL	a) To house turbo-generating Sets. b) Generators usually arranged in a single row, to facilitate the handling of equipments by a travelling crane. c) Hall is mostly rectangular.	a) Centrally located b) Directly approachable from the outside.	a) The length, width and height of the machine hall is - determined by the overall physical dimensions and arrangements of generating sets. b) Dimensions are finalised by the equipment suppliers and the Power House Engineers. c) According to Doland the generator area per unit may be taken as 3.15 times the area occupied by the outside Shell of the generator. Therefore - Total generator area = $\frac{4 \times 3.15 \times \pi \times 10^2}{4}$ = 990 Sq. Meter d) According to Guthrie Brown, $\frac{X}{D_2} = 5.2$ where X = Distance between machine centre lines. and D_2 = Max. runner discharge diameter. Therefore X = 2.9 x 5.2 = 15 meters e) Guthrie Brown further states that there is no full proof formula for the exact 'Space' required for the machines.	Interior a) Spatial effects. b) Finishes on walls and floors c) Proper selection of roof structure and its aesthetics from the interior. d) Colour scheme on the body of the machine and its auxiliaries. e) Harmonious scale and proportion of fenestrations. f) Art of illumination of the hall. g) Aesthetics of general details. Exterior a) Exterior form with its relation to its function, the exterior Engineering Structures and the landscape. b) Aesthetics of exterior design c) Aesthetics of roof structure. Environmental Engineering Factors: a) Thermal comfort b) Illumination-Natural and Artificial c) Ventilation-Natural and Artificial

1	2	3	4	5	6
8	Passages and ducts for cables and pipes.	Cables are required for the control of generators, turbines, switch gear and transformers. These are housed in ducts and passages.	Ducts are generally taken to the longitudinal direction of machine hall, in basement or semi-basement and preferably on the upstream side.	It's diamentions are decided by the requirements of cables. It is decided by the Power-house-Engineers.	Good finishes on walls and floor. General illumination.
9	Transformers (out door)	Power distribution from high power transmission line is effected through distributing network, by means of transformers.	May be in a room. Out side the building upstream or downstream side.	It's requirements and dianension are decided by the Power House and equipment suppliers.	Architectural form for the dividing wall between transformers; for the purpose of protection.
10	Switch yard (out door)	It is required for the transmission of Power and its Control, and busbar arrangements.	The location shall depend on the availability of flat site around a building and location of the transformers.	Area to be decided by the Power House Engineer.	Selection of proper material for the basbar arrangements. Fencing design. Treat of paving.
11	Draft Tube deck (out side)	Is provided for operating the gatry crane, and for removing and reins-talling the gratings.	On the dowm stream side of the Power-house.	Of sufficient width, for the workmen to work is parallel to the length of the power house.	Design of parapet Lighting arrangements.
12	Administration : i) Offices ii) Conference room iii) Display room iv) Store cum Record	For caring out the total administration of the Power House. Conference Room is provided in a very large Power House.	Can be in a seperate block or near the entrance of the Power house, with a seperate entry.	It's diamensions to be decided by the Architect, based on the staffing policy of the Electricity boards of each state.	Finishes on the walls, floors and ceiling. Layout and design of furniture. Illumination.
13	Personal Amenities: i) Small canteen ii) Lunch or Tiffen room iii) Common room with lockers arrangements. iv) Toilets v) First Aid room vi) Covered Parking for Vehicles, Cars, Scooters and Cycles.	For the general welfare and the social interaction of personal.	Near the entrance or at the suitable place as per the total design.	as above	as above
14	Public Amenities: i) Open Parking for Visitors. ii) Drinking water iii) Toilets for gents and Ladies. iv) Visitors gallery	For the general welfare	Linking with the approach room and near main entrance Near the entrance hall -do- Overlooking the turbine hall on the short or long side.	Depends upon approximate No. of visitors to a Power House.	Pavement material Toilet fixtures and finishes.