REPORT

ON

INVESTIGATIONS FOR THE PROJECT

OF

MARINE AQUARIUM IN THAILAND

Overseas Technical Cooperation Agency

TOKYO, JAPAN

P R E F A C E

The Government of Japan, in response to the request of the Government of Thailand, decided to conduct a study on the design for construction of the Thai National Marine Aquarium, and entrusted this study to the Overseas Technical Cooperation Agency (OTCA), which is the executing agency of the Government of Japan.

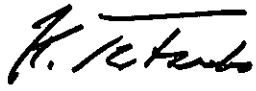
OTCA organized a study team of 3 experts headed by Mr. Toshio Tsutsumi, Chief Curator, Aburatsubo Marine Park, and dispatched it to Thailand in May, 1971.

The study team remained in Thailand for 10 days and successfully completed its field study, including discussions with the Authorities concerned and the collection of data with the whole-hearted cooperation of the Government of Thailand and other parties.

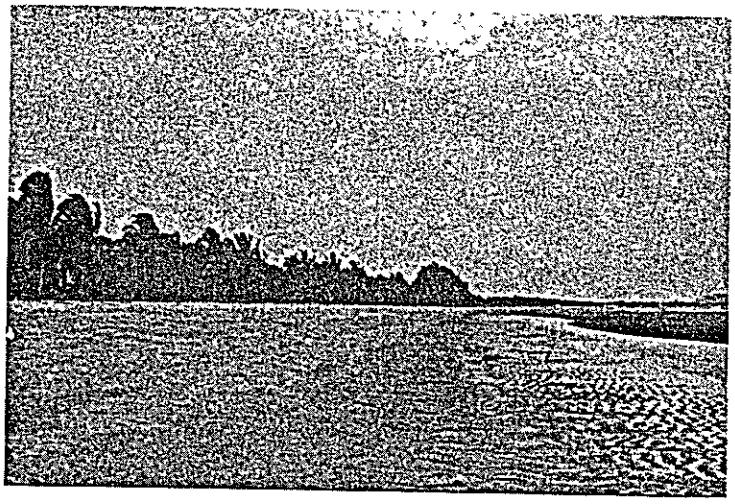
After its return to Japan, the team made f rther studies on data and information, and the results have been compiled into the present report.

Finally, on behalf of OTCA, I wish to take this opportunity to express my sincere gratitude for the generous cooperation and assistance extended to the team during its stay by the Government of Thailand.

September, 1971



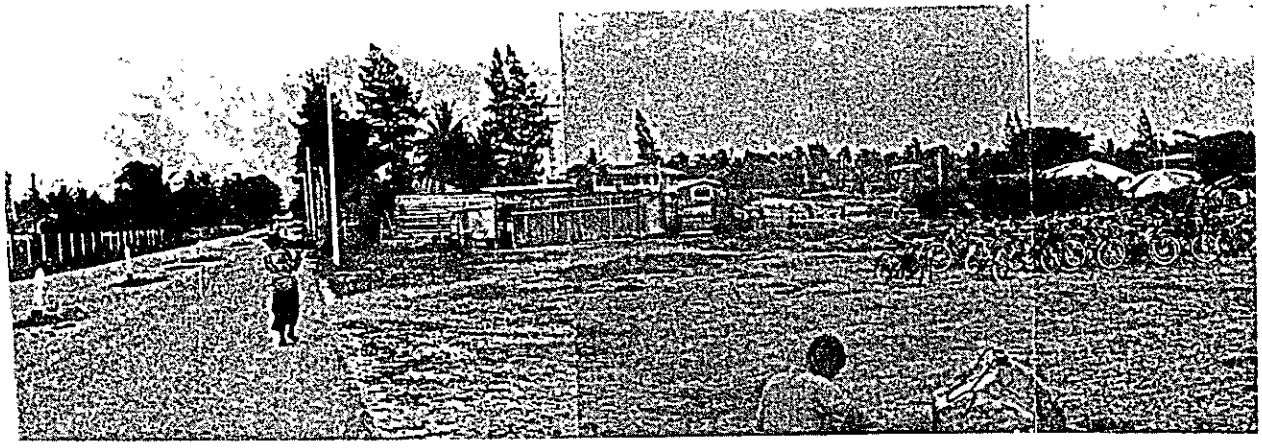
Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency



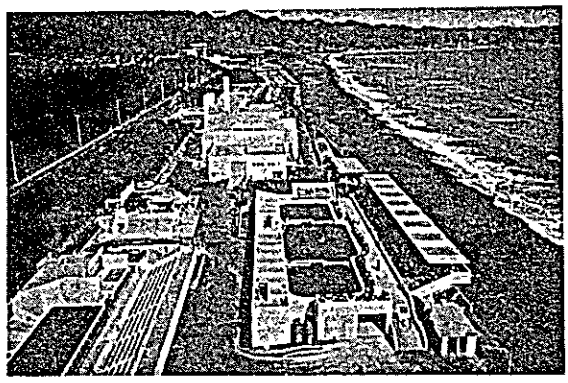
Bang Saen Beach

Plantation of Bang Saen Beach

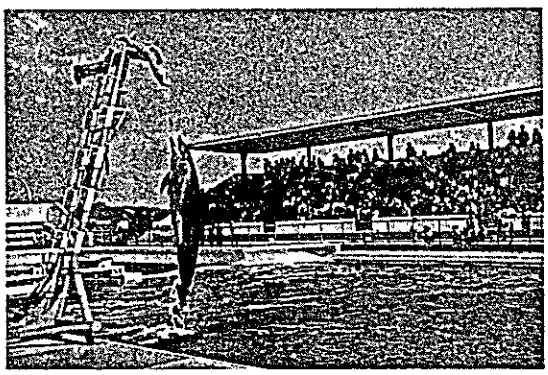
Road of Bang Saen Beach
(Vicinity of proposed site of
Aquarium construction)



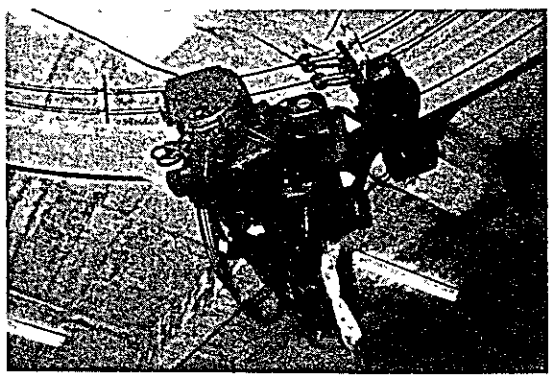
Proposed site of the Bang Saen Aquarium



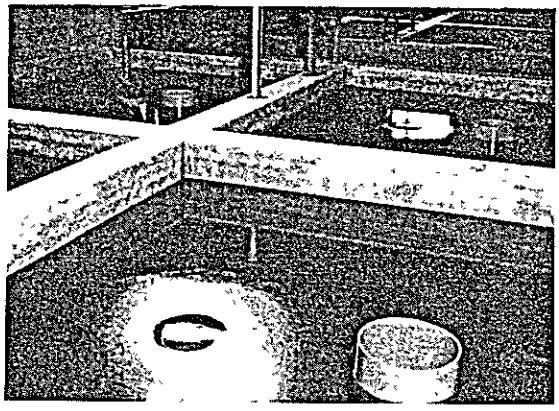
A case of Assorted establishment
of Aquarium and Dolphin pool
(Kamogawa Seaworld,
Chiba Prefecture near Tokyo)



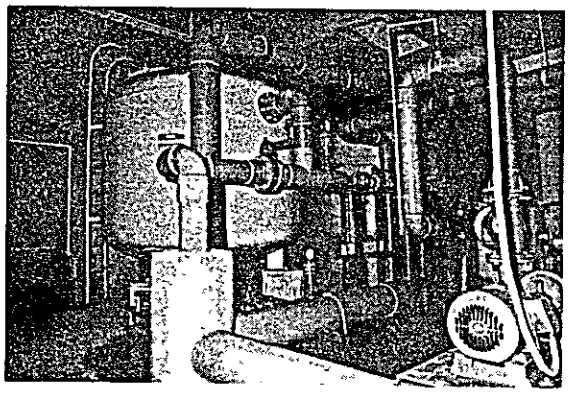
Dolphin pool and Stand
(Kamogawa Seaworld)



Electrical Transport Equipment



Filtering facilities (Open tipe)



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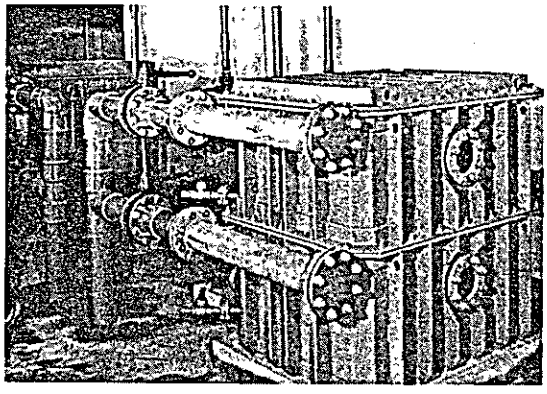

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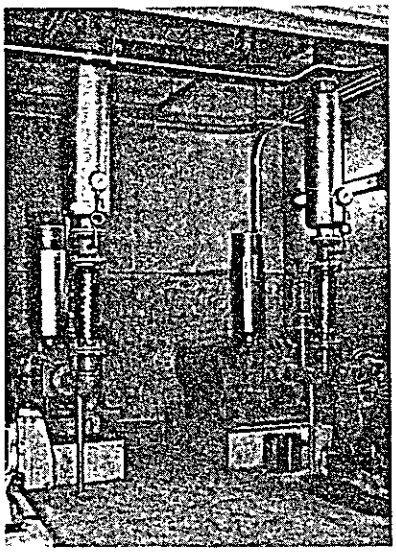
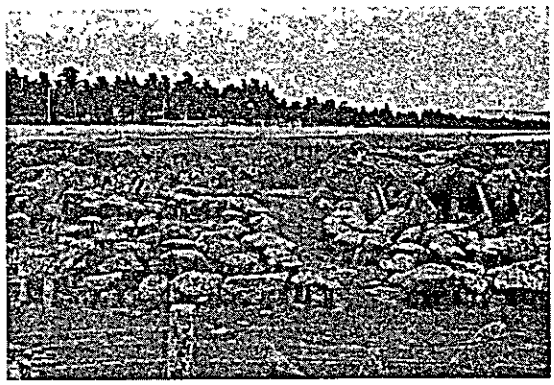
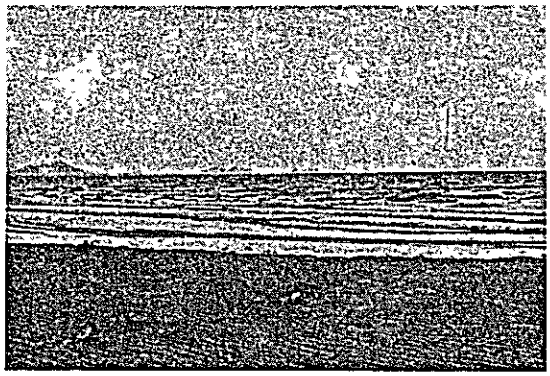


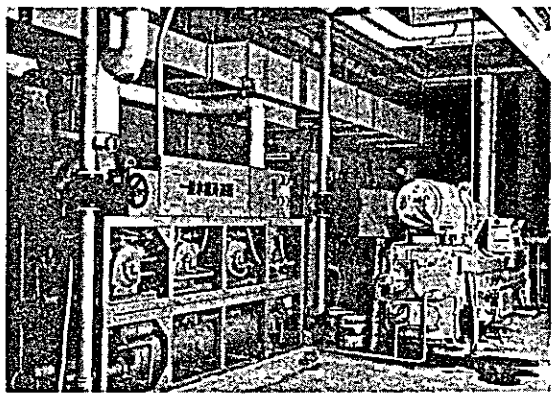
Oxygen Supply facilities



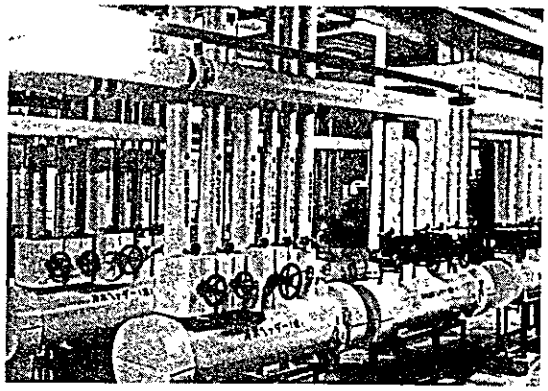
Oyster farm near rocky place



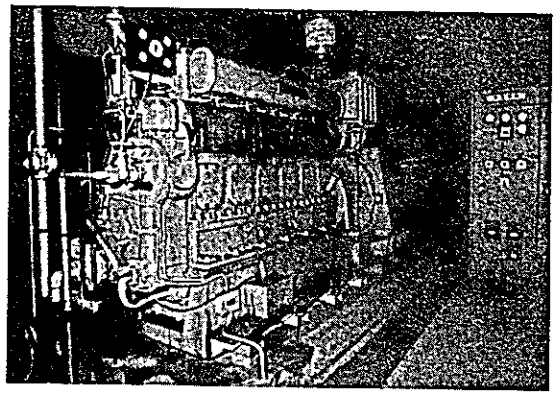
Sandy beach in front of the proposed site



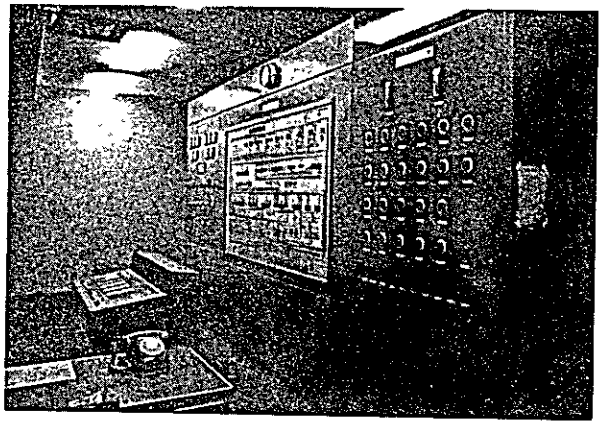
Refrigerator for display tanks and air-conditioning refrigerator



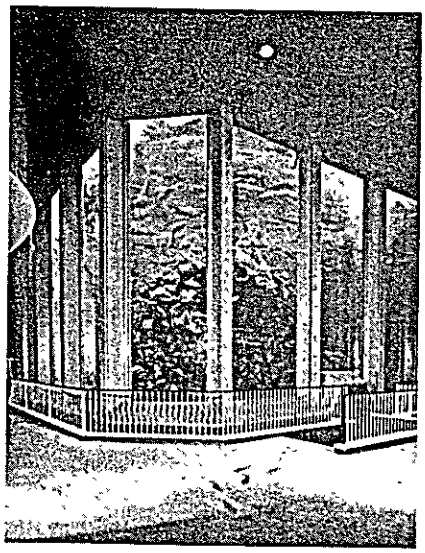
Systematic piping of water tanks
at The Kamogawa Seaworld



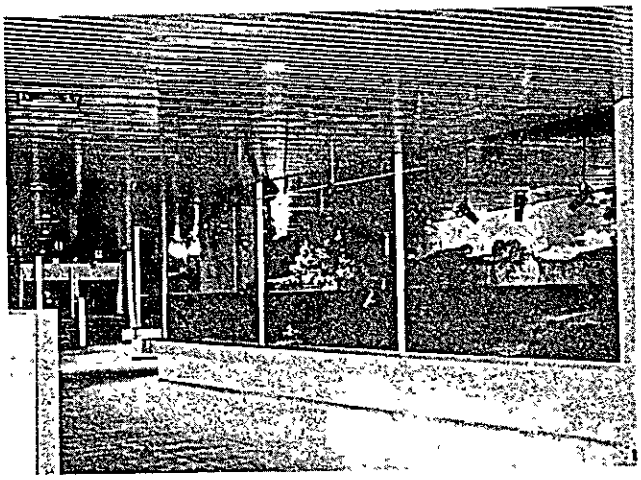
Private generator facilities



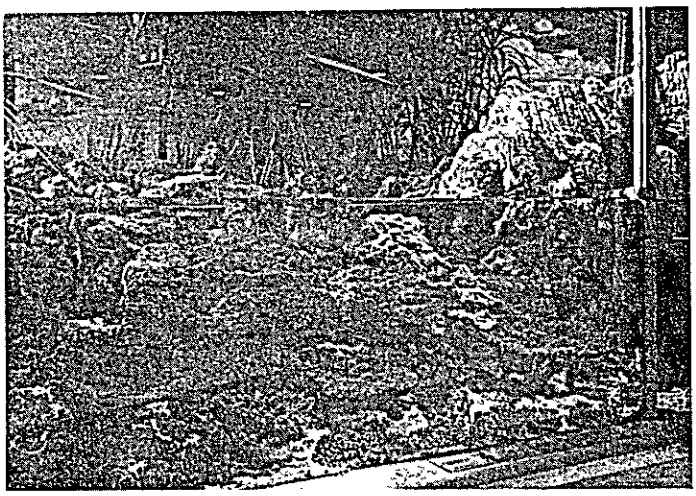
Central Supervisory panel at
the Kamogawa Seaworld



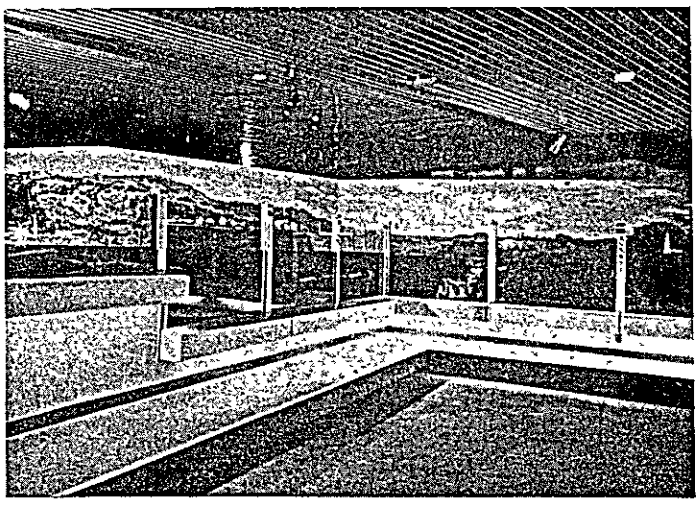
Fishes in a Big display tank



Arrangement between Big glass pane and internal tank at the Kamogawa Seaworld

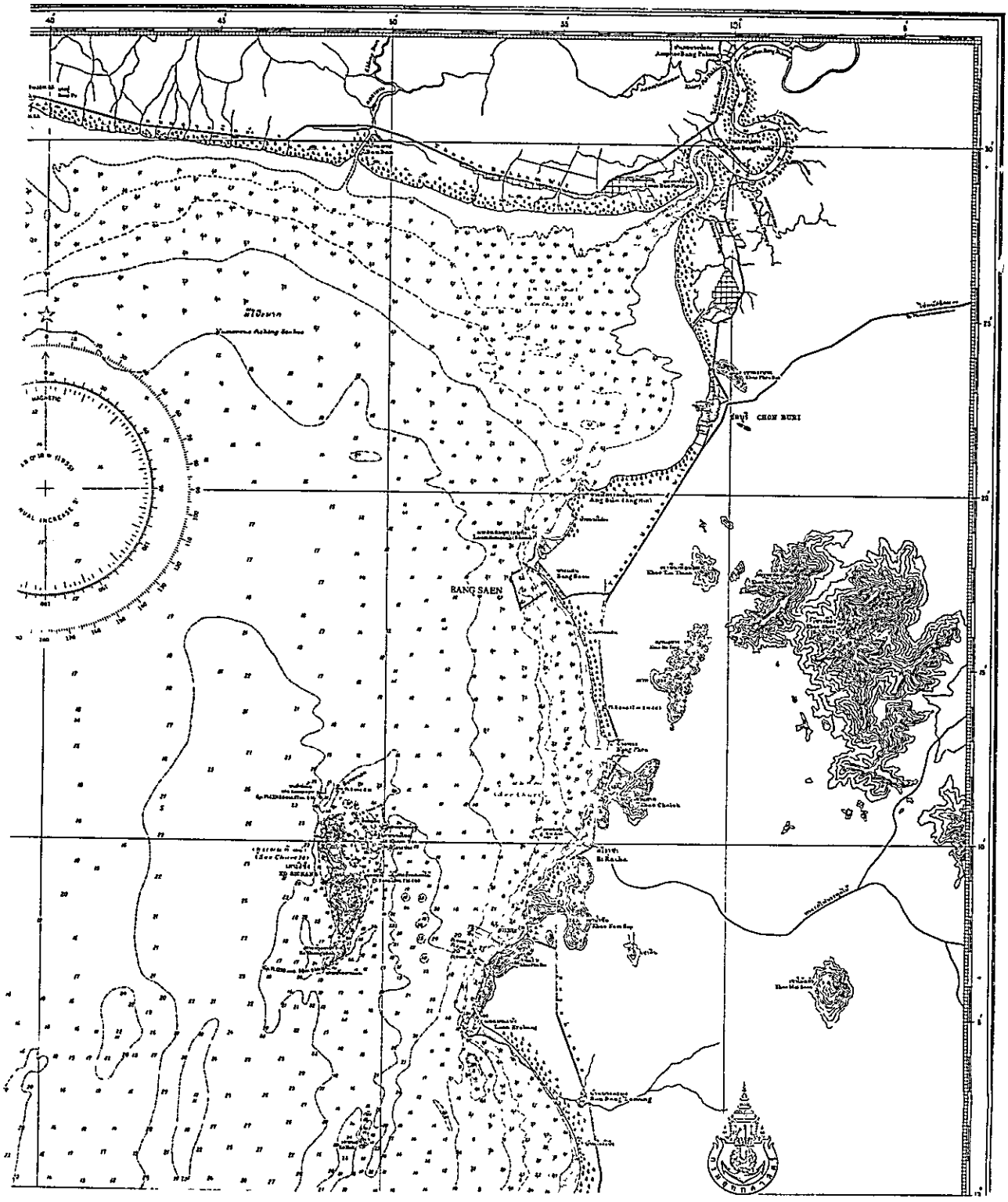


Arrangement in a display tank

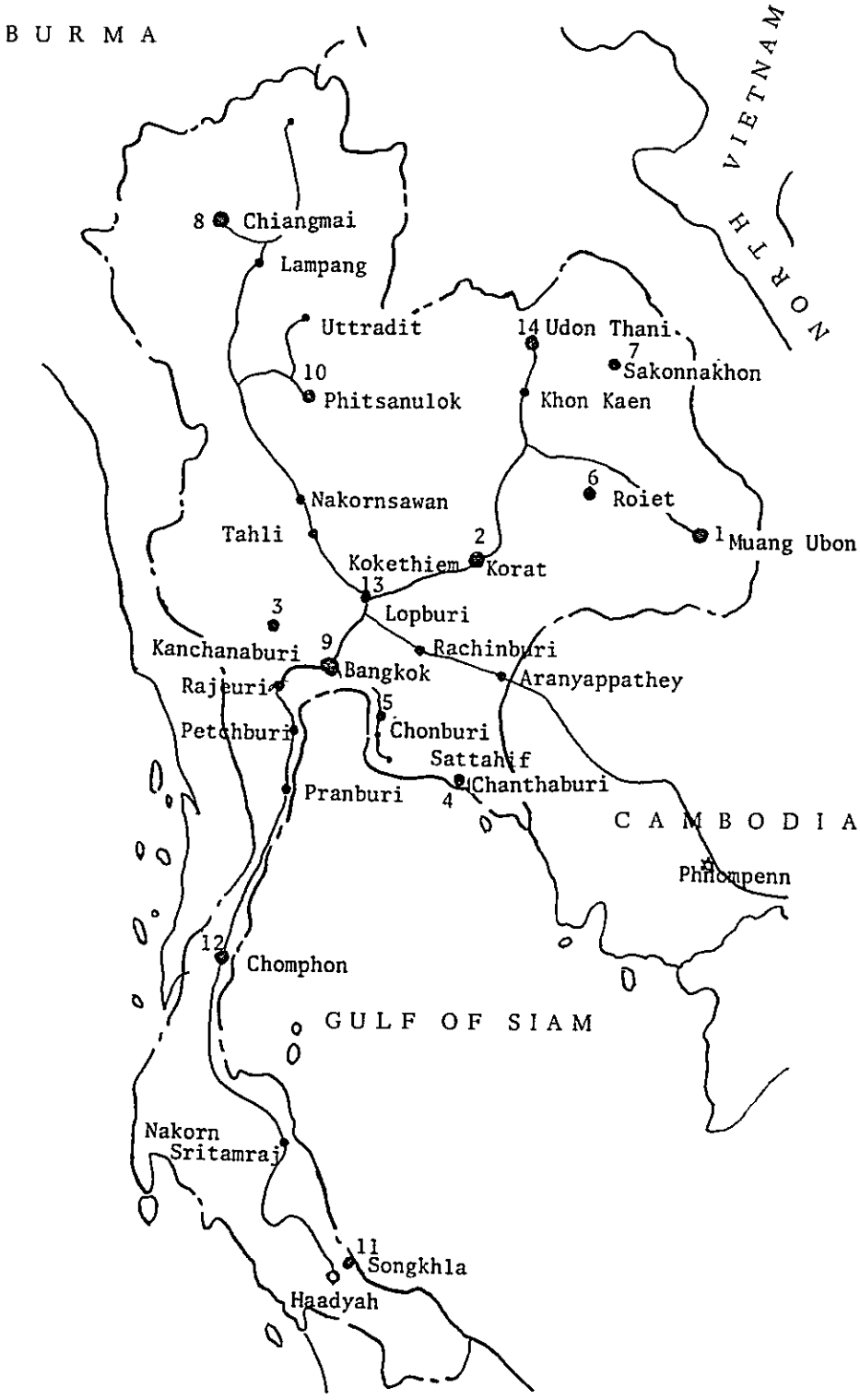


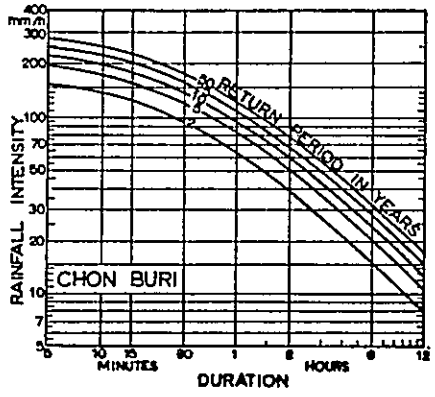
Show in a display tank arranged by Sound and Light

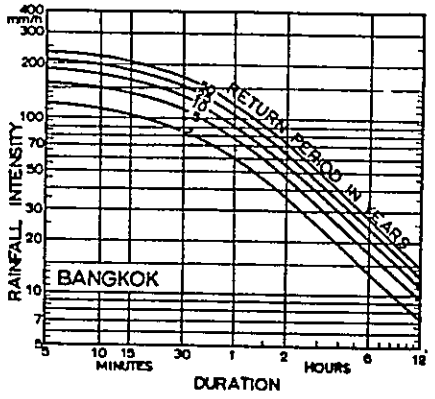
MAP OF BANG SAEN AND ITS VICINITY



"RAINFALL INTENSITY AND DURATION"







Rainfall of an intensity of 160mm/h continues for 5 minutes once in a return period of 5 years in Bangkok (Rainfall of the same intensity continues for 17 minutes once in a return period of 10 years)

$i = 160/h = 0.00004$ m/sec

Assuming that 100 mm of rain falls in 30 minutes for the sake of safety from the Rainfall Intensity-Duration Curves No. 1,

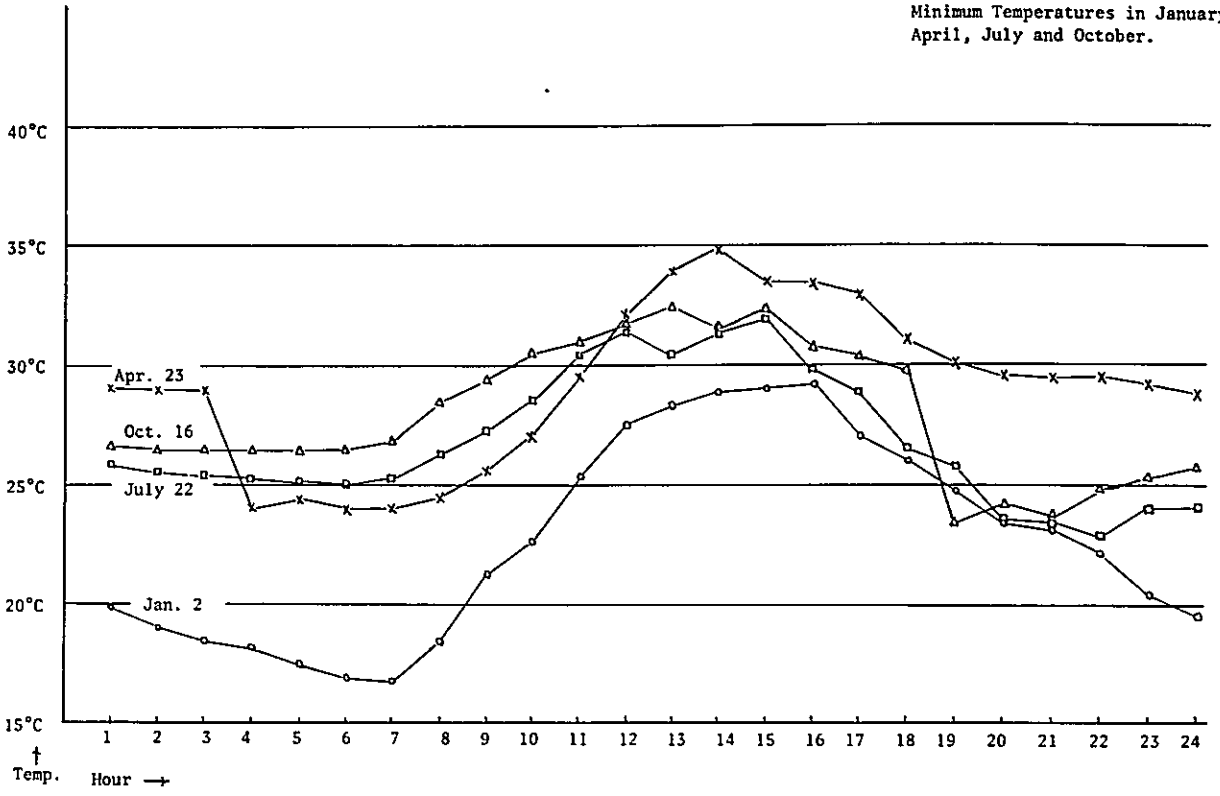
$i = 100$ mm/30 min $= 0.000056$ m/sec

In Bangkok, therefore, it is reasonable to assume that

$i = 0.00005$ m/sec (Safety factor· danger of heavy rain recurs in a return period of 7 to 8 years)

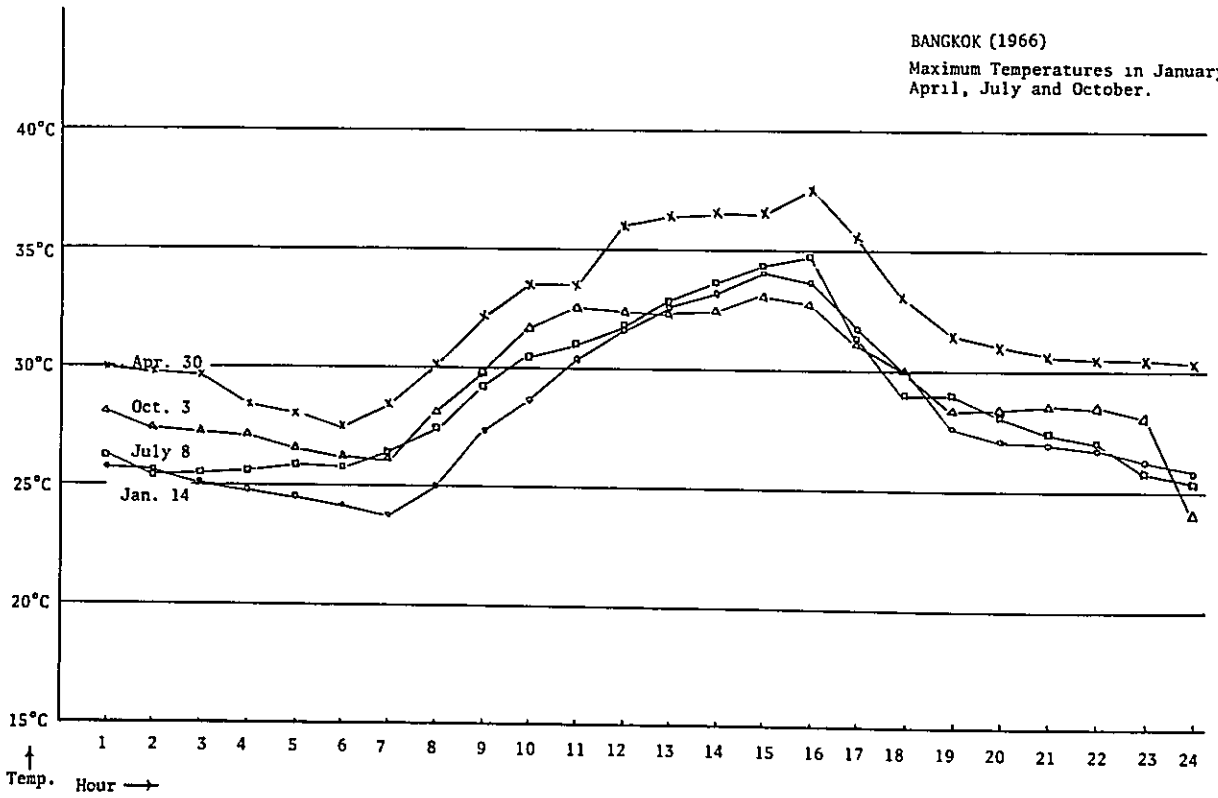
BANGKOK (1966)

Minimum Temperatures in January, April, July and October.



BANGKOK (1966)

Maximum Temperatures in January, April, July and October.



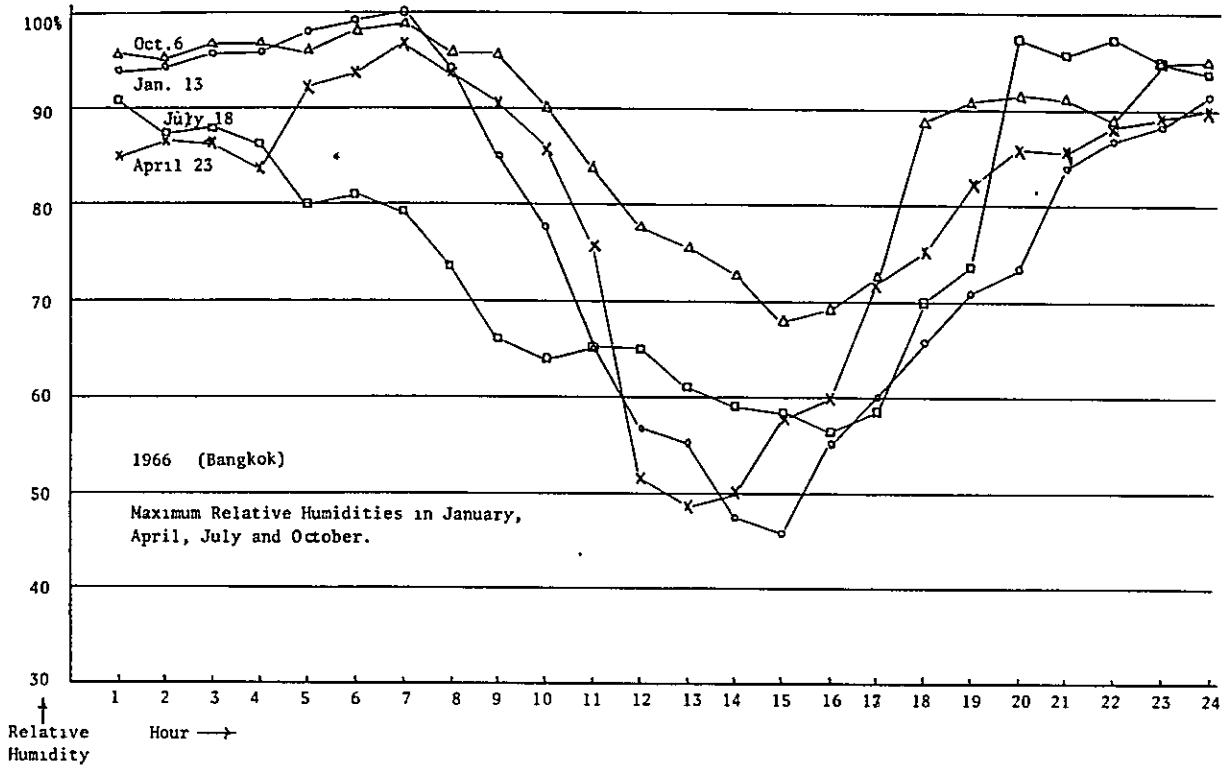


Table Showing the Value of Temperature, Turbidity, Salinity and O_2 in Sea Water at Aung-Sila, Chon Buri

Date	Time	Temp., ℃		Turbidity	Salinity	O_2	Date	Time	Temp., ℃		Turbidity	Salinity	O_2
		air	sea	ppm SiO_2	‰	ml/l			air	sea	ppm SiO_2	‰	ml/l
7 May 69	6.30	28.3	28.8	-	31.91	4.75	4 Oct. 69	07.30	-	-		22.09	-
17 "	6.25	28.7	28.7	-	32.29	4.80	12 "	07.30	28.2	28.0	105.0	23.78	5.04
31 "	6.30	26.0	26.5	60.0	31.13	5.73	25 "	07.30	28.5	29.5	17.0	30.19	2.51
4 June	6.50	27.0	27.3	-	32.37	4.22	27 "	07.30	27 0	30.0	10.0	29.78	2.96
15 "	6.25	28.0	28.3	8.2	30.79	5.57	4 Nov.	07.30	25.7	27.9	17.5	31.02	3.76
28 "	6.35	27.0	27.5	19.0	30.10	5.18	10 "	07.30	23.8	25.3	65.0	28.89	4.82
1 July	6.30	28.0	28.2	25.0	30.59	2.66	20 "	07.30	23.9	26.5	25.0	29.97	4.49
15 "	6.30	26.8	28.0	30.1	30.19	6.76	4 Dec.	07.30	17.8	20.5	61.0	28.68	6.63
27 "	6.30	28.5	27.0	91.0	20.44	5.26	18 "	07.30	23.9	24.2	7.5	29.90	5.13
5 Aug.	6.25	26.8	27.3	60.0	9.80	5.63	4 Jan. 70	07.30	23.0	24.0	14.0	31.09	5.48
15 "	6.20	24.6	23.0	6.5	25.36	5.46	19 "	07.30	24.4	25.0	11.0	32.20	4.83
16 Sep.	07.30	26.5	28.5	17.5	21.33	5.05							

Transparence

Bangsan (Station 2C)

	k	Secchi disc reading (m)
February	0.209	7.1
April	0.217	10.0
July	0.451	4.1
September	0.561	3.1

South Bhattaya (Station 4B)

February	0.307	5.0
April	0.179	10.6
July	0.292	5.7
September	0.200	8.3

Calculation of the extinction coefficient of light in sea water

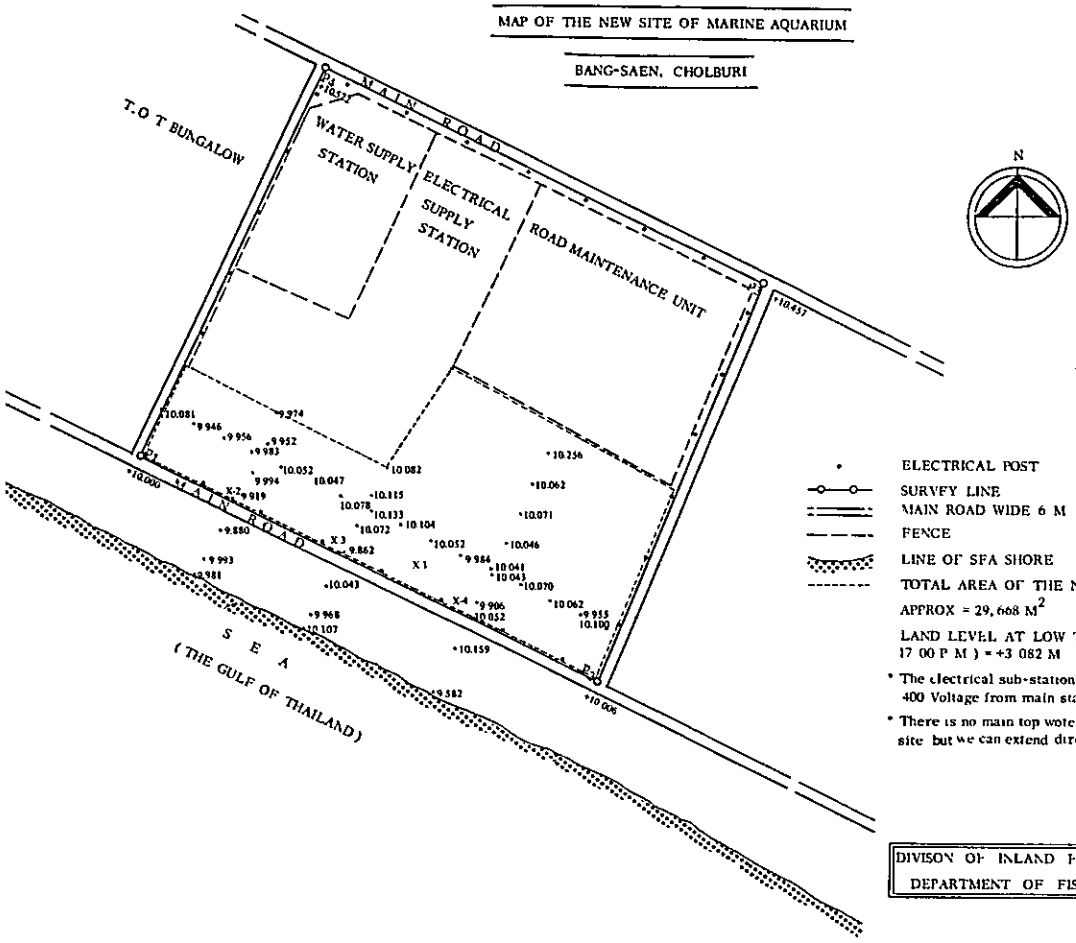
$$k = \frac{2.3\ (\log 100 - \log 10)}{d10 - d100}$$

d 100 = the light depth of 100% = 0

d 10 = the light depth of 10% of the surface intensity

MAP OF THE NEW SITE OF MARINE AQUARIUM

BANG-SAEN, CHOLBURI



- ELECTRICAL POST
- SURVEY LINE
- MAIN ROAD WIDE 6 M
- FENCE
- LINE OF SEA SHORE
- TOTAL AREA OF THE NEW SITE

APPROX = 29,668 M^2

LAND LEVEL AT LOW TIDE (19 MAY 1971, 17 00 P M) = +3 082 M

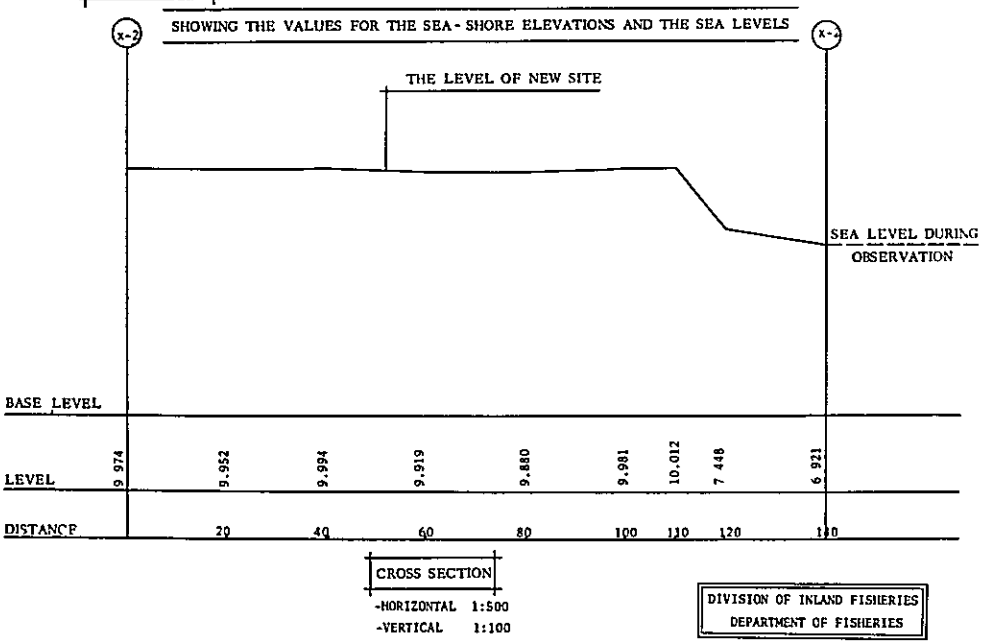
* The electrical sub-station air receiving 400 Voltage from main station

* There is no main top water line close to the new site but we can extend directely from the station

DIVISON OF INLAND FISHERIES
DEPARTMENT OF FISHERIES

CROSS SECTION

SHOWING THE VALUES FOR THE SEA - SHORE ELEVATIONS AND THE SEA LEVELS



CROSS SECTION

-HORIZONTAL 1:500

-VERTICAL 1:100

DIVISION OF INLAND FISHERIES
DEPARTMENT OF FISHERIES

Contents

I. Introduction

This report contains the findings of the investigations conducted by the Japanese survey team at the request of the Thai Government for the projected construction of a marine aquarium in Thailand.

Prior to planning the construction of the projected modern aquarium, the Thai Government dispatched Mr. Karnasut, Director General, Department of Fisheries, and Mr. Chimchome, Chief Architect, Department of Municipal Public Works, to Japan for inspection of aquaria located at different places. Recognizing the fact that Thai's request for the investigations was occasioned by their understanding that Japanese aquaria are on an international level, the survey team exerted its best to meet the expectation of the Thai Government.

Moves are gaining impetus in Southeast Asia towards the construction of aquaria. It is hoped that this report will not only furnish the findings of investigations but will also serve to provide the guiding principles for the construction of the projected aquarium for which Japan is ready to extend her further assistance.

The survey team wishes to express its gratitude to Dr. Ino, Southeast Asian Fisheries Development Centre, whose frequent contacts with the Thai authorities have led to their proper evaluation of Japanese aquaria and their request for Japan's cooperation in the recent investigations.

Acknowledgement is also due to Obayashi-gumi Co., Ltd. and Saito Shozo Shoten Co., Ltd. for valuable cooperation in data collection as well as to Mr. Moriya Miyamoto, OTCA Thai Office, and the following officials of the Thai Government whose unlimited assistance made it possible for the team to fulfil the purpose of investigations as originally scheduled.

Mr. Prida Karnasut	Director-General, Department of Fisheries
Mr. Snit Chimchome	Department of Municipal Public Works
Mr. M. L. Prachakslip Tongyai	Department of Fisheries
Mr. Urupan Boonprakob	Department of Fisheries

1. Outline of investigation

1-1 Background of investigation

The investigation was conducted as part of the Colombo Plan undertakings at the request of Thai Government made in November 1970. Its execution took place in May 1971 by the Overseas Technical Cooperation Agency after the team members are recruited and necessary arrangements made for the investigation.

1-2 Purpose and scope of investigation

The investigation was carried out to select the site and map out the construction plan of the projected national aquarium.

To fulfil the purpose of the investigation, the team engaged in the activities hereunder described.

a. Discussion with Thai authorities about the purposes and activities of the aquarium.

b. Collection of data and investigation of the sea water and sea bottom conditions near the proposed site and of other conditions relating to the construction plan.

c. Preliminary investigation of the aquatic animals to be exhibited.

d. Estimation of the expected number of visitors.

e. Investigation of electric supply, water supply, drainage, availability of telephone facilities, etc. in the neighbourhood of the projected site.

f. Interim report and discussion on the investigation results.

Each member of the team engaged in his own specialized field of activities within the above-mentioned scope to meet the purpose of investigation.

1-3 Formation of survey team

Name	Occupation	Assignment
Toshio TSUTSUMI	Chief Curator, Aburatsubo Marine Park	Expert on aquarium installation, general coordination
Mamoru MORO	Deputy Director, Ishida Design Office	Engineer of Aquarium Installation
Yuji KOH	Chief Architect, Ishida Design Office	Architect

1-4 Work-schedule

The investigation was carried out for a period of 10 days from May 11 to May 20, 1971 according to the following works schedule.

Schedule

May	11, 1971	Arrival in Bangkok, Arrangement of time-schedule with Mr. Miyamoto of OTCA.
	12,	Discussion with Director-General of Department of Fisheries.
	13,	a. Visit to Marine Fisheries Laboratory concerning data of water conditions in Bang-Saen Area.
		b. Discussion with Department of Public Work.
	14-15	Investigation of the proposed site in Bang-Saen.
	16	a. Investigation of aquatic animals to be exhibited in the projected aquarium.
		b. Excursion in Pattaya Area
	17	a. Discussion among the Japanese experts about the investigation above-mentioned.
		b. Discussion with Director-General of Department of Fisheries.
		c. Observation of the site for projected Fresh-water Aquarium in Dusit Zoological Garden.
	18	a. Discussion with Director-General of Department of Fisheries
		b. Preparation of the Report on the investigation.
	19	Submission of the Report to Director-General of Department of Fisheries.
	20	Departure for Japan.

2. Purpose of projected construction of aquarium

The investigation revealed that the projected construction of a national aquarium is based on the strong Government's volition for awakening Thai people to the importance of fisheries and that situations are mature for such construction. This fundamental approach made by Thai Government is identical to that of Japan where the construction of aquaria aims primarily at promoting public education.

Purposes of the aquarium are as follows.

a. Public education for propagating knowledges of fishery among people.

b. Recreation and propagation of knowledges.

c. Research on aquatic animals.

d. Introduction of domestic sea life to tourists.

From the above description, it may well be said that the projected aquarium will play a significant role of enhancing the researches in aquatic animals and providing an ideal place of recreation for the nation.

Considering the reaction shown by the visitors to Bang Saen Zoological Museum and Marine Aquarium, a facility attached to a normal school in Bang Saen, when it was opened to the general public in 1971, the projected plan is truly commendable not just because it provides a good place of recreation but because it contributes to public education as well. With a rich variety of coral insects living in the nearby sea waters, the projected aquarium will become an earner of foreign exchange attracting many tourists from abroad if it succeeds in breeding dugong, a protected marine mammal.

Construction conditions of the aquarium are based on the preliminary report of the investigations.

3. Sea water conditions near proposed site

The reconnaissance conducted at and around the proposed construction site on Bang-Saen seashore disclosed the following facts.

3-1 Adhesive and bottom animals

There are found oyster farms near the proposed site. It is suspected that after the spawning season of oysters, their wafting lavae would adhere to underwater structures including pipes and impair their proper functions. It is also suspected that underwater structures might be subjected to the damages due to sea mussels and bottom animals such as star fishes.

Underwater facilities of the aquarium should therefore be constructed with sufficient care taken to provide against such damages.

3-2 Bottom topography

Bang-Saen is a bathing resort with the shoal extending to a great distance from the shore. Sea water for the aquarium should therefore be taken at the deepest possible point favoured with the following conditions.

a. Water quality is stable (sufficient salinity and oxygen content).
b. Adhesion of marine animals to the pipe inside can be minimized.
c. Effect of high waves can be minimized.

These conditions must be satisfied by suitable technical arrangement.

3-3 Water quality

The team studied the various data provided by the Department of Fisheries and discovered that the sea water condition at Cholburi district near Bang-Saen is as tabulated below.

The above table clearly indicates that the salinity declines largely due to the admixture of fresh water in the wet season from July to October. Particularly in August, the sea water condition loses its balance almost completely. A closed circulation system must therefore be planned for the aquarium.

Comparison of Mean and Standard Values of Sea Water Conditions in Cholburi District during the Period from May 1969 to January 1970

	Air Temp.	Water Temp.	Salinity (0/00)	0_2 (ml/l)
Mean	24.7°C	27.0°C	28.0	4.85
Standard	-	-	35.0	4.0 - 5.0

The above table covering a considerable long period also indicates that the salinity drop must be coped with by the installation of proper facilities and by the application of water quality control techniques. Oxygen content was noted to be deficient in some districts but the above table shows that it remains in a satisfactory range.

4. Selection of Construction Site

In the initial stage of the aquarium project, Thai Government had two alternative sites i.e., Bang-Saen, a well-known tourist resort in the vicinity of Bangkok, and Pattaya, but Bang-Saen was finally selected.

Bang-Saen, about 100 km to the south of Bangkok, is a seaside resort conveniently located for the citizens of Bangkok. Since Highway No. 3 was opened, one can reach there by one and a half hours' drive from the centre of Bangkok. Motorcars and buses carry many visitors to this place over the week-end. From the end of the branch road extending from Highway No. 3 to the coast, a straight coastline extends in the northwest direction for about 2.5 km until it hits the tip of the rocky zone. The sea-front main road has a width of 6 m, and is protected by palm plantations on either side. On the

northeastern side (mountain side) of the road are arranged T. O. T. 's bungalows whose stylish and attractive appearance adds to the atmosphere of this excellent seaside resort. There is another row of palm trees on the shore side about 30 m from the main road. On this 30 m wide well-shaded promenade, people take a walk or rest. Beyond the second row of palm trees, there lies a flat land having a width of about 13 m on an average to the coastline, then the land enters the sea water with a mild grade.

The sea-front main road passes through Bang-Saen district, turns northward near the reef zone in the northwest to surround the hilly area, reaching the vicinity of Chalburi.

4-1 Investigation of initially proposed site

As the site for the projected construction of aquarium, Thai Government proposed an area between the sea-front main road and the coastline which is located near the aforementioned rocky zone. After a survey of this area, the team obtained the following findings.

a. No facilities at all are found on the shore side of the 2. 5 km extension of the sea-front main road excepting the palm plantation and the promenade. Bang-Saen Hotel, T. O. T. 's bungalows and other structures are all found on the other side of the road. Construction of an aquarium on the proposed site, which would call for the removal of the outer row of palm trees, is not advisable for the protection of the coast line or for the preservation of the scenic beauty of the coast.

b. If the aquarium is to be built without removing the road-side plantation, then the distance from the road to the coastline would be about 35 m. This allows too small an area for the aquarium considering the approach to it and the parking space.

c. Most people visiting Bang-Saen are found in the area extending from the intersection of the branch road of Highway No. 3 and the main road to the vicinity of Bang-Saen Hotel. The initially proposed area near the roacky zone is a little off this central area.

4-2 Investigation of selected site

Upon giving an explanation on the above findings to the Director-General of the Department of Fisheries, the team was requested to investigate an area of approximately 38, 500 m^2 located to the southeast of Bang-Saen Hotel which the Department proposed as an alternative site of projected aquarium. The team immediately embarked on the investigation of the conditions and surrounding environments of this new site and obtained the following findings.

a. The site is about 600 m from the end of the branch road, and visitors to Bang-Saen are now found converged in and around the site.

b. The main road runs along the site for about 300 m. On the northwestern side, the site adjoins another road beyond which are found T. O. T. 's bungalows. Construction of an aquarium at this site is believed to create an integrated resort centre with Bang-Saen Hotel and T. O. T. 's bungalows.

c. The size and configuration of the site are suited for the scale and substance of the projected aquarium, allowing a sufficient space for parking facilities and gardens.

d. Supply of city water and electric power can be assured since Bang-Saen Hotel and T. O. T. 's bungalows are located nearby.

As a result of these findings, the Department of Fisheries reached the final decision to construct the aquarium on the site where the surveying activities were subsequently carried out. This project has been prepared on the basis of these findings and the results of surveying work.

5. Plot plan

Access to the aquarium from the main road is to be made through a main gate. With the number of owner-drivers visiting Bang-Saen being on a steady increase, the passenger and car traffic within the compounds of the aquarium was naturally given due consideration in mapping out the project.

The plot plan is so worked out that all visitors will enter through the main gate so that their traffic may be readily regulated.

All owner-drivers entering the compounds of the aquarium are to be separated from buses carrying sightseeing parties by leading the former to the left hand side facing the aquarium and the latter to the right hand side, while individual visitors to the aquarium on foot would be led directly to the front entrance. As for the layout of the buildings, the main building of the aquarium is to be constructed on the lefthand side as viewed from the beach and the dolphin pool on the righthand side. These two blocks are to be interconnected by a deck-like passageway from which the visitors enter the aquarium and the dolphin pool. It is envisaged that the visitors will be guided, as a rule, to the aquarium first to make a trip round show tanks, and then leave the aquarium through

said passageway enter the dolphin pool. The passageway is intended not just for interconnection between the two blocks, but for providing visitors with a resting place as well. It should therefore be equipped with outdoor toilet facilities, and its terrace is to be so installed as will face the inner court of the aquarium, with a place for rest also provided for the visitors.

Service gates leading to the entrances of the breeding section and the machine room of the aquarium and to the entrance of the breeding section of the dolphin pool are to be provided on the northwestern side of the site. The dormitory of the aquarium's staff is to be built at the northern end of the site.

Further, a bus drivers' waiting room will be constructed on one side of the parking space of buses.

6. General concept of project

The following fundamental conditions must be taken into consideration in designing the aquarium.

a. Smooth flow of visitors along the predetermined route from the entrance to the exist must be ensured. The visitors' route should not intersect at any point.

b. Exhibition should be arranged using diversified display methods so as to attract the visitors throughout their trip in the aquarium.

c. The breeding sections and the administration rooms should be so arranged that both breeding and management works may be carried out efficiently. To assure satisfactory breeding work, particular attention should be given to the transport, preservation and preparation of feeds as well as to securing a sufficient space for breeding work.

The project is mapped out with efforts made to satisfy the above conditions by an architectural approach.

6-1 Outline of main building of aquarium

The main building of the aquarium is to be a single-storied (partly two-storied) reinforced concrete structure with its floor elevated 1.0 m above the ground level.

On the road side is to be built the aquarium block accommodating the show tanks and the visitor's passageways. In the back of the aquarium block is to be built adminis-

tration block housing office rooms as well as machine rooms. The visitors' entrance and exit are to be provided at the southeastern opening between these two blocks, and the service entrance at the other end. It is planned that the visitors will enter the exhibition room through the side entrance and follow their route while appreciating aquatic animals exhibited in small and big show tanks until they reach the display corner to watch the individual display tanks. After that, they will observe the big show tank through the peep holes provided on its back, and proceed through the panoramic display hall and reach the exit.

The keepers' passage is to be on the second floor above the big show tank and the individual show tanks. On the second floor, there will also be provided a service space, storage, etc. which will be connected to the breeding section on the first floor by staircase or lifts.

6-2 Outline of dolphin pool

The dolphin pool is to be a reinforced concrete structure and occupy the southeastern part of the site. Visitors who have made a trip around the show tanks in the main building of the aquarium will be guided to pass through the deck-like passageway and ascend the northwestern staircase to enter the dolphin pool. Since the ground water level is expected to be rather high at the construction site, the main pool and the training pool on its both sides are to be built above the ground level to minimize the underground structure as far as possible. The dolphin pool including its stage will therefore be comparatively high above the ground, but as the result this is considered to give a symbolic effect in the surrounding open space. The spectators' stand is to be covered and equipped with 1,000 seats facing the stage. The southeastern staircase will be usually used as visitors exit and in case of emergency as well

The space beneath the stand is to accommodate a filter tank and a sea water reservoir while that underneath the stage is to be used for breeding work, and the service trucks will come to its back for loading and unloading.

6-3 Outline of connecting passageway

As described in Section 5 (Plot plan), the connecting passageway is designed to be located in between the main building and the dolphin pool. Visitors are guided from the main gate to this passageway. It is planned that the passageway will be a reinforced concrete structure, with its floor elevated 1 m above the ground level. It will be furnished

with a simple covering supported by light wooden pillars and beams. This arrangement is expected to give the passageway a comfottable atmosphere in contrast to the aquarium and the dolphin pool, making it a resting place architecturally harmonized with the surrounding inner court. Outdoor toilet facilities connected to the passageway are also to be provided.

7. Display plan

The purpose of display in an aquarium is to obtain the visitors' clear and accurate understanding. Accordingly, aquatic animals, their specimens, photos and other materials should be presented with the local and specific characteristics of an aquarium.

When these principles are firmly established and a display plan based on original and creative ideas is materialized, then the visitors will receive a fresh and profound impression which will lead to their understanding. The purpose of an aquarium can be achieved only when such communication takes place.

To present the characteristics of the projected aquarium, the big display tank should exhibit large migrating fishes swimming in groups, caranx leptolepis, yellow-tails, snappers, groupers and turtles.

The composition of marine animals to be exhibited in the big display tank should be so arranged that an ecological effect will be reproduced by the fishes living in different depth ranges. For this reason, coryphaena hippurus swimming in the surface water should be exhibited together w th snappers, yellow-tails, platax pinnatus and shirks swimming in mid-waters. In the bottom water should be exhibited holocentrus spinsis-simus, myripristis murdjan, chaetodon auriga, globefishes, pterois lunulata, , rays and skates, and turtles. The bottom of the tank should be rocks with table coral arranged on them to add a colourful aspect to the natural sea-life reproduced.

The big show tank should aim at a dynamic exhibition and an illustration of coastal fishes. It is expected that colourful tropical fishes swimming with large fishes in the same tank will give an excellent display effect.

In the individual show tank, collection types of different aquatic animals are to be exhibited. This display method is commonly adopted by many aquaria. In these show tanks, various fishes such as chromis notatus, Stephanolepis cirrhifer, snappers,

Chaetodon auriga and so forth are to be exhibited collectively by family, genus and species.

It is expected that the visitors will be attracted by the ecological presentation of aquatic animals including the display of symbiosis of Amphiprion bicinctus and coral and of Labroides bicolor and groupers or large fishes. The exhibition of the symbiosis is considered to impress the visitors with the harmony of nature.

Display of different fish schools swimming in the tidal current reproduced in the migrating tank is another indispensable feature of an aquarium.

Besides exhibiting these fishes, aquatic animals such as Pterois lunulata, globefishes, rays and skates, Siganus fuscescens should be displayed to enlighten the visitors on their poison, and in addition, fishes with peculiar ecological characteristics should be displayed to make the exhibition rich in variety.

Further, it is proposed to breed dugong if circumstances allow. No attempt has yet been made to breed dugong, and if the projected aquarium succeeds in it, it will help the visitors understand the value of this area marine mammal and the need for its protection.

It is urged that the projected aquarium be designed and constructed with due consideration given to the above-mentioned display plan so that it will take full advantage of its sea-side location and meet the expectation of the people.

The description given above can be briefed into the following tentative display plan.

Tentative Display Plan of Projected Aquarium

Display Tank	Sea-Life to be Exhibited
Big Display Tnak	Coryphaena hippurus, Caranx leptolepis groups, snappers, Holocentrus spinosissimus and Chaetodon auriga
Individual Display Tank	Chrysipteraholllsi fowlei and other fishes of Chromis notatus Gen.
- do -	Dascyllus primaculatus (ruppell) and Tetradrachmum aruanum (linne)
- do -	Chromis notatus and Abubdefbuf sexfasciatus (lacepbae)
- do -	Chaetodon auriga
- do -	Heniochus acuminatus and Zanclus cornutus
- do -	Morays
- do -	Holocentrus spinosissimus and Platax pinnatus
- do -	Snappers
- do -	Stephanolepis cirrhsfer
- do -	Balistes nigen
- do -	Forcipiger longirostris
- do -	Species of Wrasse
- do -	Species of Parrot Fish
- do -	Platax pinnatus, live coral insects and other fishes
Ecological Display Tank	Fluorescence of coral insects
- do -	Symbiosis 1 - sea anemones and Amphiprion bicinctus
- do -	Symbiosis 2 - groupers and Labroides bicolor
- do -	Poisonous fishes - global fishes, Pterois lunulata, Siganus fuscescens and rays and skates
- do -	Peculiar swimming habit - Aeoliscys strigatus
Panoramic Display Tank	Coral, Diadema setosum, sea chestnuts, shellfishes, trepangs, gobies and small fishes.

8. Aquarium installations

Installations of an aquarium can be broadly classified into the breeding facilities, electrical facilities and air conditioning, sanitary and plumbing facilities. Though these facilities are installed to perform their respective functions which are all essential for the operation of an aquarium, the breeding facilities for maintaining the life of aquatic animals are of particular importance. As the life of aquatic animals is directly related to the control and maintenance of water quality, the breeding work should be carried out in close relation with the operation of electrical facilities. The air conditioning, sanitary and plumbing facilities are also important for an aquarium to assure that the visitors will enjoy seeing aquatic animals in comfort. In an aquarium which is rather divergent from other display establishments, maximum efficiency of respective facilities cannot be ensured unless they are operated in close relation with each other an in perfect harmony with the layout of floor plan and breeding work. The installations bear closely upon the inspection and maintenance required during the closed hours as well as upon the management of the aquarium. The planners should therefore be fully aware of the significance of their task from the initial stage of planning.

The installation at the projected aquarium should proceed with perfect harmony maintained between individual facilities and with the aquarium construction work and breeding work throughout the all stages of planning, designing and execution.

8-1 Facilities for breeding aquatic animals

8-1-1 Maintenance and inspection

The following fundamental conditions must be fulfilled in planning the breeding facilities to ensure their satisfactory maintenance and inspection.

a) The breeding facilities should be systematically arranged so that they may be prevented from being operated erroneously.

b) Equipment suited for breeding in both quality and material should be selected.

c) Emergency measures should be established for the satisfactory breeding work.

d) Extra equipment, standby power source and extra transport equipment should be provided.

e) Refrigerators suited for storing feed of aquatic animals should be provided.

Condition a) need to be satisfied in prevention of the possible erratic operation that could be caused by complexity of the piping work. Erroneous valve operation could lead to the death of aquatic animals since it occassionally drains water from the show tank. Valves provided around the show tanks should be so arranged that they can be readily descriminated and operated by anyone if circumstances call for. In arranging valves, particular efforts should be made for their easy visual inspection.

Condition b) must be fulfilled since the equipment to be installed will be operated 24 hours a day. Further, the equipment must be specially arranged from the beginning for handling sea water. Since the breeding work covers a wide range of species, equipment for water temperature adjustment must also be installed. To reduce the cost and running expenses of facilities, it is advisable to minimize the intake of outside fresh water which imposes a large heat load. It is to be noted that equipment are sometimes made of materials soluble in sea water, and that the concentration of dissolved materials rises because of the closed circulation of sea water. Since the ionized metals are considered to give an adverse effect on aquatic animals, efforts must be made to select equipment made of materials with as small a solubility as possible. The solubility entails the problem of electrolytic corrosion. Particular attention must therefore be paid to the contact parts of metals.

Condition c) must be fulfilled primarily for reason that the health of aquatic animals is occassionally impaired. Auxiliary tanks having an independent circulation system must be installed at places not exposed to the visitors to accommodate unhealthy animals. The increase in the size of show tanks gives rise to the breakage of glass panes of show tanks. To provide against the outflow of water resulting from such breakage, sutable annunciators and emergency water level regulating facilities must be installed. Provision of automatic annunciators is desirable since the erroneous operation cannot be totally eliminated even if the condition a) and b) are fulfilled. The annunciator should have a special detector terminal capable of withstanding sea water.

Condition d) must be fulfilled just as in the installation of facilities at other establishments than an aquarium. Installation of extra and spare equipment is indispensable for the operation of an aquarium since the stoppage of any equipment largely impairs the breeding work. For this reason, extra and spare equipment must be provided for each major equipment should be fitted with a changeover device so that they can be instantly connected to the standby power source if circumstances call for.

Delivery of heavy cargoes such as new aquatic animals and feed is one of the routine works of an aquarium. It is to be noted that the cargo handling equipment are employed daily to rationalize the breeding work rather than to transport machines and parts. Since the projected aquarium will breed and display dolphins in addition to other marine animals, installation of the said equipment must be carefully studied from the initial stage of planning.

Condition e) must be fulfilled because the feeding constitutes a major part of the breeding work. The refrigerators must be placed at positions most convenient for breeding and feeding work. Since the projected aquarium will be composed of the main building and the dolphin pool constructed independently at some distance from each other, a refrigerator must be installed for each of them. The capacity of the refrigerators must be determined after making a comprehensive study on the availability of a fishing port or a fish market in the neighbouring area, kinds and number of aquatic animals to be exhibited, and the daily consumption of feed.

It may be added that the refrigerator used at an aquarium is generally required to have the capacity to store feed for a week or more.

8-1-2 Filtering and circulating facilities

The water circulation system adopted at an aquarium can be broadly classified into the closed and open circulation systems. Under the open circulation system, sea water pumped up from the sea is fed to the show tanks and drained by means of an overflow pipe. Under the closed circulation system, on the other hand, water is used repetitively by circulating it through a filter tank. The open circulation system incurs a less installation cost, but is directly subjected to the changes in the sea water conditions such the temperature drop due to heavy rain. When the sea water conditions are degraded by red tide or other causes, the pumping operation must be suspended, causing a detrimental effect on the breeding conditions particularly at aquaria having large display tanks. The closed circulation system is advantageous in that it is little subject to the changes in sea water conditions and capable of adjusting the water temperature under a small heat load, but it calls for the provision of a filter tank. It is not suited for breeding invertebrate animals since it reduces the population of planktons. The range of aquatic animals to be bred at an aquarium can be expanded by combinedly employing the advantages of the two systems and by installing such special facilities as the temperature regulating device and the filter tank.

The water quality, transparency and other sea water conditions near Bang-Saen, the proposed site of the aquarium, have not yet been made clear. Investigations must be made in future to clarify these sea water conditions. Insofar as the team discovered within the limited period of its site investigation, both water quality and transparency are not satisfactory. Further, with the shoals extending far from the coastline, the sea water conditions at Bang-Saen cannot be considered favorable.

For this reason, the main building and the dolphin pool of the projected aquarium should be equipped with a closed circulation system having filtering facilities.

a) Need for filtering facilities

Installation of filtering facilities in intended primarily for the physical filtering to maintain the transparency of water and secondly for biochemical filtering to decompose and remove the wastes of feed and the excrement of animals. The physical filtering is identical to that required of ordinary filtering facilities. The importance of filtering facilities installed at an aquarium lies in their biochemical filtering function which is indispensable for the breeding of animals. However, for marine mammals such as dolphins and seals which are bred chiefly to present a show to the visitors, the filtering facilities are to be used solely for maintaining the water transparency since these animals have lungs.

The following is a brief description of biochemical filtering.

The nitric compounds discharged by aquatic animals accumulate in water either in the form of nitrate or solid phosphorus compounds or phosphate. Accummulation of these materials in water is believed to give a large affect on water quality. Content of ammonia in water, even if as small as 0.3 ppm, is detrimental to the interaction between the blood and oxygen and to the subsequent discharge of carbonic acid gas. Ammonia in water is hard to be dissolved, and is increasingly accumulated in water. Dissolution of ammonia must resort to the function of filter bacteria in water. Among them are the nitrite-forming bacteria which transform ammonia into nitrous acid and the nitrate-forming bacteria which transform nitrous acid into nitrate. These bacteria are found in show tanks but their quantity varies by the number of aquatic animals being bred. The sand filter layer which provides a favorable condition for these bacteria is usually used in the filter tank since the ammonia generated cannot be readily balanced in quantity with the ammonia oxidized and assimilated by the bacteria.

In determing the type of a filter tank for breeding fishes, studies must be made on the total quantity of fishes and feeds, volume of water to be filtered, filtration area, filtering velocity, coefficient of sand grain diameter, and thickness of the sand layer. In other words, it must be clarified in advance whether themaximum filtering capacity of the tank per unit time is equivalent to the load imposed on the tank.

b) Type of filter tank

Filter tanks can be broadly classified into the internal type tanks and external type tanks depending upon the arrangement of the circulation circuit. The internal type tanks are those placed inside the tanks, and the external type tanks are those installed at a place outside the tanks. The external type tanks are subdivided into the open type and the closed type, and the open type tanks are further classified into the gravity type and the balancing type, and the closed type into the single layer type and the multiplied type.

1) Open type gravity filter tank

Under the open type gravity filter system, water overflowing the tanks flows into the tank by gravity, and is led to the reservoir after filtered through the filter layer, then returned to the tanks by the circulation pump. Supply of oxygen gas is a prime question to be solved in installing filter tanks of this kind. Since the oxygen supply to the the tanks is of vital importance for the life of fishes, it should be given careful consider consideration. In designing the arrangement of this system, care must be taken to ensure that water supplied to the tank will be sufficiently exposed to air. This sistem is advantageous in that its function is highly stable and enables the operator to check the tank condition directly by visual inspection, but entails a large power loss if water must be pumped up to the head tank or display tanks. Further, when adopted for a large tank, it demands a large filtration area and a large floor space and causes a greater heat load on the surface of the display tank, filter tank and reservoir. Though this system has these demerits, it allows a large volume of water to be used for the breeding purpose by virtue of the filter tank, reservoir, and show tanks and can therefore be generally recommended for filtering water at an aquarium.

2) Open type balancing tank

The open type balancing filter system is similar to the gravity filter system except that the filter tank and show tanks are placed on a same level so that a same water level is maintained in all these tanks. This arrangement allows the application of the

air-lift system to the circulation pipes and also enables the oxygen supply to be conducted readily in time with the pumping operation. Even when a filtering pump is to be employed, the small actual head required under this system makes it possible to consider the frictional resistance alone. Hence, the pump need to have a smaller head relative to the gravity type filter system and the power loss can also be reduced. Further, the maintenance work can be carried out with ease since the filter tank is on a same level as the show tanks, and the filter tank can be used as a standby sea water tank. This system is most suited for installation at an aquarium equipped with medium and small size show tanks.

3) Closed type single layer filter tank

This system was originally developed as the rapid pressure filter tank for industrial use, and has come to be employed at aquaria with some modifications. It is advantageous in that its construction is relatively simple, no large installation space is required for the filter tank, and filteration can be carried out against a large filter bed resistance. Further, because it is a closed system, the circulating water can be maintained free from pollution by air. The demerits of this system are that the difficulty in checking the tank inside gives rise to deficient maintenance and inspection service and that changes are liable to occur in the quality of filtered water because of the difficulty in maintaining a constant filter velocity.

If this system is to be employed, the problem is where in the circulation circuit the oxygen supply is to be conducted. Since this problem has an immense effect on the filtering efficiency, it must be given a careful consideration.

This system is suited for a big display tank or a dolphin pool.

4) Closed type multiplied layer filter system

Developed specifically for use in aquaria, this system employs a number of filter tanks laid on top of the other so that the installation space is made smaller relative to the filteration area. The thickness of the sand layer is made smaller than that of a single layer for slow filteration, and this arrangement allows the air-lift system to work in time with the oxygen supply, and causes a small power loss since the filter pump need a small head.

This system is suited for medium and small tanks.

5) The internal filter tank used chiefly for small show tanks has an ideal circulation system. However, since its filter medium must necessarily be placed on the bottom of the show tank and cannot therefore be cleaned easily, it is not suited for use in a big

display tank. Subjecting the merits and demerits of all the aforementioned systems to a close analysis with account taken of the scale and breeding conditions of the projected aquarium, it is considered that the big display tank in the main building of the aquarium should be provided with the closed type single layer filter system, the medium and small tanks in the same building with the closed type multiplied layer filter system, and the dolphin pool with the closed type single layer filter system.

c) Filter medium

Filter media used in a filter tank include sand, anthracite, diatom earth, and activated charcoal. Among these materials, sand alone satisfies the dual purpose of physical and biochemical filtering required at an aquarium. Filter sand used for such filtering must fulfill the following conditions.

1) Uniform and hard quartz sand grains containing a small percentage of flat or brittle grains and free from dust, clayey materials and other impurities which produces an unpleasant appearance should be used.

2) The effective diameter of sand grains should be within the range of 0.45 - 0.70 mm.

3) The uniformity coefficient of sand grains should not exceed 1.70.

4) The specific gravity should be within the range of 2.55 - 2.65.

5) The maximum grain diameter should not be larger than 2.0 mm and the minimum not smaller than 0.3 mm. Even if sand grains whose diameter is smaller or larger than these values are mixed under unavoidable circumstances, they should not occupy more than 1% of all sand grains.

d) Supply of oxygen

All fishes inhale oxygen gas dissolved in water and exhale carbonic acid gas. The volume of dissolved oxygen in water is therefore very important for the breeding of fishes. Under the closed circulation system, installation of an air supply device is a always required to provide against the decrease in the dissolved oxygen. Under the open circulation system in which fresh sea water is circulated and drained, however, installation of such a device is rarely required.

8-1-3 Sea water supply facilities

The sea water supply facilities perform functions of vital importance for the operation of an aquarium, and their maintenance and inspection are largely affected by

their design and arrangement. Design of the sea water supply facilities must therefore be preceded by sufficient field investigations as well as by studies to be conducted in collaboration with the administrative staff of the aquarium on the location of intake, intake system, location of pump station, sea water reservoir, and other factors. Determination of these factors must be based on the results of detailed prior study of the topography of the projected site, sea bottom configuration and topography, water depth, driftage, water quality, water temperature, transparency, tidal current, waves, tidal range, inflow of river water, location of drain, and the sea conditions during storms. As described in Section 8-1-2 (Filtering and circulating facilities), the site of the projected aquarium faces a bathing resort and oyster farms are found in its vicinities. The existing conditions surrounding the site and their future prospect should be taken into consideration in working out the project.

a) Location of intake

A point near the rocky place about 1, 300 m to the west of Bang-Saen Hotel was first considered as the location of intake, but the sea bottom investigation disclosed that the water quality, transparency and bottom conditions are not favourable around this point due to the effect of oysters and that the water and bottom conditions turn for better towards Bang-Saen Hotel. Installation of an intake at this point, which is considerably far from the selected site, is not advisable since it will demand a large power for pump operation and will also incur large running and construction costs. Further, installation of an intake and pump station at a place far from the aquarium cannot be justified from the viewpoint of satisfactory maintenance.

For these reasons, it is considered that water should be taken at a point closer to the aquarium if the sea water conditions at that point are similar to those observed near the above-mentioned rocky place. It is to be noted, however, that if water is to be taken from the sea facing the site, then the intake must be located at a point far in the offing since the sandy beach surrounding the site is a bathing resort.

b) Intake system

The following three intake systems are conceivable.

1. Direct intake of water from the sea by means of a pump.
2. Intake of water by a pump from an intake well or a perforated intake pipe provided in the sandy beach.

3. Pumping feed to the aquarium from the reservoir constructed on the beach to which sea water is led through a concrete pipe laid to the intake point in the sea.

Choice between the above three systems is to be determined by future detailed investigations as well as by the intake capacity.

The sea water intake pump and the auxiliary equipment are one of the most important facilities of an aquarium. An extra set of the pump and auxiliary equipment should therefore be procured. The pump capacity is to be determined according to the reservoir capacity, total tonnage of display tanks, backwashing volume of the filter tank, and daily volume of fresh sea water supply. In the case of the projected aquarium which will have a large independent dolphin pool, the pump capacity should be large enough to cope with an emergency need. The pump operation should be changed over from automatic to manual and vice versa as circumstances may call for, and care should be taken not to pump up sea water when the water quality, transparency and other conditions are not satisfactory.

c) Pump station

The position of the pump station should be determined in due consideration of the characteristics of the intake pump. In other words, the pump station should be located as close to the water surface as possible to minimize the suction head. From the topographic condition of the area surrounding the site, it is justifiable to construct the pump station between the main road and the promenade. The exact position of the station should be determined according to the results of future detailed investigations. The pump station should preferably constructed under the ground level to minimize the suction head of the pump, with attention directed to ensure perfect drainage and ventilation within the station.

d) Reservoir

A sea water reservoir is required for both the main building and the dolphin pool since the two structures are to be built far from each other. It is generally accepted that at an aquarium where sea water of satisfactory quality cannot be obtained constantly, the reservoir capacity should be larger than the total tonnage of show tanks. In the present project, it is envisaged that 300 ton reservoir capacity will be secured by the installation of two 150 ton reservoirs to be installed beneath the machine room assuming that the total tonnage of show tanks is approximately 250 tons. The two reservoirs are

to be put in use alternately for sterilization of fresh sea water and for cleaning. As for the dolphin pool whose total tonnage for both the show pool and the training pools is about 1, 700 tons, a reservoir capacity of about 500 tons is considered sufficient since dolphins are mammals. Sea water pumped up from the sea contains various driftages, seaweeds and sand. It should therefore be filtered before it is fed to the reservoir. In the design of the reservoirs, architectural considerations including the provision of a sand-pit similar to the one fitted in ordinary reservoirs are necessary so that the cleaning work will be facilitated.

8-1-4 Temperature regulating facilities

Aquatic animals are generally more susceptible to temperature change than terrestrial animals, and this is quite natural considering the difference in specific heat between sea water and air. Atmospheric temperature varies largely not only by the changes of seasons but also by different times of the day such as morning, daytime and nighttime, whereas the sea water temperature shows little difference throughout the day. The poor adaptability of aquatic animals to temperature change is considered ascribable to scuh difference in environmental condition. A sudden temperature change occurring to the limited water volume in a show tank gives an enormous effect on aquatic animals exhibited, and occasionally impacts a fatal blow on some of them. Constant care must therefore be taken to prevent such a sudden temperature change. Installation of temperature regulating facilities is a must for the projected aquarium by reason of the closed circulation system to be employed and of the planned breeding of wider ranges of species. The facilities, however, will not be required for the dolphin pool where marine mammals are to be bred

Show tanks of an aquarium can be broadly classified into the big display tank, individual show tnaks of medium and small size, migrating fish show tank, panoramic show tank, and show tank with "aqua-master". These show tanks should be systematically arranged according to the species to be exhibited, and care must be taken to maintain a constant water temperature in each of them.

a) Cold source

A refrigerator is to be used as the cold source. An aquarium is provided with a refrigerator for air-conditioning, but the refrigerator for supplying chilled water to display tanks must be the one intended exclusively for chilled water supply and operating 24 hours a day since its function bears closely on the life of the animals being bred.

However, the changeover arrangement should be made in advance so that chilled water may be supplied instantly from the air-conditioning refrigerator in the event of a failure of the exclusive refrigerator for show tanks.

A chilling unit is usually employed at aquaria as the refrigerator for show tanks.

b) Heat exchanger

In selecting the heat exchanger for use in an aquarium, particular attention should be given to its materials and their effect on the aquatic animals. Further, the exchanger should be the one having a proven high reliability because its minor failure could be conductive to the death of aquatic animals. A heat exchanger used in an aquarium is subject to heat transmission problems similar to those which must be considered for ordinary heat exchangers, and it should be made of materials capable of withstanding the corrosive effect of sea water. The materials should be so arranged that they will be free from the electrochemical corrosion and other adverse effects.

There is an instance where a heat exchanger made of austenite stainless steel (18 Cr - 8 Ni) which was manufactured with careful attention given to the service conditions, machining and welding processes as well as to the grinding work was reduced to unserviceable condition within a year after its installation.

If materials of the brass group are to be used, each component must be kept clean and free from soils and mud since such materials are vulnerable to ammonia. Of the many materials of this group, those containing titanium are commendable for their excellent durability.

Heat exchangers used at aquaria include multitubular exchangers, plate type exchangers and coil type exchangers, and the one which best suits the intended purpose should be selected. Since aquatic animals must be bred in water whose temperature is maintained at a value inherent in their respective living environments, the temperature regulating device employes a resistance thermometer bulb whose function is based on the fact that the electric resistance of a metal has a certain fixed relation with temperature.

8-2 Air-conditioning facilities

The display rooms of an aquarium usually have no windows to augment the exhibition effect. Installation of air-conditioning facilities is therefore essential if many visitors are to enjoy themselves watching different aquatic animals. Absence of air-conditioning directly affects the number of visitors and the management of the aquarium. In designing

the air-conditioning of display rooms, attention must be directed, on the one hand, to the provision of sufficient air-conditioning apparatus capable of withstanding a heavy heat load on holidays when large numbers of visitors enter the display room within a short time, and on the other, to assuring a large fresh air suction capacity to meet such heavy heat load. Heat load imposed on the air-conditioning facilities is brought about mostly by the visitors' body temperature and the intrusion of outside air.

The air-conditioning of the projected aquarium should resort to the central duct system in the display room, and the individual cooling system (such as the fan coil unit and window coolers) in smaller rooms such as administrative section. The refrigerator is to be placed in the machine room. As described in Section 8-1-4 (Temperature regulating facilities), this refrigerator should be so designed as will be able to supply chilled water in case the refrigerator for show tanks becomes inoperative. In addition to the display rooms of the projected aquarium, air-conditioning is also required in the V.I P. room, director's office, conference room, office rooms, typists' room, telephone exchange room, locker room, booking office, laboratory rooms, and staff's rooms. Further, sufficient ventilation is required in the work-rooms, staff passageways, machine room, electricalroom, and generator room.

8-3 Sanitary and plumbing facilities

Sanitary and plumbing facilities of an aquarium are constructed in much the same way as those of ordinary buildings, but they should be given special consideration in the planning stage.

a) Water supply

The method applied to ordinary display facilities can be used in calculating the water consumption of an aquarium. If a same water source is to be used for breeding fresh water fishes, water supply needed for such breeding must be taken into account, but this can be disregarded in the case of the projected aquarium since it will exhibit marine animals alone. Cleaning of breeding tanks is one of the important works at an aquarium, and fresh water is used for this purpose. Hydrants should therefore be arranged at suitable places on the passageways behind the tanks. In the case of the projected aquarium, city water is to be drawn from the service main into the fresh water reservoir placed beneath the machine room, and then pumped to the head tank for distribution to hydrants.

b) Drainage

Water to be drained at an aquarium includes sewage from toilets, other waste water, water discharged from breeding tanks, and water discharged from the filter tank at time of backwashing. Soiled and waste water must be treated by a septic tank or other suitable equpment before drained. Instantaneous discharge of a large volume of drain water takes place at time of filter tank backwashing and when water is drained from both breeding tanks and the pool in an emergency. The main drain pipe must therefore be designed with due account taken of these factors and the interconnection with the filtering and circulating facilities. Another important thing to be studied in the design of the main drain pipe is where to discharge the drain water. This calls for a careful consideration for the locational relationship between the discharge point and the sea water intake. Utmost attention must be exerted to prevent the discharged drain water from being pumped up by the intake pump To attain this purpose, detailed investigations described in the section for intake facilities should be carried out so that the location of sea water intake, and then that of discharge point, will be determined. It must also be noted that a drainage plan often incurs various effects on the surrounding area after it is implemented. In the case of the projected aquarium, final decision should be reached after making detailed field investigations with attention given to the fact that the sand beach spreading in front of the site is a bathing resort.

8-4 Electrical facilities

8-4-1 Power receiving and transformer facilities

Power receiving and transformer facilities installed at an aquarium are required to be perfectly insulated, highly dependable and safe in operation, and should also allow for easy handling and maintenance. Due to the nature of its functions, an aquarium demands a far larger power for tanks than for other purposes including illumination. A balanced circuit should be designed in due consideration of this fact and care must be taken to minimize resitance and to attain a balanced potential distribution.

8-4-2 Private generator facilities

Private non-utility generator facilities are generally installed for emergency and safety purposes. At an aquarium, in particular, private generator facilities intended for the same purposes can never be dispensed with since they play the important role of safeguarding the life the aquatic animals exhibited. Illumination of show tanks must be

incorporated in the generator system because the management of an aquarium will be adversely affected if the exhibition is to be suspended by service interruption. Therefore, a considerably large load is imposed on the generator for illumination, though the largest load is imposed by show tanks. Since the generator facilities of an aquarium must include the control system, the generators are required to have a larger capacity as compared with those installed in ordinary buildings.

8-4-3 Illumination facilities

Illumination at an aquarium is conducted by various methods that can be devised by different combinations of the object of illumination, light source and lighting fixtures and the method most suited for each specific purpose is selected. In designing the illumination of show tanks and the visitors' passageway in the display room, particular care must be taken to assure that they are illuminated at a balanced intensity. At the projected aquarium, the big tank will have a top light for skylight illumination as well as projectors of halogen light source arranged on its upper part and side walls so that the display effect will be increased. In arranging the projectors on the upper part of this tank, care must be taken to set the projectors at a suitable angle. Intensity of illumination should be higher on the tank side than on the visitors' side. For the illumination of the visitors' side, it is preferable to use down lights or ceiling lights of incandescent lamps. To add to the variety of illumination, it deserves consideration to project colour spots at suitable places.

8-4-4 Power facilities

Satisfactory operation of each equipment installed in an aquarium is dependent on the smooth functioning of the power facilities. The automatic measuring and control unit which constitutes part of the power facilities is intended for the control and annunciation of water temperature and level in each breeding tank as well as for the control of water quality. Operation of each power equipment is so controlled as will meet the demand from the piping circuit of the breeding facilities.

The automatic control unit sh uld be the one which is made of materils capable of withstanding the corrosive effect of sea water. This consideration for component materials is necessary in selecting the termometer bulb.used in the temperature measurement and control and in selecting the detector terminal of pH and dissolved oxygen.

Automatic control equipment to be installed for the breeding of aquatic animals are as listed below.

a) Equipment for automatic control and upper and lower limit annunciation of water temperature

b) Equipment for automatic control, upper and lower limit annunciation and indication of water level

c) Equipment for automatic indication or recording of pH value

d) Equipment for automatic indication of flow rate, turbidity, etc.

In addition to the above listed equipment, the central remote supervisory and control system which performs the function of operation indication and annunciation of power equipment is adopted at modern aquaria. This system is highly instrumental in rationalizing various works including the maintenance and inspection of equipment, control of breeding work and so forth. If the installation of a central supervisory panel is not feasible, an indication panel should be installed either in the breeding room or in the control room.

8-4-5 Other facilities

The following miscellaneous facilities are usually installed at an aquarium.

a) Broadcasting facilities
b) Telephones
c) Interphones
d) Automatic fire alarms
e) Common TV facilities

9. Glazing work of display tanks

In designing the glazing work of display tanks, care must be taken to ensure safety, water tightness, rust prevention, accurate images of exhibited animals, wide scope, and economic justifiability. Particularly in the case of a big tank, there arises many problems which cannot be brought to a solution by the glazing techniques applied to smaller tanks. Installation of a large show tank calls for the availability of techniques for carrying out the entire glazing work including the fitting of sashes and glass panes in an integrated manner. Imperfect glazing work is liable to lead to the breakage of glass panes and leakage, and this not only incurs a danger to the visitors but also affects the management of the aquarium. The glazing work must therefore be based on a unified and integrated plan which controls the entire stage of designing and implementation.

In designing the glazing work, attention must be directed to the cautions described below.

A glass plate amply capable of withstanding the design water pressure is not completely free from the danger of breakage which could be caused by such external conditions as the impact load incurred by a thrown object or by the mischievous pounding action of visitors. In an aquarium where many visitors gather together and therefore the breakage of a glass pane could lead to a hazardous accident, single glass pane should be replaced with laminated glass panes for the safety of visitors, though it is of course important to raise the safety factor of single glass panes. The laminated glass pane should be so designed as will be able to withstand the water pressure until it is replaced by a new one when one of its layers is broken by an accident. It is to be noted that if the strain of a glass pane is too large, it gives, no matter what large strength it may have, an uneasy feeling to the visitors and its lens effect deforms the appearance of quatic animals into an unpleasant shape. To avert this drawback, the strain should be held below 1/150 - 1/200 of the shorter side of the pane. The resitance of glass panes against water pressure is calculated on the assumption that the rigidity of supporting members is satisfactorily large and that the glass panes are put in by a highly accurate glazing work. If these conditions are not fulfilled, the safety factor of the glass panes declines and the water tightness becomes less stable. In the glazing work, efforts must be made to prevent the transmission of strain of supporting members to the window panes.

The load imposed on the glass pane is the long-term uniform load if the pane is laid on bottom, and the long-term uniformly varying load if the pane is erected on sides. In either case, the load is considered the hydrostatic pressure. Besides the hydrostatic pressure, the glass pane is considered to be subjected to the dynamic water pressure at time of an earthquake and to the impact load incurred by fishes and other aquatic animals hitting against it. These loads must be studied individually. The plate glass used in ordinary buildings is considered to be subjected chiefly to the short-term wind load. In the case of glass panes used for show tanks, the load is considered the long-term load, and this calls for the consideration for the fatigue of glass.

In designing and implementing the glazing work of show tanks, particularly the big show tank, of the projected aquarium, the afore-mentioned cautions should be strictly observed, while maintaining perfect harmony with the aquarium layout.

10. Arrangement of display tanks

The arrangement of display tanks is a scenery setting intended to enhance the display effect of aquatic animals, and is subject to various restrictions particularly when the show tanks contain sea water.

What need to be reviewed in the planning stage of the display arrangement are the idea of model formation and the materils of models. Factors indispensable for producjng the desired display effect are varied flows of light, colour, movements and sound. Effective display can be produced only when perfect harmony is attained between these factors. Though the display techniques are limitless, the success of display arrangement is determined simply by whether the animals are exhibited to the fullest extent and also by whether the viewers are impressed.

a) Fundamental considerations

Display arrangement of show tanks resorts to various methods of formative and graphic art for realistic reproduction, deformation or symbolic presentation of the natural sea life. It is preferable that the arrangement be varied according to the kind of animals exhibited. The discharge and suction ports provided in the tank for water supply and drainage should be hidden from the viewers. This arrangement must be made in due consideration of the breeding facilities because scenery settings placed in the tank occasionally causes poor water circulation, turbidity, eddy current or stagnant water.

b) Materials of models

Materials of unstable quality, if used for models to be placed in show tanks, particularly those containing sea water, sometimes incur an unfavourable effect on the aquatic animals. It is therefore advisable to prepare large settings with mortar or plastic materials which are stabilized after curing. As for paints, suitable kinds should be selected from among resin paints. In an attempt to create the desired display effect, mirrors and other materials are often used, with the physical characteristics of air and water employed on some occasions.

c) Illumination and colour

The most effect media for producing the display effect are illumination and colour. Illumination can be employed in diversified ways by changing the light source or light intensity and by adopting flashlight, dimmer, diffused light or convergent pencil of light.

An equally great diversity is found in the methods of employing colours. On certain occasions, fluorescent paints are employed combined with the light source to produce the display effect.

d) Effect of movements

Movements in a broad sense include the changes of illumination and colours produced by dimmers and other means as well as the bubbles produced by aeration. Since water is abundantly available at an aquarium, it is commendable that movements are induced into water to create streams, springs, fountains or falls.

e) Sound effect

In addition to a good visual effect produced by the harmonized interaction of illumination, colour and movements, it is preferable to appeal to their visual and acoustic senses of the visitors by making full use of sound effect so that they will understand the purpose of exhibition and be induced into the atmosphere of natural sea life reproduced.

PROJECT OF AQUARIUM, BANGSAEN, THAILAND.

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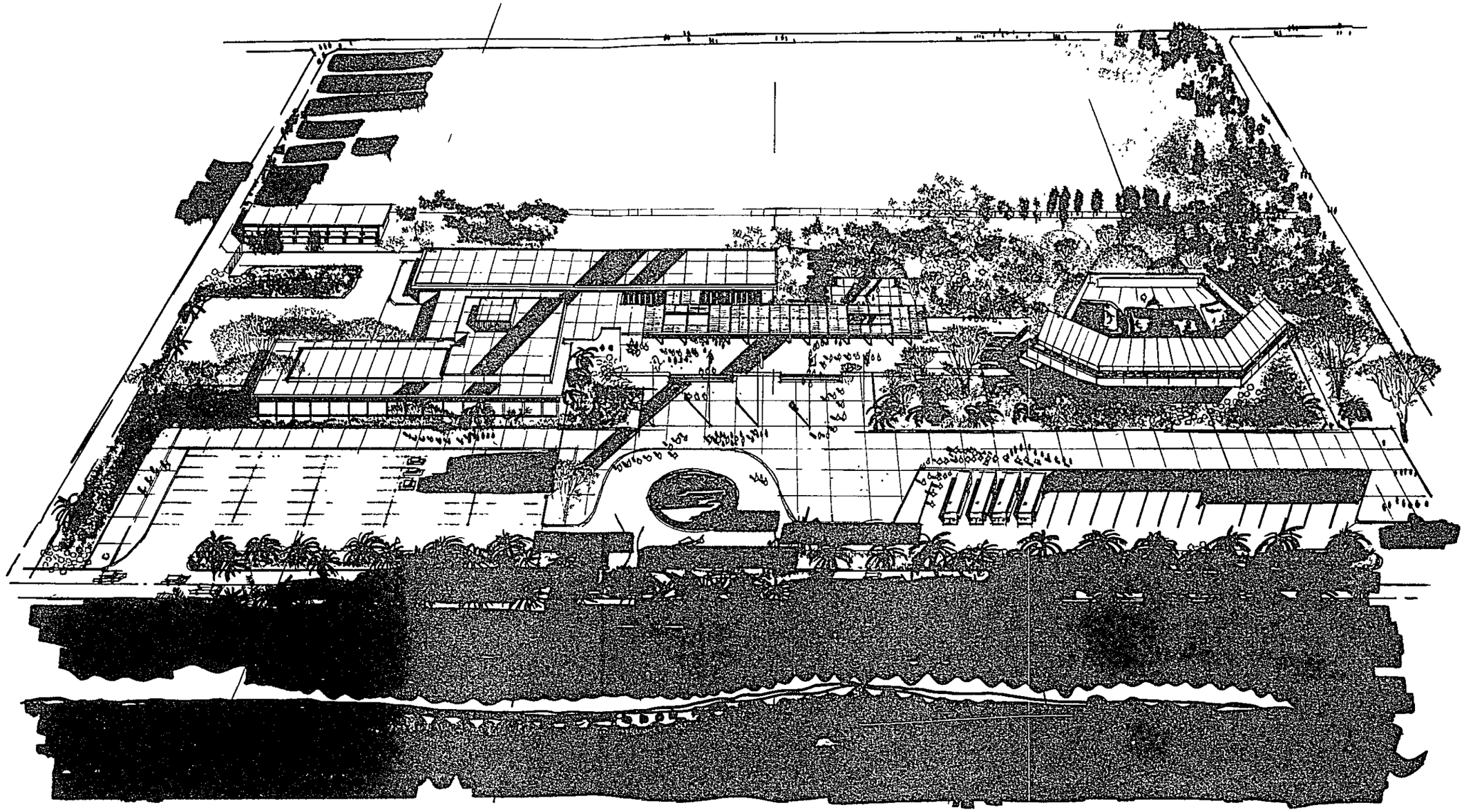

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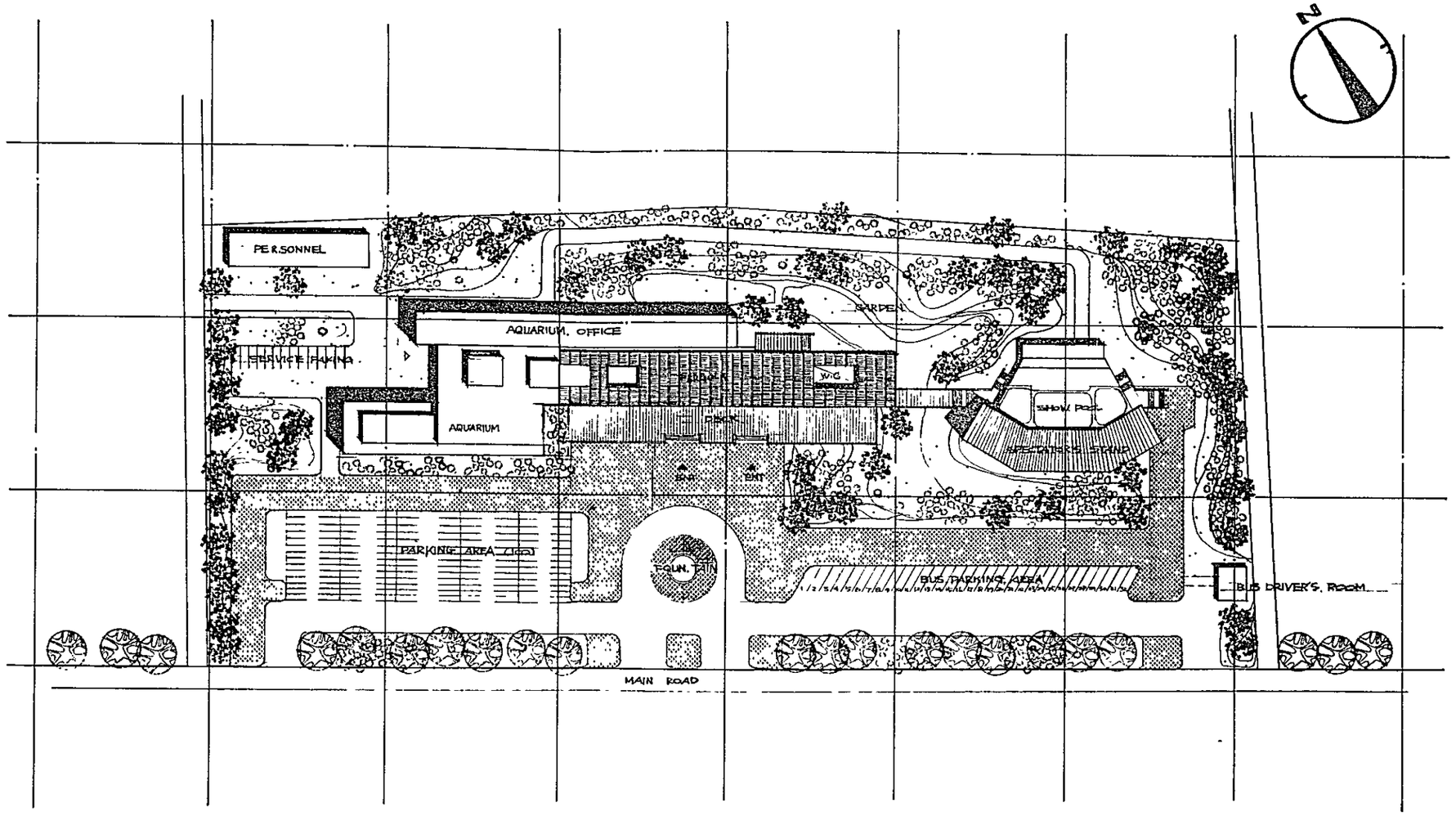


PLOT PLAN S = 1 : 1000

LOT AREA 38,503 M²

	FLOOR AREA (M²)				
	BM	1ST	2ND	PH	TOTAL
AQUARIUM	139.20	228.20	383.60	60.00	2870.00
SHOW POOL		112.30	638.70		1768.00
TOTAL	139.20	340.50	1022.30	60.00	4638.00
DECK	240.00				240.00

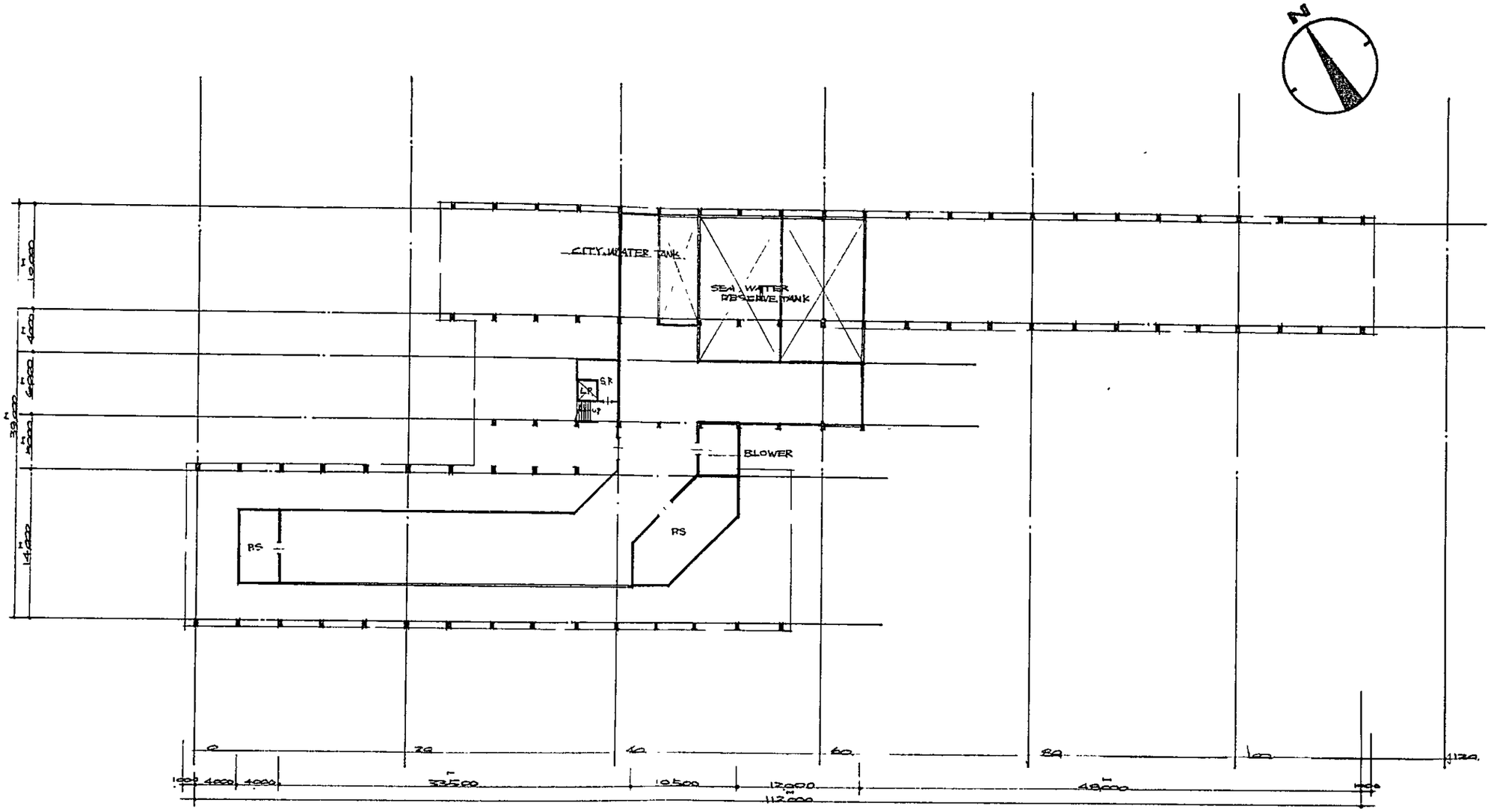
APARTMENT FOR THE PERSONNEL : NOT INCLUDED

件名 設計番号 44024
PROJECT OF AQUARIUM, BANGSAEN, THAILAND.

図名 縮尺 製図年月日
PLOT PLAN S=1/1000 JULY 20, 1971

株式会社 石田設計事務所
ISHIDA DESIGN OFFICE CO., LTD.

図面番号 2



BM FLOOR PLAN S 1:300

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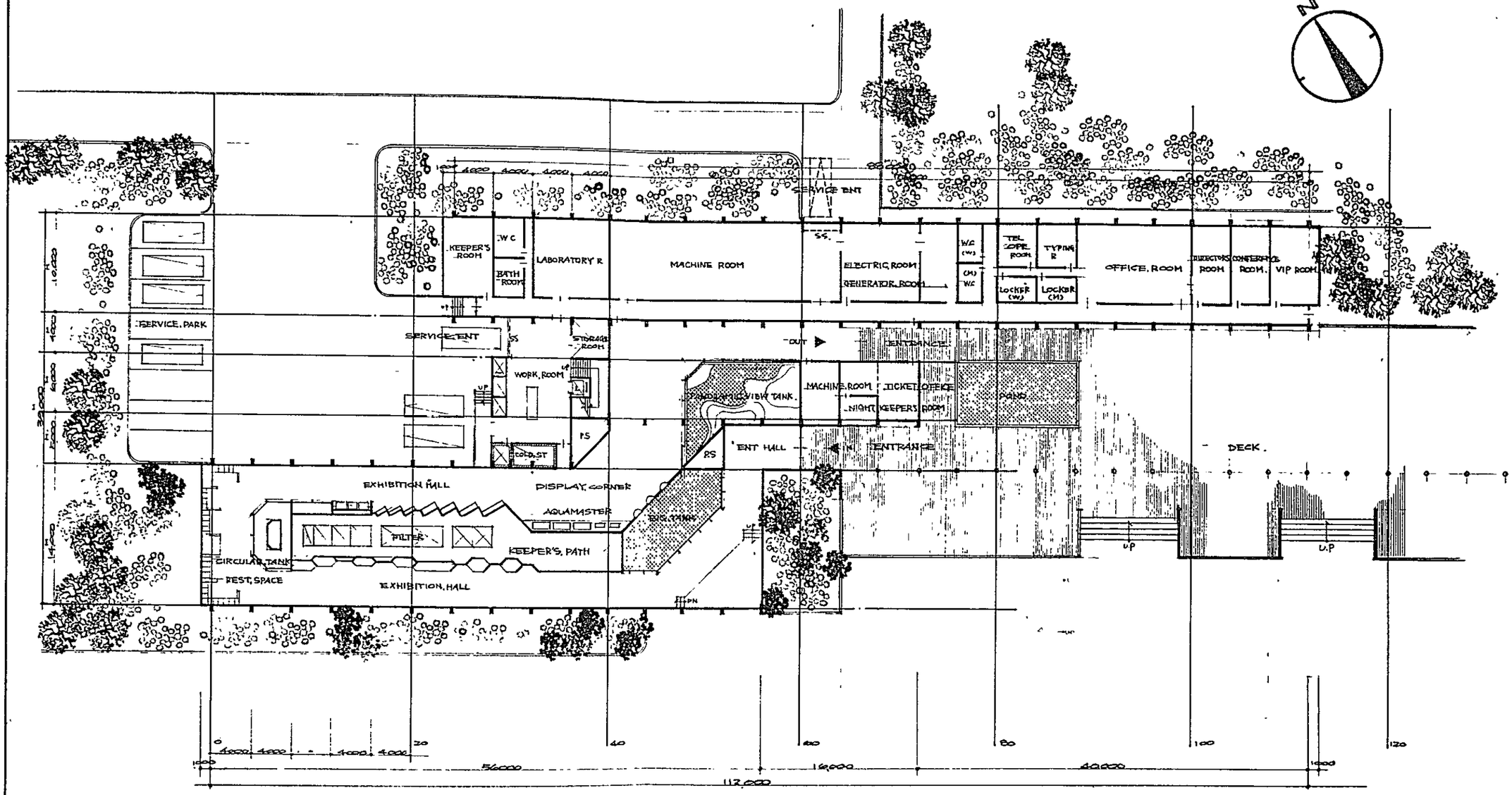

1ST FLOOR PLAN S 1:300

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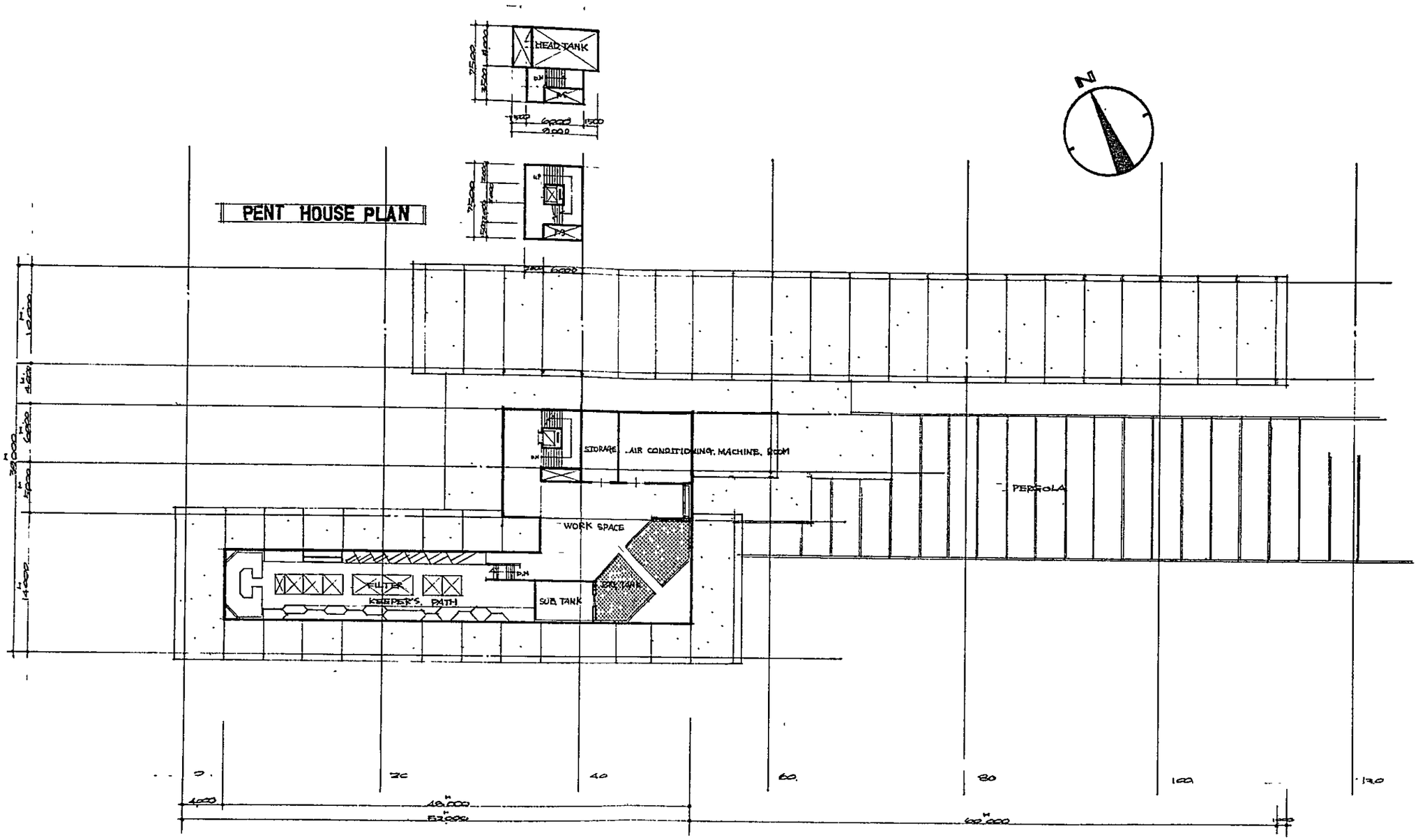
株式会社 石田設計事務所 ISHIDA DESIGN OFFICE CO., LTD.		図面番号	4

PENT HOUSE PLAN



2ND FLOOR PLAN S 1:300

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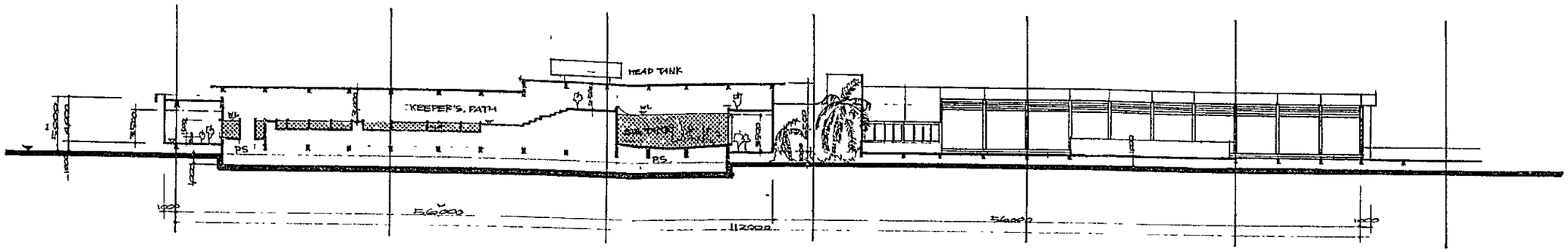

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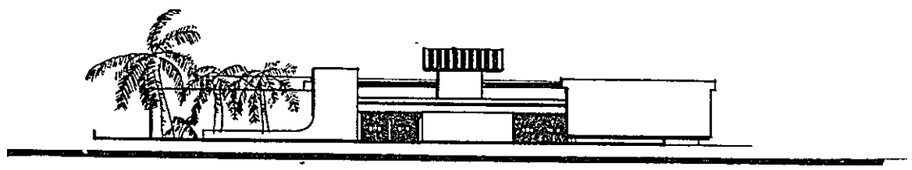
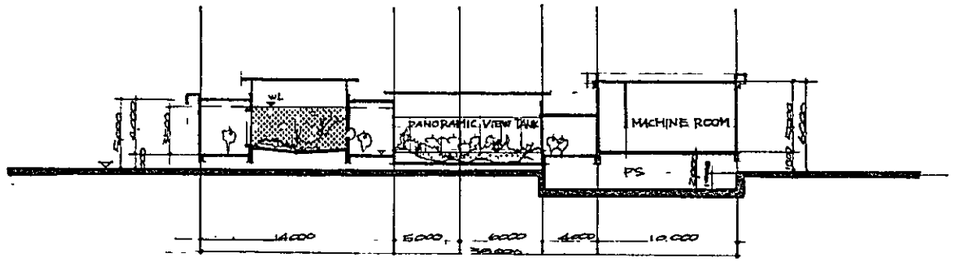


REAR ELEVATION S 1:300



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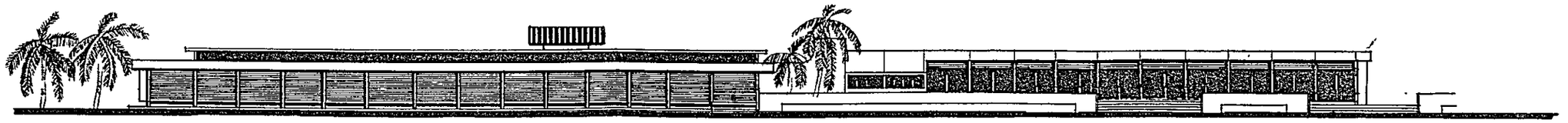

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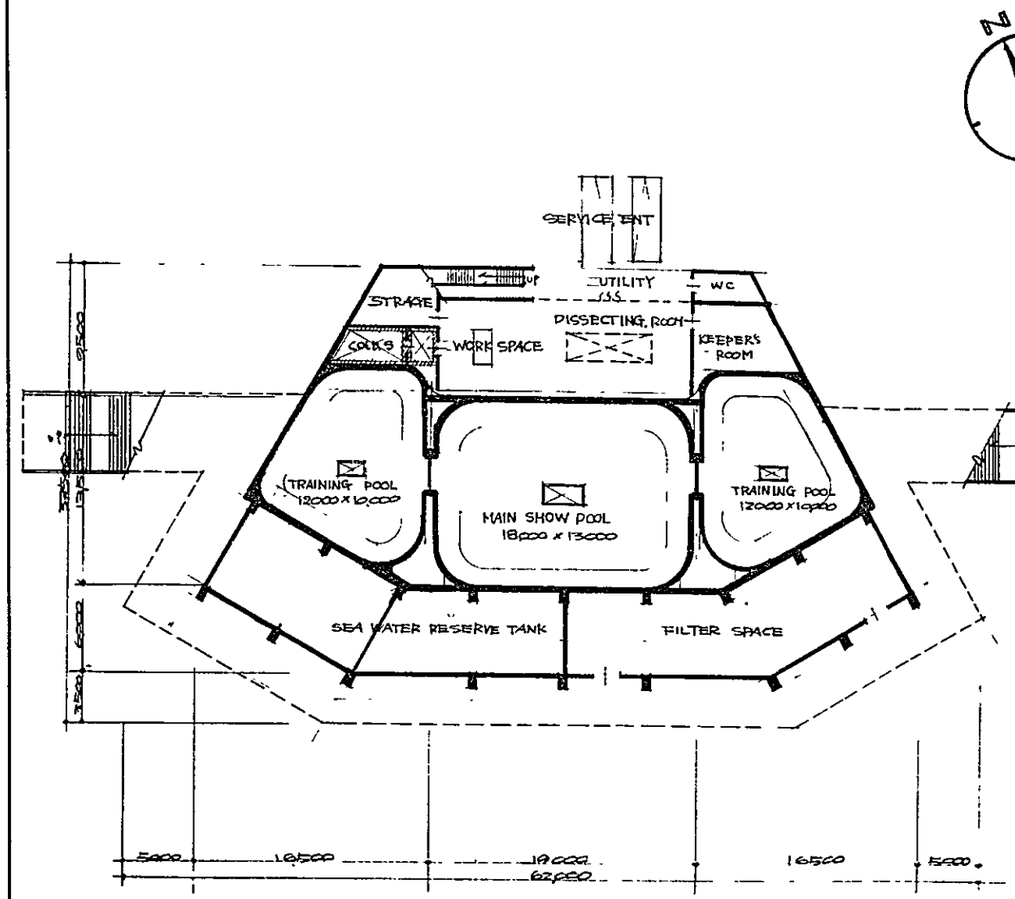
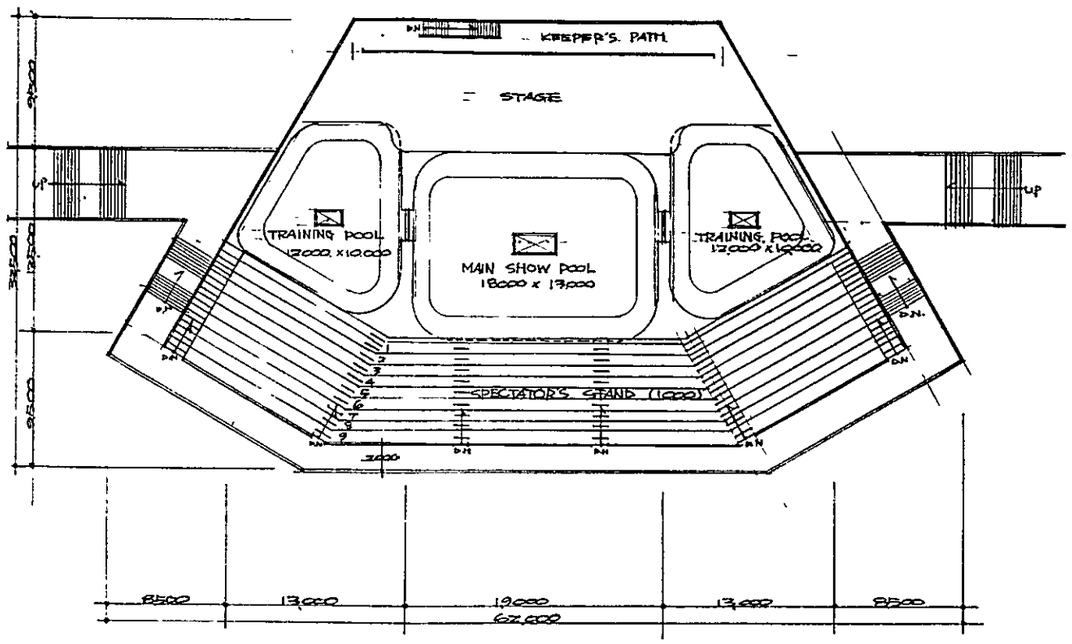


1ST FLOOR PLAN S 1:300



2ND FLOOR PLAN S. 1:300

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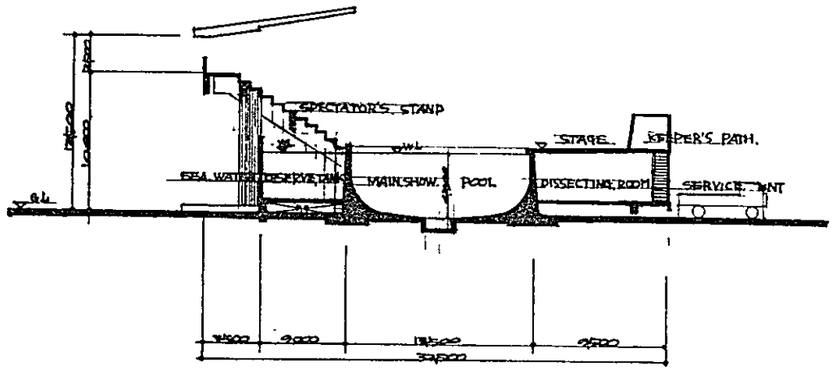
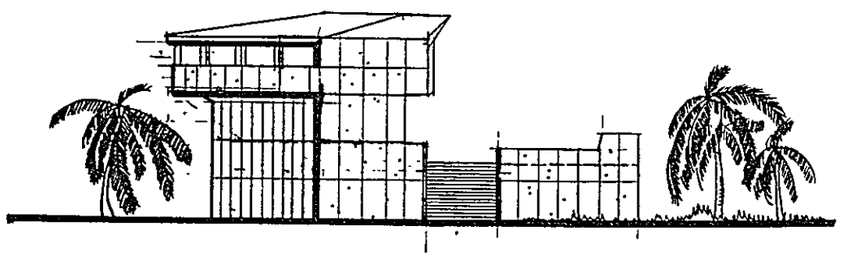
図名 SHOW POOL. 1ST, 2ND FLOOR PLAN S=1/300 縮尺 製図年月日	鈴木 高橋 石田
株式会社 石田設計事務所 ISHIDA DESIGN OFFICE CO., LTD.	図面番号 7



SHOW POOL SECTION S 1 300



SHOW POOL REAR ELEVATION S 1 300

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株式会社 石田設計事務所 ISHIDA DESIGN OFFICE CO., LTD.		図面番号 8