GUIDE TO THE PLANNING

OF KUWAIT AQUARIUM

April, 1974

OVERSEAS TECHNICAL COOPERATION AGENCY

TOKYO, JAPAN

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INTRODUCTION

In response to the request of the Ministry of Public Works of the Government of Kuwait for the envisaged National Aquarium to be built in Kuwait, an expert mission of three Japanese namely Dr. Fujio YASUDA, Mr. Yoshitaka ABE, and Mr. Koichi YANO visited Kuwait during the period of February 11th to 19th in 1974.

The mission prepared the present report at the request of the Ministry of Public Works, treating the subject tentatively giving a rough sketch of the Kuwait Aquarium (Part One), and general survey of the problems (Part Two).

Since this is a master plan, needless to say, another discussion in detail with the Kuwait Government Officials must be made for finalization.

It is hoped that the present report will be a step nearer towards acheiving a successful venture.

The preliminary design of the aquarium was made in cooperation with M/S Ishida Design Office Co., Ltd. who have had considerable experiences in such type of design works.

The members of the mission express their deep sense of gratitude to Mr. Salem I. Al-Mannai, of the Ministry of Public Works and his assistants, Mr. Al-Assousi, Mr. Bader Al-Naqui, and staff of the Kuwait Institute for Scientific Research, Mr. Katsuji Tainaka and Mr. Hiromu Ikenoue, for their kind hospitality during their fruitful stay in Kuwait.

Dr. Fujio YASUDA, Tokyo University of Fisheries
Yoshitaka ABE, Ueno Zoological Garden Aquarium
Koichi YANO, Saito Shozo Shoten Co., Ltd.

PART ONE: GENERAL CONCEPT OF THE PROJECT

PRIMARY REQUISITES OF THE KUWAIT AQUARIUM

The mission had several meetings with the staff of Kuwait concerning the aquarium project, and exchanged valuable opinions on the general problems in contriving the scheme.

The members of Kuwait side stated their own ideas and ambitions for this project for which the mission gave frank opinions of the pros and cons of the project. Consequently, the primary requisites necessary for the Kuwait Aquarium is briefly summarized as follows.

1) Kuwait Aquarium should be of a very high standard one and the most suitable for the State of Kuwait of 800,000 population, carrying the functions, such as amusement of public, education of public, and research activities. Special emphasis should be placed upon the function of amusement or recreation of public.

2) The project is to be carried out near the premises adjoining the site of the Japanese Garden Project in Salimiyah.

3) The kinds of animals to be displayed in the aquarium are not limited to the local marine invertebrates and fishes of the Arabian Gulf, but extended to the representative fresh water fishes with show value from every continent of the world, including those of the Tigris and Euphrates Rivers.

4) The show pools for marine mammals such as dolfins and smaller whales will be excluded at the start of the scheme though the site for future construction is reserved at the premises of the aquarium, because they require additional or separate facilities from those for fishes.

5) The facility of a giant marine tank with the capacity of several hundred cubic meters of water to contain sharks, rays, and schools of migratory fishes is preferably equipped as an introduction into aquatic world. A pond for the beautiful varieties of colored carps, as well as table tanks for goldfishes, are to be located in the miniature Japanese Garden proposed in the cafeteria.

6) The latest technics and facilities such as radio guide, underwater TV, oscilloscope for electric fishes, apparatus to hear sounds in water, micro-projector for microscopic organisms etc., are widely adopted to the unique displays and explanation of the animals.

7) For educational purposes, the aquarium needs, exhibition galleries for the introduction of fisheries of Kuwait, increase in biological

knowledge on aquatic animals, and a combined movie theatre and lecture hall.

8) The research laboratories for the aquarium staff, specimen rooms, a breeding room, special tanks for the treatment of animals and a library are needed for the function of research activities. The pier to bring the collection vessels alongside of the aquarium is one of the prime necessities for running the aquarium.

9) The incidental facilities such as parking, refreshment shop and booth selling souvenirs or guide book of the aquarium are also necessary.

Table 1. The arrangement of display and kinds of animals along the gallery of Kuwait Aquarium. The Alphabet and figures of the displays correspond to those in the drawings.

NAME OF DISPLAY	KIND OF ANIMAL Kuwait name or common name-scientific name	SIZE OF TANK width x depth x height (m)	Volume (m^3)	REFERENCE
A. Sea fishes of the Arabian Gulf				
A-1 Migratory fishes	Zobaidy-Pampus argenteus, Halway-Formio niger, Hamam-Carank spp., Khubbat-Scomberomorus guttatus, Beyah-Liza macrolepis, Lihlah-Chorinemus lysan, etc.	8 x 5 x 2.5	100	An attractive display as an introduction to aquatic world.
A-2 Fishes of coral reef	Anfooz-Pomacanthus maculosus, Pomacanthus imperator, Chaetodon obscurus, Heniochus acuminatus, Hamer-Mulloidichthys auriflamma, Terr-Parapercis nebulosa, Meelaz-Stethojulis interrupta, Velvet Damselfish-Pomacentrus sindensis, Sail-finned surgeonfish-Zebrasoma xanthurus, Deyayah-Pterois volitance, E'-Nezah-Chelonodon patoca, etc.	5 x 2.5 x 2	25	Typical coral fishes found in the waters of South of Kuwait. The tank to be decorated of coral reef.
A-3 Fishes of estuary	Boshalambo-Periophthalmus waltoni, Cryptocentrus filifer, Pseudapocryptes dentatus, Boefchach-Thryssa mystax, Shing-Scatophagus argus, Mud Crab, etc.	2 x 2 x 1.2	4.8	Artificial tidal zone modelled after the nature of the Kuwait Bay.
A-4 Fishes of rocky shore	Hamoor-Epinephelus tauvina, Naisarah-Lutjanus spp., Sheiry-Lethrinus spp., Fasker-Acanthopagrus bifasciatus, Yanam-Plectorhynchus schotaf, Mochwah-Diplodus noct, Mozaizy-Acanthopagrus berda, etc.	5 x 2.5 x 2	25	Fishes found in the water of rocky shore of the south of Kuwait. The tank with the decoration of rocks and caves.
A-5 Fishes of sandy shore	Teeb-Therapon theraps, Andag-Argyrops spinifer, Chimh-Arius thalassinus, Ghazal-Polydactylus sextarius, Bassi-Nemipterus japonicus, Hayyasa-Chiloscyllium griseum, Suboor-Hilsa ilisha, Hakool-Tylosurus leiurus, etc.	5 x 2.5 x 2	25	Fishes caught together with shrimp by the operation of shrimp trawlers from the sandy bottom of the Arabian Gulf.
A-6 Small-sized sea fishes:	Kofaah-Bothus pantherinus, Psettodes erumei, Mezlak-Pardachirus marmoratus, Kasoor-Saurida undosquamis, Ewharah-Platycephalus indicus, etc.	5 x 2.5 x 2	25	Display of the protective colour change of sandy bottom dwellers; flounders, flatfishes, etc.

	NAME OF DISPLAY	KIND OF ANIMAL Kuwait name or common name-scientific name	SIZE OF TANK width x depth x height (m)	Volume (m^3)	REFERENCE
A-7	Small-sized sea fishes	Hasoom-Sillago sihama, Manchoos-Allanetta forskali, Eshmahy-Jonius aneus, Fattrah-Torpedo penthera, Siny-Loiognathus spp., Badah-Gerres spp., etc.	2 x 2 x 1.2	4.8	Common sea fishes found in the waters of Kuwait belonging to different families.
A-8	Small-sized sea fishes	Nakkaka-Batrachus grunniens, Firyalah-Minous monodactylus, Spotted Seahorse-Hippocampus kuda, Cholaib-Eldow-Triacanthus biaculeatus, etc.	2 x 2 x 1.2	4.8	Common sea fishes found in the waters of Kuwait belonging to the different families.
A-9	Giant marine tank	Yaryoor-Carchrhinus menisorrah, Lokhmah-Himantura uarnak, Balando-Rhynchobatus djiddensis, Lazzag-Echeneis naucrates, Sikin-Rachycentron canadus, Hiff-Chirocentrus dorab, Thelah-Chorinemus lysan, Nakroor-Pomadasys argenteus, Newaiby-Otolithes argenteus, Hamrah-Lutjanus coccineus, Sea Turtles, etc.	18 x 5 x 6	540	A dynamic display by a giant marine tank containing schools of migratory fishes and large fishes found in the Arabian Gulf.
B.	Marine invertebrates				Marine invertebrates found in the coastal waters of Kuwait.
B-1		Octopus or Sea squids	1 x 1 x 0.8	0.8	
B-2		Shrimp and Crab	1 x 1 x 0.5	0.5	
B-3		Sea Snail	1 x 1 x 0.5	0.5	
B-4		Sea Urchin and Starfish	1 x 1 x 0.5	0.5	
B-5		*Coral, Jellyfish and Sea Anemone*	1 x 1 x 0.5	0.5	
C.	Freshwater fishes of the world				
C-1	Freshwater fauna of Tigris-Euphrtes Basin	Cyprinids fishes: A'djzan-Barbus subquicunciatus, Gattan-Barbus xanthopterus, Shilik-Aspius vorax, etc. Catfishes: Djirri-Silurus triostegus, etc. Frogs and Toads: Birds: Reptiles:	20 x 4 x 0.5	40	Aqua-terrarium for fishes as well as Amphibia, Reptiles, and Birds of Shatt-Al-Arab Region. The tank with thick vegetation of date palms and other plants.
C-2	Freshwater fishes of Africa	Lungfishes-Protopterus aethiopics, Protopterus annectens, Protopterus dolloi, Bichir-Polypterus bichir, etc.	1.5 x 2 x 1.2	3.6	"Living Fossils" of Africa.

	NAME OF DISPLAY	KIND OF ANIMAL Kuwait name or common name-scientific name	SIZE OF TANK width x depth x height (m)	Volume (m^3)	REFERENCE
C-3	Freshwater fishes of Africa	African Knifefish-Notopterus nigri, Mormyrids fishes-Gnathonemus petersii, Gymnarchus niloticus, Heterotis-Heterotis niloticus, Butterfly Fish-Pantodon buchholzi.	2 x 2 x 1.2	4.8	Endemic freshwater fishes in Africa.
C-4	Freshwater fishes of Africa	Congo-tetra-Micralestes interruptus, Distichodus-Distichodus sexfasciatus, Up-side Down Catfish-Synodontis nigriventris Jewel Fish-Hemichromis bimaculatus, etc.	1.5 x 2 x 1.2	3.6	African Characins and others.
C-5	Freshwater fishes of Tropical Asia	Climbing Perch-Anabas testudineus, Kissing Gourami-Helostoma temmincki, Giant Gourami-Osphronemus goramy, Pearl Gourami-Trichogaster leeri, etc.	2 x 2 x 1.2	4.8	Anabantids fishes, native in Tropical Asia, with peculiar air breathing organ.
C-6	Freshwater fishes of Tropical Asia	Rasbora - Rasbora heteromorpha, Indian Glass Fish-Chanda ranga, Sumatra-Barbus tetrazona tetrazona, Red-tailed Black Shark-Labeo bicolor, etc.	2 x 2 x 1.2	4.8	Beautiful varieties of small-sized Cyprinid fishes.
C-7	Freshwater fishes of Tropical Asia	Knife Fish-Notopterus chitala, Silver Barb-Barbus schwanenfeldi, Giant Danio-Danio malabaricus, etc.	2 x 2 x 1.2	4.8	Representatives of Tropical Asia.
C-8	Freshwater fishes of Temperate Asia and Europe	Carp-Cyprinus carpio, Grass Carp-Ctenopharyngodon idellus,	2 x 2 x 1.2	4.8	Very common species of Cyprinidae, also commercially important.
C-9	Freshwater fishes of Temperate Asia and Europe	Sturgeon-Aciperser spp., Perch-Perca flavescens.	2 x 2 x 1.2	4.8	Representative species of Northern Eurasia.
C-10	Freshwater fishes of Temperate Asia and Europe	Pike-Esox lucius, Brown Trout-Salmo trutta, etc.	4 x 3 x 1.2	14.4	Representative species of Northern Eurasia.
C-11	Freshwater fishes of North America	Garpike-Lepisosteus spp., Bowfin-Amia carva.	2 x 2 x 1.2	4.8	"Living Fossils" in North America.
C-12	Freshwater fishes of North America	Blue-gill Sunfish-Lepomis spp., Sucker-Catostomus spp.	1.5 x 2 x 1.2	3.6	Native fishes of North America.
C-13	Freshwater fishes of Central America	Swordtail-Xiphophorus helleri, Platy-Xiphophorus maculatus, Guppy-Lebistes reticulatus, Four-eyed fish-Anableps anableps, etc.	1.5 x 2 x 1.2	3.6	Beautiful varieties of viviparous killifishes.
C-14	Freshwater fishes of South America	Piranha-Rooseveltiella nattereri	2 x 2 x 1.2	4.8	Carnivorous Characin of Amazon River.

	NAME OF DISPLAY	KIND OF ANIMAL Kuwait name or common name-scientific name	SIZE OF TANK width x depth x height (m)	Volume (m^3)	REFERENCE
C-15	Freshwater fishes of South America	Giant Pirarucu-Arapaima gigas, Arawana-Osteoglossum bicirrhosum.	5 x 2.5 x 2	25	The largest freshwater fishes of the world.
C-16	Freshwater fishes of South America	Neon Tetra-Hyphessobrycon innesi, Silver Hachet Fishe-Carnegiella levis, Metynnis-Metynnis roosevelti, etc.	1.5 x 2 x 1.2	3.6	Beautiful tropical freshwater fishes of South America.
C-17	Freshwater fishes of South America	Armoured Catfish-Callichthys callichthys, Angel Fish-Pterophyllum emekei, Anostomus-Anostomus anostomus, etc.	1.5 x 2 x 1.2	3.6	Representatives of South American Freshwater fish fauna.
C-18	Freshwater fishes of Australia	Australian Lungfish-Neoceratodus forsteri.	1.5 x 2 x 1.2	3.6	"Living Fossils" of Australia.
C-19	Giant Salamander	Giant Salamander-Megalobatrachus japonicus.	1.5 x 2 x 1.2	3.6	The largest Amphibia of the world. One of the important natural monument of Japan.
D.	Ecological Display				
D-1	Feeding behaviour of Archer Fish	Archer Fish-Toxotes jaculator.	2 x 2.5 x 1.2	6	Display of peculiar feeding behaviour ejecting water from its mouth at insects on leaves overhanging the water.
D-2	Electric discharge of Electric Eel	Electric Eel-Electrophorus electricus.	2 x 2 x 1.2	4.8	The tank with oscilloscope and volt meter.
D-3	Blind cave fishes	Blind Cave Characin-Anoptichthys jordani, Blind Barb-Caecobarbus geertsi.	1.5 x 2 x 1.2	3.6	Adaptation of blind fishes living in subterranean water. The tank with decolation of stalactite cave.
D-4	Spawning behaviour of Tilapia and other Cichlids fishes	Mouth Breeder-Tilapia spp., Jewel Fish-Hemichromis bimaculatus, etc.	2 x 2 x 1.2	4.8	Display of interesting nature of reproductive habits of these fishes, pairing, nest building, guarding eggs and young.
D-5	Symbiosis behaviour of Anemone Fishes	Clown Fish-Amphiprion percula, Anemone Fishes-A. frenatus, A. xanthurus.	1.5 x 2 x 1.2	3.6	The most striking examples of symbiosis between fish and lower invertebrates.
E.	Exhibition gallery				Educational exhibition or special display based on the researches and experiments, and display of microscopic organisms by micro projectors or TV.
E-1-10	Goldfishes	Goldfishes-Carassius auratus auratus	0.9 x 0.45 x 0.45	about 0.18	Beautiful varieties of Goldfishes in 10 special table tanks.

NAME OF DISPLAY	KIND OF ANIMAL Kuwait name or common name-scientific name	SIZE OF TANK width x depth x height (m)	Volume (m^3)	REFERENCE
F. Exhibition gallery				Photo exhibition gallery.
G. Lecture hall Movie theatre				Three hundred seats. Showing films of marine biology and fisheries science.
H. Japanese Garden				Beautiful varieties of coloured carps in the Japanese garden pond.
H-1 Colored Carps	Colored Carps-Cyprinus carpio.	5 x 5 x 0.5	12.5	
I. Dolfin show	Dolfins and smaller whales			The facilities for dolfin show similar to those in Hawaian Sea Life Park. The pools with glass windows at its side. The dolfin show is to be performed from the famous 'Dhow' boat of Kuwait kept in the pools.
I-1		15 x 10 x 5	750	
I-2		10 x 5 x 5	250	

THE OUTLINE OF THE KUWAIT AQUARIUM

The aquarium having all the facilities as mentioned above is believed to be of high standards, and one of the largest and most educational aquariums in the world.

The scheme of the project, needless to say, must be worked out according to their desires and opinions of the staff of Kuwait, however, at the same time, it must be proper and practical.

Thus the main point was how to reflect and formalize those requisites in a practical scale for the Kuwait Aquarium.

The facilities of dolfin pools were throughly discussed in every detail in the present report, though they are considered at present as a future extention.

The total floor area of the acquarium building exclusive of the dolfin pools is about 8,640 m^2. Animals are exhibited in 38 glass-fronted wall tanks for fishes, 2 special floor pools for dolfin show, 1 floor pool for colored carps, and about 10 table tanks for goldfishes. The arrangement of displays along the gallery is shown in Table 1. The total amount of water circulating in the systems including reserve tanks is estimated around 1,000 cubic meter. The volume of water in the circulation system of the dolfin pools is about 1,000 cubic meters.

The following is explanatory data prepared by the aquarium architects on the outline of the aquarium building (Figs and Table 2).

The building consists of two different facilities, namely the aquarium and the show pool. In order to connect these two blocks both functionally and architecturally, a spacious hall which is accessible directly from open space of the site is to be designed. The hall provided with staircases and lounge on the second floor serves not only as an entrance hall but as a lobby for the visitors.

Although the building is designed as one unit, it would be possible to execute the construction work in two stages, the aquarium and the show pool separately.

During planning, the following fundamental conditions have been taken into consideration in designing the aquarium.

a) Smooth flow of visitors along the predetermined route to the exit must be ensured. The passage route of visitors should not have any hindrance on the way.

b) Exhibits 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 administrative rooms should be so

arranged that both breeding and management works may be carried efficiently and independently. To assure satisfactory breeding, particular attention should be given to the movements, preservation and preparation of feeds as well as securing sufficient space for breeding.

Outline of building

Aquarium*: 3-storied, including machine room and filter space on the ground floor mainly reinforced concrete structure.

Show Pool: 2-storied, including pools, reservoir and filter space on the ground floor mainly reinforced concrete structure except roof in steel structure.

Table 2. Floor Area in Square Meter

	Aquarium*	Show Pool	Total	Remarks
Ground Floor	1,130.00	900.00	2,030.00	Pilotti not included
1st Floor	2,835.00	1,000.00	3,835.00	Surface of pools not included
2nd Floor	1,250.00	-	1,250.00	
3rd Floor	3,200.00	400.00	3,600.00	
Pent House	225.00	-	225.00	
Total	8,640.00	2,300.00	10,940.00	

* Entrance hall included

PART TWO: GENERAL SURVEY OF THE PROBLEMS**

HISTORY AND PRESENT STATUS OF AQUARIUM

Fishes and other aquatic organisms require quite different living conditions from those of terrestial animals as they are poikilothermal and breathe with gills. Since keeping and exhibiting aquatic organisms under satisfactory conditions are only made possible under a sophisticated mechanical device, the so-called aquarium appeared for the first time after the industrial revolution and the real aquarium were constructed only in the present century.

San Francisco Steinhart Aquarium, completed in 1923 under the direction of the ichtyologist, Dr. David Star Jordan, is one of the first aquariums where scientific researches are emphasized. At present, this aquarium is equipped with 8 separate water systems meaning that water circulates independently in each system and its temperature is controlled separately, and in addition to exhibition of living fishes, has many unique displays such as apparatus to hear sounds in water, the polarized screen, the oscilloscope, and the volt meter for electric fishes, and the artificial tide pool modeled from the natural.

John G. Shed Aquarium in Chicago facilitated with new mechanical renovation was opened to the public in 1929. This large aquarium has 5 separate water systems and 300 display tanks. The fundamental idea of the establishment of this aquarium was to carry on scientific studies rather than to exhibition of fishes, though the building itself inherited the traditional so-called museum style.

In Europe, Frankfurt Exotarium has old history and is one of the first grade aquariums. In this aquarium, the gallery is so designed that visitors can observe the 'back stage' of the aquarium such as filters, piping and pumping systems, heaters and reserve tanks. In Japan, there is an aquarium following the design as Exotarium. Denmark Aquarium opened to the public in 1939 is highly functional in exhibition purpose, encased in a modern building. Bergen Aquarium in Norway was completed in 1960. In this aquarium, the unique display is intended to provide the visitors with the broad informations about fresh and sea water fishes in Norway while observers walk through the mazy route of the gallery. This type of display was adopted in Vancouver Public Aquarium opened in 1967 and also in Vivarium in Basel which was built in 1972.

National Fisheries Center in Washington, DC is trying to reproduce entire natural ecosystems placing plants such as those growing on the seashore, swamp, and other fresh water bodies. The idea derived a view that aquarium should display the whole life mode of the verious organisms, but not merely display of different species of animals.

Apart from the aquarium in the sense of ordinary uses, there are 'oceanarium' and 'marine land' operated under commercial enterprises

located in the semi-tropical land with clear water available. They have huge pools or tanks filled with seawater directly pumped up from the sea to exhibit the schools of dolfins, smaller whales, and migratory fishes such as skip jack and tuna. The system attracts the public by the tricks performed by the aquatic animals or often under water show by girl divers. Such marine land and oceanarium are distinguished from the ordinary aquarium, but they also contribute to public education, because, without huge tanks as those, big fishes like skip jack and tuna will not be kept successfully for an extended period.

In Japan, a group of aquariums were constructed as the facilities connected to the marine laboratory of national universities, most of them appeared between the end of 19th century and the beginning of 20th century. At present about 100 aquariums are opened to the public under the management of both public and private organizations. In recent year there is a tendency that the tanks are constructed bigger in size, and many aquariums have such large tanks for migratory fishes carring as much as 1,000 tons of water.

THE FUNCTION AND ROLE OF THE AQUARIUM

Human beings instinctly become impressed and fascinated when they find and face the 'nature'. The primary reason for the existence of zoos and aquariums today may be attributed to this fundamental human nature. However, the public are believed to have different impression, when they meet the zoo and aquarium. It is natural that they are more familier with the terrestial mammals in the zoo often even trying to play with them. On the other hand, fishes never show kinship as animals on land, and are not personified as the latter, because they are observed only through a glass window. With the concept as above the aquarium may be said to carry the function of a device for education of public.

From the function of it, the objectives of the acquarium may be categorized as follows:

1. the entertainment or recreation
2. the promotion and dissemination of biological knowledges and interests
3. the scientific research under large-scale rearing facilities.

Further the aquarium located near large cities are functioning as a medium to demonstrate and advocate conservation of nature against the water pollutions caused by urban industrial discharges.

All these facts as to the function of aquarium must be analysed carefully before the planning, and the function must be defined as clearly as possible based on the status of the general social characteristics of the region or country where they are projected, as well as jurisdiction under which it is placed. It may not be exaggeration to conclude, therefore, that the function of the aquarium, if left vague,

will not only make the planning obscure but also result the management extremely difficult, because the management either successful depends on the morale of the personnel running the aquarium.

It may be preferable to effect the idea that the aquarium is the place where the beauty of nature is simply displayed with the possible minimum presentations in quantity rather than to simulate museum system in which extensive exhibitions are demonstrated as if they are playing a role in the education of public.

From such a point of view, the design of the surroundings such as building, tanks and illumination must be well considered and made to create the harmonizing general atmosphere with the living organisms in the water. For the educational purpose alone some special displays should be made based on the researches and experiments actually conducted in the aquarium. Guide book of high standard will be necessary.

WATER CIRCULATION SYSTEM IN THE AQUARIUM

Aquatic organisms excrete their metabolic wastes into the tank water. In natural environment such organic matters thus excreted are decomposed by bacteriological function and some are absorbed by plants. In fresh water tanks such natural cycle of nitrogen can be effected by placing plants inside, which are properly illuminated. This is called a balanced aquarium. However, sea algae are usually hardly kept in fish tanks for an extended period, therefore, it is necessary to provide other procedure to keep the water uncontaminated.

There are several methods for the purpose. The filteration method usually adopted in the aquarium is called biological filtretion. The nitrogen compounds contained in the water, and uneaten remaining feeds, are decomposed by bacteria, firstly into toxic ammonia then to nitrites and finally to non-toxic nitrogen for the fishes in the water. While the water passing through sand layers in the filtration tank, ammonia is changed into nitrates and removed by the biochemical processes as noted above.

There are at present two types of water circulation systems. One is called closed system, where same water is circulating again and again in the system through purification effected by filtering materials placed in the filtration tank. The other is called open system, where water is pumped up into the tanks from the sea and the water used is returned to the sea. Recently, the open system is not much in use, since the uptake of sea water by pumping is often greatly restricted by the weather condition and the polution of coastal water. While, closed system is adopted in many aquariums, because of the reasons that not only water is economized but also the temperature and other qualities of the water could be kept stable, thus, allowing to keep fishes under unchangable conditions.

It is usually to see that more than one water systems are equipped

in order to provide waters of different temperatures as required by different organisms. By dividing the water circulation into a number of systems animals are allowed to live in their optimum condition and, at the same time, the infectious diseases if occurred are prevented from their contamination into other tanks in the other systems. Ideally, each tank should have its own filter as well as heat exchanger despite of its control and maintenance being laborious. The circulation systems whether closed or open should be carefully determined by considering the planning of the display, arrangement of tanks, possible rearrangement of them, future development of the aquarium in scope, and so on.

In the closed system aquarium, there are several types of filters; 1. Open sand filter, 2. Closed sand filter, and 3. Balanced circulation system (where the water is lifted by air but not by pumps). Each one of filters above, however, has merits and demerits, and choice of the types will be made according to the characteristics of the organisms in the tank. It is one of the general rules that before entering into the filter tank, the water drained out of the fish tanks will be led into the precipitating tank which has capacity to contain about the same amount as that of the total fish tanks in one circulation system. By such system the filter can be used longer since larger debris are precipitated in the precipitating tank, which can be removed. The water circulating in the system for considerable periods become yellowish in colour due to humic acid derived from diatom growing on the tank wall. As the water should be as clear as possible for the observation through glass, the humic acid must be absorbed by carbon activated or bone ash. For this purpose, the additional water route leading to the absorbent tank is placed between the filter tank and fish tanks. If chlorine is added to the water for sterilization and cleaning purpose another absorbent tank will become necessary to remove chlorine.

Practical design of water system must be discussed in details with the specialists. It is ideal to see that the whole circulation system including pumps, filters and tanks should be duplicated so that one system can be sustained for cleaning and maintenance purpose, while the other is operating.

BASIC CONCEPT OF DISPLAY AND THE KINDS OF ANIMALS

When the new aquarium is planned the questions such as what kinds of animals will be kept and how they are arranged for display should be considered to begin with. The display must show tidy when the aquarium is first opened but, at the same time, it must be left flexible for enlargement in future, because the display will have to grow larger continuously as times go on. However, the sizes of the water tanks, their arrangement and water systems once fixed are not easily changed, accordingly, every future possible changes must be counted at the first stage of the planning.

The main point of serious consideration is how to deal with the

display of 'ecosystem' and the presentation of species. Concerning the display of ecosystem there seems to be several problems. As observed in contemporary museums which have been trying to display the condenced models of nature in its small space (Georama) but so far without much success. Reproducing the ecosystems in the water tank will require tremendous amount of tasks. However, it is remained that ecological display, the peculiar behaviors of the organisms such as spawning of fish could be shown quite effectively, on the other hand, the mere presentation of kinds of animals the typical species with phylogenetical significance could be assembled. Since different species of animals have different appearance, the display of those is attractive and showy. Especially, speaking of freshwater fishes, so-called fossil-fishes occurring in each continent are worth exhibiting, for example, Gar-Pike, Sturgeon, and Amia in North America, Lepidosiren in South America, Neoceralodus in Australia, and Protopterus and Polypterus in Africa, are greatly apart taxonomically from the main groups of fishes at present.

The conclusive statement derived under the circumstances will be that the best arrangement will be obtained by a balanced combination of the ecological and taxonomical displays.

Depending on the scope of the aquarium the inclusion of animal groups to be displayed will be varied, though the following lists will show animals generally appeared in contemporary aquariums in the world.

1. Marine invertebrate animals
2. Marine fishes
3. Freshwater fishes
4. Amphibians
5. Reptiles
6. (Penguins and sea birds)
7. (Dolfins and whales)

Though marine invertebrates and fishes will play main roles in display, amphibians, reptiles, and others are preferably included for the better understanding of its phylogenetical relation to the lower vertebrates or fishes. Since groups 6 and 7 above need special facilities separated from those for fishes, they may be excluded in consideration at the start though the site for future construction is better reserved in the premises of the aquarium.

Concerning the marine invertebrates and sea fishes, a collection of the representative species distributed in the Arabian Gulf will be quite sufficient.

Freshwater fishes, as mentioned before, contain many indispensable species for the display, and every effort should be made to obtain them.

The fish fauna of the Nile and the Tigris and Euphrates may be introduced in the display prepared at a special corner if possible.

The sizes and number of the water tank necessary to keep the organisms expected to be collected are as follows:

1) Marine invertebrates

Since some of the marine invertebrate animals are specially sensitive to unclean water and also since many of them become prey for fishes they should not be kept together with fishes. Also, independent water circulation systems will be necessary for them. The possible species to be collected from the Arabian Gulf for display are as follow: 1) Octopus 2) Sea squid 3) Coral and sea anemone 4) Jellyfish 5) Shrimp 6) Crab 7) Starfish 8) Sea urchin, etc. Needless to say the larger the size of the water tank, the better for the living conditions for these organisms. However, it is pointed out that tiny organisms in it gives incompact impression to observers. Naturally large organisms are put in water tanks of large capacity and vice versa. The water tanks for invertebrate animals are not required high in dimension since many of them, except jelly-fish, live attached to the bottom and since the attention of visitors will be lessened if there is a wide water mass lying above the animals. Tanks for octopus and sea squid may be 1 m in width, 1 m in depth and about 80 cm in the height of water. Other tanks may measure about 1 m x 1 m x 50 cm. Total number of tanks necessary will amount around 5 for display, and 5 for reserve.

2) Marine fishes

About 300 species of fishes are reported from Arabian Gulf, and since they contain most of the representative species of sea fishes there will be no difficulties in the selection and collection of specimens.

As many species as possible from each family explained in 'Fishes of Kuwait' will be taken for the display.

The species arrangement of local marine fishes tends to be monotonous since about 70% of them belongs to Perciform well resembling from one species to another in appearance. Accordingly several dynamic display of fish schools in large tanks for instance is recommended.

The number and sizes of fish tanks to show local marine fishes are discussed as follows in the knowledge of the fish fauna along the coast of Kuwait. As sea fishes are believed eventually the main displays of the aquarium at Kuwait, further elaborations will have to be made.

a) Large tanks

An attractive and dynamic display should be placed at the entrance of the aquarium as an introduction into the aquatic world. Recently the development of acrylic pane, which replacing glass, made its use for the

tanks more than 700 tons in capacity. Though the larger size of tank is not always the better, it certainly impresses visitors irresistibly. However, the effective size and shape for the display of animals are to be considered as one of aquarium management method. The common shape of the large water tank is round or doughnut shape for smooth circulation of the water in tank. It is possible to display in the same tank sharks, rays and larger migratory fishes living in the Arabian Gulf.

b) Medium size tanks

According to the writer's experience, a water tank 5 m wide, 2.5 m deep and 2 m in water height is believed to be most convenient both for observation and management of the tank. In a tank of this size, fishes living along the shore of Kuwait will be exhibited according to the different habitats as follows:

1. Fishes of coral reef
2. Fishes of rocky shore
3. Fishes of sandy bottom
4. Fishes of estuary
5. Others

A total number of 5 tanks will be sufficient for the purpose.

c) Small size tanks

Small fish may be displayed in larger tanks if they form shoals, if not, put in the small tanks. Several tanks will be necessary.

3) Fresh water fishes

Needless to mention that for the people in Kuwait, a better understanding of the fishes in the Arabian Gulf is more important. However, it is as important to learn about exotic fishes and to obtain general knowledge about the whole animal kingdom. Accordingly, efforts should be made for an adequate collection of fresh water fishes of the world.

Since fresh water fishes can be fairly well adapted to the small confined environments compared to the sea fishes also many of them small in size, the tank necessary for their accommodation does not require such large sizes.

The atmosphere of the native habitat is believed to be fairly well by placing water plants of their habitats in the fresh water tank. The design of the tank for successful display must be considered after the species to be displayed and their arrangement are decided, accordingly.

4) Amphibians

The aquarium will become rich in taste by showing amphibians and reptiles in their collection. Amphibians are divided into two groups: Salamanders (Caudata) and Frogs (Salientia) and majority of them are reared in the terrarium. The giant salamander which grows as large as one meter in length, occurring only in Japan and China, is one of the animals included in the aquarium collection. As many smaller amphibians feed on insects, special knowledge is required for their rearing. The display of frogs and salamanders may be started on a small scale until aquarium staff are trained for that purpose.

5) Reptiles

Sea snakes and sea turtles can be kept in the same tanks with fishes. However, sea turtles are preferably placed in the outdoor pool or in the water tanks with independent water circulation system as they discharge profusely and easily spoil the water. Also, reptiles living along waters such as alligator and fresh water turtles may be added in the collection if space permits. The selection of terrestrial reptiles must be carefully made so as not to overlap the animals of Kuwait Zoo. The rearing of reptiles also requires special techniques and the aid of experts will be necessary at the beginning of the work.

THE BASIC STRUCTURE AND DESIGN OF WATER TANKS

The depth of water tank seen through the front glass appears to be shorter than the true depth by the refraction of light; this is similar to the phenomenon where people are hallucinated to feel the depth of water shallower than the actual. It is accordingly important to have a clever design by which the water tanks look spacious and deep. Though ideally the back wall should not be seen through the front glass, it is nearly impossible to make it in the limited space where water is required to be clear. Following points are fundamental to the design of tank:

1. The actual depth is permitted to be as deep as possible; 2. The back wall is smooth and a little concaved; 3. The decorative materials are placed only near the front glass; 4. The wall of tank is coloured in several grades in shade so that the brightest colour comes near to the front glass and the darkest to back wall; 5. Illumination is also decreased with the depth.

For the wall of the tanks, abstractive design by fine sculptors seems to show better effect than placing natural stones or artificial rocks modelled from the nature. The basic design as noted above is held for the tanks of both fresh water and marine fishes.

On the other hand, the tanks must be constantly taken care of to maintain the good environmental conditions so that they are in the shape

of convenience for cleaning and other handlings, and the water should not become stagnent due to the uneven surface of the tank wall. Followings are key to the convenient maintenance of the tanks:

1. All the corner in the tank can be seen from the back stage.
2. Nets must be handled with ease in the tank for the transfer of fishes.
3. The cleaning of tank is done without difficulty.
4. Valves in the circulation system are operated with ease.

The passages behind tanks must be wide enough to place spare tanks and also to allow hand cart passing through. For the circulation of water it is important to see that the water flowing into the tank must move in the tank smoothly without any sort of blocking up. Accordingly the tank is so designed that the water supplied from the top and drained from the bottom. The explanation in details of the piping in the tank will be discussed elsewhere.

THE WORKS REQUIRED IN AQUARIUM OPERATION

Roughly speaking three types of works are needed: 1. rearing of animals; 2. maintenance of machines; 3. general affairs.

Many of the staff working on the rearing of animals are biologists who are required to be professional in these subjects as follows:

1) Collection of organisms for display

(a) Collection, (b) Purchase, (c) Exchange with other aquarium, and (d) Present of specimens.

2) Rearing

(a) Feeding, (b) Maintenance of tanks, (c) Control of water quality, (d) Checking up of diseases and their cure, and (e) Breeding.

3) Display and educational activity

(a) Presentation of explanatory cards and labels, (b) Planning of special exhibitions and their practice, (c) Rearrangement of the decorations and animals in the tanks, (d) Giving lectures to the public, and (e) Preparation of the guide book and pamphlets.

4) Researches

(a) Identification of species and taxonomic study,

(b) Improvements in the rearing methods and display,

(c) Joint researches with other research institutes, and

(d) Preparation of samples and collection of data.

More detailes for the management will be discussed later if necessary. To accomplish the works mentioned it must be considered at the state of planning, what kinds of facilities are needed in the aquarium, as examplified below:

(a) Material necessary for the collection of fishes

(b) Vehicles to carry living fishes

(c) A room for water analysis

(d) Freezers for storing the feeds

(e) A special room to set the water tanks for breeding

(f) A room to prepare the feeds

(g) A room to cure sick animals

(h) A workshop for preparing the display

(i) Laboratories for researches

(j) Office space or rooms to store data and specimens

FINAL REMARKS

There are various problems awaiting solution about the aquarium and there will be many opinions arising from different angles, specially on the function and role of the aquarium. The architects will throw interests in the artistic appearance of the building and tanks, and educators will insist public education toward the knowledges of natural science.

It is definitely stated that an unique and good aquarium will be created only through the discussions spent by the people of different fields, and the ideas held by conservative specialists will never bring such an ideal aquarium.

** This part is mostly a duplication of the personal suggestions previously reported to Mr. Al-Mannai in 1972 by Yoshitaka ABE, a member of the mission. For the better understanding of PART ONE, the mission agreed to attach this part to the present report.

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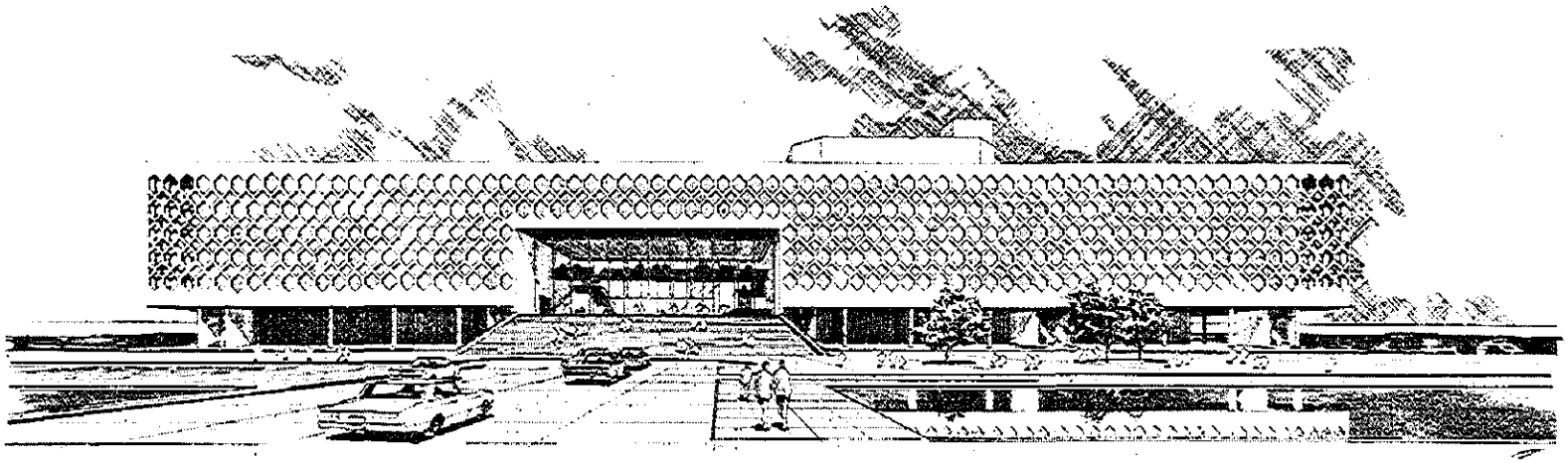

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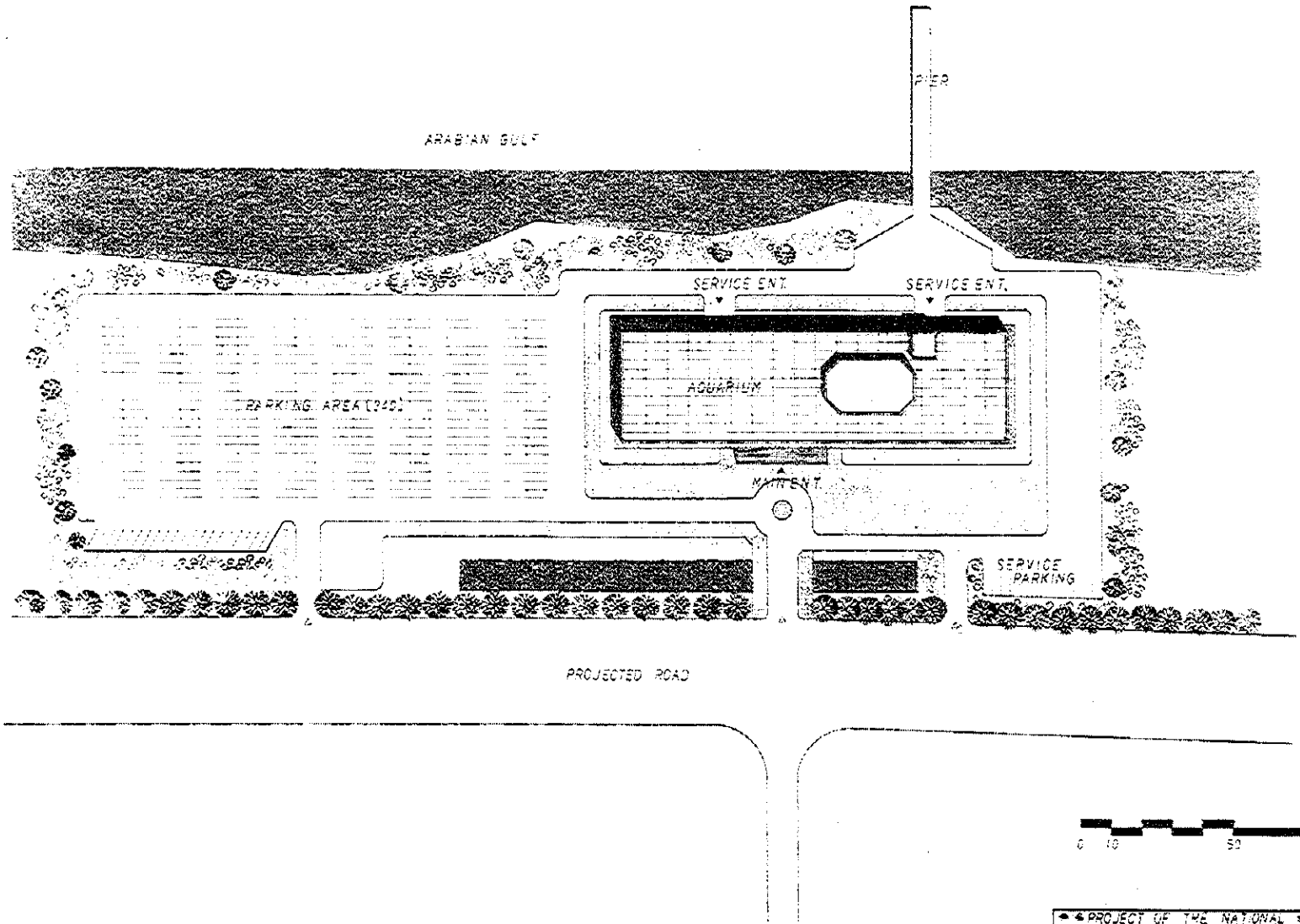
PERSPECTIVE



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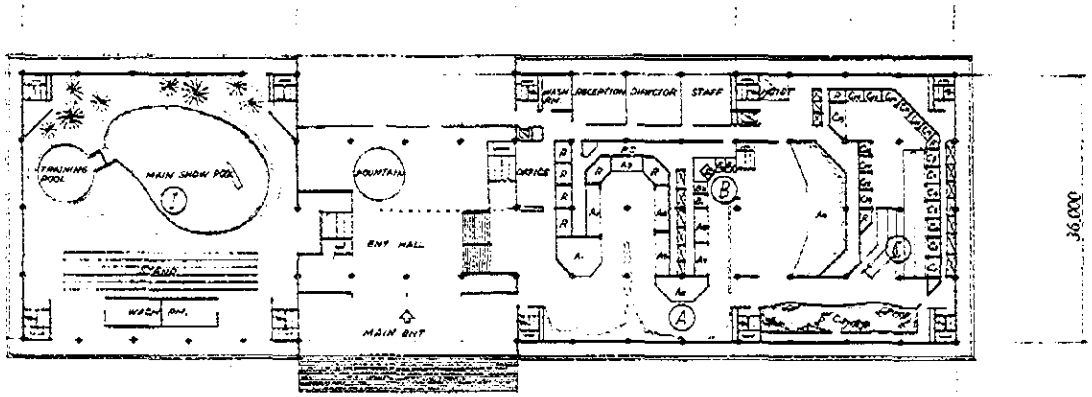
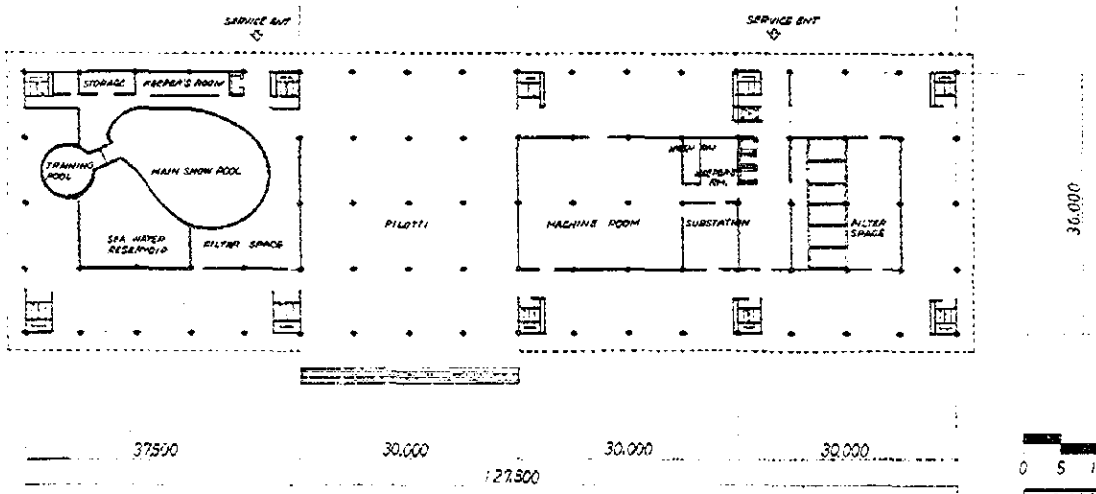
PLOT PLAN

2



1ST FLOOR PLAN



GROUND FLOOR PLAN

0 5 10 30 50m

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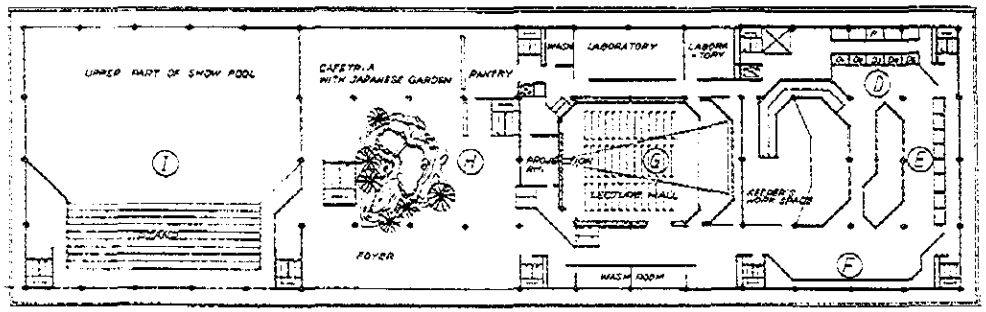
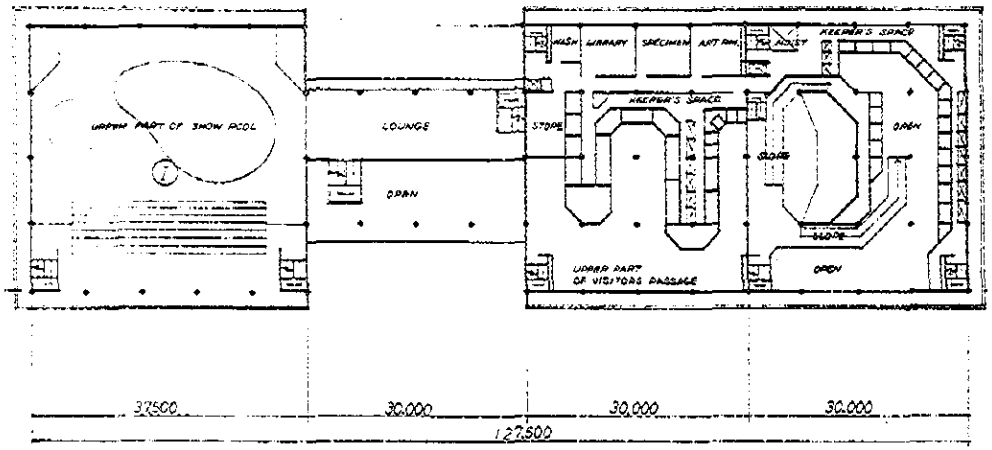
FLOOR PLANS NO. 1

3



3RD FLOOR PLAN



2ND FLOOR PLAN

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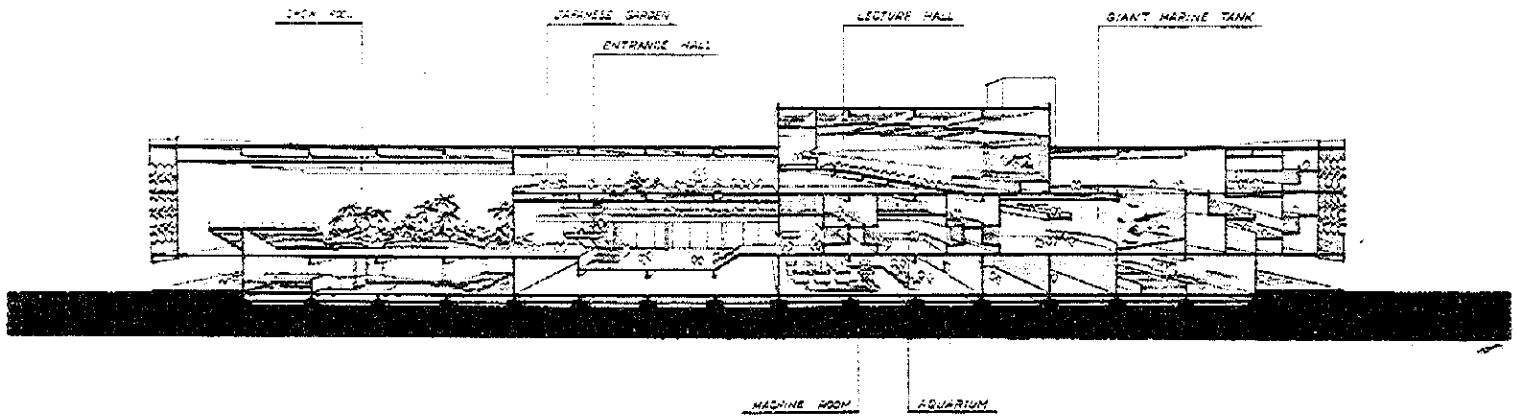
FLOOR PLANS NO. 2

4



PROJECT OF THE NATIONAL AQUARIUM OF KUWAIT

PERSPECTIVE SECTION

5