REPORT

ON

THE SURVEY FOR THE WATER SUPPLY WORKS IN IRAQ

MARCH 1964

OVERSEAS TECHNICAL COOPERATION AGENCY
OF JAPAN

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PREFACE

This Report is a summary of the records of the technical preliminary survey made by the Japanese Waterworks Survey Team in close cooperation with Iraqi Government authorities as a contributing effort toward the development of Waterworks in Iraq, as requested by the Government of the Republic of Iraq.

The Survey Team, consisting of seven expert engineers, was organized and dispatched by the Overseas Technical Cooperation Agency of Japan. The Survey Team made various surveys of the several waterworks sites and their related districts in cooperation with Iraqi Government officials and technical experts. They carefully made investigations and research into Iraqi waterworks, water sources, with tests of water quality. Also, a design was proposed for a central water laboratory, appropriate both technically and economically.

It is a great pleasure for our Overseas Technical Cooperation Agency, which has since its establishment in 1962 provided various technical cooperation of the Japanese Government, that this Report, made by our two countries in close cooperation, can be hereby submitted to your Government. It is our sincere hope that the recent survey will contribute to the development of the Iraqi Waterworks in the near future, and also to a better mutual understanding between our nations.

This preface is concluded with our deep respect and gratitude to the Iraqi Republic Government and its authorities, as well as the Iraqi people, who so kindly gave their fullest support and co-operation to the survey.

March 1964

Shinichi Shibusawa
Director General
Overseas Technical
Cooperation Agency

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Chief of Japanese Survey Team
for the Water Supply Works in Iraq

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I. Introduction

The Japanese Government, acting through the Overseas Technical Cooperation Agency of Japan (OTCA), dispatched a Survey Team of experienced waterworks engineers to Iraq in the fall of 1964. Thus, a liaison was effected between the two governments to further mutual friendly relations by a cooperative endeavor in the planning of waterworks construction in Iraq.

The Survey Team, consisting of seven engineers, visited Iraq for 42 days between October 19 and November 29, 1964, to conduct an intensive survey. The successful completion of this survey owed in large measure to the good offices and cooperation extended by the various concerned offices of the Iraqi Government. Consequently, the Team is now able to submit to the Iraqi Government, Part I of its survey report consisting of (1) the observations made by the Japanese engineers of the Iraqi water system, (2) the results of tests and studies made after their return to Japan, and (3) recommendations.

The Team has further prepared, as Part II of the survey, a detailed account of the waterworks in Iraq, which has been submitted to the Japanese Government and various related organizations to increase general understanding of Iraq in Japan.

Prior to the visit of the Survey Team, there was no information available in Japan on water systems in Iraq. Thus, the personnel of the Team were selected with the possibility in mind that it might be necessary to do working designs for waterworks construction in two or three cities of Iraq.

When members of the Team became aware of the problems regarding water quality, they attempted no more than a general definition of the problem based on tests at the sites. Rather, they gathered adequate samples of water for examination, and brought such samples back to Japan where they have been submitted to advance testing techniques in the Japanese Water Laboratory. The tests clarified various problems and have formed the basis for the opinions and recommendations contained in the present report.

It is the opinion of Japanese engineers that an Iraqi Central Water Testing Laboratory needs to be established in order that the water works of Iraq might attain independent status, and evolve according to the country's best interests. The Iraqi Waterworks Authority also was reported to realize keenly the necessity for such a laboratory.

Japan has excellent water testing laboratories of ultra-modern design, and Japanese techniques for designing such equipment are highly advanced. It is with confidence that this Report proposes (1) a basic policy including guiding principles and (2) a tentative plan for design of a Iraqi Central Water Testing Laboratory.

Japan thus hopes to contribute, even in a small way, to the future development of the Iraqi waterworks system.

II. Characteristics of Iraqi Waterworks as Viewed by the Japanese Survey Team

A. The Iraqi Waterworks and Their Water Source

The waterworks of Iraq proved to be far more advanced than the Japanese Survey Team had anticipated.

The Team was able to inspect the representative waterworks situated on the plains extending South from Baquba, where the river beds of the Tigris and Euphrates have a gentle gradient.

Furthermore, the Team acquired a knowledge of the available literature and data for Iraq regarding atmospheric temperatures, precipitation, humidity, evaporation, and the volume of the river flow on the Tigris and Euphrates river systems. As large quantities of well or underground spring water are used in Iraqi waterworks, qualitative studies were made of such water as well as of water at various points on the Tigris and Euphrates rivers, based on documentary data, and on the analyses of the various water departments and concerned governmental agencies of Iraq.

The Team brought to Iraq as much testing equipment and chemicals as the members could carry with them. They tested and made records of the water quality at the various locations inspected, confirming that a major problem for the Iraqi waterworks is the quality of available raw water. All raw water drawn from surface flow water has a high degree of permanent hardness due to a magnesium content. This fact tends to be overlooked because the total hardness does not greatly exceed permissible limits. However, magnesium hardness renders main water uneconomical for the user, and tends to be harmful to the health when used as drinking water over a long period of time. Therefore, it is important that research be conducted to improve the quality of water supplied by waterworks throughout Iraq.

During the irrigation season, the further the Euphrates River enters its lower stretches, the less satisfactory are its waters for use as raw water for waterworks, because of the increased salt content resulting from the irrigation drainage. The Team noted that the city of Samawa on the Euphrates River especially suffered from damage to water quality caused by irrigation drainage. The Team was informed that lithiasis disease was common among the population which drank this water.

The salt content of waters of the Tigris does not appear to be as high as that of the Euphrates River water. Salt content of waters of the Euphrates River system varies greatly with location, and season. Today, it is technically quite feasible to purity water so as to eliminate or greatly reduce hardness and saline content in the degrees found in the Euphrates and Tigris river waters. The problems involved are those of cost and ease of operation. The more expensive processes such as ion exchange should be limited to use as a final resort, as in desert areas, where sources of good quality water are nonexistent. In the plain regions where there exists a possibility of finding raw water, careful investigation of possible sources should be made over a wide area. It is economically preferable to deliver water through mains from a considerable distance rather than to use the ion exchange process. This conclusion is supported not only by results of the Team's water testing on-the-spot in Iraq, and by the subsequent testing of water samples in Japan, but also by the plan of the Water Section, Directorate

General of Planning and Design, of the Ministry of Municipal and Rural Affairs, to draw water for Samawa from a canal at Rumaitha.

The waters of the Tigris and Euphrates rivers are highly suitable for irrigation use, but cannot be considered of good quality as a source of raw water for the various waterworks.

Our Survey Team also brought back to Japan and tested samples taken from an artesian well near Akhaider Castle which served as an underground water source. The Team also inspected Blue Spring. Red Spring, and the Small Spring located at Ain Tamur. In Japan also, there are a number of springs or ponds, the waters of which reflect in various colors in the rays of the sun, due to their considerable sulfur content.

B. Purification Plants at Iraqi Waterworks

The Survey Team inspected as many purification plants as was possible during its 42-day stay in Iraq. All these plants were modern, employing sedimentation with coagulation as a pre-treatment prior to rapid filtration. The Team gave special attention to the filtration facilities in Iraqi waterworks.

The course of development of Iraqi waterworks can be understood by viewing the pioneer facilities of the purification plants for the city of Baghdad.

The Sarafiyah Purification Plant of the Baghdad waterworks was completed as early as 1925. The methods of purification for the public water supply include both the orthodox type gravity rapid filter and a horizontal pressure filter of a type designed for a factory water supply. The Shalchiya Purification Plant built soon afterward uses only the orthodox type of gravity filter. However, the Karadah Purification Plant completed in 1940 reverted to a design employing exclusively horizontal pressure filters. Finally, the Meshih Purification Plant completed most recently in 1959 is provided with gravity filters for two-thirds of the total capacity but is equipped also with pressure filters to constitute the lesser one-third of its total filter capacity. Most of the Liwa (regional) waterworks employ pressure filters, although there are gravity filters in a few of the most recent plants.

There are probably various reasons why the above two types of filtration have been used separately or in combination, but this practice is rarely seen in the waterworks engineering world.

For disinfecting water, all Iraqi waterworks have adopted a chloramin system, employing both chlorine and ammonia, and which is the most modern method. Large quantities of chlorine are used as a safeguard against the fluctuations in water quality attendant to filtration by the horizontal pressure system, followed by injection of ammonia to kill the resulting chlorine odor. However, in most cases, this system was not working effectively.

C. <u>Water Quality in Iraqi Waterworks</u>

Whether the raw water source be surface flow or underground water, the tap water is invariably hard water. And even though the total hardness be within permissible limits with only a low temporary hardness caused by calcium, there almost invariably exists a high permanent hardness due to the presence of magnesium.

Usually, even boiling tap water produces little improvement in the degree of hardness. An exception to this general rule is the Nassiriya waterworks, where the treated water is of good quality.

In contrast, the tap water furnished by the Samawa Waterworks actually has a salty taste. Raw water obtained from the lower reaches of the Euphrates River system has a troublesome content of salt in certain seasons.

Water from the shallow well of Akhaider has a large content of both gypsum and salt (NaCI) so that it is unsuitable for waterworks use.

A detailed report of the Survey Team's investigation of water quality is the various areas of Iraq is contained in the following chapter III.

D. The Distribution System for Iraqi Waterworks

Due to the flat topography of Iraq, all waterworks seen by the Survey Team employed boosting pumps to deliver water, and there was no instance of the employment of gravity flow. Elevated service tanks were used, standardized in sizes of 50 M.G., 25 M.G., and 10 M.G. Within the limits ascertainable by the Survey Team, it did not appear that the determination of capacities had been logically calculated from consumption curves of the served areas.

For forcing mains, imported steel pipe was occasionally used. However, cement asbestos pipe made in Iraq was mainly used for the distribution net piping. The Survey Team visited the cement asbestos pipe factory because the users of domestic made pipe appeared to lack trust and confidence in their product. The Team studied the fabrication methods employed, and the asbestos. Also, they brought back to Japan for careful study fragments of cement asbestos pipe which had proved unsuited for use. A brief summary of the conclusions reached by the Team is given in the following paragraphs.

1. The asbestos used in Iraq is undoubtedly of good quality, being even superior to that ordinarily used by first line makers in Japan.

2. According to test results using a sample fragment of pipe, the strength and general quality of the Iraq-produced cement asbestos pipe is about 80% that of Japanese-produced pipe. This is sufficient so that users may place justified trust and

confidence in the Iraq-made pipe.

However, manufacturing methods in Iraq, especially for the curing process, need to be changed and improved. Also, there still is room for studying the quality and characteristics of the cement used. In the field of design, the elimination of water hammers deserves more study. Finally, it would seem desirable to have an increased awareness that cement asbestos pipe requires special care and different methods of handling and transportation than cast iron or steel pipe.

III. Our Proposals

A. The Survey Team reached the conclusion that, in developing Iraqi waterworks system, first priority should be given to building a Central Water Laboratory.

The fundamental problem of Iraqi waterworks relates to attaining a suitably higher quality for potable water. Only on the basis of adequate testing of water can policy be correctly formed in regard to choice of water sources, the selection and design of purification plants and their proper operation.

B. There is a necessity to not only train larger numbers of staff engineers but also water engineering operators.

This program should be begun at once, establishing a training program based on personnel requirements for present waterworks capacity plus the additional facilities envisaged in the Iraq Five Year Plan.

C. Research should be effected to remedy the hardness of water supplied from the various Iraqi waterworks.

This problem is apt to be slighted because of the difficulties of finding a satisfactory solution, but from the standpoint of public health, implications of grave importance are involved.

D. The filtering process should be improved, and particularly horizontal pressure filters replaced by gravity filters.

Superficially, the operation of horizontal pressure filters may seem simple. But unevenness in quality of filtered water and the tendency toward operational failure due to overloading are serious drawbacks to use of this type. Horizontal pressure filters are unsuitable for public water supply, the prime requirement of which is consistent good quality. Particularly, it is undesirable to operate the filtration process while applying pressures higher than the minimum necessary pressure.

Iraq, which possesses spacious areas for erecting purification plants, and also has available a plentiful supply of domestic cement for such construction, should logically build gravity type filtration equipment.

IV. Tests on Water Quality from Various Water Supply Works in Iraq with Special Reference to their Improvement

A. Test Samples

The samples were gathered by the Japanese Waterworks Survey Team.

B. Test Results

Chart I: Tests of Water Quality of Samples from the Raw Water Sources and the Treated Waters of Various Water Treatment Plants

Chart II: Tests on Removal of Undesirable Impurities

Chart III: Tests on Treatment to Eliminate Hardness of the Water

Chart IV: Tests for Coagulation

The Survey Team made an investigation of the sites to determine the atmospheric temperatures, water temperatures, and pH values of Chart I.

All other data in the above charts were obtained from tests of water samples made at the Water Quality Testing Laboratory, Waterworks Bureau, Tokyo City.

C. Analysis of the Test Results

1. Concerning the Results of Testing Water Quality (Chart I)

An examination of filtered water and raw water gathered at various purification plants on the Euphrates River System shows marked fluctuations in turbidity of the raw water, ranging from 4.5 to 2,450 degrees of hardness. However, turbidity of filtered water (with the exception of the Hilla Purification Plant where the hardness factor was 56 degrees) measured less than 1 degree at all purification plants. Soluble evaporated residue measured 600 to 2,000 ppm, which is fairly large, while the pH value was 7.3 to 7.8, indicating alkalinity. This amount of alkali varied considerably from 116 to 195 ppm. The chlorine ions measured 98 to 763 ppm, and sulfuric acid ranged from 175 to 735 ppm, both representing marked fluctuations.

Again, the values for total hardness ranging from 300 to 735 ppm were rather high. Magnesium hardness ranging from 230 to 530 ppm, accounted for most of the total hardness.

It is thus evident that sulfuric acid ion and magnesium impurities form the main part of the soluble evaporated residue.

Test results for samples of both raw water and treated water gathered in Iraq indicate that the quantity consumed of potassium permanganate ($KMnO_4$)(with the single exception of the raw water sample from the Samawa Purification Plant which required 95 ppm) is limited at all purification plants to 5 ppm. These low consumption figures for $KMnO_4$ indicate that there are comparatively small quantities of organic matter in both raw and treated water.

Ammonium nitrogen, nitrogen nitrite, nitrogen nitrate, were not found in the test samples, indicating that organic matter contained in the water decomposes rapidly and is diluted to an unusual degree. This is evidently a special native characteristic of Iraqi water.

Summarized in the following paragraphs are results of tests made of the quality of filtered water at various purification plants, with special reference to the water quality standards of the World Health Organization.

(a) Mahmoudiyah

Chlorine ion is 270 ppm; sulfuric acid ion is 210 ppm and magnesium hardness, 250 ppm. All these values exceed the permissible limits of the WHO standards, but the water at Mahmoudiyah would be satisfactory for practical purposes provided the magnesium hardness is reduced.

(b) Hilla

Magnesium hardness alone tests 315 ppm, which exceeds the WHO permissible maximum total hardness of 300 ppm. Treatment is feasible to improve this factor so that it meets WHO standards.

(c) Suq-Ash-Shiyoukh

Tests of filtered water samples showed the chlorine ion to be 512 ppm; sulfuric acid ion, 612 ppm; totaled hardness, 535 ppm; and magnesium hardness, 390 ppm. These figures exceed by far the permissible limits of the WHO standards.

(d) Nassiriya

Only the magnesium hardness value of 230 ppm was above the desirable hardness value. In other respects, the filtered water met WHO standards.

(e) Samawa

Tests of the samples of raw water from this purification plant showed soluble evaporated residue to be 2,080 ppm, rendering this raw water unfit as a supply for the purification plant. However, the raw water at the Rumaitha Canal meets WHO standards except for the slightly excessive value of 240 ppm for magnesium hardness.

Records of the survey team show that during the irrigation season, the raw water used at the Samawa Purification Plant has a large saline content, and even the filtered water tests salty. This causes lithiasis sickness, and it would appear desirable, from the stndpoint of improving water quality, to draw water from the Rumaitha Canal raw water source.

(f) Sarafiyah, Karadah, Mesbih in Baghdad

The raw water for these three purification plants is taken from the Tigris River system. Both the raw water and filtered water samples tested in Japan showed an evaporated residual matter of less than 500 ppm, acceptable for good quality water.

The pH value of 7.6 to 7.8 indicates alkalinity. The degree of alkalinity of 147 - 155 ppm, the chlorine ion value of 72 - 98 ppm, as well as the sulfuric acid ion index of 156 - 186 ppm are all normal. Only the tests of magnesium hardness with values ranging from 180 to 240 ppm exceeded WHO standards in some instances.

The consumption of potassium permanganate tested 2.2

to 2.4 ppm for raw water, a value even lower than for waters of the Euphrates River system. Also, the presence of am- monium nitrogen, nitrogen nitrite, nitrogen nitrate were not evidenced in the tests, indicating that decayed material was remarkably minimal.

The conclusion is that although the magnesium hardness value is slightly high, the quality of the filtered water, furnished Baghdad from the above three purification plants utilizing raw water from the Tigris River system, generally conforms to WHO standards.

An investigation of spring waters shows that they are clear without turbidity, but evaporated residue exceeds 2,000 ppm.. Especially, chlorine ion tested 518 - 590 ppm; sulfuric acid ion, 690 - 2,500 ppm; and total hardness, 820 - 1,890 ppm. All these factors are so high that such water is not considered suitable as a source of raw water for water-works.

However, spring waters appear clear to the eye, are plentiful, and fluctuation in quality appears to be slight. When circumstances leave no alternative source of raw water other than spring water, treatment is feasible by ion exchange resin. Thus, spring water resources should be carefully conserved as a potential emergency source.

2. Data on Results of Tests to Remove Undesirable Impurities and to Eliminate Hardness

The magnesium hardness factor is high for all sources of water supply, and lowering this factor would considerably improve the quality of the filtered water. Therefore, the results of the tests are set forth in Chart II and Chart III, in such a manner that they can be easily studied and interpreted.

(a) The use of sodium hydroxide (NaOH) would act to eliminate hardness from water from both the Tigris and Euphrates river systems. However, the Euphrates River waters respond less readily to NaOH treatment than do the Tigris River waters, and would thus require the use of larger quantities.

(b) The use of carbonate of soda (Na_2CO_3) will successfully reduce hardness due to calcium but is not conducive to treating magnesium hardness (see Chart II-B)

(c) Tests of the use of calcium hydroxide, $Ca(OH)_2$, to reduce water hardness indicate that magnesium hardness is lowered but unfortunately, calcium hardness is increased (see Chart III-A).

(d) Fairly good test results in reducing water hardness were obtained by treating water samples simultaneously with 100 ppm each of carbonate of soda (Na_2CO_3) and calcium hydroxide ($Ca(OH)_2$). (see Chart III-B)

(e) Tests using zeolite showed both calcium and magnesium hardness are appropriately reduced. The use of zeolite appears to be highly practicable. Although testing was not done with ion exchange resin, results superior even to zeolite may be assumed with fair certainty (see Chart III-C).

Furthermore, if alkaline chemicals are used to eliminate hardness without neutralizing the residual alkali, sedimentation will occur when such water is boiled, rendering it unsuitable for use. This point should be given careful consideration.

3. Data on Results of Coagulation Tests

Kaolin was added to the water samples to reduce their turbidity to about 300 degrees, after which alum, calcium hydroxide and other chemicals were used (see Chart IV).

(a) Alum gave good results in coagulation used in amounts of 20 - 30 ppm.

(b) Results were not satisfactory when calcium hydroxide was used without other chemicals. However, good results were obtained by using 15 ppm of activated silica along with 100 ppm of calcium hydroxide. Limestone, the raw material for burnt lime, is plentiful in Iraq. Thus in instances that the turbidity of the raw water is slight, coagulation will probably be best effected by using activated silica and burnt lime.

4. Conclusion

(a) Filtered water provided from the Tigris River system is superior to that from the Euphrates River system. However, the water from either river contains excessive magnesium hardness.

(b) The three purification plants serving Baghdad (Sarafiyah, Karadah, Mesbih) — all of which draw raw water from the Tigris River system — are providing filtered water approximately meeting WHO standards. Moreover, the lowering of the magnesium hardness factor would further improve the quality of this water.

(c) The water districts served by the Euphrates River system may be summarized as follows:

(1) The filtered water supplied by Mahmoudiyah and Hilla does not fully meet WHO standards. However, by reducing

the degree of magnesium hardness, considerable improvement could be effected in quality.

(2) The raw waters used by the Suq-Ash-Shiyoukh and Samawa purification plants contain excessive amounts of salts. Suq-Ash-Shiyoukh might profitably obtain raw water from the Nassiriya water source, while Samawa should use the Rumaitha Canal source.

(d) Elimination of hardness may be accomplished by alkali chemicals. However, still better results may be obtained by using zeolite of ion exchange resin.

(e) The best coagulant for both river water systems is alum. Furthermore, it is desirable also to study the possibilities for using burnt lime (calcium hydroxide) and activated silica.

Chart I: Tests of Water Quality of Samples from the Raw Water Sources and the Treated WatersSources and the Treated Waters of Various Water Treatment Plants

Test Sample Bottle No.	1	9	7	10	13	12	11	3	6	8	14	4	5	2	15	16	17	18	19	20
River Water System: A. Tigris River B. Euphrates River	B	B	B	B	B	B		B	B	A	A	A	A	A	B					
Location at which Sample Was Taken	Mahmou-diyah	Mahmou-diyah	Hilla	Hilla	Suq-Ash-Shiyoukh	Suq-Ash-Shiyoukh	Nassiriya	Samawa	Rumaitha Canal	Mesbih	Mesbih	Mesbih	Karadah	Sarafiyah	Kufa	Under-ground Water	Under-ground Water	Under-ground Water	Under ground Water	Under-ground Water
Type of Sample	Raw Water	Filtered Water	Raw Water	Filtered Water	Raw Water	Filtered Water	Filtered Water	Raw Water	Raw Water	Raw Water	Raw Water	Filtered Water	Filtered Water	Filtered Water	Raw Water	Shallow Well	Spring Water	Spring Water	Spring Water	Deep Well
Date of Gathering Sample	10/28/64	10/28/64	10/28/64	10/28/64	11/11/64	11/11/64	11/12/64	11/12/64	11/12/64	11/14/64	11/11/64	11/11/64	11/12/64	11/12/64	11/17/64	11/17/64	11/17/64	11/17/64	11/17/64	11/17/64
Air Temperature (C°)	22	24	26	24	23	-	-	28	28	25	22	22	21.5	22	17.7	28	-	24	24	28
Water Temperature(Field Test)	19	21	19	21	17.5	23	23	22	18	17	17	17	17	17	15.5	24	25	25	25	25
Turbidity (Field Test)	100	-	60	-	-	-	-	350	100	6	10	-	-	-	-	-	-	-	-	-
Turbidity (Laboratory Test)	45	0.15	11	56	4.5	0.15	0.75	2,450	46	0.8	0.8	5.3	0.2	0.65	21	0.1	0	0	0	0.3
pH Value (Field Test)	7.5	7.3	7.3	7.6	7.8	7.6	7.7	7.5	7.5	7.7	7.7	7.7	7.6	7.8	7.5	7.1	7.4	7.3	7.3	7.3
RpH Value	7.5	7.4	7.3	7.6	-	7.6	7.7	-	7.5	7.7	-	7.6	7.6	7.8	-	-	-	-	-	-
Alkali Content (as $CaCO_3$ ppm)	145	116	131	117	120	123	119	195	120	152	147	157	150	155	118	122	168	172	176	174
Chlorine Ion (ppm)	166	270	150	150	404	512	98	763	166	98	85	98	72	98	178	518	590	569	575	525
Sulfuric Acid Ion (ppm)	232	210	190	205	405	612	144	635	175	156	180	186	162	172	210	2,500	690	750	750	1,100
Total Hardness (as $CaCO_3$ ppm)	370	330	395	385	500	535	300	735	310	330	270	325	285	320	390	1,890	830	820	880	985
Calcium Hardness (as $CaCO_3$ ppm)	75	80	75	70	130	145	70	205	70	90	90	95	80	70	215	1,300	385	370	425	595
Magnesium Hardness (as $CaCO_3$ ppm)	295	250	320	315	370	390	230	530	240	240	180	230	195	250	175	590	445	450	455	390
Sodium (as Na ppm)	75	82	58	75	232	276	55	390	75	56	53	72	55	52	86	264	328	276	75	268
Potassium (as K ppm)	3.2	3.1	3.1	3.2	5.1	5.8	1.6	1.3	3.2	1.6	1.6	1.7	1.6	1.5	3.2	26	26	25	25	22
Sodium/Potassium	24	26	19	24	45	48	34	30	23	34	33	42	34	36	27	10	13	11	3	12
Consumption of Potassium Permanganate (as $KMnO_4$ ppm)	4.8	3.0	3.0	3.6	4.0	3.6	2.0	95	2.6	2.2	2.4	1.6	2.2	2.2	3.6	3.6	3.4	3.6	3.8	5.2
Evaporated Residue (ppm)	728	627	643	636	1,252	1,498	440	7,596	709	486	484	508	486	485	672	3,650	2,017	1,956	2,009	2,131
Soluble Matter (ppm)	628	617	603	603	1,252	1,471	-	2,080	585	481	488	501	478	415	631	3,650	2,019	2,055	2,037	2,179
Conductivity (Field Test)	560	540	-	816	-	-	-	4,028	912	522	-	-	-	-	-	-	3,000	2,800	2,800	2,800
Conductivity (Lab)(UV/cm at 25°C)	940	840	820	805	1,620	1,850	705	2,800	820	690	670	740	705	740	1,100	3,320	2,660	2,680	2,600	2,760
Ammonium Nitrogen (ppm)	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none	none
Nitrogen Nitrite (ppm)	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Nitrogen Nitrate (ppm)	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"

Chart II: Tests on Removal of Undesirable Impurities

A. Tests of Treatment of Water Hardness with Sodium Hydroxide (NaOH)

1. Raw Water at Suq-Ash-Shiyoukh from the Euphrates River System

NaOH ppm	pH	Total Hardness as $CaCO_3$ ppm	Calcium Hardness as $CaCO_3$ ppm	Magnesium Hardness as $CaCO_3$ ppm	Sedimented Hardness as $CaCO_3$ ppm	Total Hardness Plus Sedimented Hardness as $CaCO_3$ ppm
0	7.8	500	130	370	-	-
1 x 100	9.6	340	78.5	261.5	178	518
2 x "	10.1	260	49.5	210.5	274	534
3 x "	10.7	140	37	103	-	-
4 x "	10.9	64.5	29	61.5	404	468.5
5 x "	11.5	18.5	15	3.5	466	489
6 x "	11.4	20.5	13	7.5	-	-
7 x "	11.7	18	12	6	-	-
8 x "	11.8	17	11	6	470	487
9 x "	11.9	17	11	6	-	-
10 x "	12.0	16	11	5	474	490
15 x "	12.3	16	11	5	-	-

2. Raw Water at the Mesbih Purification Plant from the Tigris River System

NaOH ppm	pH	Total Hardness as $CaCO_3$ ppm	Calcium Hardness as $CaCO_3$ ppm	Magnesium Hardness as $CaCO_3$ ppm	Sedimented Hardness as $CaCO_3$ ppm	Total Hardness Plus Sedimented Hardness as $CaCO_3$ ppm
0	7.7	270	90	180	-	-
1 x 100	10.6	142.5	37.5	105	144	286.5
2 x "	-	73	27	46	202	275
3 x "	11.6	23.5	12.5	11	254	289
4 x "	11.9	20	9	11	266	286
5 x "	12.1	19	9	10	266	285
6 x "	12.2	16	6	10	266	282
7 x "	12.3	14	7	7	266	280
8 x "	12.4	14	7	7	266	280
9 x "	12.5	13	8	5	266	279
10 x "	12.6	13	8	5	266	279
15 x "	12.7	13	8	5	266	279

B. Tests of Treatment of Water Hardness with Carbonate of Soda

Raw Water at Suq-Ash-Shiyoukh from the Euphrates River System

$NaCO_3$ ppm	pH	Total Hardness as $CaCO_3$ ppm	Calcium Hardness as $CaCO_3$ ppm	Magnesium Hardness as $CaCO_3$ ppm	Sedimented Hardness as $CaCO_3$ ppm	Total Hardness Plus Seimented Hardness as $CaCO_3$ ppm
0	7.8	500	130	370	-	-
1 x 100	9.3	390	140	250	100	490
2 x "	9.5	320	80	240	164	484
3 x "	9.8	300	55	245	182	482
4 x "	9.95	285	40	245	214	494
5 x "	10.1	270	35	245	214	484
6 x "	10.25	270	35	245	214	484
7 x "	10.35	265	30	235	214	484
8 x "	10.40	265	25	240	218	479
9 x "	10.45	265	25	240	218	483
10 x "	10.55	260	25	235	225	485
15 x "	10.75	250	20	230	240	490

Chart III: <u>Tests on Treatment to Eliminate Water Hardness</u>

A. Test of Treatment of Water Hardness with Calcium Hydroxide ($Ca(OH)_2$)

Calcium Hydroxide ppm	pH Value	Total Hardness as $CaCO_3$ ppm	Calcium Hardness as $CaCO_3$ ppm	Magnesium Hardness as $CaCO_3$ ppm
0	--	500	130	370
1 x 100	7.2	395	155	240
2 x "	7.9	385	170	215
3 x "	9.2	375	265	110
4 x "	9.6	385	340	40
5 x "	11.1	460	435	25
6 x "	11.3	570	495	75
7 x "	11.6	740	680	70
8 x "	12.0	850	740	-
9 x "	12.1	915	880	30
10 x "	11.8	940	910	30

B. Tests of Treatment of Water Hardness with Sodium Hydroxide (NaOH) and Calcium Hydroxide ($Ca(OH)_2$)

Sodium Hydroxide ppm	Calcium Hydroxide ppm	pH Value	Total Hardness as $CaCO_3$ ppm	Calcium Hardness as $CaCO_3$ ppm	Magnesium Hardness as $CaCO_3$ ppm
0	0	-	335	150	185
100	100	10.6	135	65	70

C. Tests of Treatment of Water Hardness with Zeolite

Zeolite layer	5 cm
Filter speed	14.4 m/day
Source of test water	Filtered water from Suq-Ash-Shiyoukh, Euphrates River System

	Total Hardness as $CaCO_3$ ppm	Calcium Hardness as $CaCO_3$ ppm	Magnesium Hardness as $CaCO_3$ ppm
Before Filtering	535	145	390
After Filtering	210	120	90

Chart IV: Tests for Coagulation

Data on the test water: Kaolin was added to raw water from Suq-Ash-Shiyoukh, on the Euphrates River system, so that turbidity was approximately 300°.

Conditions of treatment:	150 rpm	3 minutes
	50 rpm	5 minutes
	Settling Time	10 minutes

A. Results Using Alum

Alum ppm	Residual Turbidity (degrees
10	7
20	3
30	2
40	1

B. Results Using Calcium Hydroxide

$Ca(OH)_2$ ppm	Residual Turbidity (degrees)
100	65
200	65
300	32
400	25

C. Results Using Calcium Hydroxide and Activated Lime

$Ca(OH)_2$	SiO_2 ppm	Residual Turbidity (degrees)
100	5	7.5
100	10	6.3
100	15	3.8
100	20	3.8

V. The Proposed Design for the Central Water Laboratory in Iraq

A. General

Based on its study of Iraqi water quality, the Survey Team has planned a water quality testing laboratory, which it considers ideal for conditions pertaining in Iraq. This planning includes detail designs and a detailed list of chemicals, sufficient to maintain and operate the facilities for two years. Also, all costs involved in establishing such a laboratory are summarized and attached for reference purposes.

These designs are both practical and ultra-modern, being based on the experience of actually constructing several water testing laboratories for the Tokyo waterworks in recent years.

B. List of Equipment and Chemicals for Qualitative Testing of Water

(Iraqi Water Laboratory Planning Data, March, 1965)

1. Instruments and Apparatus
2. Appliances and Tools
3. Glass Equipment
4. Reagents
5. Miscellaneous

1. Instruments and Apparatus

Item	Make or Type	Unit	Amount	Use
Direct Reading Balance	Shimazu, 100 g	set	1	For balancing drugs for chemical analysis, etc.
Photo-Electric Photometer	Hitachi FPW-4	"	1	For colorinetric analysis
Electrolytic Conduction Meter	Nippon Koden type	"	1	For estimating conductivity of water
Radiofrequency Titration Apparatus	Toa Denpa type	"	1	For volumetric analysis
pH Meter	Toa Denpa HM-5	"	1	For estimating pH value
Jar Tester	Iwaki, for 6 places	"	1	For determining dosage of coagulant
Electric Contrifuge	4 places for both 15 & 50 ml with 1/4 HP motor	"	1	For biological and chemical examination
Microscope	Olympus model DF-Bi-2, phase contrast	"	1	For biological & bacteriological examination
Electric Refrigerator	Hitachi, LC-70	"	1	For preserving bacterial medium
High Pressure Steam Sterilizer	Inner size, dia. 30 cm, depth 45 cm, pressure 2 kg/cm^2	"	2	For sterilizing bacteria medium
Hot Air Sterilizer	Inner size, 50x70x 45 cm Outer wall, steel Inner wall, stainless	"	2	For sterilizing glass tools for backterial examination
Electric Incubator	Inner size, 60x50x50 cm Standard type	"	2	For incubating bacteria
Camera	Nikon with micro-photographic apparatus	"	1	For photographing micro-organisms, etc.
Constant Temperature Bath	400x600x400 mm, Sensitivity $\frac{1}{2}$°C	"	1	For biological examination
Automatic Distillation Apparatus	5 l./hr, with mercury switch	"	1	For distilling water

Item	Make or Type	Unit	Amount	Use
Ammonia Distillation Apparatus	4 plates each 600 W heater	set	1	For distilling ammonia
Sieve Shaker	With time switch for 10 operations	"	1	For filter sand analysis
Electric Muffle Furnace	Max. 1,100°C, inner size 15x25x10 cm, with transformer	"	1	For gravity analysis, etc.
Drying Oven	Inner size 40x60x70	"	2	For drying glass bacterial testing equip.
Electric Low Temperature Incubator	Hirayama stainless steel	"	1	For BOD and low temp. incubation
Demineralizer	Organo-Monopet type	"	1	For water purification

2. Appliances and Tools

Item	Make or Type	Unit	Amount
Pharmaceutical Balance	Teraoka type, 1 kg	set	2
"	" 200 g	"	2
"	" 100 g	"	3
Spring Balance	4 kg	"	1
pH Comparator	SZK type, 6 ranges	"	1
"	" 2 ranges	"	2
Recording Thermometer	7-day type	"	1
Mercury Barometer	Fortin type	"	1
Rain Recording Gauge	7-day type	"	1
Maximum Thermometer	Rutherford	each	1
Minimum Thermometer	"	"	1
Maximum & Minimum Thermometer	Standard type	"	5
Aspiratory Hygrometer	August type	"	1
Tester		"	1
Stop Watch	Seiko 1/5 sec. scale	"	2
Anemograph	Weekly chart	set	1
Electric Water Bath	With 10 plates	"	1
"	With 4 plates	"	1
Automatic Heater	Engel type	"	3
Electric Drying Oven	Waver type	"	1
Standard Sieve	JIS, 10 sieves	"	1
Sample Divider	JIS, 6 mm aperture	"	1
Almite Dish	see specification sheet	each	8
Magnetic Stirrer	With 1/4 HP motor	set	1
"	With 1/8 HP motor	"	2

Item	Make or Type	Unit	Amount
Stirring Rod		each	1
Sliding Door Steel Cabinet	see specification sheet	set	12
Test Tube Holder	For 12 tubes	each	2
"	For 12 of 100 cc tubes	"	8
"	For 12 of 50 cc tubes	"	8
"	For 36 of 50 cc tubes	"	10
Burette Stand	For 4 burettes	"	3
Pipette Stand	Wood	"	4
Funnel Stand	Wood	"	4
Bunsen Stand	Iron	set	2
Burette Holder	Stainless Stell	each	5
Electric Hot Plate	Square type, 1.5 kw	"	10
Bunsen Burner	Tekle type	"	5
Burner for Handcraft		set	1
Tripod	Stainless Steel	each	2
Crucible Tong	Brass	"	2
"	Stainless Steel with platinum tip	"	1
Propane Gas Apparatus	see specification sheet	set	1
Hand Tools	23 varieties	"	1
Cork Borer	Table type, 12 pcs.	"	1
Water sampling Apparatus	500 cc capacity	each	1
Pettenkohr Thermometer		"	3
Blackboard		"	3
Vernier Caliper		"	1
Micrometer		"	1
Normal Hydrometer	19-piece set	set	1

Item	Make or Type	Unit	Amount
Alcoholmeter	3-piece set	set	1
Glass Cutter	With diamond	each	1
Nickel Dish	200 cc, dia. 9 cm	"	10
Platinum Dish	35 g, 100 cc	"	1
Curve Rule	30-piece set	set	1
Clock, Interval Timer	60-min. wall type	each	5
"	with electric switch	"	2
Shears		"	3
Sample Bottle Box		"	1
Sample Bottle Bag		"	1
Solder Tongs	100 w	"	1
Demineralizer	10 1/hr.	set	1
Petri Dish Sterilization Box		each	20
Pipette Sterilization Box		"	10
Test Tube Holder	Large size	"	6
"	Medium size	"	20
Test Tube Basket	Wire netting, square	"	12
"	" cylindr.	"	20
"	For incubation	"	6
Electric Constant Water Bath		set	1
Spray	Handy type	each	1
Pot	Dia. 30 cm	"	2
Thermos	Dia. 20 cm, H. 30 cm	"	1
Colony Counter	Nakamura Auto-type	set	2
Water Sampling Apparatus	Hailoute	each	20
Pipette Pan	"	"	2

Item	Make or Type	Unit	Amount
Suction Pump	Hailoute	each	1
Finger Sterilizer	Medium size	"	3
Slide Rule	Chemical Engr. type	"	2
Cork Press	Rotary type	"	1
Raincoat	see specification sheet	"	2
Developing Tank		"	2
Vacuum Pipe	With 6 cocks & 3 burette holders	"	1
Wash Basin		"	10
Pail		"	5
Watch		"	4
Wash Basin Stand		set	1
Bicycle		each	1
Folding Rule		"	2
Handy Centrifuge	With 2 tube holders	"	1
Microscope Illuminator	Nihon Kogaku	set	2
Objective Micrometer	For microscope	"	1
Ocular Micrometer	"	each	1
Plankton Net	For tap	"	4
Magnifying Glass		set	1
Sand Sampler	Large size	each	2
"	Small size	"	5
Slide Preparate Holder		"	5
Hand Computer	4-figure type	"	5
Sedimentation Tube Holder	For 10 tubes	"	5
Filtrability Measurement Apparatus		set	1
Mechanical Stage		each	1

3. Glass Equipment

Item	Make or Type	Unit	Amount
Automatic Burette	50 cc, colorless, with 2 1. bottle	set	3
"	50 cc, brown, with 2 1. bottle	"	3
"	25 cc, colorless, with 1 1. bottle	"	5
"	25 cc, brown, with 1 1. bottle	"	5
"	10 cc, colorless, with 1 1. bottle	"	10
"	10 cc, brown, with 1 1. bottle	"	10
Mohr Burette	50 cc, with blue line & cock	"	10
"	50 cc, brown, with cock	"	5
Volumetric Flask	2 1., colorless	each	3
"	2 1., brown	"	2
"	1 1., colorless	"	6
"	1 1., brown	"	3
"	500 cc, colorless	"	10
"	500 cc, brown	"	5
"	250 cc, colorless	"	10
"	100 cc, colorless	"	10
"	50 cc, colorless	"	10
Measuring Cylinder	2 1.	"	3
"	1 1.	"	5
"	500 cc.	"	5
Measuring Cylinder, with stopper	200 cc	"	20
Measuring Cylinder	100 cc	"	20
"	50 cc	"	10

Item	Make or Type			Unit	Amount
Volumetric Pipette	100 cc, hard glass			each	5
"	50 cc	"		"	5
"	25 cc	"		"	15
"	20 cc	"			5
"	10 cc	"			20
"	5 cc	"		"	10
"	2 cc	"		"	5
"	1 cc	"		"	5
Graduated Pipette	10 cc, hard glass			"	50
"	5 cc	"		"	10
"	2 cc	"		"	50
"	1 cc	"		"	300
Automatic Pipette	10 cc			"	1
Graduate	2 1.			"	2
"	1 1.			"	3
"	500 cc			"	3
"	100 cc			"	10
"	20 cc			"	10
Reagent Bottle, narrow mouth	10 1., colorless hard glass			"	3
"	5 1. "	"	"	"	10
"	5 1., brown	"	"	"	3
"	2 1., colorless	"	"	"	20
"	2 1., brown	"	"	"	10
"	1 1., colorless	"	"	"	100
"	1 1., brown	"	"	"	20
"	500 cc, colorless	"	"	"	100
"	500 cc, brown	"	"	"	30

Item	Make or Type	Unit	Amount
Reagent Bottle, narrow mouth	250 cc, colorless hard glass	each	50
"	250 cc, brown "	"	30
"	100 cc, colorless "	"	200
"	100 cc, brown "	"	30
"	50 cc, colorless "	"	20
Reagent Bottle, wide mouth	500 cc, colorless hard glass	"	30
"	250 cc, "	"	30
"	100 cc, "	"	30
Aspirator Bottle	10 l., colorless hard glass	"	6
"	5 l., "	"	3
"	5 l., brown "	"	2
Griffin Beaker	3 l., hard glass	"	10
"	2 l., "	"	5
"	1 l., "	"	20
"	500 cc, "	"	50
"	300 cc, "	"	50
"	200 cc, "	"	50
"	100 cc, "	"	50
"	50 cc, "	"	50
"	500 cc, thick glass	"	10
Erlemmeyer Flask	500 cc, hard glass	"	20
"	300 cc, "	"	40
"	200 cc, "	"	50
"	100 cc, "	"	50
Erlemeyer Flask, with stopper	200 cc, "	"	30
Flask	500 cc, round bottom	"	5
"	200 cc, "	"	5

Item	Make or Type	Unit	Amount
Bottle, narrow mouth	2 l., polyethylene	each	20
"	1 l., "	"	50
"	500 cc, "	"	50
"	250 cc, "	"	50
Separating Funnel	500 cc	"	5
"	200 cc	"	10
Test Tube	50 cc, for LB test	"	200
"	10 cc, "	"	500
"	1 cc, "	"	1,000
"	For sampling	"	500
"	For agar	"	200
Durham Tube	50 cc, for LB test	"	300
"	10 cc, "	"	800
"	1 cc, "	"	2,000
Automatic Medium Divider	9 cc	set	2
"	10 cc	"	2
"	50 cc	"	2
"	99 cc	"	2
Petri Dish	Dia. 9 cm	each	500
Sampling Bottle	100 cc, with metal cap	"	100
Pot with cap	500 cc	"	10
"	250 cc	"	10
Microscopic Staining Jar	Vertical type	"	10
Alcohol Lamp	130 cc	"	5
D.O. Measuring Bottle	100 cc	"	30
Incubation Bottle	250 cc	"	20

Item	Make or Type	Unit	Amount
Dilution Cylinder	1 l.	each	5
Filtering Flask	Witt type	"	2
Thermometer, Chemical	0-360°C, scaled in 1°C	"	5
"	0-200°C, scaled in 1°C	"	5
"	0-50°C, scaled in $\frac{1}{2}$°C	"	20
"	Alcohol 0-100°C	"	10
Specific Gravity Bottle	JWWA type	"	5
Colorimetric Bottle	30 cc, with stopper	"	100
Porcalain Evaporating Dish	Dia. 300 mm, 3 l., round bottom	"	10
"	Dia. 162 mm, 500 cc, "	"	10
"	Dia. 100 mm, 150 cc, "	"	50
"	Dia. 90 mm, 100 cc, "	"	50
"	Dia. 70 mm, 50 cc, "	"	50
Porcelain Crucible	25 cc, CC mark	"	20
Glass Filter	25G, No. 29	"	2
"	" No. 3	"	2
"	" No. 4	"	2
"	3G, No. 2 Crucible type	"	3
"	" No. 3 "	"	3
"	" No. 4 "	"	3
Porcelain Mortar and Pestle	Dia. 15 cm	"	3
"	Dia. 12 cm	"	3
Jar, Cylindrical	Dia. 30 cm, Depth 30 cm	"	5
Jar, Rectangular	30x30x30 cm	"	5
Gas Generator, Kipp	1 l.	"	2
Gas Washing Bottle	250 cc	"	5

Item	Make or Type	Unit	Amount
Spray Bottle	500 cc	each	10
Bottle, Washing, Polyethylene	500 cc	"	5
Filter Pump		"	10
Dessicator	Colorless, dia. 30 cm	"	5
"	Brown, dia. 30 cm	"	2
"	Colorless, dia. 15 cm	"	4
Filtering Flask	2 l.	"	2
Watch Glass	30 mm	"	10
"	80 mm	"	50
"	130 mm	"	50
Glass Funnel	105 mm	"	10
"	60 mm	"	20
"	45 mm	"	5
Ribbed Funnel	180 mm	"	3
Pipette Holder	With plastic cover, 12x50 cm	"	4
Pipetter Washing Apparatus	With siphon	"	2
Pipette, Komagome	With 5 cc rubber bulb	"	10
"	" 2 cc "	"	10
"	" 1 cc "	"	10
"	" 0.5 cc "	"	20
Slide Glass	With graduation	"	20
Slide Glass		box	5
Cover Glass	18x18 cm	"	5
Hole Slide Glass		"	1
Glass Vial	20 cc, with cork stopper	each	500
Griffin Beaker	5 l.	"	5

Item	Make or Type	Unit	Amount
Dropping Bottle	250 cc, colorless, with rubber bulb	each	20
" "	250 cc, brown, with rubber bulb	"	20
" "	50 cc, colorless, with rubber bulb	"	20
" "	50 cc, brown, with rubber bulb	"	10
Column for Ion Exchange	see specification sheet	"	10
Muffle		"	3
Triangle		"	5
Retort	1 l., for heating ammonia	"	10
Condenser		"	6
Color Comparison Tube	100 cc, JAWW type	"	50
" " "	50 cc, " "	"	300
Weighing Bottle	30 cc	"	10
Weighing Tube		"	10
Glass Tubing	Inner dia. 13.5 mm	"	10
" "	" " 10.5 mm	"	20
" "	" " 7.5 mm	"	50
Glass Rod	Outer dia. 7.5 mm	"	10
" "	" " 4.5 mm	"	10
pH Test Tube	5 cc, with graduation	"	100
Stopcock	Outer size 7.5 mm	"	20
Stopcock, three-way	" "	"	10
T-shaped Tube	" "	"	10
Centrifuge Tube	100 cc, with graduation	"	50
" "	10 cc, " "	"	100

4. Reagents

Item	Make or Type	Unit	Amount
Sodium Carbonate	Standard Reagent, 100 g	bottle	5
Sulfamic Acid	" 25 g	"	2
Sodium Chloride	" 500 g	"	1
Sodium Oxalate	Merck G.R., 500 g	"	1
Potassium Bichromate	" 100 g	"	3
Zinc	Standard reagent, 100 g	"	2
Potassium Chloride	Merck G.R., 100 g	"	3
Potassium Riphthalate	" 25 g	"	5
Sodium Borate	" 500 g	"	1
Hydrochloric Acid	Extra pure, 500 g	"	20
Hydrochloric Acid	Pure, 500 g	"	40
Sulfuric Acid	Extra pure, 500 g	"	20
"	Pure, 500 g	"	50
Nitric Acid	Extra pure, 500 g	"	5
Phosphoric Acid	Extra pure, 500 g	"	5
Acetic Acid	Extra pure, 500 g	"	5
"	Pure, 500 g	"	10
Hydrogen Fluoride	Extra pure, 500 g	"	2
Oxalic Acid	Extra pure, 500 g	"	6
Tartaric Acid	Extra pure, 500 g	"	2
Citric Acid	Extra pure, 500 g	"	2
Perchloric Acid	Extra pure, 500 g	"	1
Fuming Sulfuric Acid	Extra pure, 50%, 500g	"	1
Sodium Hydroxide	Extra pure, 500 g	"	15
Potassium Hydroxide	Extra pure, 500 g	"	5
Ammonia Water	Extra pure, 28%, 500g	"	10

Item	Make or Type		Unit	Amount
Barium Hydroxide	Extra pure, 500 g		bottle	10
Calcium Hydroxide	"	"	"	2
Cobalt Chloride	"	"	"	1
Sodium Chloride	"	"	"	5
"	Pharmaceutical Standard, 500g		"	5
Barium Chloride	Extra pure, 500 g		""	2
Aluminium Chloride	"	"	"	1
Ammonium Chloride	"	"	"	5
Calcium Chloride	"	"	"	1
"	For drying		"	20
Magnesium Chloride	Extra pure, 500 g		"	1
Stannous Chloride	"	"	"	1
Ferric Chloride	"	"	"	1
Potassium Bromide	"	"	"	1
Mercurous Bromide	"	25 g	"	1
Potassium Iodide	"	"	"	5
Mercuric Iodide	"	500 g	"	1
Sodium Fluoride	"	"	"	1
Potassium Fluoride	"	"	"	1
Mercuric Chloride	"	"	"	1
Silver Sulfate	"	25 g	"	1
Cupric Sulfate	"	500 g	"	3
Zinc Sulfate	"	"	"	1
Sodium Sulfate	"	"	"	1
Potassium Sulfate	"	"	"	1
Manganese Sulfate	"	"	"	2

Item	Make or Type	Unit	Amount
Aluminium Sulfate	Extra pure, 500 g	bottle	2
Magnesium Sulfate	" "	"	5
Ammonium Sulfate	" "	"	2
Ferrous Ammonium Sulfate	" "	"	1
Sodium Sulfite	" "	"	3
"	Pure, 500 g	"	15
Sodium Thiosulfate	Extra pure, 500 g	"	5
"	For photography	"	6
Potash Alum	Extra pure, 500 g	"	1
"	Pure, 500 g	"	5
Silver Nitrate	Extra pure, 500 g	"	1
Potassium Nitrate	" "	"	1
Ferric Nitrate	" "	"	1
Lead Nitrate	" "	"	1
Sodium Nitrite	" "	"	1
Potassium Nitrite	Pure, 500 g	"	1
Mercuric Nitrate	Extra pure, 25 g	"	2
Uranium Nitrate	" "	"	1
Potassium Phosphate, Monobasic	Extra pure, 500 g	"	6
" Dibasic	" "	"	2
Sodium Phosphate, Dibasic	" "	"	5
Ammonium Phosphate, Dibasic	" "	"	1
" Monobasic	" "	"	1
Sodium Acetate	" "	"	1
Ammonium Acetate	" "	"	1
Lead Acetate	" "	"	1
Sodium Carbonate	Extra pure, anhydride, 500g	"	3

Item	Make or Type		Unit	Amount
Sodium Carbonate	Pure, anhydride, 500 g		bottle	10
Calcium Carbonate	Extra pure, 500 g		"	1
Ammonium Carbonate	"	"	"	2
Sodium Ricarbonate	"	"	"	2
"	Pharmaceutical Standard, 500g		"	5
Potassium Ricarbonate	Extra pure, 500 g		"	1
Sodium and Potassium Tartrate	"	"	"	1
Sodium Arsenite	"	"	"	1
Sodium Sulfidt	"	"	"	1
Potassium Chromate	"	"	"	1
Potassium Dichromate	"	"	"	1
Sodium Dichromate	Pure, 500 g		"	3
Potassium Permanganate	Extra pure, 500 g		"	3
Potassium Cyanate	"	25g	"	3
Potassium Rhodanide	"	500 g	"	1
Potassium Ferrocyanide	"	"	"	1
Platinous Potassium Chloride	Extra pure, special grade, 1g		"	3
Potassium Chlorate	"	500g	"	2
Potassium Bromate	"	25 g	"	2
Ammonium Rhodanide	"	500 g	"	1
Ammonium Oxalate	"	"	"	1
Ammonium Bichromate	"	"	"	1
Ammonium Molybdate	"	"	"	1
Ammonium Persulfate	"	"	"	1
Ammonium Citrate	"	"	"	1
Ethyl Alcohol	Extra pure, anhydride 99.7% 500 g		"	10

Item	Make or Type	Unit	Amount
Ethyl Alcohol	Pharmaceutical Standard, 500g	bottle	20
Methyl Alcohol	Extra pure, 500 g	"	5
Ethyl Ether	" "	"	3
Amyl Alcohol	Pure, 500 g	"	2
Acetone	Extra pure, 500 g	"	2
Benzol	" "	"	3
Chloroform	" "	"	5
Agar Medium	100 g	"	50
Endo Medium	100 g	"	26
Brilliant Green Lactose Bile Broth	100 g	"	20
Eosin Methylene Blue Agar	100 g	"	10
Lactose Broth	100 g	"	75
Beef Extract	500 g	"	5
Polypepton	500 g	"	10
Lactose	500 g	"	10
pH Test Paper	B.T.B.	"	4
"	P.R.	"	4
"	Universal, 8 kinds	"	2
Bacterial Agar Powder	500 g	"	5
Bile Powder	25 g	"	5
Boric Acid	Extra pure, 500 g	"	3
Bromine	" "	"	1
Iodine	" 25 g	"	3
Zinc Powder	" 500 g	"	1
Zinc Granulated	Extra pure, anhydride, 500 g	"	1
Reduced Iron	Special quality powder, 25 g	"	3
Sulfur Crystals	Extra pure, 500 g	"	2

Item	Make or Type		Unit	Amount
B.T.B.	Extra pure, 5 g, Takeda		bottle	5
P.R.	"	"	"	1
B.C.G.	"	1g	"	1
T.B.	"	"	"	1
B.P.B.	"	"	"	1
N.C.P.	"	"	"	1
Methyl Orange	"	25 g	"	1
Phenolphthalein	"	"	"	1
-Naphthylamine	Merck G.R., 25 g		"	2
Sulfanilic Acid	Extra pure, 500 g		"	1
Phenol	"	"	"	1
"	Pharmaceutical Standard, 500g		"	10
E.T.A.	Extra pure, 500 g		"	1
Hydroxylamine Hydrochloride	"	25g	"	3
O-Tolidine Dihydrochloride	"	"	"	10
Zirconium Oxychloride	"	"	"	1
Alizarin S	"	"	"	2
Diphenylcarbazide	"	"	"	1
Diphenylcarbazone	"	"	"	1
Alminon	"	1g	"	2
Hematoxyline	"	5 g	"	2
Oxime	"	25 g	"	2
Hydroxylamine	"	"	"	2
Hypiridine	"	1 g	"	5
C-Phenanthrotine	"	5 g	"	1
Sodium Diethyldiethiocarbamate	"	5 g	"	22
Maleic Acid	"	25 g	"	2

Item	Make or Type	Unit	Amount
Dithizone	Extra pure, 5 g	bottle	2
Curcumin	" 0.1 g	"	1
Sodium Azide	" 50 g	"	1
Picric Acid	Pure, 500 g	"	1
Glycerin	Pharmaceutical Standard, 500g	"	3
Neutral Red	Pure, 25 g	"	1
Methylene Green	" "	"	1
Bismarck Brown	" "	"	1
Crystal Violet	" "	"	1
Eriochrome Black T	Extra pure, 25 g	"	1
Murexide	" 1 g	"	1
Indigo Carmine	" 5 g	"	1
Methyl Red	" 5 g	"	1
Fuchsin (Acid or basic)	Pure, 25 g	"	2
Methylene Blue	" "	"	2
Eosine (bluish or yellowish)	" "	"	2
Brilliant Green	" "	"	1
Metol	" "	"	10
Hydroquinone	" "	"	20
Safranin (T or bluish)	" "	"	1
Fluorescein	" "	"	3
P-Dimethylaminobenzaldehyde	" "	"	1
Salicylic Acid	Extra pure, 25 g	"	5
Kaolin	Pharmaceutical Standard, 500g	"	3
Galatin, Powder	" "	"	3
Pumice	Chemical grade	"	1
Active Carbon, Granulated	500 g	"	2
Active Carbon, Powder	500 g	"	1
Starch	Extra pure, 500 g	"	1

Item	Make or Type	Unit	Amount
Silica Cel	For drying, 500 g	bottle	5
Invert Soap	500 g	unit	10
Saponated Solution of Gresol	18 l.	can	1
Cedar Oil	25 g	bottle	2
Canada Balsam	25 g	"	2
Liquid Paraffin	500 g	"	5
White Soft Paraffin	Pharmaceutical Standard, 500g	"	2
Hard Paraffin	" "	"	3
Solution of Hydrogen Peroxide	Extra pure, 28%, 250 g	"	2
Sodium Peroxide	" 500 g	"	1
Magnesium Oxide	" "	"	1
Silicone Anhydride, Powder	" "	"	1
Arsenous Acid	Extra pure, 500 g	"	1
Mercury	" "	"	1
Amber Light IR 120	500 cc	"	1
" IRA 410	"	"	1
Soda Lime		"	1
Formalin	Pharmaceutical Standard, 500g	"	5
High Test Hypochlorite	500 g	"	20
Sodium Chlorite	1 kg	"	5
Mercurochrome	Pharmaceutical Standard, 25g	"	2
Oil Base Zinc Oxide	" 500 g	"	3
Carbon Tetrachloride	Extra pure, 500 g	"	5
Denatured Alcohol	18 l.	can	2
Xylene	Pure, 500 g	bottle	10
Petroleum Benzin	Pharmaceutical Standard, 500g	"	20
Thinner	" "	"	10
Dermatol	" "	"	5

5. Miscellaneous

Item	Make or Type	Unit	Amount
Bond VL	1 kg	bottle	1
Bleached Cotton Cloth	High quality, 10 m	bolt	10
Cauze	10 m	bag	10
Stopper Cotton	High quality	kg	60
Bamboo Basket	Dia. 30 cm	each	10
"	Dia. 15 cm	"	10
Oil Paper		sheet	200
Nylon Brush	Large size	each	20
"	Medium size	"	20
" te Brush	Small size	"	20
Burett		"	5
Pipette Brush		"	5
Ultra-Red Ray Lamp	375W HR-type	"	5
Clip		"	2
Magic Ink Pen		dozen	20
Soapless Soap	1.6 kg	can	10
Polishing Powder		bag	100
Soap		each	100
Match	10	pack	50
Cleaning Cloth		sheet	100
Absorbent Cotton	500 g	bag	5
Asbestos Wire Net		each	10
Water Test Report Forms		sheet	1,000
Above Forms for Duplicating		"	2,000
Monthly Water Quality Report Forms		"	1,000
Above Forms for Duplicating		"	1,000

Item	Make or Type	Unit	Amount
Chart Forms for Chemical Test Reports		Sheet	200
Chart Forms for Bacterial Test Reports		"	200
Forms for Chemical Test Reports		"	1,000
Forms for Bacterial Test Reports		"	1,000
Chart Forms for Test Reports		"	1,000
Report Forms for Bacterial Tests of City Tap Water		"	500
Above Forms for Duplicating		"	500
Section Paper	50 sheets	pad	30
Roll Rilm	35 mm	each	40
Electric Bulb for Printing	For Chlorobromide	"	5
" " Developing		"	5
" Enlarging		"	5
Printing Paper	250 sheets	box	5
Paper for Reprinting	100 sheets	"	3
Cellotape		each	10
Platinum Wire	With holder	"	5
Cartridge Paper	500 sheets	pack	4
Suction Bulb		each	5
Double Suction Bulb		"	20
Spoon, Stainless Steel	For reagents	"	10
Spoon	For medium	"	2
Tweezers, Bamboo		"	4
Negative Glass		set	5
Red India Ink		bottle	10
Sulfate Paper		sheet	100
Twine, Special		kg	2

Item	Make or Type	Unit	Amount
Scrub Brush		each	20
File	10 cm	each	20
Tweezers	Medium size	"	5
Photography Vats	3 assorted sizes	set	4
Filter Paper	No. 101, 60x60 cm	sheet	200
"	No. 2, dia. 11 cm, 100 sheets	box	5
"	No. 2, dia. 18.5 cm, 100 sheets	"	5
"	No.5A, dia. 11 cm, 100 sheets	"	5
"	No.5B, dia.11cm, 100 sheets	"	5
"	No.5C, dia.11 cm, 100 sheets	"	5
Shot	Associated sizes: 1g., med., sm.	kg	2
Rubber Stopper		each	1,000
Cork Stopper		"	1,000
" , Ball Type	5 cc, 2 cc, 1 cc assortment	"	100

C. Estimate Sheet of Construction Cost

Type of Construction	Item	Unit	Unit cost (fils)	Cost (fils)	Notes
1. Building	One-story Reinforced Concrete Structure Area: (9,000x8,000)+(8,000x 36,000)+(9,000x9,000)+ (3,000x6,000) = 459 m^2	459	39,000/m^2	17,901,000	
2. Water Laboratory	Cost Estimates for Equipment			6,234,550	Refer to attached detail sheet
	Cost Estimates for Light and Power	459	5,250	2,409,750	
	Cost Estimates for Air Conditioning and Sanitary Facilities			32,832,600	Refer to attached detail sheet
	Total:			59,377,900	

D. Cost Estimates for Equipment for Water Laboratory

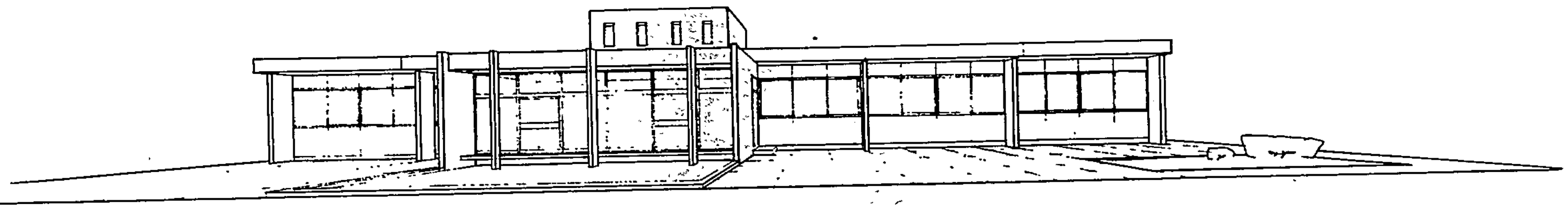
Category	Item	Quantity	Unit	Unit Cost (fils)	Cost (fils)
1. Office	Office Desk	6	unit	7,500	45,000
	Table and Chairs, for reception room	1	set		35,000
	Director's Desk	1	unit		25,000
	Chair	6	"	5,000	30,000
	Director's Chair	1	"		7,500
	Blackboard	1	set		2,500
	Cabinet	9	unit	27,000	243,000
2. Chemical Laboratory	Chemical Testing Counter	4	"	187,500	750,000
	Drawing Table, Work Tables (2) and Sink	4	"		135,000
	Low Sink	1	"		11,250
	Measuring Counter	1	"		117,750
	Instrument Cabinet	1	"		48,000
	Machine Closet	1	"		48,000
	Reagent Cabinet	2	"	42,000	84,000
3. Incubation Laboratory	Incubation Counter	1	"		172,500
	Incubator	2	"	195,000	390,000
	Low Temperature Incubator	1	"		195,000
	Sterilization Cabinet	1	"		45,000
	Electric Refrigerator	1	"		225,000
	Counting Table	1	"		112,500
	Cabinet	1	"		67,500
4. Popuration room for Bacterial Testing	Tool Cabinet	1	"		48,000
	Chemical Cabinet	1	"		48,000

Category	Item	Quantity	Unit	Unit Cost (fils)	Cost (fils)
4. Preparation Room for Bacterial Testing	Work Table, with sink	1	unit		157,500
	Work Table	1	"		127,500
	Draining Table, Horizontal Stand and Sink	1	"		84,000
	Desk	1	"		37,500
	Dryer	2	"	97,000	195,000
5. Biological Laboratory	Testing Stand, with cabinet	1	"		172,500
	Microscope Stand	1	"		120,500
	Breeding Table and Sink	1	"		97,800
	Drainboard, Work Table & Sink	1	"		117,000
	Tool Closet	1	"		37,000
6. Balance Room	Balance Table	1	"		52,000
	Desiccator Stand	2	"	52,500	105,000
7. Draft Chamber	Semi Draft	1	"		450,000
	Draft	1	"		525,000
8. Dark Room	Work Table and Sink	1	"		52,500
	Enlarging Table	1	"		45,000
	Enlarging Cabinet	2	"	12,750	25,500
9. Handicraft Room	Woodwork Table	1	"		48,000
	Metalwork Table	1	"		52,500
	Material Storage Area	1	"		60,000
10. Constant Temperature Room	Shelving	1	set		97,000
	Interior Finish	1	"		157,500
11. Material Storage Room	Shelving	1	"		72,750
12. Tool Storage Room	Shelving	1	"		225,000

Category	Item	Quan- tity	Unit	Unit Cost (fils)	Cost (fils)
13. Reagent Storage Room	Shelving	1	set		112,500
14. Dressing Room	Lockers	1	"		99,000
	Total (Categories 1 - 14):				6,234,550
15. Air Conditioning	Air Conditioner, switchboard with auxiliary wiring included, $67,500/m^2 \times 423\ m^2$				28,552,500
	Ventilation Equipment	1	set		600,000
16. Sanitation	Sanitary Fixtures, 1,950 x 423				824,850
	Water Supply, 2,250 x 423				951,750
	Drainage Facilities, 4,500 x 423				1,903,500
	Total (Categories 15-16):				32,832,600

*For dimensions, please refer to blueprints.

FIG. I PROPOSED DESIGN OF THE CENTRAL WATER LABORATORY



PERSPECTIVE ELEVATION

FIG. 2 PROPOSED DESIGN OF THE CENTRAL WATER LABORATORY

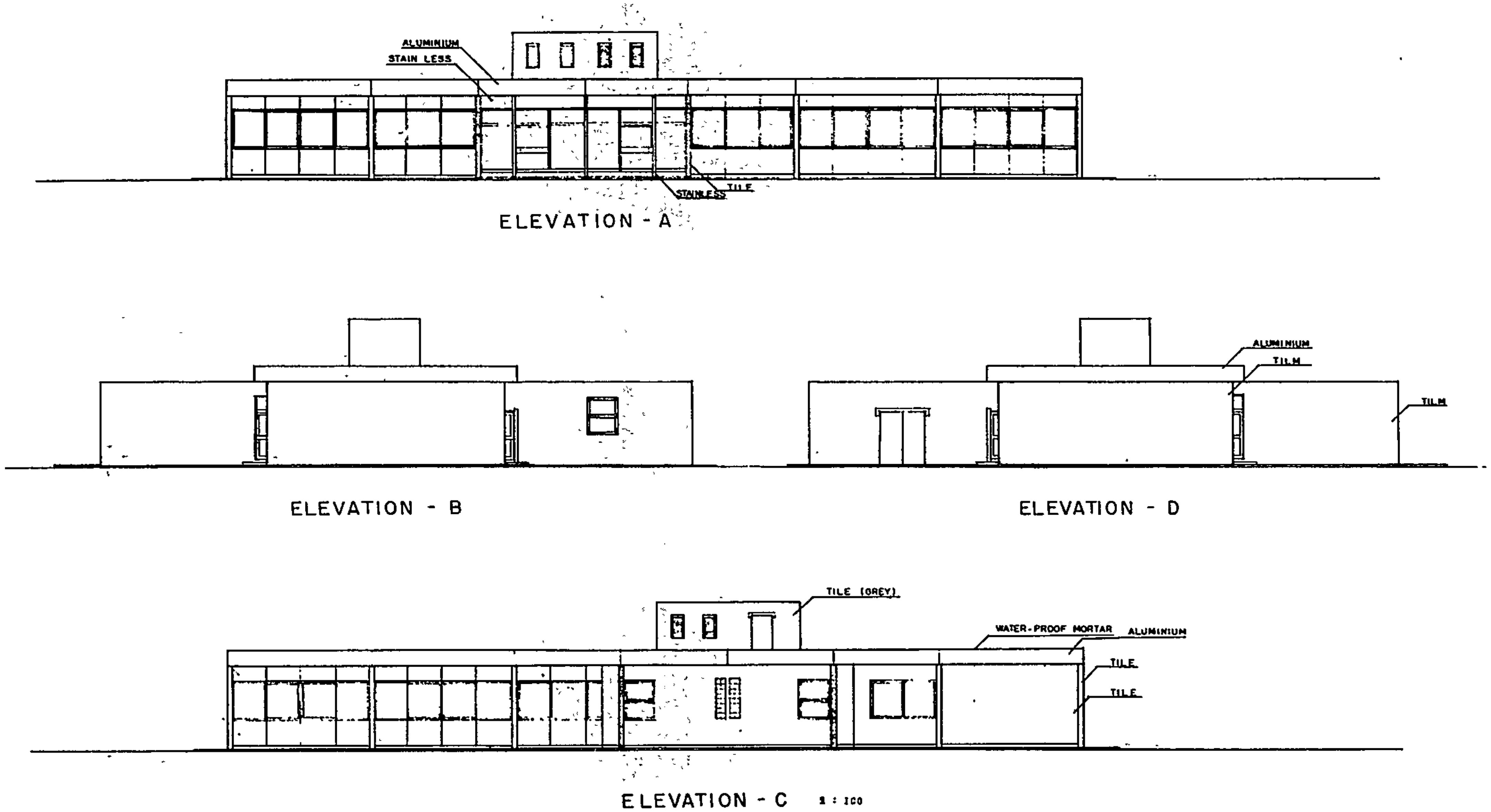
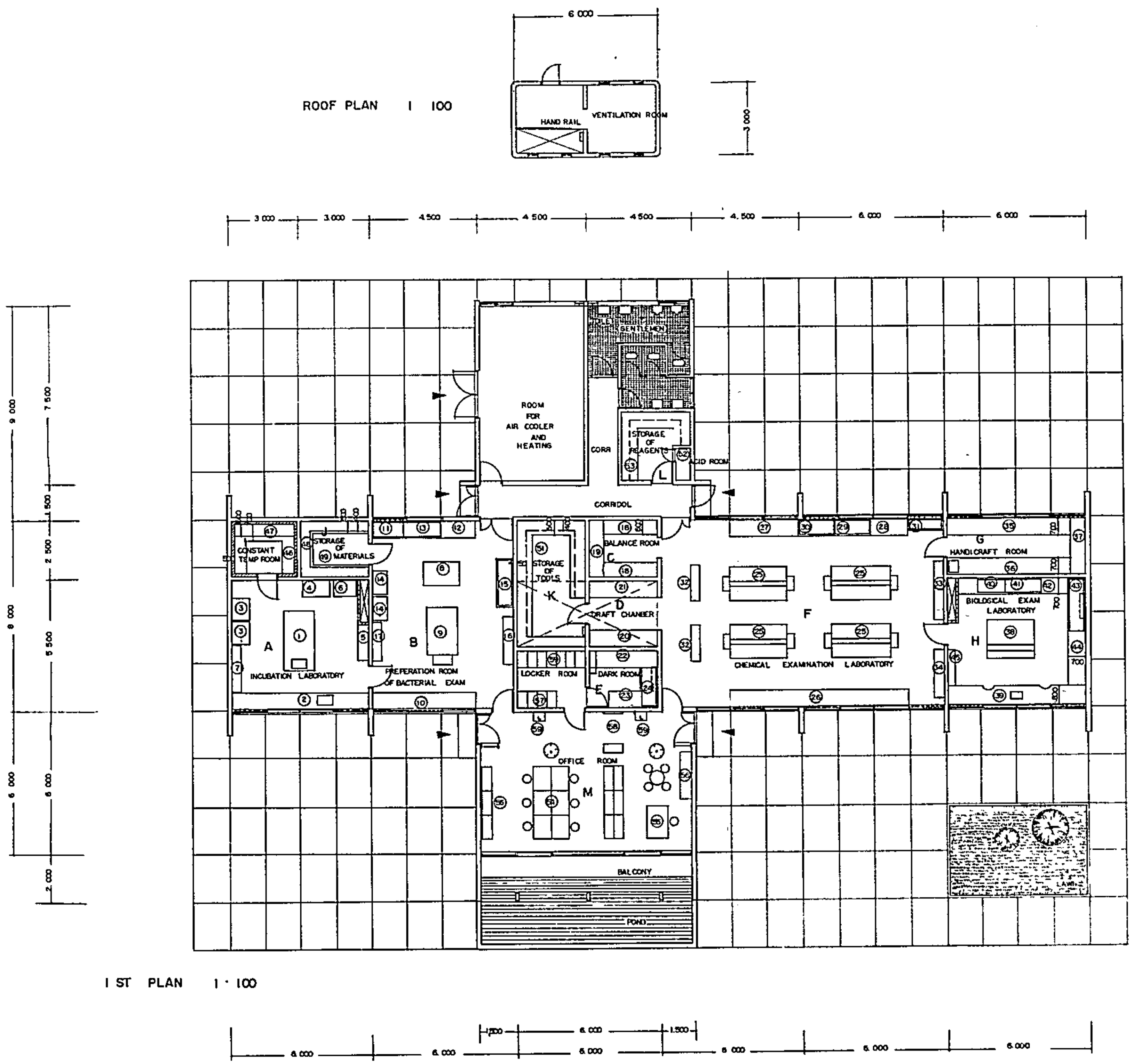


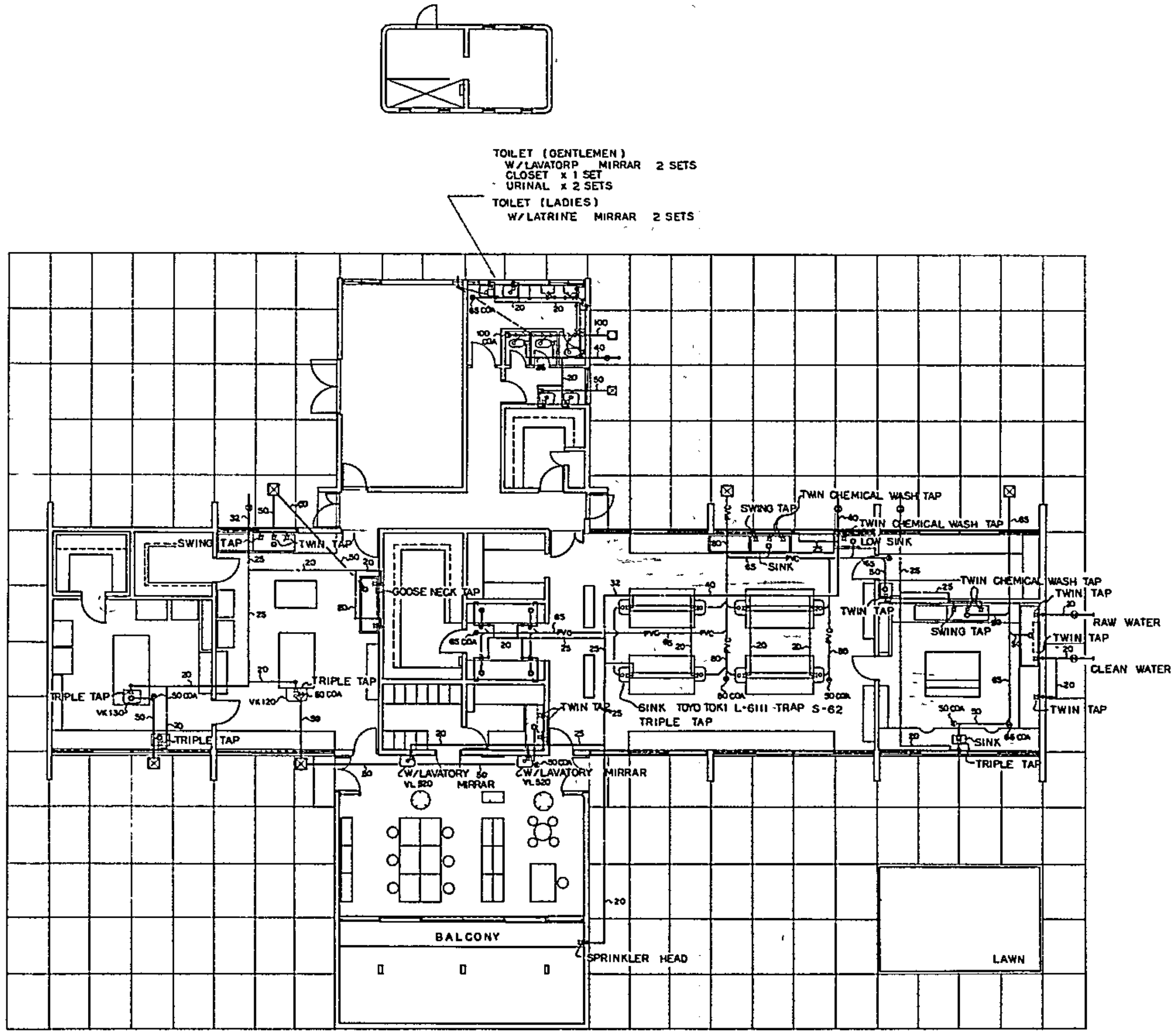
FIG. 3 PROPOSED DESIGN OF THE CENTRAL WATER LABORATORY

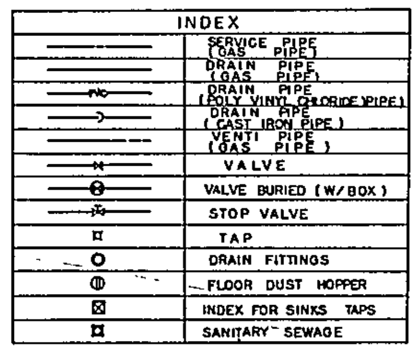


INDEXS

NO	FURNITURE
	A INCUBATION LABORATORY
1	INCUBATION COUNTER
2	COUNTING TABLE
3	INCUBATOR
4	LOW TEMP INCUBATOR
5	STERILIZATION CABINET
6	ELECTRIC REFRIG ERATOR
7	CABINET
	B. PREPERATION ROOM OF BACTERIAL TESTING
8	WORK TABLE WITH SINK
9	WORK TABLE
10	" "
11	DRAWING TABLE
12	HORIZONTAL STAND
13	SINK
14	DRY STERILIZER
15	AUTOCLAVE
16	CHEMICAL CABINET
17	TOOL CABINET
	C. BALANCE ROOM
18	DESICCATOR
19	BALANCE TABLE
	D. DRAFT CHAMBER ROOM
20	DRAFT
21	SEMI DRAFT
	E. DARK ROOM
22	ENLARGING TABLE
23	ENLARGING CABINET
24	SINK
	F CHEMICAL LABORATORY
25	TESTING COUNTER
26	MEASURING COUNTER
27	WORK TABLE
28	" "
29	SINK
30	DRAINING TABLE
31	LOW SINK
32	REAGENT CABINET
33	INSTRUMENT CABINET
34	MACHINE CLOSET
	G. HANDICRAFT ROOM
35	WOODWORK TABLE
36	METALWORK TABLE
37	MATERIAL STORAGE AREA
	H. BIOLOGICAL LABORATORY
38	TESTING STAND (CLOSET FOR BIOLOG SPECIMENS)
39	MICROSCOPE STAND
40	INCLINED DRAINBORD
41	SINK
42	WORK TABLE
43	BREEDING SINK
44	BREEDING TABLE
45	TOOL CLOSET
	I CONSTANT TEMP. ROOM
46	SHELVING
47	"
	J MATERIAL STORAGE ROOM
48	SHELVING
49	"
	K. TOOL STORAGE ROOM
50	SHELVING
51	"
	L REAGENT STORAGE ROOM
52	ACID DEPOSITORY
53	SHELVING
	M OFFICE
54	OFFICE DESK
55	DIRECTOR S DESK
56	CABINET
57	LOKER
58	BLACKBOARD
59	WASH STAND

FIG. 4 PROPOSED DESIGN OF THE CENTRAL WATER LABORATORY

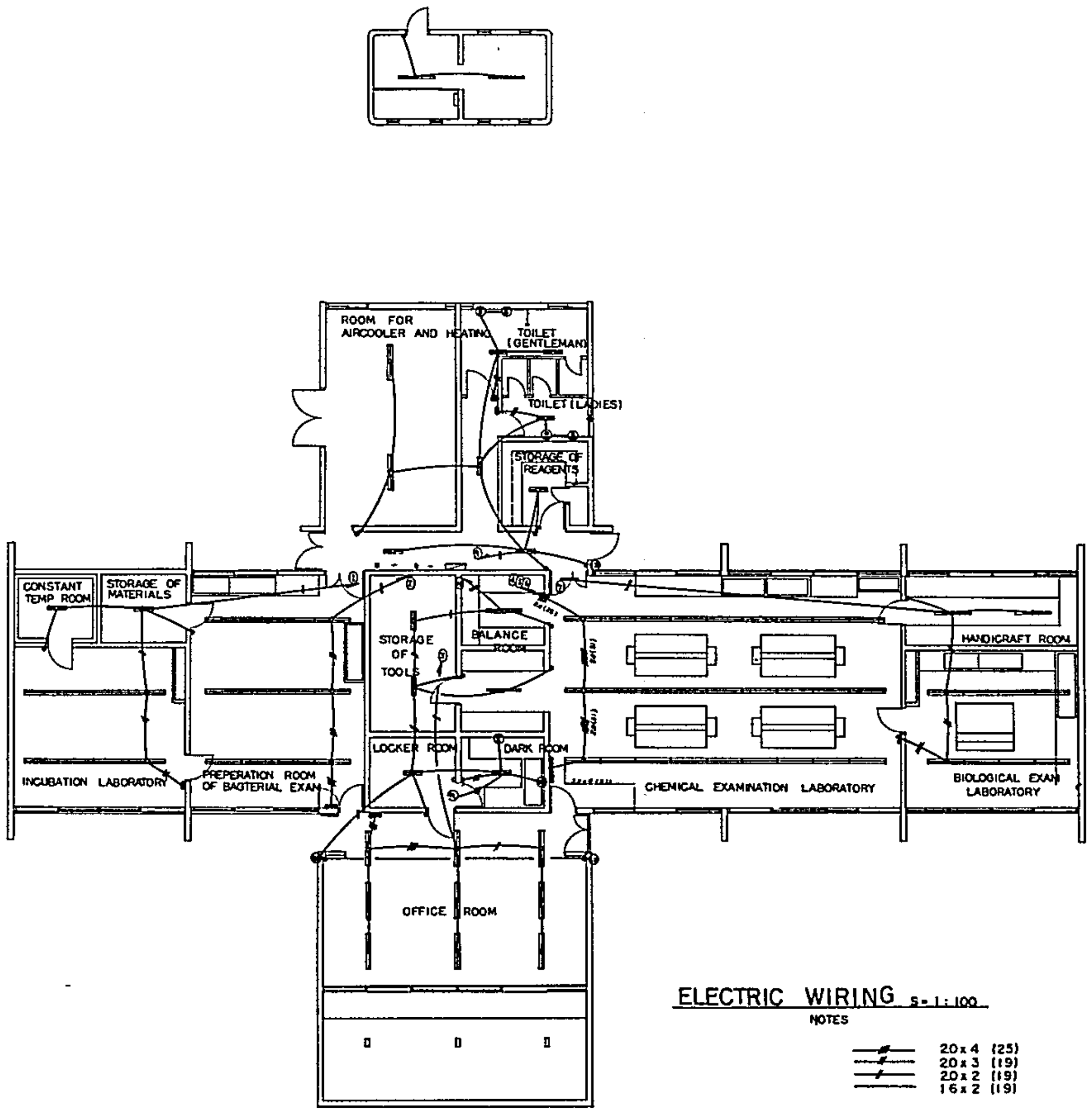




GOOSE NECK TAP	TOYO-TOKI	T23B 1/2
TWIN TAP	"	T44B 1/2 or T42B 1/2
TRIPLE TAP	"	T42C 1/2 or T44C 1/2
SWING TAP	"	T30AR 1/2
SPRINKLER HEAD	"	T27 1/2

PLAN OF PLUMBINGS S 1/100

FIG. 5 PROPOSED DESIGN OF THE CENTRAL WATER LABORATORY



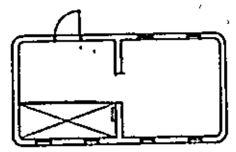
INDEX		
SYMBOLS	DESIGNATION	REMARKS
———	CELLING FLOOR, WIRING-CONDUIT TUBE	
	. FLUORECENT LAMP	FL40W x 2
	. .	FL40W x 2 x 5 FL40W x 2 x 9
	. .	FL40W x 1
	. .	FL20W x 2
	. .	FL20W x 2
	. PILOT LAMP	
•	. TUMBLER SWITCH	IP-15A
	. DISTRIBUTION BOARD	

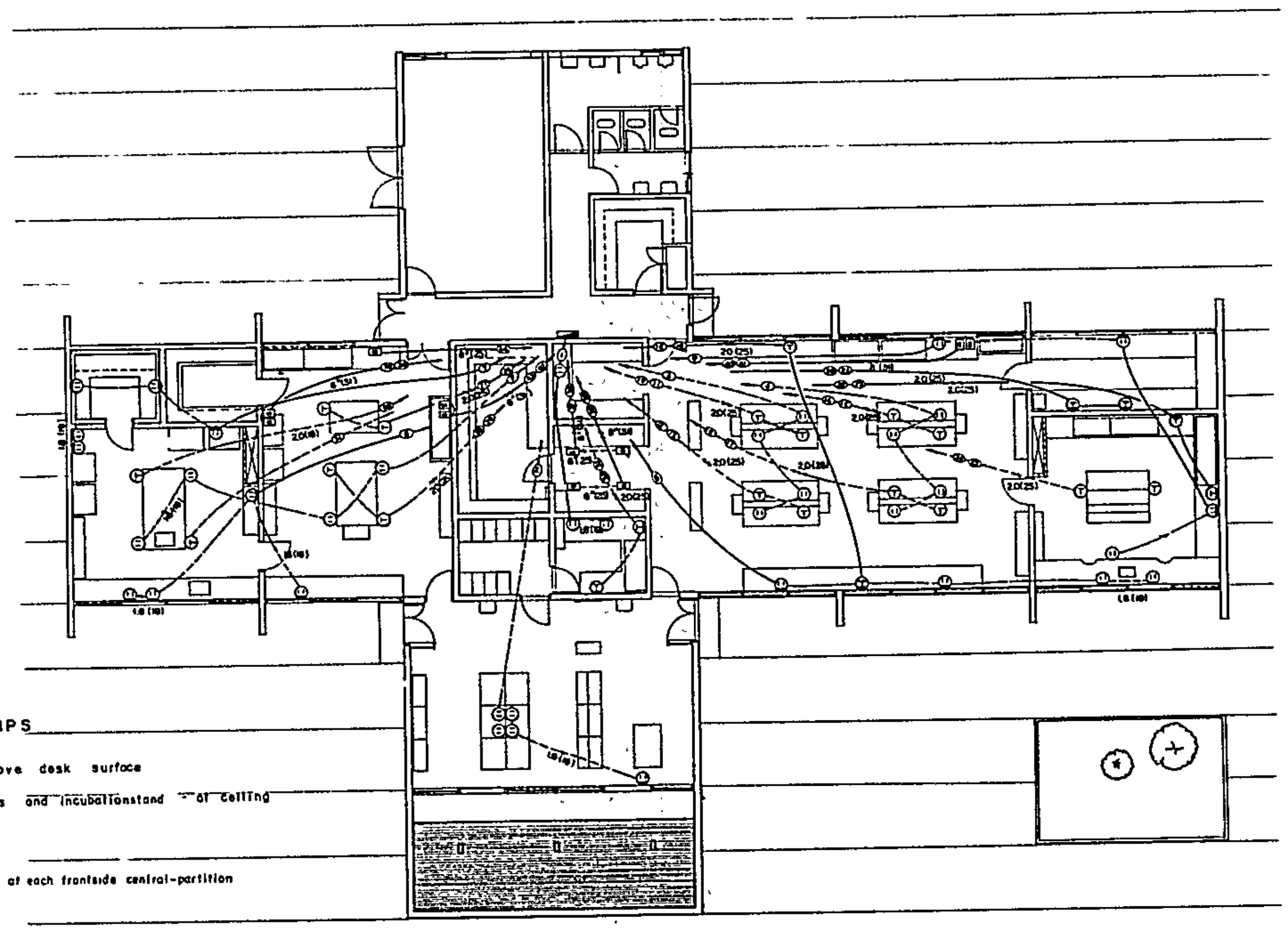
ELECTRIC WIRING S=1:100

NOTES

	20 x 4 (25)
	20 x 3 (19)
	20 x 2 (19)
	16 x 2 (19)

FIG. 6 PROPOSED DESIGN OF THE CENTRAL WATER LABORATORY





INDEX	
	SWITCH BOARD
	KNIFE SWITCH (40 Amp)
	WALL 10 A PLUG SOCKET
	TABLE 10A PLUG SOCKET
	WALL 20 A PLUG SOCKET
	TABLE 20 A PLUG SOCKET

LOCATION OF LAMPS

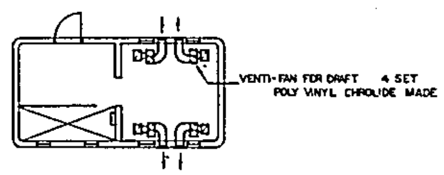
1) Desk lamps - 15 cm above desk surface

2) Side lamps of worktables and incubationstand - at ceiling

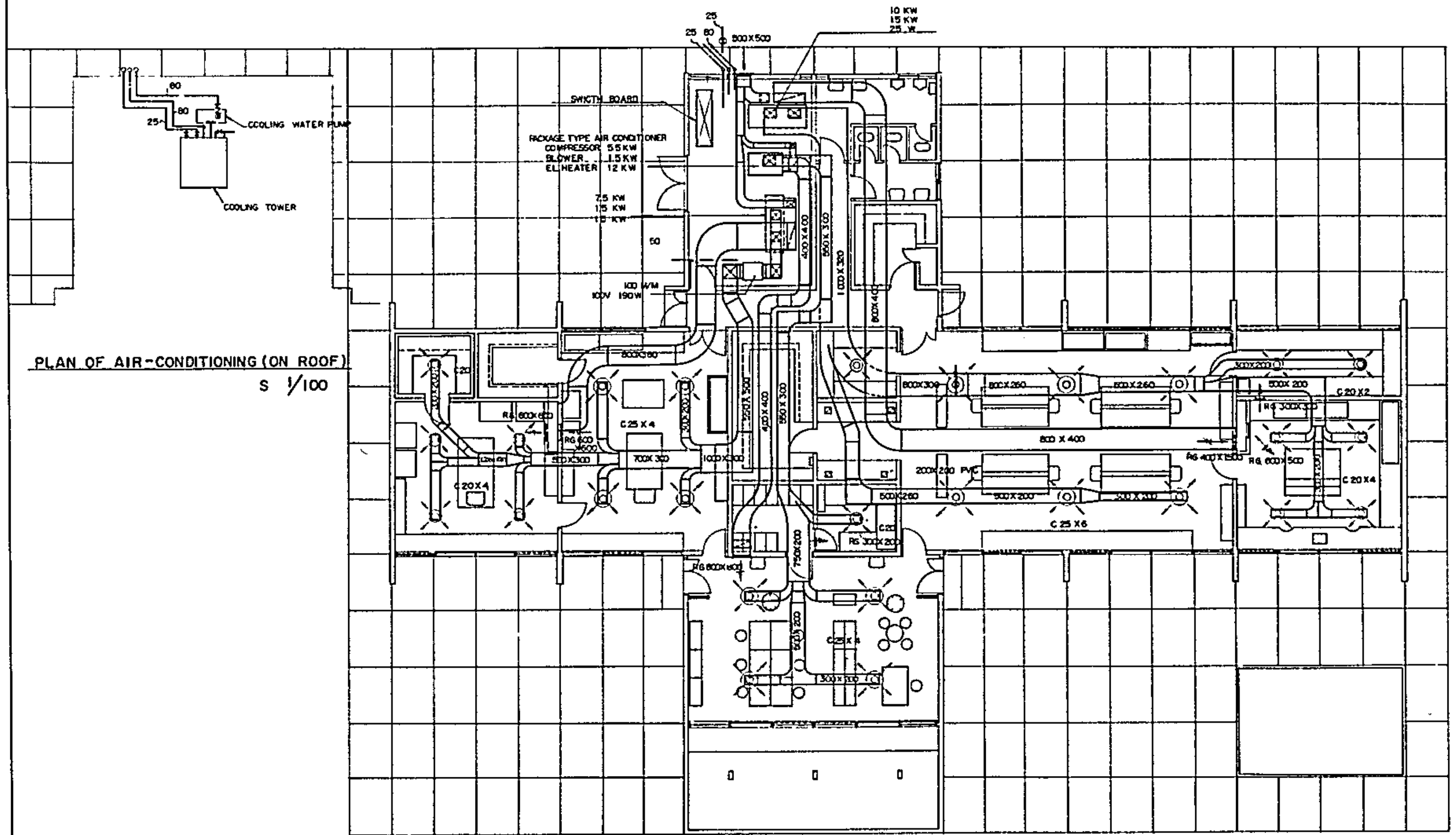
3) Chemical Testing stand lamps at each frontside central-partition

THE WIRING DIAGRAM

FIG. 7 PROPOSED DESIGN OF THE CENTRAL WATER LABORATORY



PLAN OF VENTILATING (ON ROOF) S 1/100



PLAN OF AIR-CONDITIONING S 1/100

SPECIFICATION OF THE AIR CONDITIONER	
PACKAGE TYPE AIR CONDITIONER FOR THE CHEMICAL EXAMINATION LABORATORY	
COOLING CAPACITY	44 000 Kcal/h
HEATING CAPACITY	21 000 Kcal/h
COMPRESSOR	10 Kw
BLOWER	1.5 Kw
EL. HEATER	25 Kw
PACKAGE TYPE AIR CONDITIONER FOR THE INCUBATION LABORATORY	
COOLING CAPACITY	27 000 Kcal/h
HEATING CAPACITY	13 000 Kcal/h
COMPRESSOR	7.5 Kw
BLOWER	1.5 Kw
EL. HEATER	15 Kw
PACKAGE TYPE AIR-CONDITIONEF OFFICE ROOM	
COOLING CAPACITY	20 000 Kcal/h
HEATING CAPACITY	11 000 Kcal/h
COMPRESSOR	5.5 Kw
BLOWER	1.5 Kw
EL. HEATER	12 Kw
COOLING TOWER	
COOLING CAPACITY	110 000 Kcal/h
WATER CONSUMPTION	520 ℓ/mm
COOLING WATER PUMP	
WATER CONSUMPTION	520 ℓ/m
TOTAL HEAD	35 m
MOTOR	7.5 Kw
COTTRELL	
CAPACITY	100 m^3/m
VENTI - FAN	
TYPE	MADE POLY VINYL CHROLIDE NO 1 1/4
MOTOR	100 W

VI. Basic Principles for Planning a Water Laboratory

Included in the Team's report as Chapter VI is the following treatise on the planning and designing of a water laboratory entitled "Planning and Management of Water Testing Laboratories," specially prepared by Dr. Sadao Kojima, an authority on water laboratory design. Dr. Kojima has designed numerous water testing laboratories and he has long years of experience in the water laboratories of the Tokyo Waterworks. His intention in preparing this treatise has been to provide all the basic information requisite to a better understanding of the proposed design of a Central Water Laboratory for Iraq, for which Dr. Kojima provided invaluable assistance and advice.

Planning and Management of Water Testing Laboratories

by Dr. Sadao Kojima

(I) Preface

The earliest water testing laboratories established in Japan were evidently modelled after university and research laboratories, and rather inconvenient for testing water. Subsequently, many of these laboratories were haphazardly repaired or enlarged, usually rendering them far from ideal places to test water.

The necessity in postwar Japan for new, modern laboratories became acute, thus providing the author the opportunity to plan and design many water testing laboratories, both large and small during the last ten years. Each time, painstaking consideration was given the problems of designing an efficient testing laboratory. The ideal laboratory is simply that in which the functions of testing can best be carried out. To successfully achieve this goal, it is necessary to ascertain in great detail the exact purposes of the testing, the testing procedures and the problems of managing the laboratory so that the equipment and the layout may be designed correctly for maximum satisfaction.

In this paper, I intend to set forth the basic ideas and principles in planning testing laboratories, accompanying my thesis with design drawings of test laboratories actually planned according to these principles. My hope is that this will prove useful to those who in the future may be charged with the responsibility of planning or renovating water testing laboratories.

The design plans used herein are chiefly laboratories for testing drinking water but the same principles apply for laboratories in testing sawage water or water for industrial use. I believe they also apply to research laboratories specializing in research on testing procedures.

II . The Purposes of Water Testing and the Nature of the Operations Involved

As stated above, plans for water testing laboratories should be made with reference to the proposed laboratory's intended objective. Since the objectives of water testing laboratories vary surprisingly widely, it is necessary to carefully determine (a) the character of the objectives, and (b) the type of operation required for their realization with greatest efficiency.

A. The Purposes of Water Testing

There are many different kinds of water testing, which may be divided according to purpose as follows:

1. Tests for maintenance and control of purification plants and sewage treatment plants.

   Such tests are the most important function of field testing laboratories and they may be divided into two categories.

   a. Tests conducted for purposes of hygiene control

      (1) To determine if the water is polluted (or if there is a sudden increase in pollution).

      (2) To determine whether or not purification is thorough and safe, hygienic water is being produced and delivered, and whether or not such water reaches the consumers in a safe condition. Most of the daily tests, both of water at the purification plant and of tap water, come under this heading.

      Both the above types of testing will become increasingly necessary in the future with the rise in pollution.

b. Tests conducted to aid in the purification and treatment process

(1) To determine the amount of turbidity of the raw water, how much alum should be put in, and whether or not the amount of alum presently being added is enough.

(2) To determine whether or not plankton are increasing in the reservoir, and, if they are, how to control them by proper timing and quantitative regulation of chemical injections.

(3) To determine if deodorization and removal of iron and manganese are proceeding as desired.

These tests ensure a maximum purity and aid the smooth operating of the purification process. This type of test will be more and more important in the future in handling the inevitable large yearly increases in the amount of water to be purified, and in the rationalization of the operation.

2. Tests for Improvement of Operational Efficiency

Tests conducted to improve the plant and purification operations, and in some cases to improve the water testing methods themselves. These tests are conducted to improve maintenance and management. Under plant managers who plan progressively and constructively, such tests will be conducted in great numbers, contributing greatly to the improved efficiency of the operations.

3. Tests Conducted for Investigation

These tests are conducted to investigate potential new sources of water, to determine standards for equipment and utensils, or when testing new materials. Investigative tests are mainly the function of testing laboratories specializing in advanced research testing, although they may be one phase of the work of field laboratories. Research testing is also essential when expanding facilities and so will no doubt be increasingly important in the future.

4. Basic Investigation and Research

Such tests are mainly the function of large general research laboratories and university research laboratories. They are extremely difficult to carry out in purification plant laboratories. But, basic research is absolutely essential, even if on a very small scale, to avoid irreparable lags in technical progress. Therefore, where no organization or installation exists especially for this type of research, minimum adequate facilities must be made available in the purification plant laboratories.

B. The Nature of Water Testing Procedures

The most important task of water testing in field laboratories is, as stated above, the daily tests necessary for proper maintenance and management. Field laboratories must perform within a limited time schedule these essential tests which include the three categories of chemical, biological and bacteriological testing. University and other pure and applied research laboratories are allowed to experiment more leisurely, more extensively, and with greater specialization. But, the data gathered from chemical, biological, and bacteriological testing in a field laboratory must immediately be gathered together and evaluated as a whole to have any value in maintenance or management. This must be done quickly enough so that each day's tests can be judged on that same day. Moreover, the various kinds of testing must be so coordinated that their results are available at approximately the same time. To attain this result, cooperation and harmony between the various test personnel is extremely important, and efficient communications should be carefully considered in planning the laboratory.

Field tests conducted for improvement or investigation are not radically different from the research laboratories' except that they are directly related to current problems in the field.

Education and study need to be continually carried out within the laboratory; the success of such a program is an additional necessary condition for a successful water testing laboratory.

III . Location and Size of Water Testing Laboratories

A. Location

Certain industries may well become completely automatic in the future with machines doing the work, supervised by a few workers. In the case of water testing, however, no matter how much progress may be made in measuring equipment, technical personnel will always be the dominant element.

Environment greatly affects the efficiency of human labor; thus, the environmental conditions of the laboratory need special attention. In the past, it was the custom to place the laboratory on the north or west side of the purification plant building. This was partly to shield chemicals and delicate equipment from the strong eastern and southern rays of the sun, and partly to make use of the more diffuse light from the north for microscopic examinations. However, modern artifical lighting and improved equipment have rendered obsolete this arrangement. The north and west sides of a building afford the least pleasant working conditions, being hot in summer and cold in winter. Delicate operations are not easily or efficiently possible under such conditions. Recent design practice tends to locate conference rooms along the north and west sides of buildings since they are usually used sporadically and infrequently.

The water testing laboratories should be located on the south side of their building with especial attention to proper ventilation. Technically, it is not difficult to heat a room during winter but efficiency stands in danger of being halved if ventilation is poor in the summer. However, if the building has 100% temperature control afforded by both central heating and air conditioning, the above rule may be ignored.

Next, it is important that the laboratory be located near the purification control center so that the filtration plant will be visible from the laboratory and easily accessible for quick inspection. These conditions usually require the placement of the laboratory near ground level on either the first or second floor.

B. Size

In determining the area necessary for the laboratory, it must be considered that much of the total area will be occupied by machinery, and cannot be claculated on the basis of the number of personnel. On the other hand, the required area for an office is directly related to its personnel strength and to the area required for their desks. In these two cases, there exists a fundamental difference in space requirements.

The measuring equipment used for water tests is being designed for greater precision in recent years, is larger in size, and requires more space for installation. This trend indicates that laboratories ten or twenty years in the future will need considerably more space than at present, even though the number of the laboratory staff remains unchanged.

Space requirements vary greatly according to the size of the purification plant, the sources of the water, the type of water, the method of purification, and the kind of work expected of the laboratory. When the source of water is surface water, a work area of sixty to seventy square meters (see Figure 2) is necessary to carry out the everyday tests for a plant producing several tens of thousands of cubic meters per day of drinking water, while a work space of 150 to 200 square meters (see Figure 3) is needed for an output of 100,000 to 200,000 cubic meters per day of water if testing for improvement and investigation are done in addition to everyday tests. Large scale water systems, required to perform basic research in addition to everyday testing and routine investigations, require a laboratory of between 300 to 400 square meters in size. (These areas are not large compared to the city of London's laboratory of 1,000 square meters, or Chicago's South Side Purification Plant laboratory of 500 square meters.) Where underground water or artesian flows are being used, the amount of space can be considerably smaller.

IV. Division of Laboratory Space and Relative Position of Individual Laboratories

A. Advantages and Disadvantages of Division of Laboratory Space

1. Advantages

The laboratory space may either be used as one large room or may be divided by walls into smaller rooms. Opinions differ as to which system is preferable, so the comparative advantages of both will be discussed.

a. If two types of experimentations mutually interfere or require radically different conditions, these work areas should be separated by a partition. For example, in the preparation room for bacterial testing, considerable steam and dust is raised, creating adverse conditions for bacterial incubation and for microscopic tests. Consequently, a separating wall is desirable between the two operations.

b. Scales and other delicate equipment may require a separate room to give them necessary protection from changes in temperature, poisonous gases and the effects of direct sunlight. In such instances as cited above, partitioning of the laboratory not only prevents interference between experiments, but makes for working conditions free of disturbance.

c. Still another advantage to partitioning is that it enables the space to be used three-dimensionally. Vertical arrangement of equipment and chemicals is not only space saving but, as will be elaborated later, enables marked savings in working movements.

d. Therefore, when the space available to the laboratory is inadequate, it becomes necessary to create additional space by intelligent grouping and partitioning.

2. Disadvantages

a. It will be less fessible to change the division of work space between the various functions in the future, and it is often impossible later to put smaller rooms to a different use. However, provided the original plans are carefully drawn, major changes in layout of a laboratory should seldom be necessary. It seems unnecessary to submit to inconvenience and disadvantages in laboratory design for the sake of an intangible and uncertain future advantage. The use of cabinets as dividers may seem to have the dual advantage of partitioning and future movability; however, such makeshift partitions are impermanent and obviously substitutes.

b. The second disadvantage of partitions is that the resulting separation of personnel may impair inter-communication, and render it difficult to share equipment. In view of the nature of water tests, this point warrants careful, special attention. When communication between testing personnel is impaired, this may lead to estrangement. Each room then tends to become a separate group, whose members' thinking is centered inward on their special field. In designing a water laboratory with partitioning, great care should be taken to prevent estrangement, including such measures as providing a water quality office so that laboratory workers may meet frequently, installing transparent glass panels in the doors, and installing louds-speakers to facilitate communication.

B. Laboratory Units Requiring Separation

Those laboratory units that particularly need a separate room are as follows:

1. <u>Chemistry Test Laboratory</u>

The experiments done in this room often give forth steam and gases, necessitating its separation. Chemical tests require considerable space with long operational lines which also make division desirable. In instances that the chemistry laboratory is very large, it may be desirable to design it within two rooms.

2. <u>Preparation Room for Bacterial Testing</u>

This room should definitely be separate because of the steam from the sterilization equipment and bits of cotton fuzz in the air from making cotton stoppers. This room tends to become cluttered because of the nature of its operation; thus partitioning it will improve the general cleanliness of the laboratory as a whole.

3. <u>Incubation Laboratory</u>

Great care should be taken to avoid pollution in this room so that in addition to being separate, sterilization equipment should be installed. Location of this laboratory should be so that traffic in and out will be at a minimum.

4. <u>Biological Laboratory</u>

This area should be protected from steam, dust and noise to ensure the accuracy of the microscopic examinations. Special equipment is required for incubation, thus making preferable a separate room. Where this is not possible, the biological laboratory may be included in the same area as the incubation laboratory.

5. <u>Central Office for Water Testing</u>

An important room for handling paper work relating to water tests, scheduling the work, bringing together and judging the data, and conducting education and study. Interviews with guests will also be held here to avoid disturbing experiments. This room has not been included in previous designs and a subsequent section will give further details. In small laboratories with few workers, it is permissible to locate this office in either a corner of the chemical laboratory, or in a suitable area of an extra wide hall.

6. Scale Room

A separate room, quiet and free from drafts, dust, gases, vibrations and direct sunlight, is desirable.

7. Dark Room

The use of photograph for tests and observations may be expected to increase in the future. Also, certain chemical tests require a dark room.

8. Draft Chamber

A separate room is essential because the experiments give off large amounts of poisonous gas and steam. If sufficient space can be allotted, it would be desirable to locate the electric muffle furnace in this same room.

9. Storeroom

Space is required to store reserve supplies of utensils and chemicals and also to store equipment and materials not needed for current operations but usable in the future. Although this storeroom has not been provided in previous laboratories, experience shows one of generous size to be necessary.

10. Other Rooms

The inclusion of (a) a workshop for making and repairing simple experimental equipment, (b), a low temperature room (5°C) and a cold dark room (10°C) for preserving test materials and low temperature experiments, (c) a room for precision measurement with constant temperature (20°C), (d) a dark room for spectroscopic analyses, (e) a dressing room, and (f) an acid storage room completes a modern laboratory. A laboratory for experiments related to radiation would be special but related equipment.

The above list was made with regard for the needs of a large testing station, the responsibilities of which would include basic research and tests to improve equipment and work operations. Small scale testing stations would naturally require fewer rooms and one room might conveniently be used for several kinds of experiments. However, there should be a minimum of three rooms, so that chemical tests, preparation for bacterial testing, and bacteria cultivation may be done in different rooms. Of secondary importance are rooms for the scales, storage, the draft chamber and dark room.

The proper planning of rooms is essential to an efficient laboratory.

C. Required Areas and Relative Locations of the Various Laboratories

1. Required Areas

In older laboratories, the chemistry laboratory occupied the greater part of the space with the bacteriological laboratory limited to a small area. Needless to say, allotment of space to the various functions of a water testing laboratory is not decided solely by the importance of the experiments but by the space requirements of the equipment and special needs (whether performed standing still or moving) of the operation.

Based on estimates of present and future anticipated work loads, the author believes the areas of the chemical, bacteriological, and biological laboratories should be in the ratio of 2 to 1.5 to 1. Where biological problems are few, this ratio might be altered to provide equal areas for the chemical laboratory and for the bacteriological and biological laboratories combined. The factor of 1.5 for the bacteriological laboratory may be divided between the preparation room and the incubation room in the rate of 1 to 0.5.

In determining the size of laboratory rooms, it is not always true that the larger room is better. Not only is space wasted when rooms are oversize, but waste motions are created. Experience shows that rectangular rooms about 4 x 6 to 6 5 meters (or 5 x 7 to 8 meters) provide convenient sizes in which waste motions are minimized. Smaller rooms may serve for small water testing laboratories, but square-shaped rooms should be avoided. Rooms larger than the above sizes either be partitioned into suitable size units, or the layout of the equipment should be so designed that the result is equivalent to partitioning.

The scale room, dark room, and handicraft room should be at least 2 x 2.5 meters in size, but a draft chamber 0.7 x 2.5 meters should be adequate for most work. Generous storage areas are desirable but since first priority must be accorded to the various laboratories, it is seldom that more than 5 per cent of the total laboratory area remains for storage use.

The water testing office should be large enough to hold the office files, and the desks of all the laboratory workers, with lockers for their personal belongings. As stated previously, a corner of the chemical laboratory may be used for this purpose in smaller laboratories where personnel are few.

2. Relative Locations of the Laboratories

The following rules, based on the function and nature of the operations of each room, are suggested to be followed in designing the layout of a laboratory.

a. The office should be near the center of the laboratory, convenient to all laboratory workers. A well-lighted, pleasant location is desirable since this room must be used for interviews, resting, assembling data and discussions. If the location of this room is poorly chosen, it will not become a gathering place as intended.

b. The dark room, storage room, workshop and dressing room should be shared by all concerned personnel, and located near the office. These small rooms do not require sunlight or windows; they should be kept together for reasons of convenience and economy in ventilation.

c. Microscopic tests require great concentration and are extremely tiring, so the biology room should be located in a quiet, pleasant area without irritating disturbances. The microscope stand should be placed where it will not receive direct sunlight. The work done here is independent of the other laboratories, enabling it to be located some distance from the central area.

d. The necessity to prevent pollution in the incubation laboratory dictates that entry should be limited to personnel for actual experiments. Therefore, this room may be located apart from the center of operations. Also, windows are not essential unless the same room is also used for a biological laboratory, in which case proper ventilation and pleasant working conditions become important.

e. The preparation room for bacterial testing should be well ventilated, as the room is used continuously for long hours, and heat is often employed.

f. The scale room, draft chamber, precision measurement room, and cold dark room should be situated in or near the chemistry laboratory, while the low temperature room must be near the incubation laboratory. The above-mentioned constant temperature rooms should be as close together as possible to facilitate control of their temperature.

D. Other Important Factors in Dividing Up Space

1. Space should be divided by straight walls with no indentations or projecting elements. Not only do such elements mar the room's appearance but they block off the natural lines of movement, cut lines of vision, and create waste space.
2. Every room should have at a least two doors. The planning should provide access to paths of escape in case of fire or other emergency, especially above the second floor.
3. Doors should be wide enough to admit the cabinets and work benches required to furnish the room, and should open in that direction most convenient for traffic.

E. Some Actual Examples of Partitioning of Laboratories

Following are some actual examples of partitioning in laboratories designed by the author according to the above principles.

Figure 1: Sample Plan of a Small Scale Laboratory

This is a laboratory of less than 50 m^2 area. The request was for a laboratory in which chemistry, bacteriology and biology experiments all could be carried out. The division of the space into only three major rooms for a chemical laboratory, a preparation room for bacterial testing, and an incubation laboratory follows basic principles. Small rooms, such as a scale room, draft chamber, storage room, and dark room were delected. In a laboratory of only 50 m^2 area, it is disadvantageous to create numerous small rooms for special purposes. There are ordinarily only one or two laboratory workers so the use of one room for several purposes is not inconvenient. A simple draft chamber may be made by placing a duct over a workbench near a window.

Figure 2: Sample Plan of a Small Scale Laboratory

The larger total area of 60 m^2 permits the adding of a storage room, draft chamber and scale room to the three-room layout of Figure 1.

Figure 3: Sample Plan of a Multiple-Room Laboratory

This layout drawing shows the plan for an existing Tokyo Waterworks laboratory. The actual floor plan here is 141 m^2 in area, providing a good example of a design for a medium-sized laboratory. Although not large, this laboratory is well arranged with almost all the necessary auxiliary rooms.

According to principles outlined above, the available space is divided into units 4 x 6 meters in size. The chemical laboratory (including its related smaller rooms) comprises two units, while the preparation room for bacterial testing, the incubator laboratory and the biological laboratory each occupy one unit of space. The building is oriented on an east-west axis so that in summer the south wind may pass through the rooms when the south and north windows are open.

The location of the office presented the most difficulty in this plan. Because of the limited total area, no space could be allotted especially for an office. Therefore, an office was designed utilizing the center south part of the hall, and doing double duty as a passage way. Because there are so few laboratory workers, no real traffic problem has arisen. The office is so situated as to block off part of the building from access to light and air, so the small rooms, which either do not need natural light or require artificial ventilation, are gathered together directly behind the office.

The other laboratory rooms are arranged in orthodox fashion, placing the chemical laboratory and preparation room for bacterial testing near the building's center, with the biological laboratory and incubation laboratory at either end. One must pass through the centrally located laboratories to reach those at the ends of the building; however, such traffic is not enough to cause any difficulty.

Placing the dark room, draft chamber, scale room, and store room in the center of the building not only facilitates and simplifies. All doors open in that direction most convenient for traffic.

Figure 4: Sample Plan of a Multiple-Room Laboratory

These plans are of another large Tokyo Waterworks Laboratory with three times the total area of Figure 3. The office is located in the center of the building, with a handicraft room or workshop, so that the plan closely follows ideal general rules. Here again, personnel must pass through the preparation room to reach the biological laboratory and the incubation laboratories.

Figure 5: Sample Plan of a Multiple-Room Laboratory

This plan is for a proposed Tokyo industrial waterworks laboratory where biological and bacterial testing are less important. Here, the space ratio between (a) the chemical laboratory and (b) the bacterial and biological laboratories was set at 3 to 2. In other respects, the fundamental design procedure was followed.

Figure 6: Sample Plan of a Multiple-Room Laboratory

This plan of an existing Tokyo Waterworks Laboratory represents an ideal layout of a test laboratory for a large-scale waterworks. The laboratory occupies 400 m^2 of space on the 2nd floor facing south, divided into an office, chemical laboratory, preparation room for bacterial testing, incubation laboratory, and biological laboratory, and with many smaller rooms for specialized uses. The dark room with its ante room, dressing room, and workshop are in a corner of the office room. The chemistry laboratory has three constant temperature laboratories — the balance room (20°C), the precision measurement room (20°C) and the cold dark room (10°C).

(V) Necessary Equipment and Their Arrangement in the Various Laboratories

A. Principles of Arranging Equipment

Equipment should be arranged to realize the greatest amount of productivity with the least amount of effort. Preliminary to making an actual layout plan, the movements involved in each operation must be analyzed, and though given to saving steps. The space between work counters should enither be too great nor too small.

The operations in a laboratory may be divided according to the type of movement required in the performance of the operation. The general principles of arrangement in each case are as follows:

1. Straight-line movement

   This category refers to operations involving movement in one direction. One example is the sterlizing of utensils in preparation for bacteriological tests consisting of:

   washing → shaking dry → putting in sterilizer → sterilizing → putting away

   Another example is the procedure in the evaporation residue test of the chemical laboratory:

   weighing of sample → evaporating → drying → weighing

   Equipment, including work space, machinery and utensils for such operations, should be arranged nearby in the order of use so that lines of movement will be simplified, will not cross, and there will be no need to walk back and forth.

2. Converging and Radiant Movement

Converging movements most often occur during preparation for a test, while radiant movements are common during cleaning up afterward. For example, in preparing for microscopic tests, the following movements occur:

instruments for microscopic examination
↓
sample ⟶ work bench ⟵ microscope
↑
reference books

During the putting away process, the direction of these movements is reversed. For convarging and radiant movement operations, the necessary equipment should be located within easy reach of the hand.

3. Reciprocal and Circulatory Movement

In both types, the same repetition of movements is involved but the term, circulatory, is to be applied when a separate operation is inserted in between reciprocal movements. Examples may be graphed as follows:

a. Operation during a microscopic examination

(1) sample ⇄ centrifugal separation

(2) Centrifugal separation of sample
↑ ⎿ microscopic examination ⟵ ⏌

b. Operation in the dark room

exposure → development → fixing → washing

For this type of work, also, equipment should be placed as close together as is feasible, and in the case of circulatory movement, the first movement should follow the last so that repetition of sequence is not awkward.

4. Sedentary Operations:

Operations in this category are done while remaining stationary for long periods. One of the above-listed types of operation will of course precede or follow.

Included are such procedures as weighing, microscopic examination and colony counting, all of which are tiring and nerve wracking. Therefore, the work space should be a well-ventilated place, without irritating disturbance, and with a view of the out-of-doors if possible.

The width of the aisle space between work counters should ordinarily be 1 meter, with widths of 1.2 to 1.5 meter in areas of heavy traffic. Efficiency is lowered when these widths are exceeded due to waste movement and, when the widths are insufficient, due to collisions between personnel.

B. Equipment Necessary in a Chemical Laboratory and Its Arrangement

1. Equipment

The chemical analysis of water is done in this laboratory. Some of the important routine operations performed are washing utensils, evaporation, filtration, drying, weighing, compounding of chemicals, titration, colorimetry, instrumental measurement, distillation, burning, and the production of poisonous gases. Easy and efficient performance of the foregoing operations requires the following equipment.

a. Chemical Testing Counter

Most of the chemical analysis is performed at this counter, making it a very important equipment. Occasionally a separate measurement counter is installed for mechanical analysis. The size of this equipment varies with that of the room but generally, a number of small counters, assignable to special uses, are more efficient than fewer large ones.

The most convenient size for the ordinary chemical testing counter is 130 cm wide and 250 cm long. However, the width may be as much as 150 cm provided chemical cabinets are placed in the center for use from either side. It is difficult to reach the middle of a larger counter. The proper height depends on the type of operation being done. For evaporation, filtration, titration, and colorimetry, a height of 85 cm is convenient. However, 80 cm is more suitable for measuring operations where the worker must look down on the measuring implements.

An exceedingly convenient type of chemical testing counter is that which is divided horizontally with a space at the center for the installation and containment of electric wiring of water pipes and drainage piping.

Whatever the design of these counters they should be covered with acid and heat resistant decola. The attached sinks should be of lined on both sides wither with porcelain or stainless steel.

b. Measurement Counter

The height of these counters, especially for instrumented measuring, should be no more than 70 to 75 cm since the work is performed from a sitting position. These counters also should have adequate leg room underneath; otherwise, their design is quite similar to that for the chemical testing counters.

c. Sinks

The various utensils used in a chemical laboratory must be washed very often, so that considerable space is needed for sinks. What seems excessive at first will prove to be no more than necessary.

The standard width for sinks should be 70 to 80 cm, and their length 150 cm. Excessive sink width renders it awkward and difficult to turn on or shut off the faucet. An overall height of 85 to 90 cm and a sink depth of 15-17 cm is most convenient. The sink top will hit the chests of the operating personnel if too high, and water will tend to splash if the basin is too shallow. The sink bottom should be about 70 cm from the floor, to prevent operating personnel from suffering fatigue.

The sinks should be stainless steel sheet with wood cores. The old-style lead sheet sinks not only look unclean but are gradually bent out of shape by the weight of heavy bottles and instruments.

The defect of concrete sinks is that they cannot be made with narrow walls, necessitating an extra width, which in turn forces operator personnel to lean against the chilling concrete while working. A drainboard with a slope of 1/50 - 1/25 so that water will run into the sink should be placed on the left, while a horizontal counter must br installed for distilled water and distillation equipment on the right side of the sink.

Faucets should consist of two or three swing taps and a goose-neck tap or twin-type tap. A drum trap should be installed in the drainpipe. Also, a small shelf of stainless steel or aluminum with holes in it installed above the sink will prove vary convenient.

d. Shallow Floor-Level Sinks

This installation is required for installing equipment such as an ammonia distilling apparatus and water quality automatic recorder, both of which are tall and require a considerable and continuous drainage of water. The bottom of the sink should be at floor level with walls 5 cm thick. This sink may be built of polished surface heavy concrete adequate in strength to hold heavy equipment. Alternatively, a stainless steel finish sink would not only be as practical as the polished surface concrete, but more attractive in appearance.

For the ammonia distilling apparatus, the low shallow sink needs to be 70 cm wide and 150 to 200 cm long. The tap should be a goose-neck tap or a twin-type tap.

e. Draft Chamber

Construction companies are not used to building this type of chamber; therefore, all details should be specified minutely. Construction methods are given in most engineering reference works, but the following points need special attention.

(1) The walls and ceiling should be of acid and heat resistant materials such as plastics to prevent condensation of steam. Plastics are better than the glass used formarly, because fabrication is simple and breakage less.

(2) A depth of 60 to 70 cm is adequate for the draft chamber. When the depth exceeds these limits, the back portion cannot be reached for use. A sink should be furnished, lead lined, with the sink height ideally about 65 to 70 cm. The faucets should be so installed that the taps face forward.

(3) The bottom of the sink should be made into a lead-lined shallow sink to serve as an acid chamber. Of course, the room must be ventilated with duct.

(4) All utensils used should be acid resistant.

(5) A sirocco-type fan should be employed for ventilation. This fan requires soundproofing and should be installed in a separate room on the roof, and never inside the draft chamber. A signal lamp to indicate when the equipment is in use is desirable.

(6) The handles of the water and gas outlets should be

be operable from the outside.

(7) The ducts for the draft should not be connected with other ventilation ducts. The reason for this is that a reverse flow of air might occur when the fan is idle. 250 m is quite wide enough for the draft outlet, which space shall be divided into two sections for use by means of a partition wall.

f. Semi Draft

This chamber is not a true draft chamber. It is used to remove the steam and bad odors from the electric furnace and water bath. A bellmouth-type duct hung from a ceiling will serve this purpose.

g. Scale Room

The scale room must be kept tightly closed when in use. Windows are not essential, and direct sunlight should never enter the room. The balance stand should be built away from the walls, about 50 - 60 cm wide and 75 high. There should be plenty of leg room under the balance stand so that the operator may sit comfortably at his work. The top should be artificial stone (terrazo) of a dark color, black to dark green. The walls of the room should definitely be in contrasting color.

h. Shelves and Cabinets.

Installation of shelves to an extent that seems excessive will eventually prove to have been just right.

Shelves should be built in all available wall space. At least 3 shelvings are essential, including machine closets, instrument cabinets, and chemical cabinets.

(1) Machine Closets:

These are used to store measuring instruments and their parts; such cabinets should be 40 - 50 cm deep, 2 - 2.2 m high, in lengths depending on the amount of available wall space.

(2) Instrument Cabinets:

These cabinets should be about 40 cm in depth for glass utensils. However, in case the cabinet is built so that utensils may be removed from both sides, the bottom shelf should be 60 cm deep and the top shelf 40 cm for proper balance. The height should be 2 to 2.2 m high.

(3) Chemical Cabinets:

To store bottled chemicals, these cabinets should be shallow, about 33 - 35 cm deep. Two tiers should be provided for large bottles and 3 or 4 for small ones so all bottle labels may be clearly and easily visible. A portion of these cabinets will be used for poisonous substances, and should therefore be equipped with locks. Their proper height is 2 to 2.2 m.

All shelves for the above listed cabinets should be of adequate thickness (about 2 cm), and their bottom shelves should be lined with planking of the same thickness. Drawers should not be installed in bottom shelves, where they would be awkward to use. Small drawers for such small objects such as rubber and cork stoppers, glass cocks, filter papers, crucibles, etc. should be brought together in a separate cabinet less than 1.5 m high. Usually, miscellaneous objects are kept in various drawers of the chemical testing counter, but a separate cabinet is much more convenient. There is no objection, however, to installing a group of drawers for miscellaneous item storage on one side of the chemical testing counter.

i. Sampling Sinks

Sampling taps are necessary to collect and bring together the various test samples. Sampling sinks each about 150 cm in length to service 10 taps, are also required to be installed. These sinks should be deep enough (at least 20 cm) to prevent water splashing, and the clearance between the tap mouth and the bottoms of the sinks should be sufficient so that personnel can use cylinders to obtain samples.

j. Major Types of Machinery

In planning the layout for the chemical testing laboratory, the initial step should be the placement of the following large-size equipment: dryer, constant temperature dryer, water bath, water distilling equipment, electric furnace, ammonia distilling equipment, jar tester, and cart for transporting samples.

2. Arrangement of Equipment

When the above equipment is arranged according to the above principles, what sort of room do we have? The flow of work movement in a chemical testing laboratory, is usually as indicated in the following chart:

instrument cabinet → chemical testing counter → sink → dryer

For best efficiency, the instrument cabinet should be located close to all the testing counters, thus limiting the work movement circle to a minimum radius. For example, in Figure 7, the instrument cabinets are in the middle of the L-shaped room, close to the testing counter space. In Figure 8, the room is large, rendering it feasible to cut the work movement circle into two motion-saving arcs by locating the instrument cabinets in the center of the room accesible from eigher of their two sides.

The sinks, too, should be in close relation to the testing counters. Usually, the sink is located at that end of the testing counter opposite to the storage cabinets. In layouts where the instrument cabinets are installed in a central location, it is both feasible and desirable to install sinks at both ends of the testing counters (Charts 7 and 8). In smaller laboratories, however, one sink is sufficient (Chart 9).

C. <u>Necessary Equipment and Their Layout for the Preparation Room for Bacterial Testing</u>

1. <u>Equipment</u>

a. Sink

Test tubes, petri dishes, and other glass utensils used in the preparation room must be washed often, so that the allotment of space for the sink must be generous. A satisfactory, standard size would be 70 to 80 cm wide, and 150 cm long. The height of the sink should be 85 to 90 cm, and its depth 15 to 17 cm, the same as the sinks in the chemical testing laboratory. The sink should be equipped with a drainboard on the left and a horizontal counter on the right. A separate small sink for cooling the culture mediums after sterilization in the autoclave is extremely useful in preventing an excessive workload on the sink.

b. Cotton Stopper Work Counter

Prepation of cotton stoppers is the most time-consuming part of the preparation for bacterial testing. This work is also unpleasant because of cotton fuzz in the air. This work is alsc unpleasant because of cotton fuzz in the air. The work counter should be low (65 cm) so that personnel may work seated with plenty of leg room below. Installation of a semi-draft ventilating hood to draw off cotton fuzz is desirable. A counter 800 cm long by 220 cm wide is sufficient for two persons to work simultaneously.

c. Work Counter

This counter is used to arrange instruments for cultures, make preparations for sterilizing and prepare the culture medium. It is preferable to provide two such counters, one for laying out instruments used in operations performed in a standing position and a lower counter for preparing the culture medium and for bacteria seed injections. The high counter should be 100 to 150 cm in width, 200 to 250 cm in length and 85 cm high, while dimensions of 100 to 150 cm in width, 200 cm in length and 65 cm height are sufficient for the low counter. If no sink is located nearby, a small sink should be installed for use with the high counter. These counters should be fitted with small drawers for convenient storing of small instruments, while the space below these counters should have double doored large compartments for keeping cotton and used stoppers.

In small laboratories, one work counter will suffice for the above-mentioned functions, and very small laboratories may be forced to use the same counter for preparation of cotton stoppers as well. In such a case, the counter should be of the low type.

d. Shallow Floor-Level Sinks

This sink is required to install the autoclave, and should be of similar design to the floor-level sinks in the chemical testing laboratory. This equipment should be built of polished surface concrete, or concrete lined with stainless steel. A water tap should be furnished, and a bellmouth-type duct provided above the equipment to draw off steam.

c. Cabinets

A cabinet for utensils used in cultures and another separate cabinet for chemicals for the culture mediums usually are part of the equipment installed. One cabinet may serve for both purposes in small laboratories. Their height shall be 2 to 2.2 m, and their other specifications similar to those of the instrument cabinets of the chemical testing laboratory. A desirable additional convenience would be a separate cupboard to keep used utensils in temporarily until they can be washed.

f. Machinery

The first consideration in planning the layout of the preparation room for bacterial testing should be the location of the following large-size equipment: dryer, dry heat sterilizer, autoclave, and equipment for distilling water.

2. Layout of Equipment

Operations in the preparation room follow a fixed flow of movement and the equipment should be arranged in order of use.

As shown in Figure 8, the first line of movement (for utensil sterilization) may be graphed: washing → drying → placing in temporary storage cabinet → assembling of the utensils → dry heat sterilization → placing in sterilized cupboard (culture room)

The second flow of movement (preparation of the culture medium) may be graphed: preparation of cotton stopper → dry heat sterilization → filling the culture medium → autoclave sterilization → cooling → placing in the refrigerator (culture room)

Provided the equipment be arranged as in the diagram, lines of movement will not cross or require retracing footsteps, so that the work will proceed smoothly and efficiently.

D. Required Equipment for the Bacterial Culture Room and its Layout

1. Equipment

a. Incubation Counter

This counter provides space to carry out the various operations relating to bacteria cultures. Most of the work is done standing so the counter may be about 85 cm high. The size of the counter should depend on the number of cultures handled at a time, but the usual size ranges from 120 to 130 cm in width and 200 to 250 cm in length. If a small sink is installed at one end of this counter for discarding specimens, its design should provide a built-in drawer for storing excess used cotton stopper.

Use of a bunsen burner is required for the process of bacteria cultivation, so either gas, propane gas or equipment for manufacturing gas should be installed in the incubation counter.

b. Measuring Counter

Colony counting and microscopic examination are accomplished at this counter, which should be about 70 cm high with generous space below to facilitate use of computing devices and microscopes in a seated position. This equipment generally looks like a built-in desk, at least 70 to 80 cm wide and 300 cm long, usually placed facing a window. This counter is also used for microscope work on occations when complete testing is done.

c. Sterilization Cabinet

Sterilized culture utensils are stored in this cabinet, which preferably should be equipped with a sterilizing lamp. Dimensions should be about 50 cm in depth, 200 cm long and 200 to 220 cm high. In small laboratories, which require only half the above space, the area underneath the incubation counter may be utilized for sterilization.

d. Major Machinery and Equipment

A refrigerator and incubator are indispensable for an incubation laboratory. A constant temperature bath for keeping warm solutions of culture medium is also necessary.

Adequate sterilizing lamps should be installed so that the incubation laboratory may be kept as bacteria-free as possible. Ultra-violet rays are harmful when viewed with the naked eye, so that such equipment should be installed in a high position, directed at the ceiling.

2. Arrangement of the Equipment

The incubation processes are organized on the radiation principle. After leaving the incubator, the sedentary operations such as colony counting and microscopic examination are completed, and finally the washing up. Therefore, all the required materials and utensils should be assembled in the order of their use as close to the incubation counter as feasible.

The layout in Figures 8 facilitates a smooth operation in which the utensils are taken from the sterilization cabinet, the samples and culture medium are brought out of the refrigerator, and the culture prepared at the incubation counter before placing in the incubator. After a fixed time, the cultures are taken from the incubator to the measuring counter. The colonies are counted, then their containers are sent to the adjoining preparation room through a cupboard accessible from both rooms.

As should be obvious from the foregoing explanation, an efficient incubation room must be compact.

E. Main Equipment in the Biological Laboratory and Its Layout

1. Equipment

a. Microscope Stand

The most important biological tests are those done with the microscope; thus counter space for this work is very important. Microscopic procedures require great concentration and are extremely tiring, so efficiency requires the working environment to be as pleasant as possible. The author has invented a desk minimizing work strain, with a concave front enabling the operator to observe through the microscope while resting on his elbows. Also, this desk has projecting sides fitted with drawers to keep samples and references close at hand. The dimensions are 80 cm depth, 200 cm in long, and 75 cm high. If a vertical cylinder is to be used, a section of the desk top may be removed, so that the microscope only can be fitted into position 8 to 10 cm below the desk top. This enables the operator to rest on his elbows while doing microscopic observations.

A small sink should be installed in or near the microscopic examination stand for disposal of no-longer-needed samples.

b. Breeding Table and Sink

These facilities are for breeding biological specimens for testing. The table should be fabricated of wood, lined with stainless steel so that water can be used freely and safely. The standard size is 70 cm deep, and 100 to 150 cm long. The design in Figure 8 utilizes three standard sinks lined up in a single row.

c. Cabinets

1. Machinery Cabinet -- Storage is required for the microscopes and their attachments. This cabinet should be sturby, and provided with a lock. Standard size cabinets are 40 to 50 cm deep, 150 to 200 cm long, 200 to 220 cm high, with 2 cm thick shelving.

2. Specimen Cabinet -- This equipment is used for preserving specimens. The cabinet need not be very deep, but it should be built strongly, similar to the machinery cabinet. Specimens are either kept in bottles immersed in liquid or in tubes stored in small boxes. Terraced shelves such as those described for chemical cabinets are very satisfactory for storing specimen bottles.

3. Utensil Cabinet -- This cupboard is required to store glass utensils, and is similar to the utensil cabinets described for the chemical laboratory.

d. Experiment Counter

This space is for certain tests related to biological tests, as for filter film and sludge, not essential in the case of small laboratories. Construction and dimensions of this fixture are the same as for chemical testing counters.

e. Refractory Experiment Counter

This counter is required for experiments using the electric furnace, or in which fire is used often. The specifications should require a concrete or artificial stone counter 80 cm deep and 80 cm high.

f. Floor-level Sink

The design should be the same as for the floor-level sinks installed in the chemical testing laboratory except that their width may be reduced to only 40 to 50 cm. This sink is used to hold equipment for recording filter resistance data, and experimenting with model filter basins.

g. Placement of Machinery

The planning of a biological testing laboratory requires an efficient layout for the following machinery: centrifugal sedimentation basin, dryer, constant temperature water tank, and a device for recording filter resistance.

2. <u>Arrangement of the Various Facilities</u>

Movements in preparation for microscopic tests are of rotating type: sampling → centrifugal separation → thickening (returning to sampling)
Also, centralizing motions occur during the bringing together of microscope, reference books and samples. Equipment and materials should be arranged so the various operations do not require needless movements.

The layout illustrated in Figure 8 locates the microscope storage in a cabinet to the rear of the microscope stand, while reference materials are kept on a hanging shelf overhead. Samples are brought to the microscope stand after being processed in the centrifugal separator and its small sink located to one side. Utensils and accessories may also be washed at this same sink.

Breeding and filter film tests are separate tests of different nature, thus requiring separate work space to avoid mutual interference.

F. Equipment and Arrangement of the Office

Equipment for the office includes the usual furniture, desks, lockers, and shelf space, plus cabinet space for books and private possessions. If a water quality recorder is installed, it should be located in this room.

The office is used for discussions and meetings, in addition to office work so that desks should be arranged in a circle suitable to this purpose. The room is also be used to receive visitors; therefore the laboratory chief's desk should be located near the entrance with sufficient free space for the visitors.

Located near the office entrance should be a wash basin with mirror and an umbrella stand.

A switchboard for all electric circuits in the laboratory should also be located near the entrance.

G. Planning the Dark Room

The most important features of the dark room are as follows:

1. If there is sufficient area, an ante-room should be established so personnel may enter freely while work is in progress. The copier and micro-reader should be located in the ante-room so they can be more effectively used. An ante-room is not advisable if it necessitates reducing unduly the size of the dark room.

2. The edge of the doors should be beveled like the doors of a safe and provided with a block wool cloth lining on the door edges to seal out light. Curtains are not satisfactory because they raise floor dust.

3. Two ventilation ducts should be installed below the sink pointing up and out, and forcing ventilation installed if possible. Ventilation is very important for both hygienic and operational efficiency, as well as for proper preservation of the developing agents and enlarging equipment.

4. The enlarging counter should be 70 to 80 cm deep, about 70 cm high and as large and well built as feasible. To the left, a separate counter for ferrotype equipment and a paper cutter is recommended as desirable.

5. A sink is required, large enough to hold quarter-sheet size vats. Therefore, the size should be at least 50 cm wide, 100 cm long and 10 cm deep. Ideal planning would include another sink 15 cm deep for washing. At least two faucets are needed → one swing tap and one twin-tap type.

6. The above-mentioned enlarging counter, work counters, and sinks should be of the same height. The facilities for the various operations → enlarging, developing, fixing, and washing → should be located in their given order so that work may proceed normally in a clockwise direction.

7. Numerous narrow shelves should be built in facing sinks and work counters. The space above the enlarger should be left free so it may have adequate clearance room. Cabinets should not be installed inside the dark room.

8. At least three or four electric outlets are needed. In addition,

two or three safety lamps should be installed.

9. The door should lock from the inside, and there should be an indicator to show whether or not the dark room is in use.

H. Planning Storage Space

1. The purpose of the storeroom is to store as many things as is possible with neatness; thus, shelves should be built to the ceiling along all four walls. The bottom shelves should be tall and wide, suitable for storing heavy materials. The top shelves should be designed shallower and closer together to store not-so-large materials. The bottom shelves might be 50 cm deep and 60 cm high, while the higher level shelves could be 40 cm deep and 40 cm apart. A metal pipe should be installed along the top shelves on which to hook a ladder to be used in loading or removing materials from the shelves. It may be necessary to build a chemical cabinet in one corner of the storeroom to keep poisonous and other related chemicals. The chemical cabinet would be similar to those previously described for the chemical testing laboratory. A broom closet should be included in the store room to help prevent cluttering.

I. Planning the Workshop

The workshop requires two work counters, one for woodworking and the other for metalworking. The woodworking counter should be low (65 cm high), and sturdily built with a hard wood or Philippine mahogany top thick enough (5 cm) to stand hard usage. The metalworking counter should be 80 cm high, built as sturdily as possible with a polished concrete top, and equipped with a small sink installed at one end. Both these equipments should be 60 – 70 cm deep with many small drawers below for storing small-size work materials.

A hardwood board about 2 cm thick, on which to hang work tools, should be fixed to the wall opposite the work benches.

Quite a bit of glass working is done in a workshop. If piped gas is not available, provision should be made to supply propane gas to the workroom. Also, 2 or 3 electric outlets are necessary for such equipment as soldering irons, power woodworking tools, and boring tools.

J. Installation of Electric Outlets and Water Taps and Drainage

The more electric outlets and water taps thè better. What seems extravagant on blueprint plans proves just right in actual use. The following points need to be considered in designing the laboratory.

1. Electric circuits may be divided into three categories:
   a. Circuits invariably turned off at night
   b. Circuits sometimes left on at night, such as for dryers, constant temperature indicators, and grain measures.
   c. Circuits never turned off, such as for incubators, refrigerators, and sterilizing lamps
2. A generous number of electric outlets should be installed. They should be provided for 10A, 20A, and over 40A currents, each type distinguished by different-shaped outlets. For example, parallel type outlets might well be used for 10A, T-shaped outlets for 20A, and knife-switches for outlets over 40A.
3. Various types of water taps should be installed in appropriate combinations at suitable points, to include swing taps, twin taps, and goose-neck taps. Swing taps are suitable for wash taps, while the twin taps are practical for ice water, and automatic hot water.
4. The drain pipes and their attachments should, without exception,

be acid proof, and every sink should have a drum trap.

VI. Operation of a Water Testing Laboratory

Laboratories must be planned for operational efficiency. Although the author has already touched on operational methods in the foregoing pages, he would like now to set forth more concretely his opinions on this subject.

A. Operational Objectives

The main purpose of a laboratory operation is to conduct the necessary water tests effectively and efficiently. The functional, efficiency-oriented type of planning heretofore described in this essay represents no more than a means toward that goal.

The objective of testing is to make it possible to carry out the everyday operations of a water purification plant smoothly and thoroughly. As explained in the preface, the cooperation of all the sub-laboratories, and speed in testing, are basic requirements.

Therefore, the laboratory management should aim at coordinating the efforts of the staff toward getting together complete test results in as short a time as possible.

However, investigation and research is also the duty of the laboratory, and education and study to enhance the qualification and abilities of the staff are still another necessity which require careful consideration by the management.

B. The Function of the Water Testing Laboratory Office

The utmost cooperation and speed in conducting tests is required in daily field tests, and the author believes that a water testing office may contribute materially toward these objectives.

The advantages of the office are the provision of special facilities for consultation before beginning work, for collective review of test results and for conducting training and study, thus adding essential finishing touches to the testing procedure. Interviews with visitors can be conducted in the office also, so that the laboratory routine is not disturbed.

Without the central office, workers in different sections of the laboratory have less opportunity to meet, rendering it less easy to achieve harmonious relations among the staff. Each section of the laboratory comes to be regarded as a private room, and cliques tend to arise.

Despite the above advantages, there still exists differences of opinion as to whether it is preferable to have a separate, central office, or for each staff member, including the director, to have a desk in his laboratory section.

The most common objection to a central water testing laboratory office is that desks and personal property are thereby removed from the laboratory itself, rendering it awkward to use reference books or organize data during an experiment. The author, however, believes that the laboratory chairs and work counters provide enough space to keep books and required data.

The second objection to the office is that it represents a waste of space since the desks are not occupied while workers are at their laboratory stations. But, at a minimum, the laboratory office is used three times a day, including for morning consultations, lunch at noon, and examining data each evening. This certainly represents a more effective utilization of space than the conference rooms, used only a few times per month.

The third objection is that there is a tendency for employees to engage in excessive exchange of small talk.

The effectiveness of the laboratory office relates closely to the purpose of a water testing laboratory. The central office is essential for the staff to obtain a mutual understanding of each other's work through discussion, training, study for the exchange of knowledge, improvement of techniques, and the creation of harmony and solidarity.

C. Instruction and Training

These two items have usually been badly neglected in water-works programs everywhere. The reasons that the importance of instruction and training are stressed in connection with the water testing laboratory are:

1. Most Japanese technicians now engaged in water testing majored in college in chemistry, pharmacology or biology. They entered careers as specialists in water testing by learning from senior staff members, and by study after entering the laboratory. This system is inefficient and should be replaced by a well-formulated instructional and training program.
2. As has been repeatedly stressed, cooperation of all the laboratory staff is of the utmost importance to successfully achieving the objectives of the water testing. Mutual contact between the various sections and good personal relations are desirable. The exchange of information and news about techniques of water testing with one's collaborators, more than any other single factor, is the basis of advanced water testing.

D. Investigation and Research

Investigation and research have only a secondary importance in a waterworks laboratory. However, continual study of new methods and efforts toward better facilities is always required. The ideal way to accomplish this is to establish a special organization which can concentrate solely on investigation and research work.

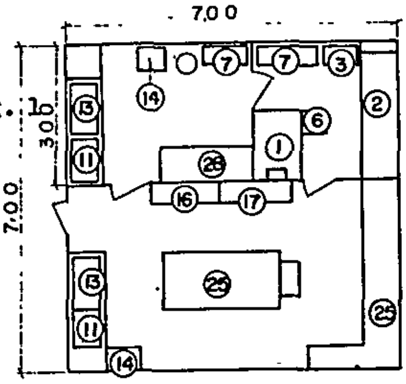
The sandwiching of research between the daily load of required testing is always more or less inefficient.

VIII. In Conclusion

In this treatise, I have set forth some principles for the planning of water testing laboratories and some sample designs of testing laboratories. These principles were arrived at from an analysis of the objectives of water testing and the characteristics of the operation.

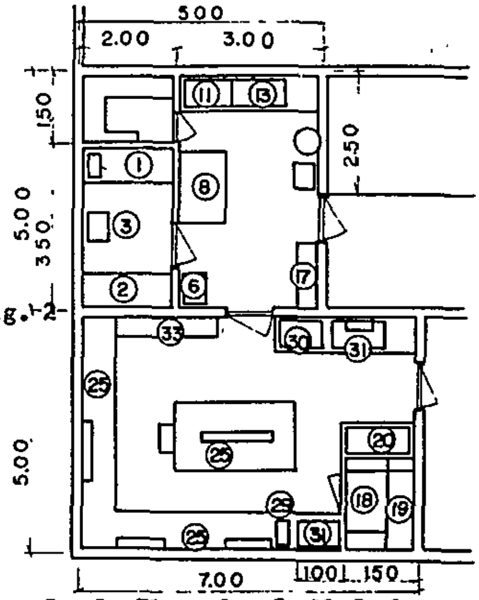
Those who make use of this brief study are bound to feel that more detailed knowledge is necessary to actually designd a water testing laboratory. However, the author believes that careful reference to the principles mentioned should enable planners of testing laboratories to avoid the more serious errors of planning and construction.

Fig. 1b



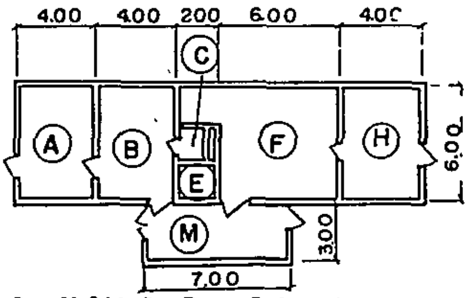
Sample Plan of a Small Scale **Laboratory**
(49 m^2 in Area)
Note: All dimensions on this and the following drawings, for which the unit is unlisted, are in millimeters.

Fig. 2



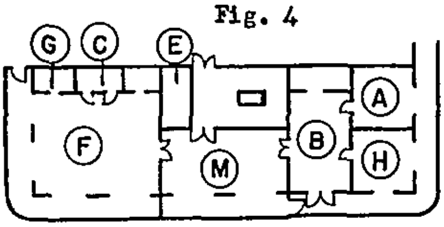
Sample Plan of a Small Scale Laboratory (60 m^2 in Area)

Fig. 3



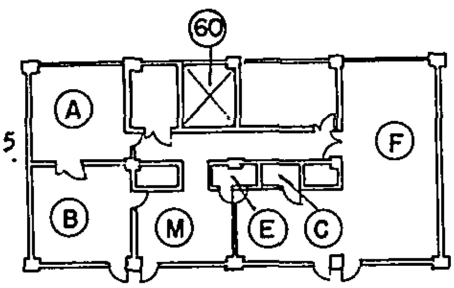
Sample Plan of a Multiple-Room Laboratory
(An Existing Tokyo Water Works Laboratory)

Fig. 4



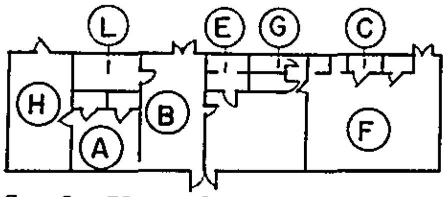
Sample Plan of a Multiple-Room Laboratory
(An Existing Tokyo Water Works Laboratory)

Fig. 5



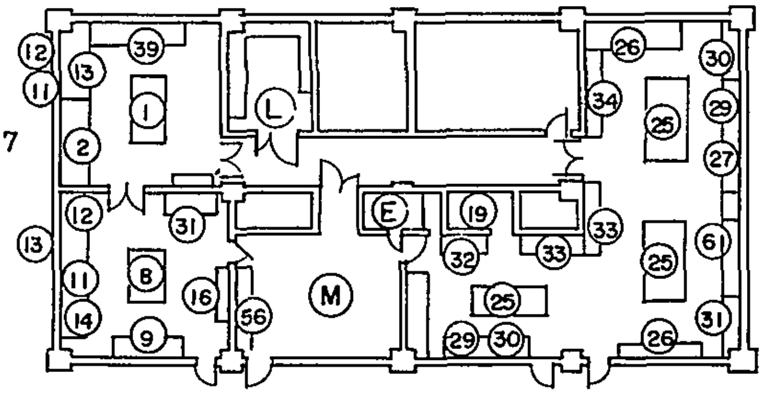
Sample Plan of a Multiple-Room Laboratory
(Proposed Plan for Tokyo Industrial Water Works Laboratory)

Fig. 6



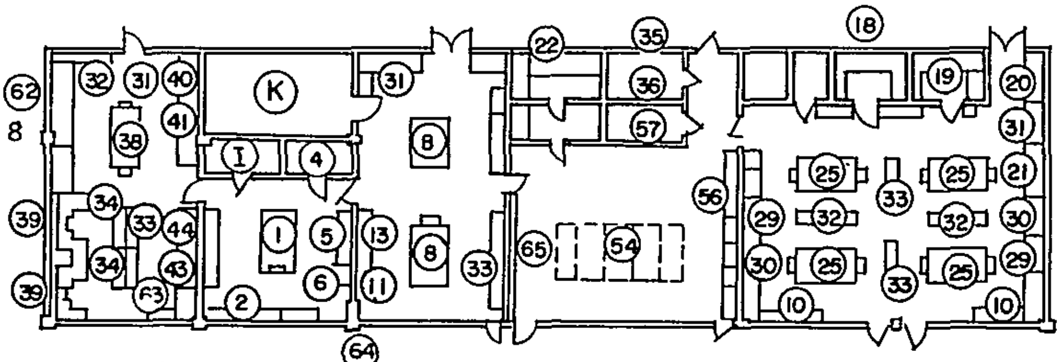
Sample Plan of a Multiple-Room Laboratory
(An Existing Tokyo Water Works Laboratory)

Fig. 7



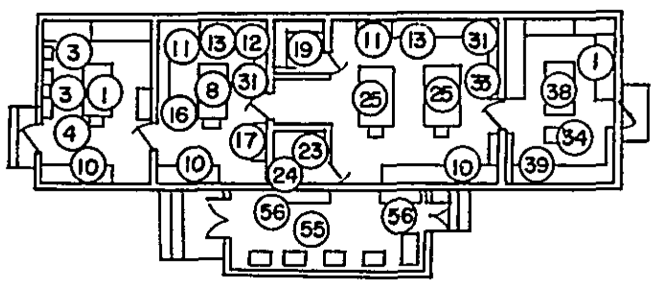
Sample Layout of Equipment in Laboratory (A)

Fig. 8



Sample Layout of Equipment in Laboratory (B)

Fig. 9



Sample Layout of Equipment in Laboratory (C)

INDEX

No.	Equipment & Furniture
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3	Incubator
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5	Sterilization Cabinet
6	Electric Refrigerator
7	Cabinet
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9	Work Table
10	" "
11	Draining Table
12	Horizontal Stand
13	Sink
14	Dry Sterilizer
15	Autoclave
16	Chemical Cabinct
17	Tool Cabinet
	C. Balance Room
18	Desiccator
19	Balance Table
	D. Draft Chamber
20	Draft
21	Semi Draft
	E. Dark Room
22	Enlarging Table
23	Enlarging Cabinet
24	Sink
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26	Measuring Counter
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60	Electric Apparatus Room
61	Electric Furnace
62	Fireproof Testing Counter
63	Specimen Cabinet
64	Washing Storage Cabinet
65	Filing Cabinet

VII. Conclusion

The Iraqi watcrworks are presently pursuing a path of development quite similar to that which Japan took some years before. This encourages us to believe that our opinions, stated humbly but honestly from past experience, amy be useful to at least some extent.

The facilities of the Iraqi waterworks are developed to a level surpassing that of the technical skills available for their operation. Some highly competent technical people are presently bending every effort to provide leadership for construction and operation of water works facilities in Iraq, but they are too few in number. Also, they lack adequate assistance on the lower technical levels. The greatest deficiency is in capable operator personnel. It is difficult to solve this problem completely in a short period of time, but decisive action should be taken quickly. A quick, easy method of carrying our personnel training might be to utilize Japanese waterworks facilities. Specifically, it is suggested that leading engineers in Iraq visit Japan for short periods to inspect Japanese waterworks, and to hold series of discussions with Japanese technicians about maintenance and operation.

The Survey Team has based its report around a detail design of a water laboratory in the belief that this would be the most effective contribution to Iraqi waterworks. In regard to the construction and operation of this facility, not only the personnel of the Team but all the members of Japan's water engineering industry will gladly offer unstinting cooperation. We will welcome being called on for service without reservation.

We also have a deep interest in various possibilities for resolving the problems of water supply to the small villages of Iraq. Research on this problem is continuing, and a report will be presented in the future.

The Japanese Survey Team wishes to thank all the various poeple in Iraq whose cooperation and help made the survey possible, and to acknowledge the importance of their contribution to this Report.

We of the Survey Team earnestly hope that the liaison established between the Iraqi and Japanese waterworks industries may continue to develop, and deepen the frindship existing between the two countries.

Furthermore, the members of the Survey Team, on returning to Japan, made a series of lectures on the waterworks of Iraq throughout the country, and published several articles introducing Iraq and its water supply system to the Japanese water engineering industry. As a result, the industry has shown increased interest in future participation in Iraqi waterworks construction.