REPORT OF
THE SURVEY FOR THE DEVELOPMENT OF
DESERT AREAS
IN THE U. A. R.

March 1964

OVERSEAS TECHNICAL COOPERATION AGENCY

TOKYO JAPAN

P r e f a c

The Government of Japan, in response t

Government, entrusted to the Overseas Technical Cooperation Agency (OTCA) the task of conducting a preliminary survey in the U.A.R. The OTCA, fully realizing the importance of the Development Program of the Desert District in the U.A.R., organized a seven-member team of experts and dispatched it to the U.A.R. on October 20, 1963 for a two month on-the-spot survey under the leadership of Dr. M. Kobayashi, Professor of Keiō University.

The OTCA, which was established on July 1, 1962, serves as an executing agency of the Japanese Government to conduct Japan's government-level technical cooperation to Asia, the Near and Middle East, Africa and Latin America. Its principal activities are acceptance of overseas trainees, assignment of technical experts, establishment of overseas technical cooperation centers and the conducting of preliminary surveys for development projects.

It is my sincere hope that this report will prove to be useful in the field of technical help to the Development Program of the Desert District in the U.A.R. and will also help to foster closer technical ties and better understanding between the U.A.R. and Japan.

Lastly, on behalf of the OTCA, I wish to take this opportunity to express our greatest appreciation and sincere thanks to the various agencies of the U.A.R. Government for their invaluable help and cooperation given to the Survey Team, without which it would not have been possible for the Team to conduct a smooth survey on the spot.

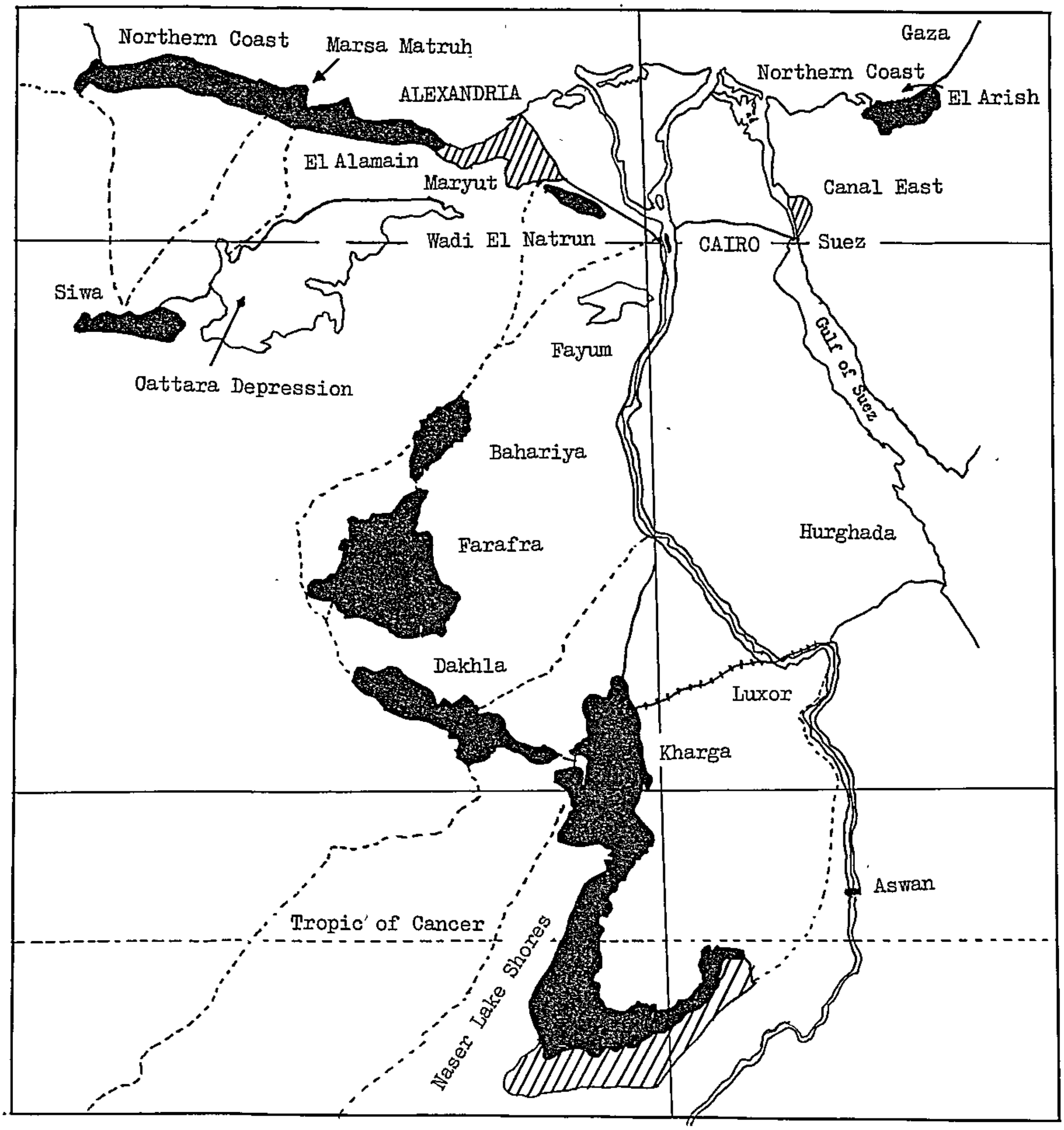
March 1964

Shin-ichi Shibusawa

S. Shibusawa

Director General

Overseas Technical Cooperation Agency



Northern Coast
Marsa Matruh
ALEXANDRIA
El Alamain
Maryut
Wadi El Natrun
CAIRO
Suez
Gaza
Northern Coast
El Arish
Canal East
Siwa
Oattara Depression
Fayum
Gulf of Suez
Bahariya
Farafra
Hurghada
Dakhla
Luxor
Kharga
Aswan
Tropic of Cancer
Naser Lake Shores

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I. INTRODUCTION

1. Organization of Survey Team

Mr. Yutaka Tsuchida, former Envoy Extraordinary and Ambassador Plenipotentiary to the United Arab Republic, had the chance to listen to President Nasser's enthusiastic speech on the New Valley Development Project. Although no definite proposal was made at that time, a friendly atmosphere was engendered leading to future cooperation. In 1961 (September), Dr. I. Kobori, Tokyo University, made a first official visit to the New Valley in close contact with His Excellency General Sobeih, the President of the Egyptian General Desert Development Organization, the Embassy of Japan (Cairo) and UNESCO (Cairo). Dr. Ootao, Technical Counsellor and Mr. Suzuki, from the Embassy of Japan, participated in this trip and the friendly connection was started. In 1962, Mr. Tsuchida contacted His Excellency General Sobeih again and met President Nasser with regard to Japan's Scientific & Technical interest in the Desert Development. Thus, His Excellency Mr. Wajima, Ambassador to Cairo, Embassy of Japan, and His Excellency General Sobeih, started to have official contacts.

In line with the above, the Government of Japan formally decided to supply assistance to the United Arab Republic in connection with the latter's desert development project, as one of the former's economic cooperation programs in foreign countries. Negotiations were held between the Governments of Japan and the United Arab Republic through His Excellency Eiji Wajima, Envoy Extraordinary and Ambassador Plenipotentiary in Cairo. It was agreed that a Japanese Survey Team would be sent to Egypt in the autumn, which season appeared to be the most suitable for the successful fulfillment of the planned survey. Therefore, the Overseas Technical Cooperation Agency, entrusted by the Government of Japan, organized the following survey team and dispatched it.

2. Members of Survey Team and surveys made

The survey team consisted of the following experts representing various fields of science:

Chief: Dr. Masatsugu Kobayashi
Utilization of solar energy and electrical communication

Member: Dr. Takao Sakamoto
Geology

Dr. Shunichi Kurosawa
Chemistry and electric power

Dr. Goro Nishikawa
Agronomy

Dr. Yoshiro Komatsu
Irrigation and drainage

Dr. Iwao Kobori
Geography

Dr. Kazuo Hayashi
Electronics

Prior to our departure, we collected as many documents and literature as possible to gain a detailed knowledge of the New Valley Project and had frequent discussions on methods of how best to carry out our planned field survey. We also procured various equipment and devices to be used in tests in the desert, including an unattended lighthouse unit, powered by solar batteries, manufactured in Japan.

At the suggestion of the UAR authorities, our survey tour was made from October through December 1963. With EGDDO as its managing center, the United Arab Republic rendered us unstinted assistance, including that given by the National Physical Research Center, the Desert Institute, the University of Cairo, etc. Supported by this assistance, our team was able to make full use of its scheduled survey period.

In the entire course of our survey tour, EGDDO provided us more than generously with various services, such as transportation and housing facilities, guidance at experiment sites, and supply of necessary information and data. As helpful were other quasi-Governmental research organs, such as NRC, the Desert Institute, the University of Cairo, the Agricultural Experimental Farm, etc. We surmise that failing assistance from the above organizations it would have been impossible for the survey team to attain its objectives.

Our survey team was also accorded a warm welcome by the inhabitants of every place visited. We were all able to enjoy close association with the UAR people in their everyday life, apart from our primary objective of studying arid lands. We wish to take this opportunity to express our deep appreciation for all the kind assistance rendered us during our stay.

3. Outline of results of our survey

At first we were concerned as to whether Japanese technology, originating in a country where there are no deserts, would be of use to the UAR desert project. Under this apprehension, we studied desert development projects proposed or currently being carried out by the UAR Government and visited sites to be developed. In each project there were a few points yet to be solved. These points are explained in detail below. We are now confident that Japanese technology is capable of working out the suitable steps to be taken in connection with these points, and have added over 20 recommended steps which are given at the end of this report.

II. KHARGA OASIS

(INCLUDING DAKHLA OASIS)

1. Outline of the project

According to the five-year project of EGDDO, the total development area of the New Valley Project is 121,000 Fds. This area is estimated at 40% of the total area, 300,000 Fds of the entire EGDDO project. The expenditure for the New Valley is $21,550.10^3$ £E, which corresponds to 35% of the total expenditure for the entire project, $62,100.10^3$ £E, but this amount of money corresponds to 40% of the difference, if we subtract Economic Development expenditures.

According to Report 1, (P.B., three lines from the bottom of page 13 to the top lines of page 14) of the EGDDO five-year project, it has been decided to develop 21,000 Fds in the first two years, and study the conservation possibilities of water resources, and contribute to the progress of the development project.

The actual plans proceeding under the development project are as follows: 27,996 Fds in Kharga and Dakhla, as of June 1963, adding 8,000 Fds to the development in 1964, totalling about 36,000 Fds by the end of 1964. If the five-year project ends in 1964, the actual developed area of the project will be 30% of the original project.

2. Water resources are a fundamental necessity for the development of oases

Every effort has been made by EGDDO to acquire water, and good results have been achieved. The investigation in the Kharga area is particularly advanced.

In the Nubian sandstone formation, five-group eight-stratum aquifers have been discovered. They are as set forth below. If we list them, starting with the deepest: (1) the first group (the first stratum), the deepest one has 15 ~ 187m of aquifer in thickness, (2) the second group (second, third and fourth strata) has 54 ~ 215m of aquifer in total thickness, (3) the third group (fifth and sixth strata) has 71 ~ 252m of aquifer in total, (4) the fourth group (seventh stratum) has 70 ~ 198m, (5) lastly the fifth (eighth stratum) has 62 ~ 200m of aquifer, which is the uppermost.

As one example that springs exist in the areas above the lowest Depression, the Ain Amur Well in the middle of the plateau, (460m above sea level) which has served caravans on their route between Kharga and Dakhla, and also the Omm-Dabadib Well on the north escarpment of the Kharga Valley, are both very wonderful. It is quite possible that the water of these high-altitude wells must have originated from the concentration of the rare rains in the Hammada Plateau, and they are independent of the Nubian sand-stone formation.

(a) Roman Wells

The water from the eighth stratum, the uppermost in the Nubian sandstone formation, has been utilized for more than 3,000 years, and millions of people owe their lives to this water. This water springs naturally out at certain spots, but most of the wells are of the man-made artesian type. The depth is at most 200 m, the diameter 40 ~ 75 cm, and the well pipes are made from the trunks of a kind of palm tree, called the Dom-Palm. Such wells are called Roman Wells.

The water in this stratum was very plentiful in ancient times, but it is now decreasing yearly. The data on the Kharga Valley is as follows:

Year	Number of Wells	Discharge in m^3/day	Average Discharge per well in m^3/day
1931	670	-	-
1941	354	123,200	348
1953	412	105,800	257
1961	285	100,051	351
1963	-	79,000	-

It has already been proved that even if the number of wells should be increased, they would only interfere with each other, resulting in no increase in the quantity of water secured.

The total number of Roman Wells in the Dakhla Valley has not been studied in as much detail as in Kharga, but it was reported that the total water discharge in 1963 was about 250,000 m^3 per day. From this result, it may be believed that the 329,000 m^3 per day discharge of water must have been drawn up in Kharga and Dakhla from the eighth stratum.

(b) New Wells

To compensate for the tendency of the water supply from Roman Wells from the uppermost eighth stratum to decrease, and also to promote new development of water resources, it has been decided to develop new aquifers. It was estimated that the total quantity of the underground water in these new aquifers is some 740,109 m^3, and it is possible that, even if no fresh supply flows in, only one third of this amount of water can irrigate farming areas of about 50 million Fds for 198 years. This amount corresponds to 1.25 billion m^3 per year, or 3.42 million m^3 per day, and a 16 mm per day decrease in the water level. By the year 1954, only seven deep wells had been drilled, but after that new wells have been dug one after another, and now the new wells in both the Kharga and Dakhla valleys total as many as 140.

The new wells in the Kharga valley are not aimed at the eighth stratum, as were the useful Roman Wells, but they are aimed at the stratum below, the eighth. The most promising of all seven strata has proved to be the seventh, just below the eighth stratum of the Roman Wells.

In each area from one to three deep wells have been dug, but these were laid out designedly so that each well draws water from an individual aquifer. This differs widely from the deep Japanese well which is designed so that it will draw water from several aquifers. There is no interference within the same stratum, but as mutual interference occurs when two wells are drilled too close together in the same stratum, intervals of 3 ~ 4 km are necessary between wells served by the same stratum.

The number of new wells and the total amount of water drawn, both now rapidly increasing, are as follows:

Year	Number of wells	Total production in m^3 per day	Average flow rate per well in m^3 per day
1961	34	63,795	1,876
1962	56	187,000	3,340
1963	140	585,000	4,040

Notes: (1) The data for 1961 and 1962 are derived from page 140 of the report, and probably refer only to Kharga.

(2) The figure for 1963 was confirmed by on-the-spot observation, 345,520 m^3 per day for Kharga (May 1963) and 239,650 m^3 per day for Dakhla, and the total being 585,170 m^3 per day.

The discharge from one well is from 2,000 to 10,000 m^3 per day, and its depth is from 400 to 600 meters. However, new problems have arisen in that the increase of discharge is mainly due to the new wells, and the apparent increase is offset by the yield from old wells being conspicuously on the decrease, which fact worries us very much. Outstanding examples, perhaps, proving that the discharge from the ten newly-dug wells in Kharga is patently on the decrease are the following:

Year	1956	1958	1959	1960	1961	1962
Total Yield (m^3/day)	80,100	61,190	47,800	44,410	36,169	29,490
Average discharge (m^3/day)	8,010	6,119	4,780	4,441	3,616	2,949
Total percentage decline	-	23%	40.3%	44.7%	54.7%	63.1%

(from page 139 of the report)

The main causes for the decrease in discharge are considered to be as follows:

1) Underground water which supplies one well exclusively shows a tendency to decrease due to less flow-in from others.

2) Even if sufficient underground water exists, the layers of earth around the well pipe become too tightly packed.

3) Corrosion of the well pipe strainer, which obstructs free flow of water.

According to on-the-spot study, the third is the principal cause.

In any case, it is desirable to learn the correct water pressure of every well, variations in the daily quantity of water drawn, the total yield of every well, and so on.

As one method of preventing strainer corrosion, it was decided to change the material the strainer is made of ordinary to stainless steel or aluminium, and this method has proved very effective, but as these materials cost more than ordinary steel, it is inevitable that the cost of every well should be higher. On the other hand, if the useful life of a well increases sufficiently, it will compensate for the disadvantage of initial higher cost, and water becomes cheaper.

Now experiments with glass fibre, synthetic resin and other materials are being carried out.

It must be added that the cost of a well differs, according to its site and depth, but the cost is roughly from 15,000 to 40,000 £E, the average being 20,000 £E, and the average life is estimated to be about ten years.

(c) Quality of water, etc.

As the deep wells in Kharga are deeper than the conventional Roman Wells, the temperature of the water from the former is higher, registering at from 32° to 40°C, the average being 36°C. The solute contained in the water is from 177 to 602 ppm, somewhat higher than the 100 ppm of the Nile river water, but still deserves to be of good quality.

Table 1. The water quality and temperature of water from the main deep wells

Item \ Well Number	Kharga No.1	Kharga No.2	Nasser No.1	Garmashin No.2	Baris No.1
P_H	7.3	7.22	8	7.8	7.65
Temperature °C	38.5	37.5	32	35	35
	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ
HCO_3^-	137	82	85.4	84	95
$C\ell^-$	41	35	119	119	105
SO_4^-	4	5.1	76	20	52
Ca^{++}	12.8	19.2	39.4	78	36
Mg^{++}	7.3	8.7	38	88	15
Na^+	27.5	27.5	61	50.5	73
K^+	27.5	27	44	36	31
Fe^{++}	1.9	2.1	-	-	-
CO_2	23	23	31	26	19
Total dissolved solids	203	193	487	330	404
Total depth	637	602	394	802	499
Aquifer Zone	I-IV.	I-IV.	VI-VII.	V-VII.	IV-VI.

Photo 1. The natural artesian spring in the Baris Oasis.

Photo 2. Traces of the Roman Well in the town of El Kharga. (Manaur el Ain Mohamed Badr)

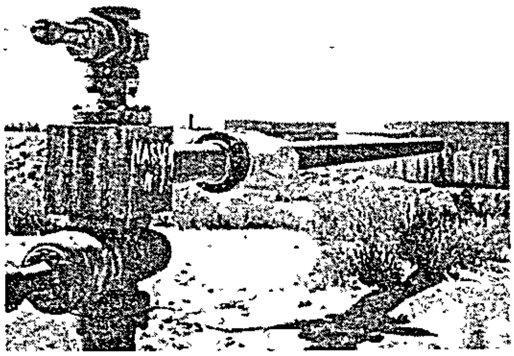


Photo 3. A new well (Nasser No.1)

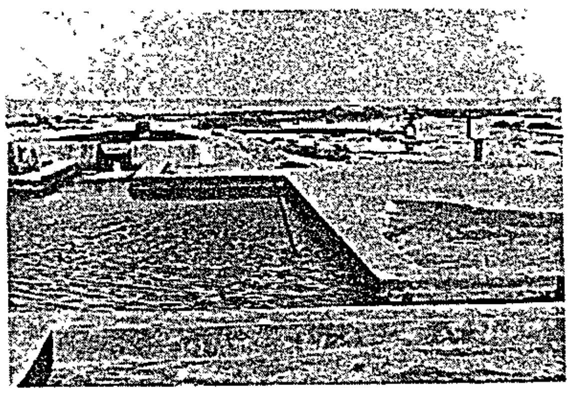


Photo 4. A new well, reservoir, notched water-level meter, ditch, and newly cultivated farm areas. (At Nasser No.1 and No.2, the latter now being unproductive)

The water from these wells is colourless and transparent, but has a slight smell of Hydrogen sulfide. When exposed to the air, the iron in solution oxydizes immediately, so that the inner walls of the reservoir and the ditch are stained the colour of iron rust. It can be easily seen that this H_2S and CO_2 are the cause of pipe corrosion.

The digging of wells is not directly done by EGDDO, but is operated under contract by drilling companies of the U.A.R. and Yugoslavia.

3. Land Reclamation

As it has been proved that we can acquire underground water by drilling deep wells, it has been decided to proceed with the development.

Well sites must be selected in line with development possibilities. Even if the water is obtained, if there is no land nearby possible of development, the water must be transported to other places over a long distance, resulting in uneconomical procedures.

(a) The process of selecting land that can be developed, land suitable for development, and execution of land development.

Land to be developed must be selected after considering a combination of the ease of acquiring water, the nature of the soil, the availability of transport, etc.

First, a rough classification of land is carried out by means of aerial photographs, and then those areas roughly selected from the point of view of possible agricultural development. Let us call these areas as land possible of development. Within the lands possible of development, the drilling spots of deep well are to be decided.

When well sites are decided upon, and the probable amount of the water available is estimated from the geological structure, the area of land that can be irrigated by the water is selected from the land possible of development, a semi-detailed investigation is made, and lastly the land is classified into five categories from the data on thickness, organization, structure, solidity, etc., of the soil stratum. It is indisputable that establishment of a utilization plan from the upper to the lowest of five classes, be made, and also consideration should be given the period necessary to dissolve and get rid of the saline content of the soil, and the balance between necessary work expenditure and the probable productivity of the soil. For this purpose, several standards have been previously given, and higher or lower efficiency can be determined by mathematical calculation. In such ways land suitable for development can be determined.

After the work of drilling a well is finished, and we come to the stage where the discharge and quality of the water are measured, a detailed survey must be performed, and finally the land to be developed is selected.

From the results a detailed investigation of soluble ions is performed, and finally, a minute classification of the land is made. With reference to this classification, the areas to be developed are finally selected, and the scheduled work follows.

Generally speaking,

i) Those areas with sand dunes to windward (north) are not desirable. In such cases there is the possible danger of dunes drifting over the land after development, covering the agricultural land obtained with great effort.

ii) In the case of fan-shaped areas at the ends of wadis, the following differences may be noted, according to the upper, middle, and lower portions of the fan.

Items	Parts		
	Upper	Middle	Lower
particles of soil	Coarse	Medium	Fine
thickness of surface soil	Thin	"	Thick
salinity	Low	"	High
difficulty or ease in removing saline material	Easy	"	Difficult

Taking sufficient account of these elements, the plan has developed to the point where it is known that long-rooted plants, such as fruit-trees, should be planted in the upper part of the fan, medium-rooted cereals in the central part, and shallow-rooted herbs in the lower part.

(b) Land Levelling

The all out development work is such that in addition to the work of drilling wells, levelling of land, irrigation, pumping and drainage are necessary.

Almost all the soil of land suitable for development, both in the Kharga and Dakhla areas, is loamy clay of heavy texture, and is non-osmotic; moreover, it contains a great quantity of soluble salts amounting to as much as from 3 to 5%. Therefore it is necessary to leach out these salts and expel them within a depth range of about one meter from the surface, resulting in the lowering the percentage of salt from 0.2 to 0.3%.

For this purpose it has been recommended that the flood-irrigation system must be adopted. The contour irrigation system has been adopted for some terrain, but the sprinkler irrigation system is not desirable. Therefore it can be easily understood that the levelling of land is a necessary procedure in the formation of agricultural land.

The standard grade in land levelling is about 1/2500, but in case the quantity of earth to be removed exceeds 600 m^3 per Fd or 1,500 m^3 per hectare, development becomes inefficient and is removed from the overall development plan because of the high expenditure involved. As the expenditure for removing 1 m^3 of the soil is estimated to be 100 yen, using Japanese terms, expenditures for levelling must be limited to 143,000 yen per HA.

Thus it is seen, that great emphasis is placed on land levelling, and that deliberate formation of basic agricultural land is making steady progress and is worthy of note.

For the purpose of land levelling work, the EGDDO has regimented two mechanized corps, each corps having a hundred or more civil engineering machines. The principal machines are bulldozers, light scrapers, heavy scrapers, land-levellers, tracters, etc., and it has been reported that their operating capacity is 500 thousands cubic meters per month, or an area of 1,000 Fds per month at full capacity.

For the maintenance and control of such a large-scale mechanized work group, a repair workshop has been built in the town of Kharga. (Details will be given later).

(c) Process of cultivation

When levelling of land has been finished by the large mechanized corps, the next process, that of cultivation, follows:

i) irrigation to leach out undesirable salts,

ii) tilling the soil with ploughs,

iii) finishing off the levelling work with small-type machines,

iv) finishing with plows, and harrows, and planting trees, to form wind-breaks,

v) making divisions and ridging by hand, by the farmers,

vi) lastly, after watering the fields, the planned sowing and planting are carried out.

(d) Irrigation and Drainage

The quantity units of water adopted for use as standards for irrigation are as follows: 40 m^3 per day per Fd. or about 10 mm per day in summer, and 20 m^3 per day per Fd. or about 5 mm per day in winter. These quantities include probable losses in canals, due to percolation and evaporation, as even if we line canals, the amount of water will decrease. Moreover, if piping is used in place of lined open ditches, further curtailment of water will result, and higher construction expenditure will also follow. At present a U-type concrete conduit is used, and it is by this means that the amount of water necessary, 20 m^3 per day per Fd. for solely earthen ditches is reduced, it is reported, to 17 m^3 per day per Fd. (15% loss) when only the main canal is lined, and to 15 m^3 per day per Fd. when all branches are lined.

As these standards for the quantity of water for irrigation are merely set down from the standards used in the execution of work in the Nile delta, we feel there must be some disparity in applying them to districts where climatic and soil conditions differ from those of the Nile delta. It may therefore take many years to learn the standards suitable for these districts, but it seems advisable to adopt such provisional standards for the purpose of speeding up the work.

According to these standards, the amount of water needed in summer is, in any case, twice that for the winter months, but as it is impossible to draw twice the amount of water from the well, we must actually decrease the acreage to be sown or planted for the sake of adapting to reality.

The frequency of irrigation should be to water once every 7 ~ 8 days in summer, and once every 12 ~ 15 days in winter.

The farm land is divided into many small subdivisions. We have two systems of irrigation, the row-system and the bed-system, the former being applied for tall plants, and the latter for ordinary vegetables.

In such districts where the soil is every sticky clay, and the salt concentration is high, the removal of salts must be given constant attention, the efficacy of irrigation by flooding being highly esteemed. It is very difficult to supply water uniformly over such a wide area, but it may be a very excellent idea to find a general solution to this difficulty, not only in these districts, but in order that all over Egypt irrigation of such subdivisions should be uniform.

However, this method of irrigating subdivisions has some demerits, such as it being troublesome to maintain these subdivisions in good order, and careful day-long attendance is necessary to supply them properly, which results in the need for a large labour force, and, moreover, the use of agricultural machines is considered almost impossible. But at present, when the farm area per family is small, and the families are large, such an intensive agricultural system may be appropriate until the time comes when modernization of agriculture must be considered.

Drainage is done by the drainage ditches. The drainage ditches consist of a main and branches, and the latter, 2 meters deep, are set at regular intervals of 50 ~ 70 meters. This water, collected from the branch ditches, uniting with the water in the main ditch, and finally flowing into the nearest depression, where evaporation and concentration take place, finally becomes a so-called "bitter pond". As evaporation proceeds, the salts will eventually form a deposit.

(e) Settlements

As wells are drilled in the above-described way, and land is ready for filling, settlement villages will be built.

At present, new settlements are being built at some 20 km intervals, along the paved road between Kharga and Baris.

The daily water discharge from one well is 2,000 ~ 10,000 m^3 per day, and therefore if we assume a reduction in depth to be 5 mm per day, this would irrigate an agricultural area of as much as 40 ~ 200 hectares or 100 ~ 500 Fds. Taking this area into consideration, the scale of a settlement can be determined.

We have inspected a village called Nasser Village.

The source of water for Nasser Village consisted of two wells called Nasser No.1 and No.2. The water flows at present at 5,500 m^3 per day for No.1 and 6,500 m^3 per day for No.2, totalling 12,000 m^3 per day, corresponding to just 5 mm per day for an area of 600 Fds. Two years have passed since the first settlement, and now 66 families have already settled there. Arable land of 5 ~ 6 Fds per family, according to its size, and one house, one cow and one donkey are all given newly settlers. The price per Fd. is £E 150, and every family can own the farm-land, including the house, under a long-term contract covering forty years for payment.

The settler's houses are built so that two one-storied houses of sun-dried brick face each other, the so-called mirror type of construction. The plan is shown as follows:

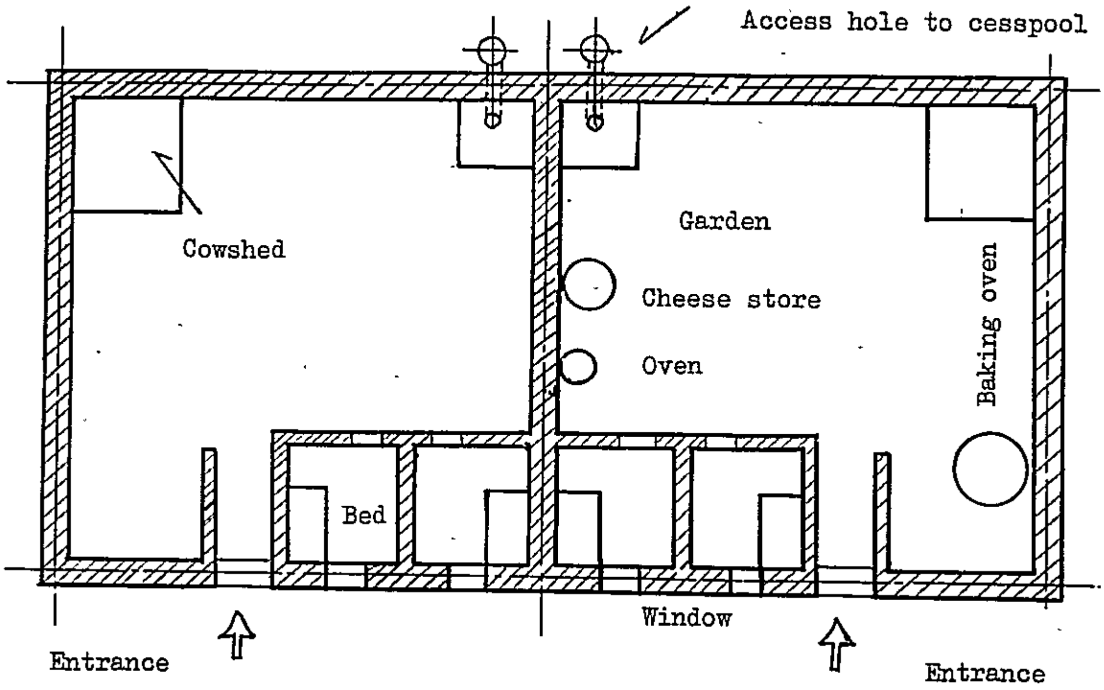


Fig 1. Nasser Village for settlement farmers

The site area per family is 200 m^2 (70 tsubo), and the dwelling area is $13m^2 \times 2$ (rooms) = 26 m^2 (8 tsubo). Measurements are paced off.

Although the houses are small and not very attractive, yet they are for superior in comparison with conventional farm houses.

In the village, the mosque, primary school and commodity booths have been established, and clinics have been built in the ratio of one to several villages.

The occupants of settlements were selected from among applicants of the Nile Valley and also from inhabitants of oases who had to migrate because of water shortage, but the former exceeds the latter in number.

Since the beginning of the five-year plan, the area newly developed to June 1963 was already 27,966 Fds., and it has been decided that an additional area of 8,000 Fds be developed by the end of 1964. (This fact has been mentioned in the summary of the plan, 2-(1)).

(f) Experimental research to be performed later

In the Enterprise office in Kharga operated by EGDDO, a Department of Experimental Research has been established, and equipment for experimental research on, for instance, the climate, particularly agricultural micro-climate, irrigation and drainage, types of agricultural plants, fertilization, etc., are now approaching completion.

The research items of particular importance are:

1) Experiments to improve the system of irrigation for subdivisions to apply to large divisions. It has been mentioned that each division is, at present, 100 m^2, which it is now planned to enlarge to 2,000 5,000 m^2.

2) Experimental research on the amount unit of water for irrigation. We were told that these experiments were not carried out on a small scale device indoors, but a large scale experimental device for use in the open are was planned. We have already mentioned that the standard quantity of water for irrigation was provisionally borrowed from that of the Nile Valley, and it is planned to test this standard against the data on the quality of the soil, etc., on the site.

3) Research on drainage, particularly by means of culverts.

This experiment was performed for the purpose of measuring the effects of steps taken for the removal of salts. It is intended that the relation between the intervals, depth, etc., of drainage ditches as it affects salt removal, be investigated.

4) Research on plants for cultivation

As the fertility of the farm lands increases, it is only natural that the growing boundary conditions of plants also change, so that various kinds of plants must be studied for adaptation to these new conditions.

5) Research on fertilizers

This research is aimed at studying the standards for fertilizers most suitable for the many kinds and qualities of soil in every district.

4. Agriculture

(a) The quality of soil

The quality of the agricultural soil in the Kharga Valley is sandy loam or light loam. It is reported that the quality of the soil in the southern section is better than that in the nothern part, resulting in higher productivity in the south. The organic material content is gennerally small, being only about 1%. The quality of the soil is much higher where the saline material has been carefully removed, but there are some farming areas where the salts have accumulated. The calcium carbonate content ($CaCO_3$) is comparatively high, sometimes as much as 17.5%, and therefore the alkalizing of the soil is not carried out over the entire scope of the farming area. There is no trace of sodium carbonate (Na_2CO_3), but there is 0.06 ~ 0.30% of sodium bicarbonate ($NaHCO_3$).

In the Dakhla Valley, the soil varies from loam to clayey soil, and although it is heavier than that of Kharga, it is better suited to agriculture. There are some places in Dakhla as well as in Kharga, where salts have accumulated, but the percentage of calcium carbonate ($CaCO_3$) in the Dakhla area is 2.1 ~ 9.7%, which is much less than in the Kharga soil. Alkalizing of some farm land is under way.

As we have stated above, the quality of the soil is not too bad for agricultural purposes, but because it has only small quantities of organic matter and also because salts tend to accumulate, it is necessary to be extremely alert in the growing of agricultural products.

(b) System of sowing and planting

EGDDO has lately adopted a system for the rotation of crops to grow agricultural plants in this district.

All agricultural land is equally quartered, and crop rotation is carried out every four years in the individual divisions in order to equalize the whole.

The above rotation system is shown in the following table:

Table 2. Sowing and planting plans in the New Valley

Year	season \ division	I	II	III	IV
1	summer winter	alfalfa	rice beans	- wheat	- barley
2	summer winter	alfalfa	- wheat	rice beans	- barley
3	summer winter	alfalfa	- barley	- wheat	rice beans
4	summer winter	rice wheat	alfalfa	- beans	- barley

In relation to this system of sowing and planting, it is considered urgent that great emphasis be placed the removal of salts and the supply of organic material, and that the growing of rice-plants in the paddyfields speeds the removal of salts from the soil, particulary from the lower depths, and, moreover, that the introduction of alfalfa, incorporated with cattle-raising, contributes to the supply of organic material to farm lands. Moreover, carbon dioxide (CO_2) is liberated at the roots by respiration, and therefore as a result, that the solution of salts is promoted, this indirect assistance in salt removal also being worthy of mention. Wheat, barley and beans are all selected because they form the staple diet of the inhabitants, but it is feared that if only these crops are produced, the quality of the soil will deteriorate sooner or later, so it is planned that rice and alfalfa also be grown, as this method is considered to be very sensible and effective.

(c) Rice in paddyfields

With regard to rice, EGDDO is now considering that, for the present, this cereal must be incorporated into the overall system, but in such a extremely arid belt as this, for if the growing of rice is not included in the crop rotation system, it is feared that salts would again accumulate. One reason why rice cannot be grown every year is that it necessitates a large amount of irrigation water, and in a district where water is precious, it is natural to think first of saving as much water as possible, but taking account of the hazard of accumulation of salts, the omission of rice planting from this system should be very carefully reconsidered. It may be more desirable to study measures for reducing the water needed for this crop.

At present, the inhabitants of this district do not habitually eat rice. Accordingly, the rice grown in the paddyfields is considered an item for export. On the other hand, in such a district, where the cost of water is too high, the cost of producing rice will be inevitably too high, and it may be very difficult to sell it at a profit. However, when rice is grown as a staple food supply for the district, the planting of rice will itself be stabilized, and combined with its efficacy in salt removal, systematizing will be complete.

In this way, if rice is planted regularly in the crop rotation system, the soil deterioration can be prevented naturally, and therefore other crops, such as barley, wheat, beans, and also safflower, soybeans, etc., in the fields now under test planting, can be produced at a high return.

As a result, effective overall production will be achieved.

To counter the curtailment of water supplied to paddyfield, it is considered that paddyfields should not be continuously flooded, but that vinyl-chloride sheets, OED, etc., be used as mulch to conserve moisture.

It must be added that if vinyl-chloride sheets are laid under the entire surface, capillary action will be completely blocked between the upper and lower soil layers. This obstruction serves to curtail the water needed for rice growing, and is also the reason for the benefit to general field planting, as it prevents the salts from the lower layers of the soil from rising.

(d) Tree-planting for shade-cover and for windbreaks.

The intensity of solar radiation is extremely strong in the desert. This intensity may be generally useful for the growing of plants, but sometimes it has proved too strong for some kinds of plants. Also, the fact that the heat is too intense promotes the evaporation of water from the surface of the soil with a consequent high accumulation of salts. Therefore it is considered that crops may sometimes tend to increase when some shade-cover is provided. For this shade-cover, the method of planting trees at suitable intervals is more economical than using artificial screens.

If the suitable trees are selected for this shade-cover, it is felt that the solar radiation from tree-top height will be softened, shelter from strong winds will be provided, fallen leaves will cover the surface, which last, combined with its deterrent effect on evaporation of moisture, will serve as organic manure. In case of tall leguminous trees, the fertilizing properties of the root-node can also be taken into account.

In developing land in oases, Casuarina Equestivolia trees, etc., are planted to mark the divisions between farms. These trees are also useful as windbreaks. These trees are arranged in single rows, both in the east-west and north-south directions. As mentioned before, 80% of the prevailing winds in this district are from the north reaching, and therefore it is considered that to attain efficient windbreaks, the density of the trees planted at right-angles to the prevailing wind must be increased. It has already been proved in Japan that if we plant trees thickly to windward, the micro-weather of farms will considerably alleviated, which is a great help in the cultivation of grains and vegetables.

(e) Improvement of the quality of the soil

With regard to the process of cultivation, first the land is irrigated to a depth of 200 ~ 300 mm in summer, next the soil is ploughed with tractors, and lastly fertilization and sowing are carried out. The quantity of fertilizer now used is considerably less than is used in Japan. As an example, in wheat cultivation, the quantity of superphosphate of lime per Fd. is 100 kgs and that of nitrogen sulphate per Fd is 75 kgs. It is reported that the wheat crop in the Baris district is 450 ~ 900 kgs per Fd., the average being 600 kgs per Fd. (the average in Japan is 800 kgs).

As the soil in the development area is clayey, after being irrigated and ploughed, it solidifies into large lumps (agglomerations), and the necessary fragmentation is very laborious. For the purpose of reducing this work, it would seem that the physical quality of the soil could be improved by mixing sand with it. If this is done, it is desirable that irrigation and plowing be done after covering all the land with sand. Through this procedure, we can expect the capillary structure of the heavy, clayey soil to be greatly changed, the dispersion velocity is much reduced, and consequently the evaporation of water is also restricted.

(f) Proposal to introduce grass

With regard to some of the Kharga and Dakhla areas, they are not scheduled to be developed as agricultural land, but there is a wide area which appears to be developed as grass land. In such areas, there is some amount of water in a layer 50 cm below the surface, and if we go 70 cm below the surface, there is sufficient water for the growth of plants. In such areas, if we mulch by using asphalt emulsion, for instance, select and sow a type of grass that will thrive in a dry climate, it would not be impossible to produce grass-covered land. There may be more of a possibility of success if we apply this method to places such as the western coastal areas where precipitation is comparatively heavy, than to try it in the Kharga and Dakhla areas.

Moreover, if we introduce such plants as lemon grass and citronella, which provide the raw materials for essential oil, by applying the above method, we can obtain the valuable essential oil merely by setting up a simple distilling apparatus, which will assist in increasing cash income. In such areas as deserts, where transportation is difficult, such products as essential oil, which are of small volume and high price, have a wide significance.

As water is comparatively abandant in soil where a plant called abal grows wild, application of the above-mentioned method seems very promising.

Moreover, the fostering of grassland will deter the drifting of sand.

(g) Date palms

Kharga and Dakhla, together with Bahariya, are famous for their dates, and particularly in Kharga, much cultivation is carried on. The production of dates in all Egypt is estimated to be as much as 6 million tons per year, of which this Oasis produces 2,000 tons.

As one of EGDDO's development projects, a date drying factory of a 4 ton per day capacity was established, and when we visited the place, it was nearing completion.

The process is (1) fumigation by carbon disulphide (CS_2), (2) washing, (3) drying in an oven at a temperature of 140° F and 50% humidity, (heated by heavy-oil burning boilers) (4) sorting and (5) packing. The plan calls for operation of the factory for 6 8 months per year, and from 50 60 laborers are employed.

Egypt desires to export as many dates as possible for sale. Using only the above-mentioned simple process, there is very little fear of rotting and deterioration in quality, the appearance of the product is enhanced, and the value of the commodity is increased. It is likely that superior methods of manufacture and processing of dates have not been sufficiently studied as yet. As dates are one of the most important assets of the desert area, it will be necessary to increase its value by further study of processing methods and its end uses.

5. Livestock and poultry raising

A great effort is being made to increase livestock and poultry in Kharga and Dakhla as well as other areas controlled by EGDDO.

As for cattle, an improvement in breed is now under way by mating the Egyptian and Holstein breeds. Cattle of the Egyptian breed produce only 3 4 litres of milk per day, and therefore increased production capacity is particularly desirable.

An effort is being made to improve poultry, and by importing Leghorns, Rhode Island Reds and Plymouth Rocks, better breeds are being raised. First of all, the Faium, indigenous to this country, is to be increased. This Faium lays 150 180 eggs a year, and when dressed for eating weighs 1.5 2.0 kgs.

Then there is the necessary equipment, such as incubators, and chick sexers are now being trained, with technical aid from Japan on this specialty also being considered.

Moreover, turkeys are imported from the Netherlands, and increase has already been planned. There are two kinds of turkeys, white and black, but the white is considered better because it survives in a hot, dry climate, and has more meat. They lay about 70 eggs a year. There are now about 1,000 turkeys at the experimental station in Kharga.

6. Repair workshop in Kharga

The development of Kharga and Dakhla depends largely upon mechanical power, and a repair workshop operated by EGDDO was established for the repair of machines for construction use.

The repair workshop consists of two main buildings of skeleton steel structure, several wooden annexes, and a concrete office building.

The offices, include a room for the manager, one for business, a blueprint room, and so on.

The two main buildings are equipped with every kind of machine tool, where the repair of machines and instruments under its jurisdiction is carried out, and where also simple metal plate work and welding are also performed.

In the wood-working department in the annex, such commodities as beds and furniture as well as a foot operated potter's wheel for the manufacture of pottery, all to be supplied to the settlement village, are now being manufactured.

The machine tools for repair work, such as lathes, planers, and drill presses, were imported from Czechoslovakia, the People's Republics of China, Denmark, Poland, West Germany, USSR, the U.S.A. etc., but not from Japan.

The number of employees in the workshop is about 300, including apprentices and 50 technicians.

Construction machinery under its jurisdiction is as follows:

250 vehicles, 50 landlevellers, 50 tyred tractors, 50 caterpillared

agricultural machines, and 150 tyred agricultural machines.

7. The energy situation

According to United Nations statistics, the situation in the U.A.R. in 1961 was such that if we calculate its total energy output in the coal equivalent, the total production was 5.10×10^6 tons and the total consumption 7.90×10^6 tons, which is equivalent to a 0.297 ton per capita consumption. This figure is rather low compared with the international standard.

With regard to electric power, the total generating capacity in 1961 was $1,182 \times 10^3$ kW, including 350×10^3 kW of hydraulic generation, and the total electric energy generated is 3.722×10^6 kWh, including 1,012 $\times 10^6$ kWh of hydraulic in the same year, so this country may be thought of as one that depends, mainly upon thermal energy and auxiliarily upon hydraulic. The electric energy consumption per capita per year is 140 kWh, and this is rather less than the international standard.

The above figures refer entirely to the Nile Valley from the Nile delta to the Aswan Dam, but in the desert areas the population is sparse, and provision of electrical energy is also out of the question.

In the Kharga and Dakhla areas, the fuel in every household is almost all used for cooking, and such fuel as exists there is the fallen leaves of date palms. Kerosene is also used for lighting.

In the New town and a part of the Old town in Kharga, the electric light and motive power are supplied from an electric power station operated by EGDDO. This electric power is generated by Diesel engines.

a) New town power plant

100 kW × 2 (made by Skoda)

30 kW × 2 (made by G.E.)

Total 460 kW

b) Old town power plant

Same as New town power plant, that is 460 kW.

c) New station under construction

460 kW × 3 = 1,380 kW

After this new power plant is completed, a) and b) will be abolished.

The electric power generated is transmitted to the town by 3-phase and 6,600-volt underground cables, where the voltage is stepped down to 220 volts for lighting and 380 volts for motive power and distributed over aerial lines to the customers. The transmission distance from the power station is within only a radius of 2 kms.

In addition to this power, the following factories are equipped with their own power-generating devices. Each factory is supplied with power by its generating plant only within its own precincts, and there are no electrical connections between factories.

I.C.C. factory	108 kW × 1 (made by Skoda) 80 kW × 2 (")
Date processing factory	80 kW × 1 (")
Wheat flour mill	80 kW × 1 (")
Machine tool factory	60 kW × 1 (")
Stand-by	60 kW × 2 (")

The total power generated is 608 kW, including 488 kW for constant supply and a 120 kW stand-by.

Besides the Kharga area, there are 140 kW × 3 in Baris and the same in Dakhla, both driven by Diesel engines.

The fuel oil consumption to drive the above electric generators is estimated at 2 kilolitres a day, and the barrels of fuel oil are transported by truck from Asyut Station.

If the generating power capacity should be increased hereafter, it would naturally be economical to use tanker lorries. It is also considered that each power generating unit is too small in scale, and that it is very uneconomical to have them independent of each other, and it is thought desirable to complete a central power station to unite all the power.

After a power station at Aswan are completed, it may be possible to connect this desert area with a transmission line, but this idea is not being very seriously considered at this time. Unless power consumption in the desert area becomes greater, it is felt that it is more economical to generate electric power locally even if it involves transporting heavy oil than to transmit power from Aswan.

The cost of electric power in the desert area is 3.0 3.5 p/kWh, (100p = 1 £E), which is higher than in Cairo (1.7 p/kWh), but does not differ greatly from the cost in Asyut and Suez. It is likely that, to some extent, political considerations may affect the charges.

The prices of fuel oils are controlled by the State, as follows:

Mobil gasoline, high quality		5.3 p/l
"	low quality	4.7 "
Diesel oil		1.6 "
Heavy oil		0.7 "

It is this policy of price control that benefits remote areas to a comparatively high degree.

8. Hydrogeology of Kharga Oasis and automatic measurements of water table.

(a) Lacustrine sediments and their soil

1) Previous studies

2) The eastern escarpment and its group of terraces in Kharga Oasis.

3) The climatic cycle and the oasis lake.

4) The evolution of the oasis depression.

5) The soil and its wind erosion in the Kharga Oasis depression

(b) The appropriate amount of water delivery, the life of undergound water storage and the technique of drawing up water.

(c) A proposal for the adoption of a central office control system by the use of an automatic observation device of the water level and its pressure (the self-recording and telemetering of water pressure by means of solar batteries as the power source)

Lacustrine sediments and their soil

1) Previous studies

Almost all reports on the geology of the Western Desert are referred to as "In the oasis depression, the lacustrine sediments are widely distributed.": H. Idris (1963) p. 19, A. Shata (1959) p. 86, R. Anwar (1954), A. Samei (1956), V.A. Kovda (1958), A. Shata (1959) has particularly referred to this as follows: "Younger Pleistocene strata consist of aeolian deposits, lacustrine sediments and Piedmont piles. (colluvial phase.)"

It has already been recognized by many scholars that these three kinds of accumulations, mixed with weathered products of the Nubian type sandstone and shale, are the base of the soil of the oasis depression -- the most important of the three being the lacustrine deposits.

"These deposits have been considered, since Beadnell in 1909, to be the sediments in prehistoric fresh-water lakes and their distribution extends N-S in the northern part of the Kharga depression, and their total area amounts to as much as 350,000 hectares. The 10,000 hectares of cultivated land around Kharga are naturally included in this area. The soil is clayey, containing 0.2 - 17% of calcium carbonate ($CaCO_3$). The clayey soil contains salts, as usual, and these salts are deposited in thin layers, showing the variation of meteorological conditions since the Pleistocene up to recent times. The soil of this oasis contains fairly large amounts of zirconium, tourmaline and rutile, ingredients common in the Nubian sandstone formation."

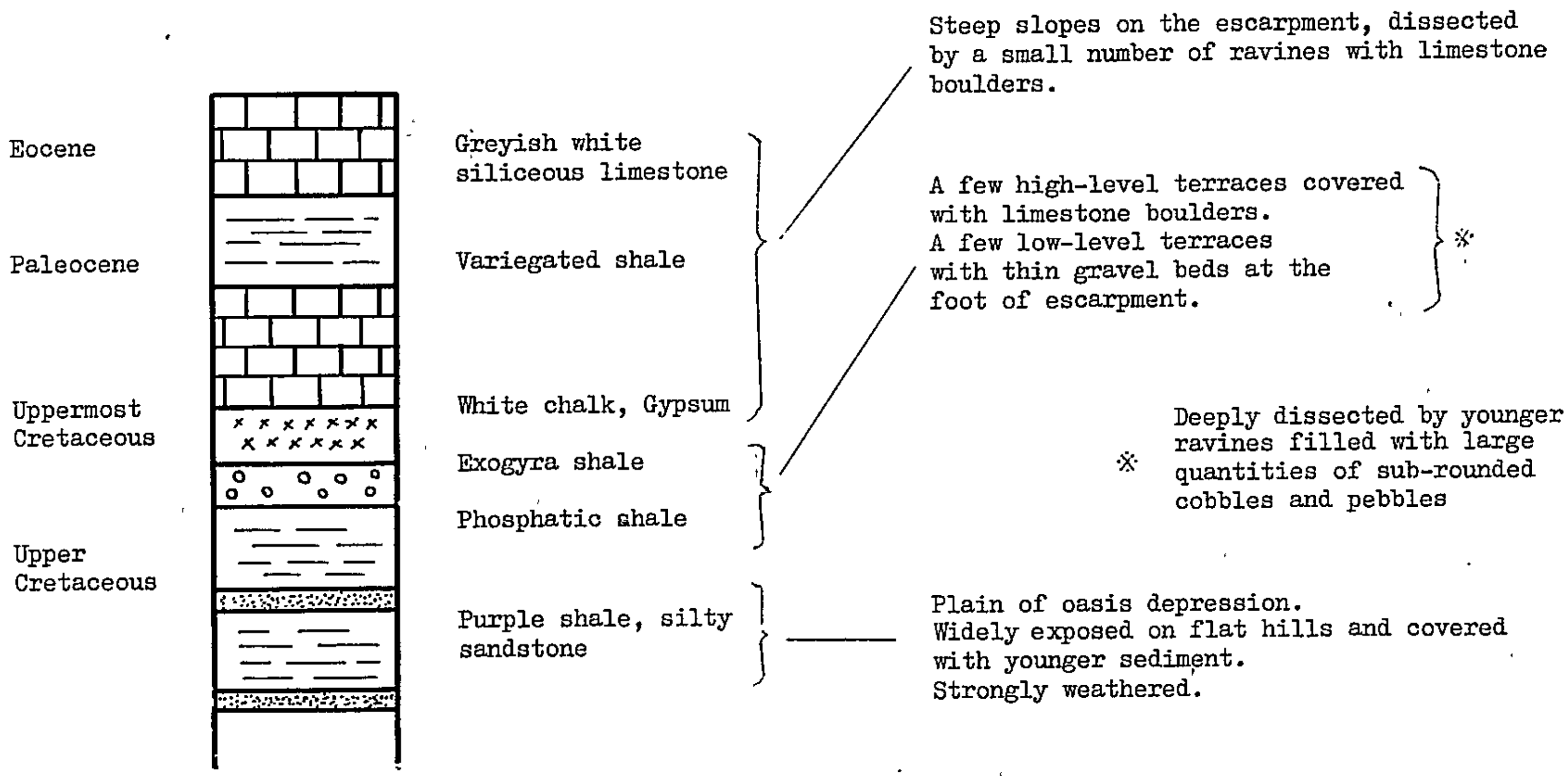
2) The eastern escarpment and its group of terraces

The writer has made the following observations at the escarpment east of Beris Village (the height above the depression is about 200 m). We were favored by Dr. A.Shata from the Desert Institute for accompanying and directing us. It must be added that conclusions reached on the evolutional stages of the terrace group express only the present writer's opinions. A sketch section of the outcrop of the escarpment to the east of Beris, Kharga Oasis.

Owing to an intensive dissection, the high level terraces are now simply a number of promontories along the slope. The fact that these are arranged laterally on ledges covered with a conglomerate bed (about 3 m in thickness) of boulders may indicate that these were once piedmont terraces developed along the lake shore at the foot of the mountain.

Among low-level terraces, there are few sedimentary terraces with boulders, but, beyond our expectations, frequent eroded terraces with exposed horizontal layers of formation some low-level terraces from conspicuous promontories, extending for several kilometers into the oasis plain. It is remarkable that the strata of low-level terraces, consisting of weathered and soft sandy shale, purple shale, etc., should retain this topography. It is likely that these low-level terraces must have been formed along the shore of a lake

A rough cross section of the outcrop on the escarpment to the east of Beris, Karga Oases



of a comparatively younger age.

All deposits of the bottoms of former lakes, along whose shores the above stated high and low terraces formed, seem to have disappeared these days in the oasis depression, leaving only a vestige in the terraces at the foot of the mountain. The so-called lacustrine sediments which at present thinly cover the surface of the oasis depression may be the deposits of a lake which has only recently disappeared.

It must be considered that such cycles of lacustrine sedimentation are not only important in the theory of soil genesis but also they suggest the genesis and stages of growth of the oasis depression itself.

3) Climatic cycle and oasis lake

The boulder layer on the terraces is about 3 meters in thickness, and tightly cemented together. On the surface outcrop, a piece of the most interesting limestone Dreikanter has been found. This is a Dreikanter 8 cm in diameter, a subrounded cobble stone, with its eadges more or less worn away.

The cobble is beheaded on one of the apices of its three edges, having long been exposed on the surface; the new surface is polished smooth by recent wind erosion. At present, on top of the plateau of Eocene limestone, many typical Dreikanter are found. These cobbles are likely to have resulted from such a process as, firstly, Dreikanter were formed by wind erosion on the plateau; secondly, they were washed down, during occasional downpours, over the edge of the escarpment into steep gullies; and finally, after being partially worn down by water erosion, they formed gravel beds and then conglomerate beds on the surface of terraces. On outcrops of the conglomerate, wind erosion resulted in beheading, and it is considered that they must have been formed in this manner. These facts clearly explain the climatic cycle of dry - wet - dry periods. Along with such climatic cycles, the appearance and disappearance of the oasis lake has been repeated.

On the limestone plateau near the entrance of the Kharga depression on the Asyut highway, there are sporadic nodules of siliceous limestone within a range of several hundred meters. This nodule is oval in form the major axis being a few scores of centimeters, and called a "desert melon". Along one edge facing north, radial grooves have been carved out in such a manner as to gradually sharpen the edge. This is due, at present, to sand blasting by the strong prevailing wortherly winds. The limestone layers on the plateau had been dissolved and left many complete nodules on the surface before the action of the sand blasting on the nodules. However, during the course of the dissolution, these nodules were not affected by sand blasting as they became exposed very gradually. This fact is also evidence of the climatic cycle; dissolution -- wind erosion, that is, humidity -- aridity.

4) The evolution of the oasis depression

It has been known from the above-mentioned examples of Dreikanter and nodules that climatic cycles have always occurred. It is also evident from a certain number of terraces that lakes have repeatedly emerged and disappeared in parallel with climatic cycles.

This leads to the conclusion that the fundamental causes of the growth and formation of the oasis depression are, "firstly, that water erosion proceeds, accompanied by dissolving action during the humid period, and next, receiving the effects of wind erosion during the dry period, the brittle portions of sediment must have been scored away." Also, in the limestone outcrops on the escarpment, beehive-shaped holes are often found, and this fact reminds us of the dissolving action of dew. Also, as the altitude above sea level of the depression decreases, the water yield of oasis springs grow greater, and this fact not only helps to increase the water level of the lake, but has kept the lake bottom wet, and prevents differential wind erosion of such brittle layers as that in Kharga, and consequently, it seems to us, serves to keep them comparatively flat.

In short, it is likely that as long as the dry climatic cycle continues, the oasis is not replenished with deposits, but is ever doomed to be scoured away deeper. It is also acknowledged that in areas where soluble material, such as limestone, chalk, etc. are particularly abundant, development is greatly promoted. It is considered that the reason for the bottom of the oasis depression being kept particularly flat is due to the powerful underground water under high pressure from the Nubia sandstone formation permeating, and preventing the differential scoring by wind erosion.

5) The soil of the Kharga oasis depression and wind erosion

The area at present under reclamation in the Kharga oasis depression is 5 - 80 meters above sea level. The brittle Uppermost Cretaceous purple shale is exposed there, or covered only by a thin layer of soil. The soil consists of a mixture of the so-called lacustrine sediment, aeolian sand and weathered products in situ derived from purple shale.

Considering the growth history of the oasis depression, the lake water had left lacustrine sediment, but these deposits had been almost completely scored away by wind erosion in the subsequent dry period. Moreover, as the wind erosion further reached the brittle rock of the basement and increased its depth, the depression gradually become expanded horizontally.

Therefore the oasis depression was originally an unstable place for deposits, which occupy the place only temporarily. This can be understood from the fact that the later Tertiary to older Pleistocene strata can hardly be discovered now in the central part of the oasis depression.

The soil of the Kharga Oasis

Ingredients	Distribution	Soil
Products of wind erosion residuals in situ of purple shale	depression of gentle slope	sandy loam, loam
same as above, but slightly sorted residuals	hill slope	loamy sand
same as above, transported and redeposited after sorting	depression	loam
aeolian sand	sand dune (thick)	drift sand
	whole area (mixed with others)	sand, loam, etc.

It is considered that the most suitable areas for cultivation are hill slopes and depressions of loamy sand and sandy loam. In particular, hill slopes of loamy sand have been irrigated frequently from ancient times, but this tendency is likely to decrease at present, due to intensive wind erosion. The cause is probably the gradual decrease in the supply of water for irrigation. In relation to this, however, it may be necessary to invetigate the sociological history of agriculture and use of land in oases since 1,000 - 2,000 years ago.

6) Appropriate water delivery, life of underground water and production technology.

In relation to the geologic structure, and hydrogeology of the New Valley, recent investigations have been published by the following authors:

M. A. Ezzat (1959),	(EGDDO, UAR)
P. E. LaMoreaux (1959, 1961),	(ICA, USA)
M. I. Pavlov (1959, 1961),	(UNESCO)
R. A. Higazy & A. Shata (1960)	(Desert Inst., UAR)
A. Shata (1961),	(")

H. A. Waik & H. Idris (1961), (EGDDO, UAR)

M. A. Ezzat & M. K. Ayouty (1961), (")

M. A. Ezzat (1962)

As a result, an estimate of the underground water budget in the entire Kharga oasis area has come to be made. (Ezzat, 1962). On the other hand, EGDDO of UAR has drilled about 140 new wells as deep as 200 - 800 meters in the three years since 1959.

From the results, such items as follows have gradually become clarified:

1) shape of piezometric surface;
2) transmissibility;
3) hydrostatic pressure, water yield, and
4) tendency of decline

Things are currently at the stage when fundamental investigations are being carried on, together with construction work. Under the present circumstances, the ultimate hydrogeologic problems that EGDDO is now facing are the amount of a safe or appropriate delivery and the life of the stored water. Moreover, there is the problem of delivery engineering amongst those of construction. Therefore it is urgent to learn as soon as possible the rate and causes of decline of the water yield.

The water yield of new wells has shown a decline of 30% one year after completion and about 50% or more five years after completion. Also, the water level of some wells has been lowered by a maximum of 200 cm per year.

The points at stake can be classified as follows:

1) rate of decline of water pressure;
2) materials for anti-corrosion screens and casings;
3) aggregate transmissibility, (advantage or disadvantage of tapping a

number of aquifers with different pressures, individually or collectively).

Although item 1) belongs to hydrogeology, items 2) and 3) are problems coming under hydraulic engineering. In relation to item 1), the non-flowing wells in several spots are used as observation wells, equipped with self-recorders for measurement of hydrostatic pressure. According to these records, the water level of wells has shown a twice daily ebb and flow, the difference between high and low being 35 cm, which corresponds to that of ocean fides. In addition to this daily variation, a steady decrease has been evident in many cases, but in others none can be detected. Sometimes the decrease reaches a maximum of 200 cm per year. As regards all the artesian wells or springs, these have been equipped with notched markers in the well-head tank for the measurement of the amount of discharge. Since 1961, small manometers have been attached to the Christmas trees around about ten wells, and by these means the hydrostatic pressure and recovery time after valve closure can be measured, and thus the equifer tests are being performed. Although all the flowing wells are natural springs, at present, it is considered that it will eventually become necessary to draw water by pumping. We have seen that one of the new wells, completed lately, is equipped with aluminum screens with saw-slots, which we heard were designed with the thought that it would become necessary to use pumps in the future.

As regards item 2), researches were quickly made, both at Kharga and at the Cairo chemical laboratories. The screen now in use is 6" 5/8 in diameter, and its total length is as much as 300 meters, in the longest case, for one well. The cost of the screen amounts to 25% of the average expenditure for the construction of a well, and renewal is difficult in case of corrosion, and these facts heavily affect the efficiency of a well and eventually the cost of water. Along with the studies on the problems of type, material and diameter of the screens, the possibility of entirely dispensing with screens in the case of some aquifers, is also being investigated.

As regards item 3), the problems have been shared recently (1963) by American technological aid experts, and are now under on-the-spot investigation. American experts mentioned a new idea that "either individual or collective delivery does not make any difference after a sufficiently long period of time," and brisk discussions are being carried out among the experts on the spot.

(d) A proposal for the adoption of a central office control system by the use of automation for the observation of the water level and pressure. (The self-recording and telemetering of water pressure by means of solar batteries as the power source)

With regard to such problems as the water budget, the limit of exploitation etc., of the oasis in the New Valley Project, Mr. H. Idris, the Chief Engineer, has stated as follows:

"In the reclamation project to utilize the underground water of the Nubia sandstone formation in the Western Desert, it is necessary to study correct data on the following items: daily yield, source, storage, decrease in rate of water pressure, period to free flow stoppage, economical limit of project, artificial increase of water pressure in the project area.

As it is by no means easy to analyze such complicated hydrogeological conditions, it was decided to try 'electric analog model experiments' for obtaining the needed data as soon as possible. We have requested Arizona University to study these problems by using 1/500,000 model, including such neighboring districts as the Sudan, Libya etc., and these preparatory experiments have already been finished; but it has further been decided to make a 1/250,000 model to obtain more detailed data."

It has already been mentioned that the decrease in the rate of the quantity of water delivered by new wells is high, and the most important cause of all seems to be the decline in hydraulic pressure. As mentioned before, EGDDO has already equipped several non-flowing wells with water level self-recorders (mechanical self-recording apparatus by use of floats), and also about ten flowing wells with monometers fixed on Christmas trees. By these means for measuring the static pressure head and the recovery time, aquifer tests are being performed.

In order to expand the water pressure observation network, EGDDO has newly prepared to drill a number of deep wells for observation, as follows:

southern part of Kharga	3 - 4 wells
area between Asyut and Kharga	1 well
west bank of the Nile	3 - 4 wells
area between Kharga and Dakhla	1 well
in and around Dakhla	several
Farafra, Baharia, Siwa	several

Of all the above-mentioned plans, in November, 1963, when our survey mission visited the plateau on the road between Asyut and Kharga, an observation well 1,200 meters in depth had already been drilled by an Italian drilling company, and was nearing completion.

Such being the case, as the decrease in the rate of water pressure is one of the fundamental problems for determining the economical limit of exploitation, it is considered desirable to record these data as precisely and succiently as possible. Therefore our survey team has proposed trying the following automatization. (Refer to report "Telemetering and recording of flow and level of wells at the central station".)

III. WADI NATROUN

Wadi Natroun is the name of an oval-shaped depression of 121,000 feddans, situated northwest of Cairo and midway of the 220-km desert road between Cairo and Alexandria. The depression lies to the west of the road with its 50 km length almost parallel to the road, and is 5 to 10 km wide. The lowest point of the depression is 7 m below sea level. The general lowland area is about 50 m below the rim of the depression. A series of salt-water lakes occupies the central part of Wadi Natroun.

1. Hydrogeologic Problems

A contour map of the piezometric surface of the water in wells in the area between the Nile Delta and Wadi Natroun is already available. The piezometric surface is about 18 m above sea level at Cairo and descends gradually towards the coast. One notes that a sharp ridge of 8-4 m runs along the Nubaria Canal. On the northeast side of the canal, the piezometric surface slopes down gently towards the Mediterranean Sea, while on the southwest side it descends steeply towards Wadi Natroun. In the northeastern part of Wadi Natroun the surface is 2 m below sea level. This may be good evidence of the fact that the Nubaria Canal plays an important role as a source of underground water. There is no doubt that the underground water of Wadi Natroun originates in the Nile Delta, but there are several differing opinions as to the route taken by the water. The following are the three main speculations:

1) In the lower portions of Wadi Natroun, wells have to be dug through a 400 m-thick sand layer containing water. The layer of sand and the stone stratum below it spread as far as the Nile Delta.

2) An old river bed lies buried between Wadi-Natroun and the Nile Delta, serving as an underground water channel.

3) The underground fault running from the barrage where the Nile divides into the Damietta and Rosetta branches, to Wadi-Natroun, is the route taken by the underground water.

2. Agriculture

The water table in Wadi-Natroun is 0.5 to 2 m below the surface of the ground. As water rises to 0.3 to 0.5 m below the surface by capillary action, the problem is how to grow seedlings until the roots are long enough to reach the water. Flooding by sprinkler irrigation is now used to solve this problem. It may also be helpful to cover the ground with a thin film of vynil, a kind of polymer, to prevent evaporation of surface moisture.

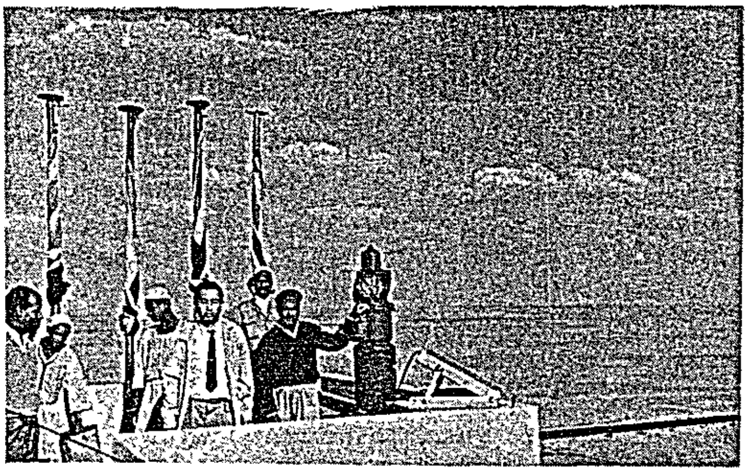
Farms are usually surrounded with casuarina trees for shelter from violent winds. More effective results would be attained by planting the trees more densely on the windward side.

Wheat, barley, onions, tomatoes, castor beans (for castor-oil), water melons, citrus and olive trees are planted in this area. It would be worth while to try growing aromatic crops, such as lemon-grass, in adjacent areas.

3. An Unattended Lighthouse Powered by Silicon Solar Batteries

In accordance with the G.D.D.O. proposal, we erected an unattended lighthouse for desert travelers in Wadi-Natroun as one way of using solar batteries in the desert. Silicon solar batteries are already used in lighthouses on the coast and in repeater stations in the mountainous areas of Japan. This is the first time solar batteries have been used in desert areas, and this field test in the desert will give us the information necessary to develop solar batteries for areas where solar energy is almost constant.

During daylight hours, the solar batteries deliver electricity to charge the storage batteries which, in turn, automatically light the lamps during the night.



As is seen in the photograph, the lamphouse and solar batteries were fixed on the 16 m-high roof of the G.D.D.O. office. The combination of 7-watt solar batteries and the Ni-Cd storage batteries can deliver sufficient power to operate the lighthouse for two weeks even under unfavorable weather conditions. The signal light was visible at a distance of 10 km at night. With a higher lighthouse, the visibility distance would be increased.

Especially in desert areas, solar batteries are expected to be used, not only for lighthouses but also for communication systems, telemetering equipment, and so on.

IV. NORTHWEST COASTAL ZONE

The Northwest Coastal Zone is a narrow strip of land extending westwards from Alexandria to the Egypt-Libya border along the coast of the Mediterranean Sea. The Government of the United Arab Republic have drawn up an irrigation project for this zone, under which productive land is expected to be created by extensive irrigation, as follows:

Arable land along the coast line	20,000 Fd.
Grazing land	60,000 Fd.
Total	80,000 Fd.

The area involved in this current project measures 499 kilometers in length, but its width varies from place to place.

1. Irrigation

In this area, there is no means of obtaining fresh water other than from shallow wells. One cannot draw fresh water from such deep wells as are widely used under the New Valley Project. Deep wells produce only salt-water. This is because the underground fresh-water stratum lies over salt-water. In this vast area there is no available source of potable water other than the shallow underground fresh water stratum and the rainfall, which is very scanty.

2. Utilization of underground fresh water

It was observed that in order to irrigate the area underground fresh water was being pumped up by windmills from independent shallow wells or, in some cases, from shallow wells connected to each other by underground tunnels at points near their outlets. The latter method is known as the Kandak system.

The use of windmills is due to the fact that the salinity of the water increases when any large amount of water is pumped up at one time from the underground fresh-water stratum. Another reason may be that no other suitable power sources are available there.

One windmill is capable of raising 10 m^3 of water per day, and by operating 6 hours a day this can irrigate about 10 Fd. of arable land where olive and fig trees are cultivated.

3. Rain-water Storage

It rains very seldom in this area, but when it does it comes down in torrents. Former generations saw the necessity of storing the water from these scarce but heavy rainfalls, and during the Roman era a number of cisterns were built throughout this area. It is said that there are still the remains of as many as 10,000 of such Roman cisterns. Some 300 of them were later reconstructed and are now in use.

Our survey team encountered a heavy shower during its stay in this area and one of these Roman cisterns was filled up with rain-water. We understand that there is a cistern capable of storing as much as 1,000 m^3 of rain-water. It can therefore be understood that these Roman cisterns contributed a great deal toward the irrigation of this area.

4. Cultivation of Underground Water

The true origin of the underground fresh water stratum should be discussed from various aspects. From various supporting evidence, however, it does not seem logical to conceive of any contributing factor other than rain-water and/or dew.

The site chosen for the current UAR Government development project happens to have, at its rear, a vast plateau. Therefore it is expected that the amount of underground water will increase by natural drainage of water from the plateau to the underground fresh-water stratum.

It would of course be possible to convert water draining from the plateau to underground water by inundating the lower plains with this water so that it will seep through the ground. A diversion project based on this principle is being implemented. However, it was observed that a considerable portion of the rainfall appeared to flow down to the sea with a minimal quantity infiltrating the soil when a heavy rain fell in the area during our visit there.

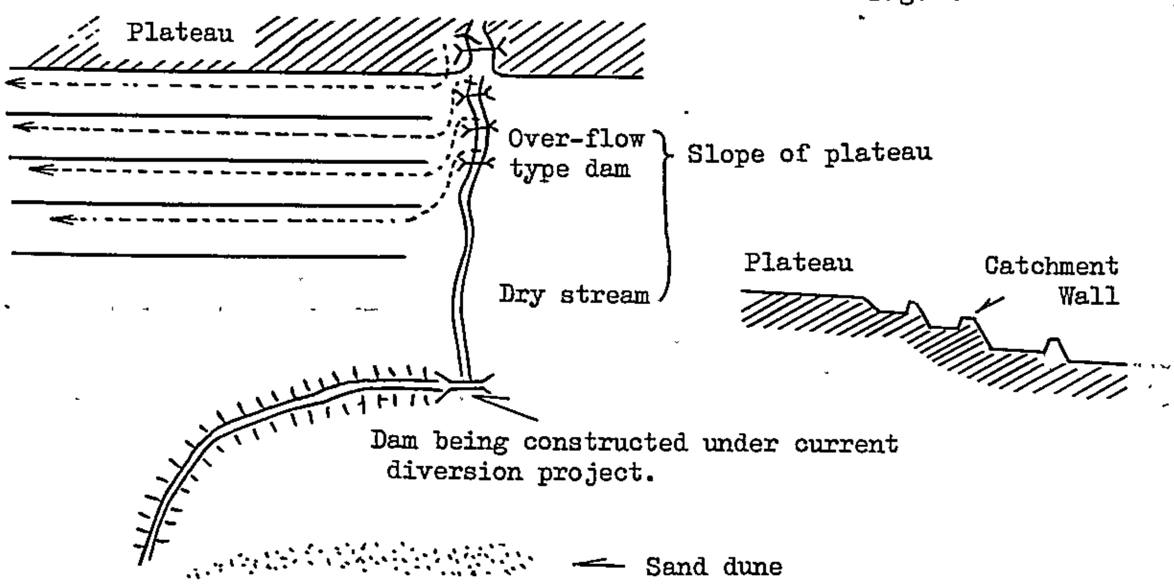
We therefore studied a method of utilizing the plateau water as effectively as possible. The following is our recommendation:

The plateau slopes gradually to the lower plain. It is suggested, therefore, that as great a part as possible of this gentle slope be utilized as a permeation surface. A possible method is to terrace the slope in parallel contour lines and build a ridge of a suitable height on the outer edge of each terrace. Such walls are usually 30 - 45 cm high in Japan.

Terraces so formed may be used for farming and will be irrigated after the Contour irrigation system by water draining from the plateau. It will be necessary for the surface soil of the terraces to be turned and softened by ploughing should it be loamy. This is because loamy soil is practically impervious to water in its natural state, while it has great permeability when ploughed and harrowed.

Figure 1 illustrates the above idea.

Fig. 1



The rain falls in brief but heavy showers in this area, and the discharge from the plateau changes rapidly. As a result, there might be some difficulty in obtaining a constant supply of water from the so-called dry streams or wadis. In order to obviate this possible difficulty, it is recommended that a number of over-flow type intake dams be constructed across the dry streams, preferably in their upper reaches, as shown in Figure 1. Water will be held by these dams and led into the terraces, first from the uppermost dam and then from the dams on the lower courses, according to the rise and fall of the water. In this manner it is expected that water led into terraces in winter will contribute effectively toward increasing the underground water by its gradual seepage into the soil. This method not only provides more arable land but also prevents erosion of the plateau slopes and the dry streams cutting downhill. There will be fewer floods on the lower plain, whereby more productive utilization of this plain will be achieved.

A study should be made from a different approach on the conservation of underground water. Dew has another importance. While at Marsa Matruh, our survey team carried out an observation of the dew on a sand dune on the sea board, at 6 o'clock on the morning of November 20, 1963. At a temperature of 18°C and a humidity of 100%, it was observed that the surface of the sand dune was moistened by the night dew. The surface of the sand was moinstened to a depth of 5 - 10 mm, below which the sand was dry. The water detected seemed to correspond to a rainfall of 1.0 mm.

This moisture evaporated as the sun rose. On the assumption that the moisture dissipates into the air simultaneously with its downward penetration of the soil, it can well be imagined that underground water will be increased by the dew. It was evident, from an observation conducted by Egyptian scientists on a sand dune at Berg-el-Arab, that the quantity of underground water drawn up was greater than provided by rain. In another experiment on a sand dune at El Arish, it was found that the daily yield of underground water from dew amounted to 2 mm.

These phenomena are the subject of further study, and we believe that the UAR Government development project of this area will be greatly facilitated by throwing light on various phases of such phenomena.

5. Acquisition and Maintenance of Potable Water

Olive and fig trees grow even in places flooded by water of considerable salinity, for instance, some 13,000 ppm. However, such water is not potable. Potable water must be less than 800 ppm in salinity. Therefore there are many places where plants will grow but practically impossible for human beings to survive.

A 6-inch-diameter water pipeline is laid between Alexandria and Marsa Matruh for the supply of potable water from the former to the latter, these places being 289 kilometers apart. Water from the Nile is, after purification, carried to Marsa Matruh through this pipeline.

This speaks eloquently of the great need for good potable water in this area, and such need is of particular poignancy to people who are unable to enjoy the benefits of the pipeline.

In order to work out a solution to this problem, our survey team brought an earth water collector unit to Marsa Matruh. The device, which works on the principle detailed in the attached pamphlet*, is expected to prove effective in obtaining good potable water with comparative ease, thanks to the almost constant sunshine at Marsa Matruh, if it is installed in such places as the hollows between sand dunes or on damp salty ground.

Dr. I. Sharkawi of the EGDDO's Marsa Matruh Laboratories agreed with us on the above, and promised to carry out a series of experiments at his laboratories.

In the meantime, Dr. Sakr of NRC had been making experiments to obtain potable water through the use of solar energy. We left four earth water collector units in his care to assist his further experiments.

It is earnestly hoped that the development of this arid area will be expedited as a result of our success in obtaining potable water which we believe can be attained as described above.

* A Method of Obtaining Water in Arid Land

M. Kobayashi, Solar Energy Vol VII No. 3, July, 1963

6. Plant Cultivation

Barley and wheat are widely cultivated in this part of the country where the soil is calcareous. Experimental cultivation is also being made of olive, pear, almond, pistachio and fig trees, grapes, carrots, dates, etc. Olive saplings, in particular, were being distributed to intending farmers.

Plantations were established on the tablelands of some big sand dunes for the cultivation of grapes, figs, and dates, and it was observed that melons and tomatoes thrived as catch-crops with the above trees.

Our survey team also saw date palms growing wild at the bases of seaside sand dunes. There seemed to be a possibility of transforming such sand dunes to date farms. In Kuwait an experiment was being made to create a forest in a bleak desert by using the earth water collector principle.

V. SIWA OASIS

For two days from its arrival at Siwa on the evening of November 22, 1963 to the time of its departure on the morning of November 25th, the survey team conducted various investigations at this place. The following are some observations relating to the subject matter:

1. Terrain and soil

The terrain slopes gradually down to Zeitun Lake and the soil is sandy. There was a heavy rainfall of 16 mm on the evening of November 23rd. It was observed that despite the sandy soil, permeability did not seem to be good. There were many muddy pools here and there even at the time of departure from Siwa on November 25th. Lumps of chemicals forced out of the ground, which are called "Karshif", were observed with particular interest. It is possible to guess the strength of these lumps from the fact that this material is used as plaster for houses. On the other hand, it is also conceivable that they are soluble in water, because many houses collapsed after a two-day continuous rain in 1925. "Karshif" was found to be more plentiful in the higher plains than in the lowlands.

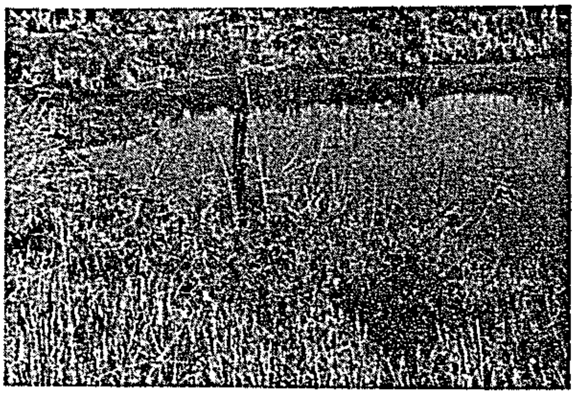
The survey team was very much interested in the changes in the water level of Zeitun Lake. However, concrete details were not available, inasmuch as there was no record of observations kept regarding the water level. Further, there appears to be no plan to keep such records in future. Without such records, it is possible to map out development projects or to drain the land for desalinisation.

2. Underground Water

Underground water seemed to be quite abundant. The team was informed that the quantity flowing from artesian wells was much greater than that needed for present use. The survey team inspected about 10 wells and found the following:

(a) The team found no water which was not potable.

Although time did not permit of carrying out investigations as to the quality of the water, it was observed that various kinds of vegetables were growing around uncurbed artesian wells which looked like ponds.



Further, in agricultural experimental stations or private farms, good results were observed. If the quality of the water were bad, such good results could not be attained. The team was informed that the water in Siwa was strongly saline. Judging from the above observation, it is assumed that some wells are of good quality and some are bad.

(b) The altitude of the well sites seemed to be from 10 to 15 m higher than the level of Zeitun Lake.

(c) Two wells out of three found near Zeitun Lake, which we observed on November 24th, were those with bountiful springs. It was assumed that the water flowed, at a guess, at a rate of about 50,000 m^3 per day. However, much of the water was not utilized and flowed down to Zeitun Lake.

3. Status of Agriculture

Good crops of various kinds of vegetables were reported at the agricultural experimental station which we visited on November 23rd. It was also observed at a private farm on November 24th, that good results were attained in cultivation of agricultural crops over a long time.

The above proved that this area could be developed as arable land.

4. Improvement of Saline Soil

It was assumed that soil conditions seemed to be better in the higher altitude areas than in the lowlands, inasmuch as "Karshif" is not found higher up. However, from the standpoint of irrigation and drainage, the lowlands would be more suitable, although a greater quantity of "Karshif" is present. Therefore it is recommended that the lower altitude areas, rather than the available wells, be considered for agricultural development, in case mechanical facilities such as pumps, etc., are not used.

Secondly, detailed information on the present use of wells and the effects on the growth of agricultural plants should be provided by conducting a survey on the quality and quantity of yield of individual wells.

As a result of the above survey, it should be possible to clarify the quality of water and the present status of its use. The above information is a good basis on which the overall development plan can be worked out.

However, recommendations are made, not on the overall development problem but on limited problems, based on factors which the writer obtained from the present survey.

The following processes are considered as a means of improving the saline soil.

(a) Remove saline lumps, such as "Karshif", forced from the ground.

(b) In case hard-pan is found, which may be deleterious to the growth of vegetables, it is recommended that this be cut or cracked by using a panbreaker.

(c) Desalting irrigation should be carried out.

A sufficient quantity of irrigation water should always be kept on the surface of the soil in order that it may gradually seep through the soil by natural drainage.

(d) Drainage.

Dig drainage ditches about 1 m deep, at a sharp slope so that water can be drained easily.

As it is easily deduced, the above recommendations can be easily put into practice. For instance, the well observed by the writer on November 24th yielded about 50,000 m^3 of water per day, but not much use was made of it all, a great deal being allowed to flow away to Zeitun Lake. It is considered that it would be easy and useful to conduct some experiments on a small scale by utilizing this water.

5. Control of Old Artesian Wells

It is understood that EGDDO is now planning to utilize fresh water held under high pressure to be found in the "Nubian sandstone" stratum which lies beneath the Post Nubian stratum by having deep wells sunk to the Nubian sandstone stratum. According to a cross-section graph attached to the Parsons Report, it is said that the fresh water stratum in the Nubian sandstone layer under Siwa is 2100 m in thickness and lies from 400 - 2500 m underground. At present, fresh water held in the Nubian sandstone stratum has partly risen into the Post Nubian stratum and thus lost much of its static hydraulic pressure. It flows in springs contaminated unit saline material. Therefore, it is believed that irrigation of the slope (average width 10 Km) lying between the plateau and the lake shore will be successful, in case water is conducted to the high terrain by utilizing the high hydraulic pressure of deep wells (7400 m). Before completing these deep wells, it is preferable to close some wells of bad quality or to control the flow from such wells as are not in present use, due to their high location, out of the existing 200 springs rising from the Post Nubian stratum. Thus the number of wells used should be minimized. In order to control the yield of well water, it is suggested that flow be controlled by raising the well cribs by piling up stones or making concrete curbs.

6. Industrial utilization of saline water and saline deposits

An analytical study of the quality of four samples of water shows that Mg/Ca tends to increase in accordance with the increase in TSM as follows:

	Sample 1	Sample 2	Sample 3	Sample 4
TSM (ppm)	2,560	8,760	22,060	30,176
Mg/Ca (hardness)	282/346	1,720/760	2,800/800	3,640/840

Of the lakes in Birket Siwa, it is reported that the highest density found in some of them registered 350,000 ppm, which was higher than the 315,000 ppm of the Dead Sea. Although the method of analysing the elements and the K content are not clear, it is assumed that some elements may be present which can be used as magnesium brine, judging from the findings in the above table.

It is considered that the saline soil is a mixed impurity formed by gypsum and salt. Therefore it is doubtful whether they would be useful as industrial raw materials. However, in case arable land can be developed after removing the saline soil it may be of great value to make a positive study of the use of gypsum as a source for ammonium sulphate, sulfuric acid and Portland cement.

VI. BAHARIYA AND FORAFRA OASES

1. New wells dug by EGDDO

After World War II pilot oil wells (about 2,000 m deep) were sunk by the Sahara Petroleum Company in the northern part of the Bahariya lowland, which have proved very useful for clarifying the underground structure of that area. (See illustration in the preceding Chapter.)

Recently EGDDO drilled 9 new wells (200 - 300 m deep) in and around the northern lowland of Mandisha Village. The lowland was once the bed of a lake and even now there is a pool in one corner. Its altitude is 99 - 104 m above sea level, the piezometric level being 127 m, and therefore underground water gushes out at a pressure of 1.8 - 2.6 kg/cm^2. Some wells in this area produce muddy water containing bluish-white colored sand when their valves are opened, forming tall heaps of sand around the well-heads.

In drilling new wells (200 - 300 m deep) at Bahariya, strong emission of underground water always occurs at a comparatively shallow level. Therefore, the specific gravity of the circulating muddy water to be used in drilling wells must always be high. We understood that there had been two "blow-out" accidents caused by the use of water of low specific gravity.

The daily yield of water from an ordinary well amounts to 7,000 - 8,000 m^3, while the best wells produce as much as 12,000 m^3 of water per day. For example, the 300 m Maser No. 1 Well, whose mouth is 99 m above sea level, produces 12,000 m^3 of water at a pressure of 2.6 kg/cm^2. This well was constructed at a cost of only £E8,000 (¥8,000,000).

Lowland wells are all intended for the measurement of underground hydraulic pressure and are not used for irrigation. On the other hand a few villages, including Mandisha, have been in straitened circumstances as old wells ran dry and the date palms withered. In order to extend a helping hand to the people of such arid villages, reclamations are being carried out on old wells and simultaneously land provided with new wells are being reclaimed at the foot of a nearby hill.

At any place where the altitude is over 120 m, for instance at the foot of a hill, underground water has to be pumped up inasmuch as the piezometric level is about 127 m, and accordingly productive artesian wells are very scarce. In the case of a repaired well at Mandisha, its usual water level is close to the ground surface, and a pump was employed to raise the water at a rate of about 3,000 m^3 per day.

At the foot of a small hill rising between Bawiti and Mandisha and of some northerly basaltic tablelands, there still remain terraces which represent the receding shoreline of an old lake. These terraces are composed of horizontal strata of lower Cretaceous variegated shale and in some places there are sandy mudstones on them. It is assumed that these mudstones were formed by the lacustrine sediments deposited during the Diluvial age. Further, the fertile soil which is often found on the gentle slopes skirting a hill is supposed to be lacustrine sediments of a later stage whose material is derived from weathered sandy shale and/or sandy mudstone and gets deposited undergoings the action of sorting to some extent. In the northern lowland plain near Mandisha where new experimental well were sunk, a thorough study of the deep soil could not be made because the surface of the ground was covered with drifted sand. It is assumed that the nature of the deeper layers of soil in this pare would decide the success or failure of any future development projects.

2. Hydrogeological comparison with Dakhla and Kharga Oases

The following Table 1 shows the rough estimate of comparative potentiality of artesian underground water storage from the four major oases:

Table 1

Oasis	Altitude of piezometric level A	Altitude of base B	Width and length of base C	Thickness of Nubian sandstone stratum D	(A - B) × C × D (Rough calculation)
	(In meters)		(In kilometers)	(In meters)	
Bahariya	130	100	30 × 60	2,000	1
Farafra	180	50	100 × 100	2,000	25
Dakhla	145	20	35 × 150	1,000	6
Kharga	75	30	60 × 150	700	3

It may be assumed that

A - B (a) is approximately proportional to the piezometric pressure, and so is

C × D (b) to the quantity of underground water storage.

The figures at the extreme right are calculated by multiplying (a) into (b) to obtain coefficients representing the order of scale of the four oases. Even taking into account a 20% error probability in respect of each figure in that column, the above order will show no change. The coefficients may be used for reference in assessing the approximate order of importance of each oasis although an exact comparison of its utility value should be decided upon after accurate data are obtained on the area of each oasis, the transmissibility of the aquiferous stratum and the quality of the underground water from different horizons.

According to the Report by R. M. Parsons & Co. (1961 - 1962), the underground water resources of the vast desert which covers the western resion of Egypt, were estimated as follows:

"Underground water to be recharged to the Western Desert:

$355 \times 10^6\ m^3/year$

Underground water drained from the Western Desert:

$1,850 \times 10^6\ m^3/year$

Balance (Loss in quantity): $1,495 \times 10^6\ m^3/year$

The above calculation elucidates the situation to be mining of underground water resources but that of an exceptionally large quantity of water resources."

Above figure for the underground water recharge into the whole area does not differ very much in quantity from that calculated for the Kharga Oasis ($0.89 \times 10^6\ m^3$/day according to Dr. Ezzat). This proves that this kind of estimate involves great difficulty. In any case, to say "a mining of exceptionally large quantity of water reserves" would be putting it properly, and the Farafra Oasis and the Dakhla Oasis, the second largest, are particularly blessed with abundant underground water.

There are various points which should be clarified in order to evaluate the estimated quantity of underground water resources in more detail. One such point is the change in the lithology found in the "Nubian sandstone formation" and that in quality of the water held therein, as the thickness of the Nubian sandstone stratum grows in some areas.

It is widely known that in Kharga the Nubian sandstone stratum consists mainly of terrigenous deposits, but as it nears the Mediterranean coast, the sandstone increases in thickness and also intercalation of sortings of marine facies.

In southern oases underground water is able to improve in quality by the constant supply of new water, and the consequent flushing away of old underground water. In northern oases, however, fewer chances of such replacement are expected and "fossil water" is apt to remain. The H_2S

content in underground water is about 1 ppm in Kharga and some 2 ppm in Dakhla. By this it can be seen that the flushing of underground water is more frequent in Kharga than in Dakhla.

An SPC pilot-well dug at Bahariya registered 300 ppm cl' at a depth of 1,000 m and 900 ppm cl' at 2,000 m. As compared with Kharga wells, which usually record 100 ppm cl' at a depth of 700 m, the quality of Bahariya water does not seem to be as good as at Kharga. The Roman well at Farafra registered 300 ppm cl'. This figure is higher than that pertaining to the Roman wells at Kharga.

It is noted from Table I that the difference in altitude between the piezometric level and that of the lowest point of each oasis, is more than 100 m at Farafra and Dakhla Oases, but at Kharga and Bahariya it is as little as 30 - 40 m. Any relation which may exist between the above figures and the rate of decrease in the yield and water level of new wells in the oases concerned, has a hydrogeological interest.

As has been reported separately, our survey team suggested to EGDDO that they adopt a centralized monitoring system powered by solar batteries, which can automatically record and telemeter the varying water levels. Through a broadening of its application, the system will enable any changes occurring at different oases to be measured simultaneously. It is assumed that this new method of measuring will serve to greatly expedite future desert development plans. Since returning to Japan last December, our survey team asked a competent manufacturer to study the possibility of such a system. A design for such a system has now been drawn up and details will be submitted in a separate report.

3. Development of Bahariya (Gorabi) Iron Mine

On December 14, 1963, our survey team went in jeeps to inspect the Bahariya Iron Mine (Gorabi and Nasser Fields) as well as the new Jeddidha

Mine.

The Bahariya Iron Mine lies about 30 km northeast of Bawiti Village, where the Bahariya - Cairo highway runs uphill over an escarpment. The site is at the northeastern extremity of the Bahariya lowland, and has sheer cliffs on both sides. There are two isolated hills between the cliffs. On the surface of these hills an iron ore bed descends northward.

The Gorabi Stope spreads over one of these hills. Its altitude is 316 m above sea level, a little higher than the opposite plateau (250 m) atop the escarpment, inasmuch as the tableland lies along the axis of the Gorabi anticline.

The Nasser Stope and the Gorabi hill stand opposite each other with a dry stream (wadi) between them. The iron ore stratum of the Nasser Stope lies along an imaginary line which extends across the dry stream from the Gorabi ore stratum in the direction of its pitch. The Nasser hill is of a cuesta type. The dry stream between the hills is 170 m high at its source and winds its way southward in an easy curve to run into the Bahariya lowland (107 m above sea level). The area and thickness of the iron ore stratum, etc., of each stope, are as follows:

Table II

Stope	Area	Thickness of iron ore stratum	Fe-fineness	Kind of ore	Lump or powder
Gorabi	5 km^2	-	50%	Goethite	-
Nasser	3km x 0.5km	15 m (0 - 20m)	60%	Hematite and Goethite	Powder 90% Lump 10%

Ten years ago a report on these ore deposits was published in a bulletin by the UAR Geological Survey Office, and an intensive exploration has been continued since 1956. Today about 1,000 people are engaged in this survey.

One pit is drilled each 10,000 m^2 without the help of machinery, under the tutelage of a Swedish company, SANTEP. An analysis of the soil is made at each additional depth of 1 m.

Strip-mining is possible on these stopes. The regolith or mantle rock is about 0 - 3 m thick there and 90% of the ore obtained is in powder form. The survey is expected to be finished during this year, when the estimates of the quantity and grades of the deposits will be determined. It is planned that following such completion a 200 km railroad will be constructed between Bahariya and Samalut on the Nile. First shipment of iron ore is scheduled for 1967 with an expected daily yield of approximately 10,000 mt.

The above survey indicates that the iron stopes will have the advantages of strip-mining, ore-washing by underground water in spite of being in an arid land, fusible Hematite, etc. No details have been divulged regarding the S, P and Cu content of the ore.

The Jeddidha Mining Field is 25 km southeast of the Nasser Stope, and occupies the entire area of a small depression in the plateau. The probable area of this stope is 3 × 2.5 km^2 and its ore stratum, lying under 12 - 15 m below the surface is known to be, as a result of prospecting, about 0 - 25 m thick. This field appears to be less productive, in various respects, compared with the Nasser Field. In any case, test-boring has just been started here.

VII. THE UNATTENDED LIGHTHOUSE POWERED BY SOLAR BATTERIES

Pearson, et al,[1] invented solar batteries in 1954 at the Bell Telephone Laboratories. The idea was to utilize the photovoltaic effect of the large flat area of silicon p-n junctions which convert light energy directly into electrical energy at high efficiency.

Silicon solar batteries are loaded on United States and U.S.S.R. statellites to supply electricity to the equipment. In Japan, we have succeeded in the application of solar batteries to unattended lighthouses[2], radio buoys, repeater stations, robot weather stations, and so forth.

We wanted to extend the application to deserts as well as the sea -- where there is plenty of sunshine and it is easy to lose oneself in the vastness -- and in accordance with the recommendation of E.G.D.D.O., we chose Wadi El-Natroun as the spot to build an unattended lighthouse powered by solar batteries.

1. General Description

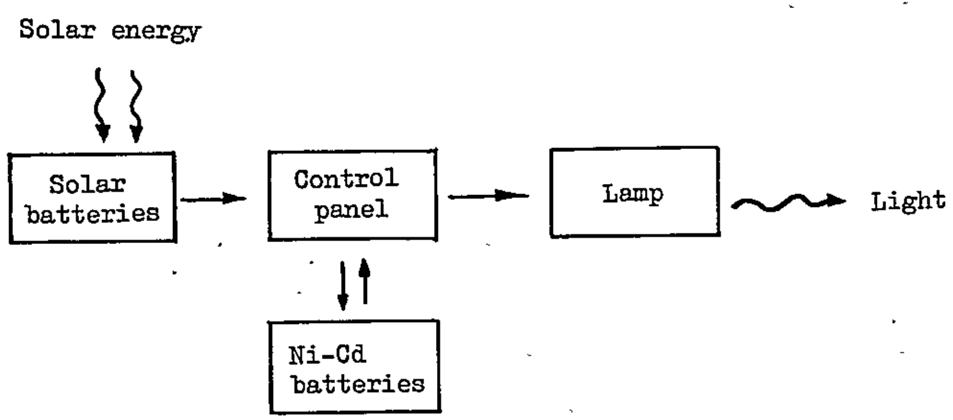


Figure 1 System of Power Supply

Figure 1 shows the schematic block diagram of the lighthouse. Silicon solar batteries convert solar energy into electricity and energize Nickel-Cadmium batteries during the day. Through the control panel the stored electricity is used to light the signal lamp during the night when darkness covers the vast desert. The lamphouse and the solar batteries were fixed at the top of the 16-meter-high roof of the E.G.D.D.O. office, and the control panel and the Nickel-Cadmium batteries were set indoors.

The greater the height of the lamphouse, the farther it can be seen. This relation is expressed by the following equation:

$$d = 2.52 \times 10^{3}(\sqrt{h} + \sqrt{m}),$$

where d is the observable distance (m), h is the height of the lamphouse (m), and m is the eye-level of the observer (m).

2. Lamphouse

A lamp of 10 watts at 12 volts flashes for 0.6 seconds at intervals of 4.4 seconds by means of a mechanical relay. Accordingly the duty cycle of the lamp is 0.12. If we assume the working time to be 15 hours in winter or on cloudy days, the average power consumption per day is

$$10^{\text{watts}} \times 0.12 \times 15/24 = 0.75^{\text{watts}} \quad . . .$$

The mechanical relay is driven by a DC motor consuming 0.03 watts, and the sunlight valve which signals the lighting of the lamp is composed of a solar cell and a relay, and consumes 0.07 watts. The total power needed is the sum of the above, and is

$$0.75^{\text{watts}} + 0.03^{\text{watts}} + 0.07^{\text{watts}} = 0.85^{\text{watts}} \quad . . .$$

3. Silicon Solar Batteries

The required output of the solar batteries is determined by the load, the amount of sunshine, which depends on the location, weather, elevation angle, etc. Roughly assuming that there are twenty fine days a month and that the solar batteries will work for an average of six hours a day, and that the loss in the control panel and the Nickel-Cadmium batteries is approximately thirty percent, the required output power of the solar batteries is -

$$0.85^{\text{watts}} \times 24/6 \times 30/20 \times 1.3 = 6.5^{\text{watts}} \quad . . .$$

One solar battery unit is composed of nine silicon solar cells in a hermetically sealed acrylic resin case. Twenty of these units were fixed on an iron panel and are connected in series and parallel so as to produce seven watts in normal sunshine, as shown in Figure 2. The solar battery panel was fixed in the sunniest spot on the roof of the office, facing south, and at an elevation angle of $30^{\circ} \pm 10^{\circ}$.

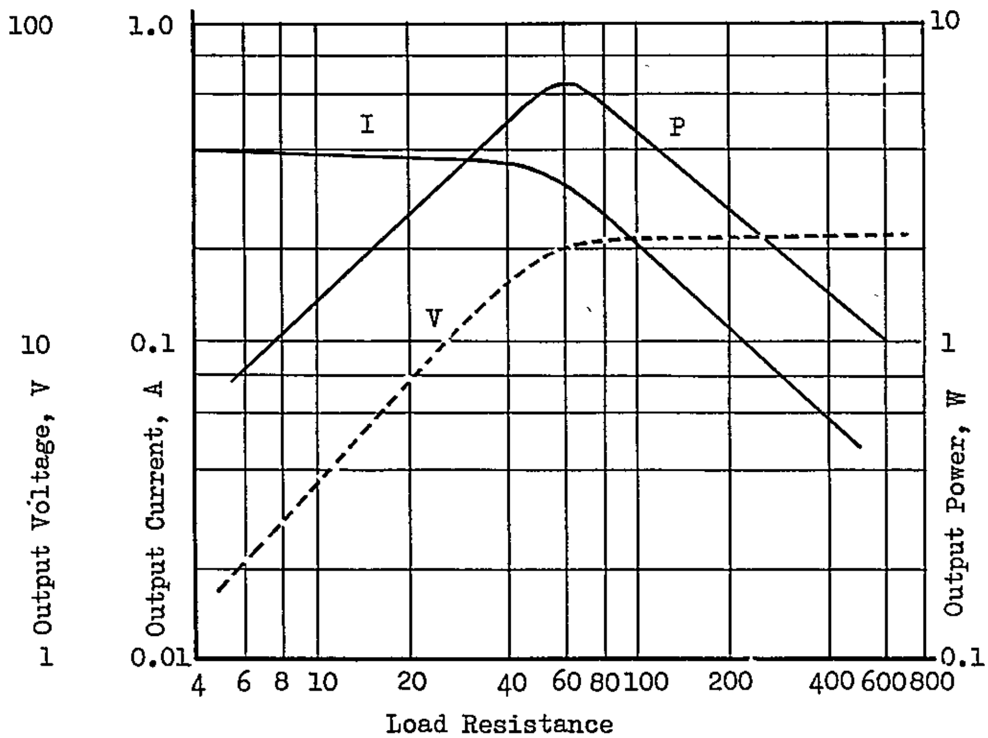


Fig. 2. Output Characteristic of Solar Batteries

The angle of elevation is adjustable so as the produce maximum average output power in the different seasons.

Solar batteries, the control panel, connections, cables, and the lamphouse should all withstand long exposure to gales, strong sunshine, humidity, and salty air.

4. Nickel-Cadmium Batteries

The output of the solar batteries is stored in the Nickel-Cadmium batteries for nocturnal use. Perfectly sealed Nickel-Cadmium batteries are chosen because of their toughness against over-charging and over-discharging, their high charging efficiency at low voltages, low self-discharging, and their nonrequirement of supplementary electrolytes. Ten Nickel-Cadmium batteries of a 23 AH storage capacity are connected in series to produce 12 volts. They can operate for two weeks without charging even in constant bad weather.

5. Control Panel

The control panel consists of terminals, diodes, switches, a volt-ammeter and a voltameter. The open-circuit voltage and the closed-circuit current of the solar batteries, voltage of the Nickel-Cadmium batteries, the charging and discharging current, and their integrated values, can be measured at the control panel.

6. Discussions

The light was visible at night at a distance of 10 km. We are now checking the balance of the charging and discharging current of the storage batteries by means of the voltameter on the control panel. The open test will give us very valuable information on the effect of strong sunshine, high temperatures, sandstorms, and other severe conditions encountered in the desert area, which cannot be reproduced in the mild climate of Japan.

In the very near future, solar batteries will contribute greatly to the development of undeveloped areas where there is strong sunshine not now utilized, and will be the source of energy and of consequent prosperity.

References:

1) G. L. Pearson et al., J. Appl. Phys., 25 276 (1954)

2) M. Kobayashi and K. Hayashi, NEC R&D, 3 46 (1962)

VIII. DESERT LOCATING SYSTEMS

When traveling in the desert, damage to motor-cars and losing track of roads are the main causes of disasters. With an adequate communication equipment and the beacon service,such disasters can be completely avoided. There are now several check points along main roads in the desert, such as the Asyut-Kharga, Cairo-Alexandria, Alexandria-Marsa Matruh and Marsa Matruh-Siwa routes, but they are not enough to prevent disasters. Communication networks in the neighbourhood of EGDDO are as follows: Telephone service between Cairo-Asyut, Kharga-Dakhla and Cairo-Alexandria-Marsa Matruh-Siwa. Stations at Cairo, Kharga, Bahariya, Farafra and Marsa Matruh are equipped with radio transmitters and receivers (frequency, 5 - 12 Mc, output, about 100 watts) and carry out the telephone, teletype and telegraph services between them. For communication between Bahariya and Farafra it is very difficult to maintain constant contact due to low transmitter output (output, 12 watts).

One of the siting systems in the desert using light is detailed in the chapter, "An unattended light-house powered by silicon solar batteries". In the chapter on "Recommendations", we have proposed a reformation of the radio beacon system and the radio and wired communication systems. In this chapter we will discuss the radio beacon system and the road-finding system in the desert.

1) Beacon system for aerial navigation

1-a) Medium-frequency beacon stations

MF beacon stations are recommended to assist in the nagivation of airplanes. A signal from a ground beacon station is received by the airborne ADF receiver, and helps the pilot to know his location and the direction of flight. The MF beacon system is used all over the world and is one of the orthodox and reliable methods of direction finding. An ADF receiver is necessary in an airplane to receive beacon signals, and it is supposed that actually a good number of airplanes are equipped with such receivers.

1-b) Airport surveillance radar (ASR)

When an airport control tower is equipped with ASR, the locations of airplanes within 100 km are plotted on the screen of the Plane Position Indicator (PPI), making it easy to give directions to Automatic Traffic Control (ATC) and also to airplanes. The merit of the ATC system combined with the ASR is that ADF or similar equipment on airplanes is not needed, except for simple VHF receivers and transmitters to communicate with ground station. It is especially important to note that PPI gives the over-all situation of airplanes above the airport, which assures safety during busy flight hours.

1-c) Doppler radar

Communication between airports and airplanes usually employs VHF. Direction finding at ground stations is done by receiving a radio signal from an airplane. The information as to location of an airplane is fed to the ATC and is also fed back to the pilot of the airplane. The Doppler system direction-finding can give much more precise location with less site-error compared with the usual Adcock system direction-finding.

COMPARISON OF LOCATION FINDING SYSTEMS *

System	MF Beacon	ASR Radar	Doppler Radar
Merits	The airplane locates the airport directly Can be utilized simultaneously by a number of airplanes	The ground station can know locations of all airplanes Special equipments on airplanes unnecessary	The ground station can know flight direction Special equipment on airplanes unnecessary
Demerits	The airport control tower can collect information on airplanes only through reports from pilots Airplanes should be equipped with ADF receivers	Airplanes can orient themselves only through ATC	Distances not measurable Airplanes can orient themselves situation only through ATC Measurements must be made individually

* All airplanes are to be equipped with VHF communication equipments.

2) Road finding system

Here is a proposed method of finding one's road when one has lost trace of it in the vastness of the desert. The following conditions are assumed:

1. The maximum over-all length of the road is 200 km.
2. Use of this system is limited to surface travelers such as motorcar drivers and pedestrians.

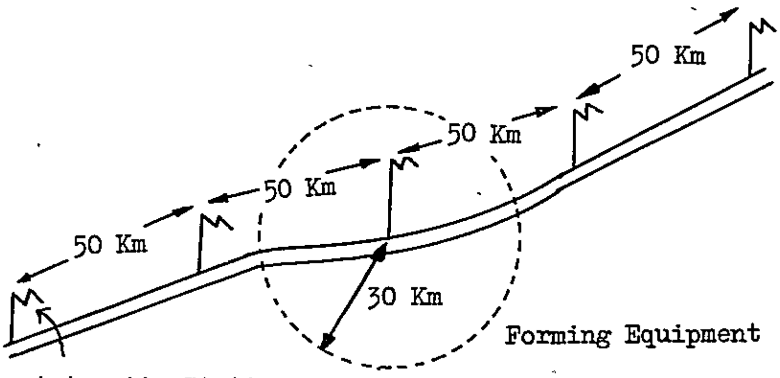


Fig. 1.

Automatic stations with transmitters and receivers are built along the road at 50 km intervals. The transmitter output is 5 watts at 50 Mc and the height of the antennae is 200 feet. The transmitter stands by, waiting for instructions. The traveler carries a portable VHF transceiver with a forming antenna, with a transmitter output of 0.6 watts, and a receiver sensitivity of 1.0 μV at 10 db of S/N ratio. When a traveler is lost, he should switch the transmitter on to call any station along the road. The effective distance of this system is 30 km, so he can make contact with at least one station. On receiving a call signal from the lost person, the switch of the automatic transmitter is turned on for a certain length of time, during which the lost person catches the signal from the automatic station and can then locate his position. The automatic stations are powered by solar batteries. A good example of solar battery power supply is mentioned in the chapter, "The unattended light-house powered by solar batteries".

IX. TELEMETERING AND RECORDING OF FLOW AND LEVEL OF WELLS AT THE CENTRAL STATION

When depending on a well for irrigation and drinking, as is the case in the desert, it is important to observe the flow, pressure or level of a well in order to learn the structure of the underground strata and to estimate the life of the well.

Generally speaking, wells are dug a few kilometers apart from each other to eliminate mutual effects and it often happens that they are at some distance from desert roads. It is usually very difficult, if not impossible and troublesome, for a man to keep records of such wells. It would seem very helpful to build a system to telemeter the conditions of wells automatically. Here is a brief description of the plan for building such a system.

a) Conditions for the system

a-1) Values to be measured

a-1-1. Flow (for springs)

a-1-2. Level (for pumped wells)

a-2) Transducers

a-2-1. Flow: Using an orifice, the difference in pressure is mechanically measured and indicated in the form of binary decimal numbers.

a-2-2. Level: Variations* in capacitance according to level is measured and indicated in the form of binary decimal numbers.

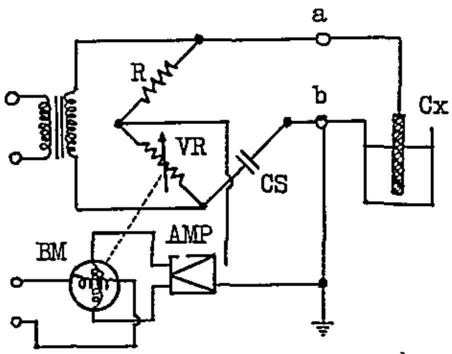


Fig. 1.

* Figures I

Changes in level vary the capacitance of the immersed cable, which provokes an unbalance in the bridge.

(Figure 1). The output of the bridge is amplified by the amplifier and energizes the balancing motor (BM) which rotates the potentiometer (VR) so as to keep the bridge in balance. Thus the angle of the potentiometer indicates the level of the well.

a-3) Number of wells

The central station should be capable of telemetering either flow or level of a hundred wells. The mean distance of neighbouring wells is taken as two km.

a-4) Measuring cycle

One measurement per hour per well is assumed.

a-5) Recording

Twenty recorders are provided at the central station, each of which keeps records of five wells. The recording paper moves at a speed of 5 cm/day.

a-6) Distances of wells from the central station

The distance of a well from the central station is assumed to be less than 300 km at the farthest.

b) A brief description of the system

b-1) Unit of measuring time

The unit of measuring time (t_1) is determined by the number of wells to be observed and the measuring cycle. In order to measure a hundred wells successively,

$$t_1 = 3600^{sec}/100 = 36^{sec}$$

b-2) Schematic diagram

The schematic diagram is shown in Figure 2. The observed values of the wells are collected at the observation station by wire and then sent to the central station by wireless. Assuming the distance between the observation station and the central station to be 300 km, and the output of the transmitter to be 5 watts, five repeater stations are required. The observation station is powered by three 50-watt arrays of solar batteries, the repeater station by a 50-watt array of solar batteries, and the central station by an eliminator power supply.

c) Principles of operation

The central station gives instructions to the observation station to send information on a selected well, then receives and records the information. This cyclic procedure is repeated for a hundred wells, and then repeated regularly. The cycle is timed by a standard clock at the central station. (Figure 3) When the stand-by receiver at the observation station receives an instruction from the central station, the switches of other instruments are turned "on". (Figure 4) A certain well is selected and the observed value is turned into a synchronous regenerative parity check code which shifts the subcarrier of the transmitter. The signal is sent for five seconds and then the observation station returns to the "stand-by" state. The central station receives the signal from the observation station, demodulates the signal and keeps a record on regulation recording paper.

Fig. 2

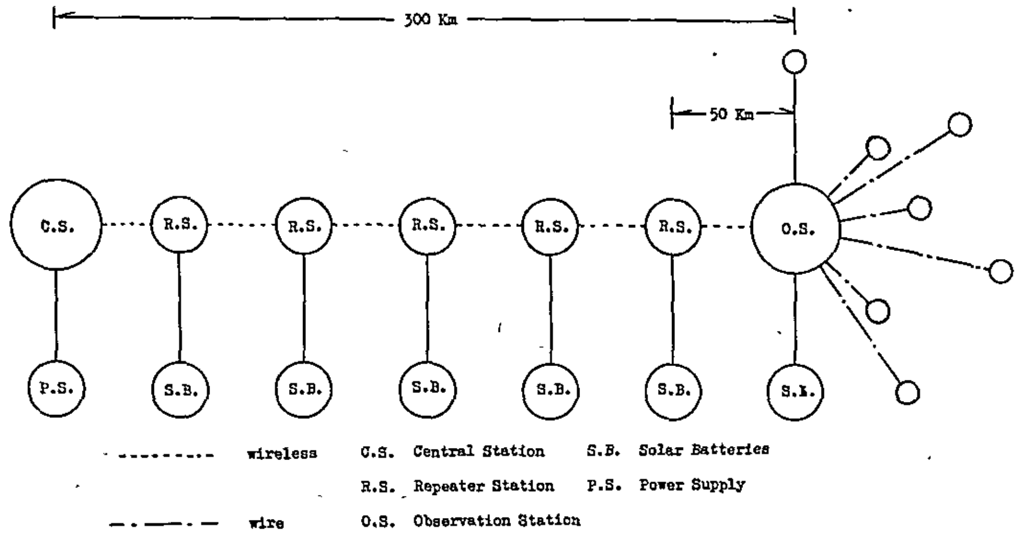


Fig. 3 Central Station

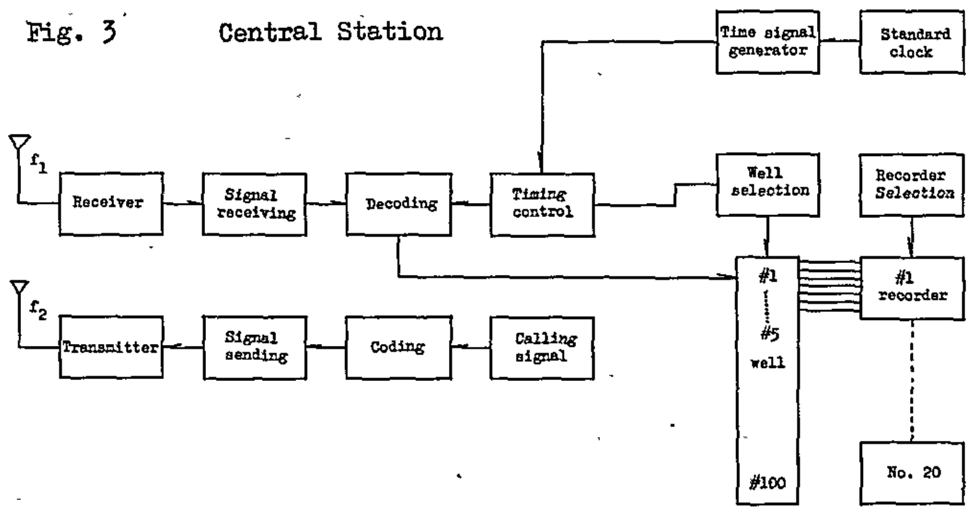
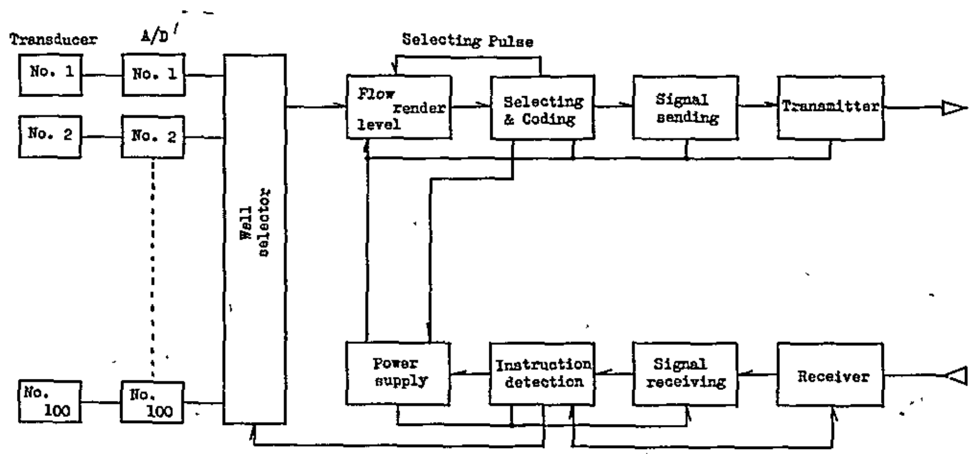


Fig. 4 Observation Station



Calling-recording is completed in ten seconds. The standard clock gives the signal to start the cycle at 36-second intervals, so the system is at rest for 26 seconds following a 10-second operation.

X. STUDY OF WATER IN DESERTS

1. Introduction

Even in a desert there is a phenomenon which suggests the existence of water. On our way back from a tour of Omm Dabadib, we caught insects between sand dunes on the arid sand. On the road to Siwa from Marsa Matruh, we saw white snail-like shells scattered over the sand. We heard that snakes and scorpions also lived in deserts.

Animals can never live without water. The fact that animals live in deserts is a sign that there is water there. Our survey team conducted a few experiments during its stay in the United Arab Republic in order to study water found in deserts. Because of the limited time of our stay there, however, no thorough study could, to our regret, be made.

2. A method of measuring moisture

The electrical resistance of the dry sand or soil is very great and may practically be construed as infinite. The more the soil is moistened, the smaller its electrical resistance. This is because electrical conductance varies depending on the thickness of the film of water which is a good conductor and covers the entire surface of a sand or soil particle. No electric current whatever runs when a particle is dry and has no film of moisture around it. In other words, the value of the electrical resistance is infinite in such aridity. The greater the thickness of the moisture film, the more the electric current to be conducted increases; that is, the value of the electrical resistance decreases.

Although it is true that electrical conductance is affected by the quality of the water which encloses a particle, any change in the electrical resistance is an index of the quantity of moisture if measurements are made only in a specific area.

Inasmuch as accurate measurements on an extensive scale did not seem suitable for a desert tour, we adopted a simple method at the sacrifice of accuracy.

Fig. 1

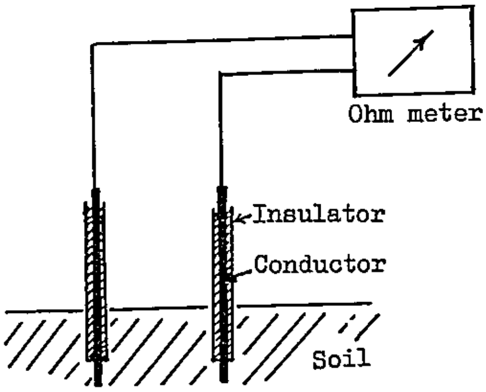
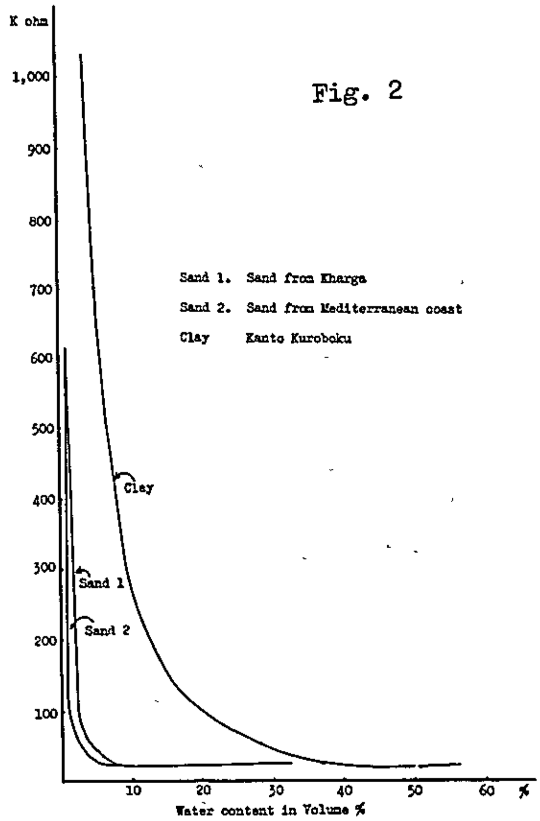


Figure 1 above illustrates this method. The electrical resistance of the soil can be determined by the use of an ohmmeter, which has two electrodes connected, as shown in Figure 1, to its two terminals. In measuring the electrical resistance of the soil, a tester must push the electrodes into the soil. In our experiments, it was observed that the value of the electrical resistance had almost no relation to the distance between the electrodes, and it was in inverse ratio to the area of each electrode exposed to the soil. Such value is also proportionate to the "relative resistance" ρ of the soil, and ρ varies according to the quantity of moisture present in the soil. Therefore, the amount of underground moisture can be easily estimated by measuring the electrical resistance value of the soil.

By means of the above instrument, mensuration of the moisture content and electrical resistance was made of the sand on dunes at Kharga Oasis and on the Mediterranean coast, and of the Kanto Kuroboku or Volcanic ash soil of the Kanto Plain around Tokyo and Yokohama.

The results of the mensuration are shown in Figure 2.

Fig. 2



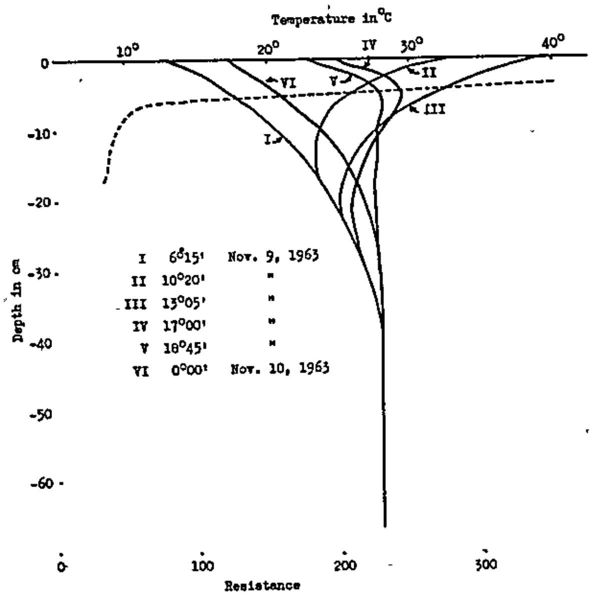
The axis of abscissas denotes the percentage of moisture content represented in the quantity of soil involved, while the axis of ordinates indicates the corresponding electrical resistance. The surface of the electrodes used was 1.2 cm^2.

We would like to refer to this simple instrument as a "moisturemeter", since, by its use, the approximate quantity of moisture present in the soil can be measured with reasonable accuracy.

3. Changes in underground temperature

One has to know of changes in underground temperature in order to detect any movement of moisture in the soil. For this purpose, we conducted experiments on sandy soil about 10 km south of Kharga. Rod type thermometers were placed in the earth at various depths. Figure 3 shows the temperature distribution recorded at various depths.

Fig. 3



The temperature of the ground surface alters from 13°C to 40°C due to the waxing and waning of solar heat. With increasing depth, temperature variations curve in a complicated pattern, and at a depth of about 40 cm or more, it is static at a uniform 28°C.

Supposing that underground temperature T is a function of x, which represents the distance between the point at which the temperature is to be measured and the ground surface, an underground vapor pressure gradient becomes + when $\frac{dT}{dx}$ or a temperature gradient is +. In other words, the vapor pressure increases as the depth increases. As a result, underground aqueous vapor rises toward the surface. In the meantime, under a condition under which $\frac{dT}{dx}$ is -, a temperature gradient also shows -, and vapor moves downward.

In furthering the study of the distribution of underground temperatures,

(1) daytime, when the earth is heated by the sun, and

(2) nighttime, when the earth is not heated by the sun

should be analysed in more detail, as follows:

(1) Daytime, when the earth is heated by the sun:

In respect of Figure 3, study begins with temperature curve I. It is noted that $\frac{dT}{dx}$ of the temperature curve is always + until the curve reaches a depth of 40 cm. This causes the aqueous vapor present in that part of the soil to move toward the surface. Supported by certain other factors, such as low temperature and high humidity, an increase in the amount of moisture on the ground surface is brought about in the early morning. In most cases, dew forms upon the ground. Thus, a moisture stratum is created on the surface of the soil.

In the above situation, the sun rises and begins to heat the ground. As a result, the temperature of the ground surface rises rapidly. Temperature curve II represents the distribution of underground temperatures observed at 10:20 a.m. The temperature stands at 35°C on the ground surface. However, the rise of temperature in the soil is slow. At a depth of 13 cm a minimal temperature of 23°C is recorded. The temperature curve dips in a trough at this depth. Above the depth of this trough $\frac{dT}{dx}$ is -, while below that level the same is +. In other words, a gradient of the underground vapor pressure lapses into this trough from both sides, upward and downward. Moisture on the surface seeps into the soil, while that deeper down is drawn up to the level of the trough.

It is noteworthy that more moisture seeps downward from the surface than is drawn up from greater depths. This is still more apparent in temperature curve III, which shows readings at 1:00 p.m. The difference between the temperature of the ground surface and that at the level of the trough is as much as 14°C.

Temperature curve IV was obtained at 5:00 p.m. when the sun was low in the west. The ground surface temperature dropped to 25°C, but the underground temperature did not show any rapid change. Due to the above, a temperature gradient $\frac{dT}{dx}$ is + above the 7.5 cm deep level, and - below that level. This shows that in soil where the temperature gradient is +, aqueous vapor is drawn upward and in deeper soil where the temperature gradient is -, the same is drawn downward. In case the quantity of the aqueous vapor so drawn to the trough of the temperature curve exceeds the saturation point at that level, water is produced and stored there.

To sum up, moisture on the surface sinks into the soil during the day and is stored at a level between 10 - 20 cm deep, such level being temporarily named the "M stratum".

(2) Nighttime, when the earth is not heated by the sum:

After the sun sets, the temperature of the ground surface gradually drops and reaches its lowest point of 13°C around 6 a.m. of the following day, before the sun rises. Temperature distribution is shown by temperature curves I, V and VI.

The supply of solar heat ceases at sunset, and therefore only radiation of subterranean heat through the ground surface is responsible for the drift in temperature curves. Curve V shows temperature distribution at 6:45 p.m. A temperature gradient or $\frac{dT}{dx}$ is + in the proximity of the ground surface. However, at a depth of 7 cm or more, a uniform temperature is obtained, creating a condition in which $\frac{dT}{dx}$ equals 0. In other words, underground moisture moves toward the surface at night. Water present in the M stratum also rises.

Temperature curve VI was obtained at midnight. The temperature of the ground surface drops to 16°C and $\frac{dT}{dx}$ shows a constant +. Under this condition underground moisture dissipates into the air. The dissipation occurs from the M stratum, if such a stratum exists. Further, it can readily be imagined from the temperature curve obtained that moisture rises to the M stratum from a lower constant-temperature stratum.

In the light of the foregoing, we know that a desert "breathes" moisture in and out through its surface. The quantity of moisture present in the air and that of underground water affect this breathing, and various types of a desert could be accounted for from this method of approach.

4. Classification of deserts:

Our survey team encountered multifarious types of deserts during its recent tour of arid areas in the United Arab Republic. Such types differ from each other but can roughly be divided into the following categories:

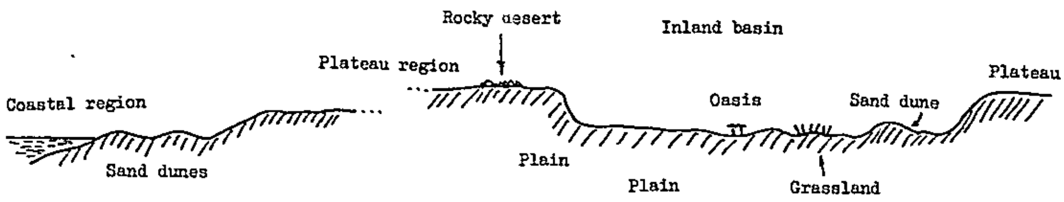
A. Plateau (Highland)
  a. Flat deserts
  b. Rocky deserts
  c. Mountainous deserts
  d. Grassy deserts

B. Lowland basin
  a. Flat deserts
  b. Sand dunes
  c. Grassy deserts
  d. Oases
  e. Saline swamps

C. Coastal district
  a. Sand dunes
  b. Flat land
  c. Swamps

Figure 4 illustrates the above classifications.

Fig. 4



It was observed that the behavior of water differed according to the type of desert in which water exists. In attempting an effective development of a desert, it is necessary that the above varieties be taken into account and the most suitable method for any individual category be applied.

5. Observation of water in deserts

A. Plateau

In general, the plateau is completely barren. In some places, however, the ground has a sparse growth of weeds. Such places suggest the presence of some water, while one can not conceive of there being any water whatsoever in the completely barren areas that form the major portion of the plateau.

As has been previously reported in this chapter, snail-like shell-fish, lizards, etc., could be seen on the sterile sandy surface.

Our survey team carried out a test in a flat desert. The site of the test was atop an escarpment where the Kharga road runs uphill over it. The soil there was of a clayey gravel type. At about 4:00 p.m., when the sun was low in the west, we tried to detect the presence of moisture on the ground surface by using a moisture meter. Moisture was found at a level just below the surface. Closer measurements should be made of this moisture in consideration of the fact that the surface of any desert "breathes", as we have reported hereinabove. The formation of dew is a phenomenon frequently observed atop mountains. Therefore, it is surmised that a so-called M stratum existed below the ground surface of the site of our test. We did not have an opportunity to perform experiments at night. We are therefore very sorry to be unable to give any decisive conclusions in this report.

Fig. 5

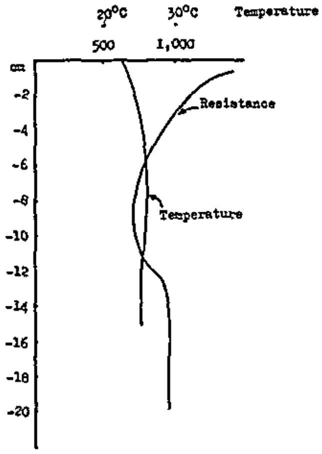
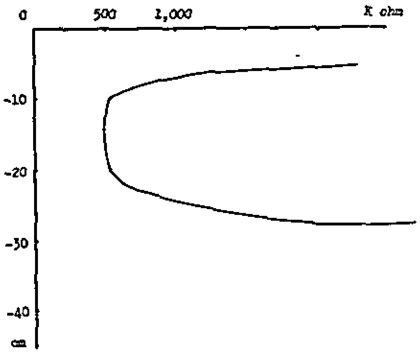


Fig. 6



B. Lowland basin desert

a. Flat deserts

It was almost impossible for our survey team to dig in deserts during its limited period of stay in the United Arab Republic. Fortunately, however, at Omm Suril we happened to come across a highway construction site where the surface soil had been cut open about 1 m deep. A section of the open cut appeared suitable for measurement of moisture distribution. We fixed the two electrodes of the moisture meter in the exposed face of the soil to measure the moisture content. As shown in Figure 6, moisture was found at a depth of 10 - 20cm. No moisture was perceptible above or below this level. This means the formation there of the so-called M stratum.

b. Sand dunes

On November 4, 1963, we made a test on a sand dune near the Copt Hill in order to take a measurement of underground temperatures and moisture there. Figure 7 shows the temperature curve observed at 10:00 a.m. near the summit of the dune. The temperature stood at 33°C on the surface, but it gradually dropped until it reached the lowest point of 26°C at a depth of 8 cm. In deeper soil the temperature began to rise again and finally stood at a constant 27°C. It is presumed that air temperature fluctuations during the course of a day affect only the temperature at or near ground level but not on soil below the 20 cm level.

Our moisture meter recorded an electrical resistance of infinity at a depth of 0 (ground surface) - 40 cm. This indicates that there is no moisture at levels near the surface of the ground and that the M stratum is seldom formed in inland sand dunes.

Fig. 7

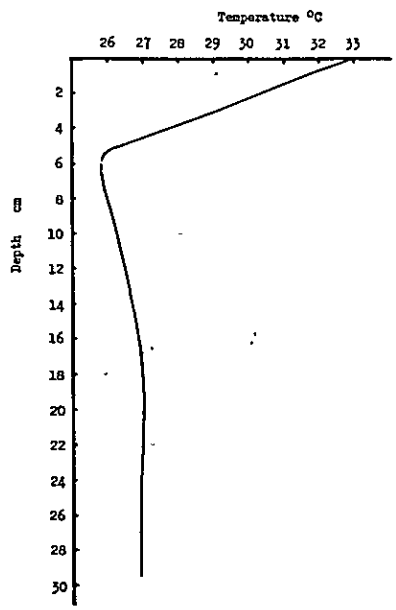
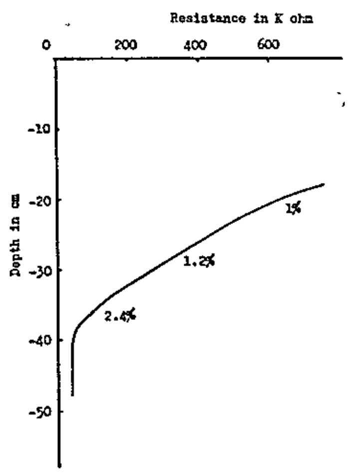


Fig. 8



c. Grassy deserts

Grassy places, whereever found - in lowland basins or on plateaux - indicate that water exists.

We carried out an experiment at a weed-grown place near Omm Suril about 45 km north of Kharga. Camel thorn grows there. Figure 8 shows the results of measurements made by using the moisture meter. The deeper the measurements, the greater the moisture.

Fig. 9

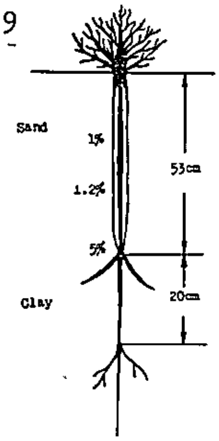
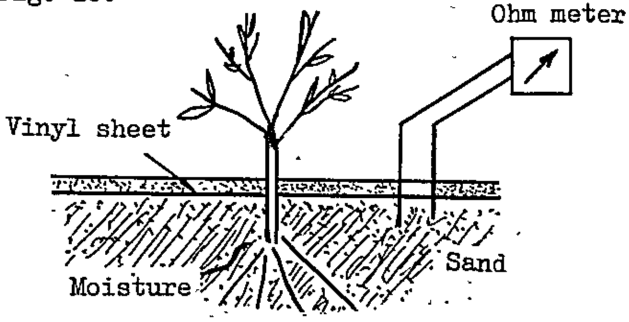


Fig. 10.



We dug the soil around a camel thorn. At a depth of 75 cm the root was 3.5 mm in diameter and there was still more below. We uprooted the plant and found hairlike roots growing out of the tip of the main root, as depicted in Figure 9.

Temperature curves in Figures 2 and 8 represent the moisture content of the soil in which the root grows, is in figures such as are given in Figure 9, that is:

At a depth of	20 cm	1%
"	30 cm	1.2%
"	37 cm	2.4%
"	50 cm	5.0%

The roots grow downward through this moisture stratum. This fact gives hope of successful afforestation over this type of soil. It would seem that grassland or forests could be formed if only there were some means of protecting young plants until their roots reach a depth of about 30 cm. Figure 10 depicts one possible method.

Consider that a sheet of vinyl is laid underground at a suitable depth, as shown in Figure 10. Moisture in deeper soil evaporates upward, but the vinyl sheet prevents it from rising to the surface. The moisture is retained below the vinyl sheet, trapping sufficient moisture where it is needed. This method would supply the young plants with the necessary moisture.

Our survey team were not able to conduct any experiments on this method during its stay in Egypt. On our way back to Tokyo, however, we happened to see a similar idea undergoing test in a desert in Kuwait. We put the two electrodes of a moisture meter into the soil through a buried vinyl sheet and observed the indicator oscillating between 40 to 50 KΩ. In this manner, it was found that there was plenty of moisture in the soil surrounding roots of the young plants.

d. Oases

At a place where underground water gushes out, an oasis is formed. Therefore, there is no concern as to the existence of water. Rather, the matter to be considered is to see that the flow shall not fail and also to drain off used water properly.

e. Saline swamps

During our survey tour of Egyptian deserts, we came across many swamps where the water was too rich in mineral salts. The origin of such swamps is from evaporation of water which once flowed into the lower parts of basins, resulting in a considerable increase in the saline content of the water remaining.

In a saline swamp area there is no lack of water. The problem is the high saline content. It is almost impossible to desalt the water of these swamps. Although there is plenty of water, this area is barren and uninhabited.

C. Coastal district

a. Sand dunes

In the coastal area there are sand dunes, plains and swamps. Here fresh water is obtained mainly from shallow wells. Deep wells do not produce potable water.

The structure of the fresh water stratum of a sand dune is a question of great interest. It rains very seldom in this area, and the yearly precipitation is as little as 130 mm.

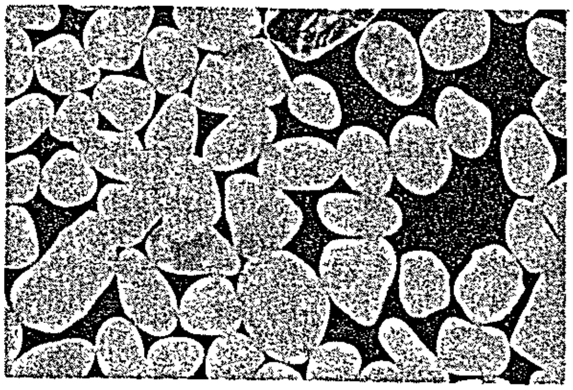
The fact that in such an arid area water for irrigation can be obtained from shallow wells by the use of windmills, tells of some source of water other than rainfall. Dew is the only possible one.

Let us consider, then, the importance of morning dew. We conducted observations on morning dew at Kharga, where dew is said to be scanty. Clayey soil in the outskirts of Kharga was chosen for our test site. We found that the ground surface there was wet and discolored in places. The thickness of the discolored soil differed from place to place, the maximum being about 5 mm.

Following the above test, another one was carried out on a seaside sand dune near Marsa Matruh at 6:00 a.m. on the morning of November 20, 1963. At a temperature of 18°C and a humidity of 100%, it was observed that the surface of the sand dune was moistened by night dew. The moisture penetrated to a depth of 5 - 10 mm, below which the sand was dry. The moisture so detected seemed to correspond, from Figure 2, to a rainfall of about 1.0 mm. In this manner, dew equalling an annual rainfall of 365 mm was formed, this quantity being three times the yearly amount of rainfall.

As outlined above, dew is one of the most important factors in the conservation of underground water in deserts. A layer of moisture on the ground surface, made by morning dew, seeps downward by the morning sunshine to form an M stratum. The greater the amount of dew formed on the ground surface, the greater must be the production of moisture in the M stratum.

Further, the grains of sand found in the sand dunes along the Mediterranean coast possess a unique advantage in connection with the better conservation of underground water. Figure 11 is an enlarged photograph of such sand grains. The grains are globular and have smooth surfaces.



As a result, considerable dampness could be sensed if it should contain moisture corresponding in capacity to only 2 or 3% of the soil. It seems that this is because moisture contained in this type of soil can move easily thanks to the force of gravity and capillary action.

If it is true that dew formed on the ground surface will first be transferred by sunshine to the M stratum and then diffused into deeper soil and sink into the fresh-water stratum by the force of gravity and capillary action, conservation of a fresh-water stratum can be maintained by dew. In order to enrich the fresh-water stratum in any area like this coastal sand dune area, it is suggested that some means should be taken to encourage as much dew as possible to form and to lead this dew downward into the soil as effectively as possible. Study of these steps is urgently needed in connection with an early development of desert regions.

b. Flat land

Here the underground fresh-water stratum lies at a shallower level as compared with that of sand dunes, and its thickness is also less. This is presumably due to the fact that the amount of morning dew formed is less in a flat land than that in the dune area.

c. Swamps

There is sufficient water but too high salinity. Here the amount of fresh water supplied by dew falls short of the sea-water flowing in.

6. Use of earth-water collector

The water in any oasis is usually hard. Water obtained from shallow wells in desert sand dunes is very salty and is not suitable for drinking. It is absolutely necessary for human beings to obtain good water in deserts for various purposes, particularly water for chemical and medical use, for batteries and for drinking.

For this purpose, experiments were made with an earth-water collector, a device which collects underground water, to discover how such a device operates in deserts. The principle of the earth-water collector* is given in detail in a separate pamphlet attached hereto.

In order to obtain 1 litre of water a day, the evaporation rate of aqueous vapor within the frame of the earth-water collector must be 1 mm per day. The accumulation of underground water by the use of an earth-water collector will naturally be successful when wet soil is fully exposed to the air and the moisture dissipated into the air is replaced by moisture present in deeper soil, this moisture being sucked up to the surface by capillary action. However, results might not be too favourable in places where the underground moisture stratum lies at deeper levels and fails to replace, by capillary action, the supply of moisture lost through evaporation. As can be noted

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* .... M. Kobayashi "A Method of Obtaining Water in Arid Lands"
Solar Energy, Vol. VII, No. 3, July, 1963

from Figure 3, changes in underground temperature do not follow the rise and fall of surface temperature. Therefore it is not desirable that the moisture stratum should lie at too deep a level.

Taking all the above into account, we conducted experiments in collecting underground water, as follows:

a. Experiment at Kharga:

An earth-water collector can accumulate underground water from clayey soil showing an electrical resistance of less than 100KΩ when the electrodes are placed in the soil to a depth of some 5mm. We performed an experiment in a cultivated field which satisfied the above condition, and obtained a yield of 1.2 l/m^2 of water. Judging from this, it appears to be feasible to obtain potable water in the vicinity of cultivated fields by utilizing the earth-water collector.

Another experiment was carried out in an arid area. We chose as the site for this experiment, a cultivated field surrounded by land covered with dead grass. Moisture was found and an earth-water collector was set up. By operating for two full days, the device collected 0.175 l/m^2 of water, but after that the yield gradually decreased.

It is assumed that the underground moisture present in the M stratum was sucked up completely, although further study is required for clarification of the exact cause.

b. Experiment in sandy soil:

Following the experiment shown in Figure 3, another measurement was carried out at the same site. No water was obtained. Here the soil, with an electrical resistance of 100 KΩ, lay under a covering of sand 5 cm thick. The water content of clayey soil is 20%, as Figure 2 indicates, but it is as low as 2% in sandy soil. In other words, in sandy soil it is very hard for underground water to be raised by capillary action, and in consequence, sufficient moisture to produce heavy vapor in the space enclosed by the frame of the earth-water collector cannot be supplied from deeper down.

Therefore, in installing an earth-water collector, a preliminary study of the possible productivity of an installation site should be made by using a moisture meter. Otherwise the results will be disappointing.

c. Swamps:

It is apparent that water can be obtained from saline swamps. No experiments are necessary, obviously, in order to prove this to be true.

7. Conclusion

Even in deserts water exists in various forms; rain water, dew, underground water, etc. The influence of solar heat on such water is a topic of vital interest.

Day-and-night cycles create a moisture stratum in the soil at a depth of 10 to 20cm. Our survey team has named this stratum the "M stratum". Thanks to the existance of the M stratum, underground water can be conserved and, in some cases, potable water can be obtained therefrom by using an earth-water collector.

This conclusion has been arrived at after making analysing the observations, experiments and findings made during our recent but very short survey tour of arid areas in the United Arab Republic. Since the above offers various suggestions, we would like to make further and more detailed studies, should the opportunity be presented.

RECOMMENDATIONS

1) Utilization of Solar Energy

In desert areas it is usually difficult to generate electricity in the usual ways, while there is plenty of sunshine, so it would be very sensible to convert solar energy directly into electricity by means of silicon solar batteries. Solar batteries can be used to operate beacon lights (cf. "Wadi Natroun", and a special chapter,"The Unattended Lighthouse Powered by Solar Batteries"), wire/wireless communication equipment, telemetering systems for weather and well observation, and so forth. Furthermore, they could be used to pump up underground water, when high-power solar batteries can be manufactured quite cheaply.

2) Utilization of Wind Energy

In the coastal zones, wind mills are used to pump up water from wells. It would be more convenient to produce electricity by wind-power. The power of the wind (P) is expressed by the following equation:

$$P = 0.37 \times V^3 \text{ (watts)},$$

where V is the velocity of the wind in m/sec.

The working efficiency of a windmill is usually between 30 and 50 % of its total power. With given values of average wind velocity, the electric power to be delivered, and generator efficiency, the necessary sweep area (effective area) of the windmill is calculated.

3) Improvement of Communication and Radar System

a) Radio Beacon and Radar System

a-1 Radio Beacon

It is recommended that medium-wave beacon stations be built to assist aerial navigation. The radio waves emitted by the beacons are received by a pilot through an ADF receiver in an airplane, informing him of his position in relation to the station or stations.

a-2 Airport Surveillance Radar (ASR)

An ASR system can show the locations of airplanes within a 100 km radius on the screen of a cathode ray tube, which is necessary for airport traffic control.

a-3 Doppler Radar

A Doppler Radar catches VHF signals from airplanes and can make directional locations of airplanes near the airport.

b) Radio Communication between Cars and between Cars and the Base Station

When driving in desert areas, radio communication is very important for car-drivers, especially in case of accident.

A contact distance of 10 to 50 km is easily achieved by using the mobile communication equipment now on the market.

c) Telephone Service along Desert Roads

Along the desert roads, such as the Marsa Matruh - Siwa route, there are open wire telephone lines. However, people cannot make use of telephone service except at a few check points almost 150 km apart.

By providing telephone booths or simple jacks at suitable intervals along the cable, and in an emergency one can call for help from a booth or by connecting a portable telephone to the nearest jack.

d) Road-Finding System

While driving in the desert, it is easy to lose track of the road in bad weather. The following road-finding system will be very helpful in such cases.

Automatic telephone stations are built along the roads at.certain intervals. An automatic station consists of a receiver and a transmitter which operates for a certain length of time after the receiver detects a calling signal. As the station is driven by solar batteries, neither power cables nor electric generators are needed.

When a traveler gets lost, he should call some of the automatic stations along the road with a VHF transceiver and search for echoes rotating the forming antenna.

4) Development of Aquarium Type Water-Collecting Apparatus

We have discussed underground moisture in a special chapter, "Study of Water in Deserts". It is possible to collect pure water from underground moisture choosing a promising spot. Using the sun as the source of heat, water is collected at the rate of around one liter/m^2 daily. It is a kind of distilled water, and is good for drinking, filling storage batteries, for medical and other chemical purposes.

Although the water thus collected is not sufficient for plant irrigation, it may be just enough for planting seedlings.

5) Cultivation of Water Resources and Improved Utilization of Land (Northwest Coastal Zone)

Under this project, land development is proceeding by utilizing underground water. It was found, however, that the quantity of underground water for irrigation purposes was quite limited. The greatest problem in the project seems to be to increase the quantity of water available. As a means of cultivating catchment basins, there is no alternative other than to catch water in a vast area of the higher altitudes and to allow it to seep into the soil to accumulate as underground water. It is recommended that as great a part as possible of all gentle slopes be utilized as a permeation surface. One possible method is to terrace the slopes in parallel contour lines and to build a catchment wall 30 - 45 cm high along the outer edge of each terrace. Terraces so formed may be used for farming and will be irrigated after the contour irrigation system by water draining from the plateau. It will be necessary for the surface of the terraces to be turned and softened by ploughing and harrowing should it be loamy. This is because loamy soil is practically impervious to water in its natural state, while it has great permeability when ploughed and harrowed. In order to develop the lower plain, the level of the underground water should be lowered. However, this problem is closely related to that of permeability, mentioned above, and therefore requires very high construction costs, together with some technical difficulties. The productivity of the soil will be greatly increased by improving drainage. Therefore a study on the development of the lowlands should be made.

6) Improvement of Saline Soil (Siwa)

The water level of Zeitun Lake is low and the land goes up to a plateau at a gradual slope. Wells used as water resources are about 10 - 15 m higher than the lake level and therefore improvement of drainage can be easily carried out. There is no information available on the quality of the well water. Judging from the fact that various kinds of vegetables are growing around artesian wells and good results are obtained by experimental agricultural stations and private farms, it seems possible to locate the good wells to be used for irrigation.

As a means of improving the saline soil the "Karshif" should first be removed and then any hard pan found should be cracked by a pan breaker. Secondly, for the purpose of leaching, considerable water cover should be maintained for a constant seepage of water through the ground. Drains should be so constructed that water will run down the slopes.

It is recommended that on-the-spot experiments be carried out on a small scale, since such experiments are easily put into practice.

7) Afforestation (Kharga)

The necessity for afforestation can be discussed from various angles.

In Kharga, it is particularly important to keep evaporation loss of water to a minimum. Afforestation is easily done by irrigation from canals. However, this is not practicable and therefore some other way must be considered.

As explained in a separate paper, it is possible to find moisture under a comparatively shallow layer of earth if suitable places are selected. In this case, water is needed only when planting. In this initial stage, mulching with various materials, such as vinyl, asphalt emulsion, O.E.D., etc., is considered effective.

8) Soil Improvement by Underdrainage (Kharga)

At the experimental area in Kharga, a study of a method of drainage is planned by implementing underdrainage. In our experience, successful improvements of the soil itself have been obtained by implementing underdrainage in a heavy clayey soil area, and it is recommended that draining experiments be conducted simultaneously with soil improvement.

9) Necessity for Studying "Microweather" of Date Farms:

In the date farm area of the New Valley Project, there are no majene (pools) such as are often found in such places as the Algerian Sahara, and date-palms are planted quite carelessly. Therefore, it was found necessary to redistribute arable land and to improve catch cropping. As a means of solving this problem, it is necessary to carry out a study of the microweather in the soil surface of the fields. As an example, in the case of Algeria, the agricultural weather should be observed within limited areas, especially from the standpoint of the construction of defense against sandstorms, selection of suitable crops (most probably millet, Deccan grass, etc.), use of irrigation water. It is advisable to establish small-scale agricultural weather observation stations in the date-palm fields and to collect data in the manner decided upon when construction of the station in Kharga was started.

10) Preparation of Overall Land Utilization Map:

Considerable progress has been made on the development of maps on a reduced scale, showing natural resources, such as the geology and soil in the New Valley area. However, overall land utilization maps of the New Valley area which would be helpful as a basis for the project have not yet been made. Even in the case of Kharga and Dakhla, it is necessary to keep exact records regarding the present status of land utilization in oases in addition to statistical figures. Further, in such places as Bahariya and Farafra, where plans are made to change the manner of using land in oases, it is recommended that various land utilization maps be prepared, for instance, of agricultural crops, the present status of plantation, etc. In this respect, Japanese map-making techniques should be utilized, inasmuch as various practical experience has been obtained by us in making a number of land maps on the 1:50,000 scale. It may also be necessary to prepare a map on the 1:1,000,000 scale to show the overall land use of the New Valley area.

11) Investigation of Water Utilization from Historical Standpoint:

In the New Valley area, one will find a regular distribution of what we call "Roman Wells". In many cases in Kharga and Dakhla, these wells were located higher up than those found at present. It will also be found, through investigation, whether these wells were used for canal style irrigation drainage or until how recently they were used, or the history of changes in use of water around oases. For instance, it will be very useful to show the distribution of wells by colors by the change of the times on a topographical map with 1 meter contour lines. It is also possible to restore the former status of oases by preparing illustrations of water utilization up to the present time. Such investigations should be conducted simultaneously with the development of land before valuable data is lost.

12) Necessity of Investigations on Social Status of Villages and Preparing Documentary Films:

Special care must be taken in observing changes in social and economic structures caused by such rapid development as is observed in the New Valley Project area. The development of deserts will be conducted not only in Egypt but also in the Sahara. Therefore, it will be very useful for desert countries, including Egypt, to keep records on traditional village structure by studying the society.

It is also recommended that documentary films be made in 16 mm or, if possible, in 35 mm (not in 8 mm), for keeping valuable records and for the education of other desert countries. In order to produce documentary films, it would be very helpful to use the advanced movie-making technique of Japanese engineers.

13) Establishment of Organization for Sand Dune Study:

There are at present no radical measures being taken to prevent damage by dune invasion to farms and villages. Therefore, it is intended that at present only stop-gap measures will be taken to divert the movement of dunes. In order to consider countermeasures by studying the origin of the dune-lines lying south to north, the following steps should be taken to establish an overall study organization:

1) Prepare a dune distribution map on a large scale by utilizing airphotographs.
2) Determine the source of the sand by studying the distribution of sand grains, rocks, minerals, etc., by selected from dunes at several locations.
3) Establish road signs around oases and along roads and determine the status of the sand movement by taking airphotographs at certain internals (for instance, one year).
4) In order to clarify the problem of sand stabilization, try to accumulate

information on microweather. Obtain fundamental data on differences in temperature and select suitable vegetables.

5) Carry out vertical measurements of changes in temperature and moisture inside dunes. In this case, study should be made of the area where dunes are found.

6) Conduct experiments of dune irrigation (particularly of dunes on the seashore) and make a comparative study of available data, such as those of Israel and California against data obtained in the New Valley area.

14) Development of a Simplified Chemical Analysis Instrument

Up to the present time, rough classifications have already been made of soil from each development site in the United Arab Republic. In order to raise useful plants successfully at such sites and to improve productivity, however, a more detailed study should be made in such a manner that the physical and chemical properties of the soil of each farm can be made clear.

For this purpose, it would be very effective if we could use an easy-to-handle measuring instrument which would require a very small sample of material, a short analysing time, and little skill. It seems possible that a conventional but simplified soil analyzer, which has enjoyed wide acceptance in interested circles in Japan, will be remodelled for use in deserts.

In attempting a chemical analysis of water found in deserts, it is suggested that a microquantity analysis method, in which Japanese scientists have wide experience, be adopted so that the quantity of a sample required for a single test may be kept to as little as 100 cc. Further, in order to make it possible to analyze samples of material where found, a portable water tester is urgently needed.

15) Importance of Mixing Soil:

In general, the soil of a portion of the Egyption deserts, falling within the area of the current UAR Government development project, is of a heavy clayey type, and its physical properties are very poor. An attempt has been made by the UAR authorities to improve its physical properties by mixing sand with the soil. In spite of such attempts, at each development site the soil settles after each irrigation, and a great deal of labor has to be spent to break up the conglomerate into grains. In order not only to merely seek to improve the physical properties by mixing sand with the soil, but also to minimize this heavy labor, it is suggested that, first, the clayey soil be covered with sand and then tilled while it is being irrigated.

By adopting this method, it will be possible to preserve the soil from clotting, and at the same time, evaporation of moisture from the surface of the soil can be reduced.

Further, sand which covers the surface of the clayey soil, or a mulch of sand, prevents underground moisture from dissipating into the air. Moisture in deeper soil rises to the surface by capillary action, but the upward drift of moisture is intercepted by an artificial mantle of sand, retaining the moisture in the soil. This facilitates the germination of seeds and the growth of roots.

16) Introduction of Rotational Rice Cultivation:

At Kharga farms, rice is grown every four years by changing farm lands to paddy fields. This cultivation system is adopted by the Government as one of its development projects. The aim of this system is to desalt the cleeper soil and prevent further accumulation of salt and seems to be very effective. Since, however, irrigation of farm lands by drawing up underground water appears to be too costly (some two or three times the cost required in Japan), it will be difficult to sell rice so produced.

In this respect, it is necessary that in Egypt the matter of rice cultivation be considered in reference to the dietary habits of farmers in reclaimed territory. In other words, rice cultivation will assist the agricultural economy in desert areas only in so far as it will result in a self-sufficiency of the staple diet of the farmers.

Desalting and preventing accumulation of salt are the important factors to which special consideration should be given in promoting the productivity of desert soil. It is, therefore, desirable that the crop rotation system for rice cultivation be continued in the future. Should it be discontinued, the loss which might accrue from the reduced productivity of desert soil arising from new accumulations of salt, would be more than the expenditures required for irrigation of paddy fields with costly underground water.

As outlined above, some economic difficulty might be involved in growing rice for sale. Therefore, it is recommended that rice cultivation here should be considered in close relation to the usual dietary habits of the Egyption people.

17) Planting of Citronella Grass and Lemon Grass as Sand Stabilizers and Cash Crops:

In pushing its farm land development program, EGDDO plans to grow, in new farm lands, food plants and/or plants for commercial raw materials. We certainly agree that this is a very wise procedure.

On the other hand, there are many places where a natural growth of trees and other plants can be observed. These places are, in most cases, covered with sand and are not suitable for agriculture. Sand covering the surface of these places must be kept from drifting in order to protect adjacent cultivated land.

Even in such sand-covered areas, it is known, as has been reported in this paper, that some moisture is present at a depth of several tens of centimentres. This underground moisture will permit the growth of hardy plants with long roots.

In determining the kinds of plants to be introduced as sand stabilizers in these sand-covered lands, it is preferable that cash crops be planted, as they will serve a double purpose. As is commonly known, in deserts the transportation situation is extremely difficult and shipment of products is a great problem. Therefore, the plants cultivated in desert farms should be such as are easy to process and the final products not bulky. Plants which may meet the above two requirements are citronella grass and lemon grass. Their cultivation will make for speedy afforestation and prevention of encroachment by sand, the formation of new arable land, the promotion of rural industries, the increase in income of farmers, etc.. It will be possible for a small distilling apparatus to produce a good amount of refined oil from citronella and/or lemon grass. These plants also seem the most suitable among agricultural products for export purposes.

18) Raising Trees to Form Windbreaks according to the Direction of Prevailing Winds:

In Egypt all new farm lands are sheltered by windbreaks of casuarina trees planted in rows. In planting such trees, however, the thickness of the row should be varied according to need. It is necessary that the windward side of a farm be protected by a thicker row of trees to act as a windbreak. In addition to their primary function, windbreaks will, if planted as above, be effective in improving the "microclimate" of a farm and also in keeping the evaporation of underground moisture to a minimum.

19) Planting of Shadetrees on Farms to Improve the "Microclimate" and the Soil:

Development sites at Kharga and Dakhla oases have deficient rainfall and direct solar heat is too constant. If the entire surface of a farm were exposed to the sun under these conditions, the land would suffer severaly -- moisture present in the soil would dissipate into the air very rapidly, plants would dry out very quickly, temperatures would rise and fall to extremes too frequently, and vegetation would suffer from the strong winds.

In order to produce the most successful results, it is advisable to try to stabilize the microclimatic conditions of a farm and to conserve as much underground moisture as possible by planting shade trees where needed. With the promotion of soil fertility taken into consideration, it is preferred that leguminous trees be used for shade inasmuch as this kind of plant fixes atmospheric nitrogen in the soil and their fallen leaves would replenish the soil with organic matter. In this respect, further and more detailed study must be carried out before the kinds of shade trees to be planted and their spacing are decided upon.

20) Use of Chemicals for Better Conservation of Underground Moisture:

In arid lands like Egyptian deserts, evaporation of underground moisture is exceptionally great. Any measures to reduce or prevent such evaporation should be studied promptly.

As possible methods, it is suggested that the surface of the soil be completely covered with vinyl sheets, etc., or a film of emulsion be formed over the surface of the soil or on pools. Early application of these proposed methods is needed, particularly in cases where trees will be planted in places not provided with irrigation channels or where saplings for windbreaks will be set.

In deserts on the Mediterranean coast where it sometimes rains in winter, one possible method of retaining the underground moisture supplied by the rain-water long enough to help plants to grow quickly, is to form, after each rain-fall, a film of emulsion over the surface of seeded soil. Or, alternatively, to spray an emulsion mixed with seeds over the soil. In addition, steps should be taken to encourage germination of seeds and plant roots to reach the underground moisture stratum (about 30 cm deep) as soon as possible.

21) Preventing Accumulation of Salt and Saving Irrigation Water through Introduction of "Vinyl Paddy Fields" and/or "Vinyl Farms":

It seldom rains in the desert and surface evaporation is very rapid. In such extreme conditions salt once dissolved in irrigation water is prone to re-accumulate. A great quantity of water is required to wash away such constantly increasing accumulations of salt into the deeper soil. This is the greatest problem confronting agriculture in desert areas.

In order to cope successfully with this difficulty, introduction of the "vinyl paddy field" or "vinyl farm" system should be considered in connection with the cultivation of rice and other farm crops.

To form a "vinyl paddy field", the surface soil is, first, opened up to a depth of about 40 to 60 cm, and then a vinyl sheet is spread out on the bottom of the excavation. Then the hole is refilled with the soil. Sand-mixed soil is preferable for such a "vinyl paddy field".

Plant cultivation, following placement of the vynil sheets, called the "vynil farm" system, has been studied and is now being practiced in Japan. We hope that this prior example will be followed to produce good crops in the United Arab Republic.

22) Development of Siwa Oasis Region should be done by Differing Methods in the High and Low Areas:

In the Siwa region, conditions for raising produce in the lowlands differ considerably from those in the highlands. In the above low area, water gushes out abundantly and drainage to Zeitun Lake is possible. It would appear that the creation of paddy fields here should be comparatively easy. Therefore, it is desirable that in the Siwa lowlands, future emphasis be placed on rice cultivation.

In the meantime, vegetables and other cash crops should be raised in the highlands by using good water obtainable from the deep wells in that area. This procedure should bring in a comfortable profit.

At Siwa, two agricultural experimental stations are needed, one to be established in the lowlands and the other in the highlands. Each station should be responsible for its own particular territory, determining what plants will grow best in its territory, and making tests of cultivation methods, fertilization and other pertinent matters.

23) Introduction of Seaside Grass to Waste Lands in Siwa Region:

A wild grass closely resembling the seaside grass grows densely in the saline areas of the Siwa lowlands. This grass is called "smar" in that area, and the inhabitants habitually collect it for sale as commercial raw material for matting and other woven products.

If this wild grass could be replaced by seaside grass of an improved type, a heavier crop of better quality could be raised. The weaving of such grasses would seem to be a remunerative side-line for the Siwa farmers. In any case, test cultivation is needed on the possibilities of seaside grass.

CONCLUSION

After fulfilling the entire course of our survey at this time, the E.G.D.D.O. advised us of their desires, of which the particulars are as follows:

1. In full appreciation of the existing state of affairs in Japan, Japanese assistance should take, in its initial stage, the form of scientific, engineering and educational cooperation (The educational cooperation appears to mean a scholarship grant).
2. However, it is most desired that such assistance should be rendered by regions, for instance, Siwa, Bahariya and the Sinai Peninsula.
3. As it is well known, the United Arab Republic is the gateway to Africa and the Middle East. In this connection, Japan's economic participation in this country is eagerly hoped for, and this will also prove of great benefit to Japan itself. The UAR Government desires to be provided with technological assistance from Japan, not in the form of export of completed goods but through export of plant equipment.

   To be more detailed:

   (a) The UAR Government would like Japan to send, during the fiscal year 1964, senior experts specializing in the following, for a period of more than six months:

      (i) Underground water

      (ii) Engineering

      (iii) Agronomy

      (iv) Administration

   The Government will be prepared to provide such Japanese experts with promising young assistants of E.G.D.D.O. and expects them to study the above four subjects thoroughly.

(b) The UAR Government would like Japan to invite, during the fiscal year 1965, several such young assistants to Japan for a period of six months to one year for thorough training.

In view of all the above proposals by the UAR Government, we will strive for early materialization thereof through Government-to-Government channels.

Apart from the foregoing, the UAR Government was particularly interested in the following new technology:

(1) Unattended lighthouses (powered by solar batteries)

(2) Telemetering and recording of flow, pressure and hydrostatic level of water in a well

In providing the UAR people with the necessary engineering guidance, it is held that the most effective means will be for the Japanese experts sent to take up the above two items as well as the first three desires mentioned previously.

Meantime, the E.G.D.D.O. showed us thirty items on which they desired advice and assistance from Japan. These items should also be settled en bloc, in the same manner as the above. After making a collective study, we would like to carry out work on the thirty items in the sequence in which preparations are made.

We debated from various aspects as to which geographical zone should be chosen for future development projects, and the conclusions arrived at were as follows:

The sites, development of which can probably be carried out according to Japanese blueprints without casting any undue burden on Japan's economy are (in order of priority):

(1) Bahariya (including Farafra)

(2) the Sinai Peninsula

(3) Siwa

The reasons are as follows:

(1) Bahariya

This inland area is one of the least developed in Egypt. Since, however, iron ore deposits of a 60 % fineness, were lately discovered in this area, it is expected that the Bahariya lowlands will show a remarkable and profitable development in the near future, centered around a mining industry.

A geographical survey will be finished during the first half of this year and thereafter development will be carried out by a Swedish company to bring an expected daily yield of about 10,000 mt. The construction of a railroad and a highway has been determined upon for the purpose of transporting the iron ore produced. The UAR Government has already asked the Japanese National Railways to assist them in such a planned construction. In view of the current demand and supply situation in the iron and steel industry of the United Arab Republic, development of the Bahariya ore deposits will certainly be expedited.

Exploitation of deserts has little commercial value, if any project is limited to agriculture only. In the case of Bahariya, however, a railroad, mining facilities, iron foundries, dwellings, roads, communications facilities, etc. should be taken into consideration, together with the consequent rapid population drift to the site and the resultant necessity of supplying agricultural products.

The Cairo-Bahariya-Farafra route is the worst of any of the roads linking oases in Egypt. Fatal accidents have often taken place along this route. Communications and security facilities are urgently needed. Since this area is still in the very early stages of the processes used for exploiting deserts, it will serve as an interesting subject for documentary films, if Japanese assistance is rendered, as such films are a Japanese speciality. Improvement in methods of rice cultivation at Bahariya will also be one of the subjects to attract the attention of interested parties.

All considered, Bahariya is the most promising site for the carrying out of a development project under the assistance of Japan. (A map drawn on a scale of 1 to 25,000 and an air photograph on a reduced scale of 1 to 50,000 of the Bahariya area, have already been completed. Therefore, fundamental data required for the implementation of such a development project can be checked with comparative ease.)

(2) Sinai Peninsula:

About 120,000 people live in the Sinai Peninsula, of whom 80,000 live in El Arish, on the Mediterranean coast. Therefore, one could correctly say that almost the entire area of the Sinai Peninsula is uninhabited. The Sinai region abuts on Israel along its northeastern frontier. In this regard, the UAR Desert Development Agency is averse to having the development of this region undertaken by the United States and/or European countries inasmuch as all these countries have some connection with Israel. On the other hand, Japan has no such ties whatsoever. Thus the choice has fallen on Japan.

Major developments considered for this area are the exploitation of ore resources (abundant nonferrous metals) in mountainous districts, the exploitation of petroleum resouces on the Red Sea coast, and the promotion of agriculture in the Mediterranean coastal zone. Exploitation of petroleum resources has already been started by Italy. Japan should therefore cooperate with the UAR Government in exploiting ore resources and in promoting agriculture.

The East Canal Project has also been drawn up by the UAR Government, under which reclamation will be carried out on an extensive scale east of the Suez Canal. Subsequent to completion of the Aswan High Dam, vast areas of arable land will be formed by the consequent irrigation from the Nile. It seems possible that Japan will be given an opportunity of participating in this contemplated reclamation plan, supported by its successful achievement in dredging the Suez Canal.

(3) Siwa:

The problem which confronts the Siwa Oasis is an effective method of draining water from the area as well as desalting the saline soil and water of this oasis. At Siwa there is no lack of water. It can be foreseen that a long-range introduction of Japanese agricultural technology, rich in experience, will contribute considerably toward improvement of the agricultural enviroment of Siwa. Procurement from saline lakes of raw materials for chemical industry is also possible. At Siwa slow and steady development is preferred to extensive and hurried exploitation, because this oasis is comparatively small. It is suggested that several agricultural engineers be sent here from Japan to give the necessary technical assistance over a long period of time.