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AYUB BRIDGE REPLACES LANSDOWNE'S BRIDGE ON THE INDUS

KARL FRIED GAUSS (1777-1855)

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In this issue

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Editorial

West Pakistan and Desalinization of salty water.

ACCORDING to the Indus Basin Treaty with India, West Pakistan is entitled to fresh water supply from only three rivers. Their total annual flow amounts to 138 million acre feet. The flow during six summer months is 110.0 million acre feet, about 70 percent of it being the result of monsoon atcivity. A large portion of this water flows into the sea and is wasted. Even if we succeed in the near future to construct reservoirs to store this run off, the magnitude of our usable fresh water resources will be 105 or 110 maf for 73 million acres of culturable area lying in the Indus Plains. At present about 72 million acre feet of water is being used for 33 million acres of land, so that hardly a foot and a half of water reaches the fields after accounting for conveyance losses and wastage. For successful agricultural operation and land management, we must have at least three times this depth of water. Thus the conclusion is inescapable that either we should reduce the area under irrigation or find new sources of water The only other available source appears to be ground water ; but unfortunately, in about 9 million acres of former Punjab and about 8 million acres of former

Sind, this water is too saline to be used for crops. As a result of the programme of reclamation of saline land, now being vigorously executed surface salts will be washed down, with the result the salinity of ground water will increase still further. This saline water cannot be drained off hundreds of miles to the sea. The best solution appears to be to take measures for desalting this water at site and using it on the land.

Moreover, about one-third of West Pakistan is arid. This comprises the region of Baluchistan, which has a furtile belt of land along the Arabian sea and a number of small valleys, and hardly 4.0 inches of rain a year. If cheaper means of conversion of sea water into fresh water become available, there is a great scope for the development of these areas At present sufficient water is not available even for human consumption. Small port towns can be developed along this coast only if fresh water is made available.

For West Pakistan saline water conversion is a must and the sooner it is done, the better. Nature is bounteous to Pakistan. It has given us gas for the interim period till we develop other sources of power. Water is the biggest source of power for this province and potential power equal to 40 million K.W., is going waste. Vast resources of wind power along the sea coast are also going waste. West Pakistan has yet to utilize this inexhaustible natural source. By using some of the methods discussed in this volume power from all these sources can be pooled together to desalt saline water. It is time we started benefiting from the experiments of world scientists, which they are assiduously conducting, for converting saline water into fresh water. During the recent years innumerable conference and symposium have been held to pool together the experiences of the various scientists working in different parts of the world. It is hoped that in the very near future development of solar energy, wind energy and similar sources of power will lower the present high cost of saline water conversion. In this country, some individual efforts are being made on the investigation of the subject, but the problem needs concerted action to keep in step with developments in this field.

AYUB BRIDGE
REPLACES THE OLD LANSDOWNE BRIDGE ON THE INDUS

Old bridge had lived its life.

The Ayub Bridge has been constructed on the down stream side of the old Lansdowne Bridge, over Rohri Channel of River Indus, between Sukkur and Rohri. The former replaces the latter which was constructed and opened to traffic in March, 1889. The material used on the old bridge was wrought iron and early steel, which after rendering service of more than half a century, started showing signs, of distortion and cracks in the concrete bed stones. As a result of detailed investigation it was decided that the bridge should be replaced. Until its replacement, engines of a lighter group were permitted to haul trains over the bridge at a restricted speed of 8 m.p.h.

New bridge to be a single span arch.

The new bridge was, initially proposed to consist of multiple spans, but this presented a great difficulty in the construction of piers and consequent high cost of construction. This design was, therefore, abandoned as a single span arch, decided to be the most suitable and economical for the new bridge. World-wide tenders were invited according to the design prepared by Steinman Boynton, Gronquist and London, Consulting Engineers of New York and the contract was awarded to Messrs Dorman Long & Co. of U. K. and M/s Gammon (Pak) Ltd. in November, 1959.

The Design.

The single span arch 806'-9" between centres of the lower bearings and rise of 180 ft. now spans the Rohri Channel of River Indus. The two arch ribs are 45 ft. apart and the arch truss is 60 ft. deep at the bearing and 24 ft. in the centre. The total height of the arch at the crown is 204 ft. above the centre of the lower bearing.

Grouting the foundation.

The foundation work was started on 21st November, 1959. The two reinforced concrete skewbacks supporting the arch have been founded on rocks. While excavating for the foundation of South Abutment, a fissure was discovered in the bed rock which penetrated right underneath the Lansdowne Bridge Abutment also. The fissure was then sealed and pressure grouted upto 15 ft. below the foundation level. The foundation work was completed towards the end of December, 1960.

The Erection.

The erection of the steel arch was commenced simultaneously from the two abutments in the form of cantilevers from the two skewbacks and creeper cranes on the two cantilevers worked progressively erecting the steel work of the arch. Shop fabrication of the steel arch was done at Messrs Dorman Long's Workshop at

Middlesbrough. The two halves of the arch were joined together about 250 ft. above the water level on 30th June, 1961. The final adjustments in the arch were kept in progress till 10th August, 1961 when the arch was finally completed and loads transferred to the holding down bolts of the bearings.

The bridge decking is suspended from the arch by 2¼" dia. wire rope suspenders. The total load that each suspender carried is 55 tons against the designed strength of 277 tons. The width of the roadway between the kerbs is 15 ft. The deck girders are 27 ft. apart centre to centre. The suspension of the deck started from the centre of the arch and worked back to the abutments by the creeper cranes. The first panel so suspended was on 15th August, 1961. The entire decking was completed in the first week of October, 1961.

The Material used.

The bridge was substantially completed in February, 1962 and tested for M.L. loading at 30 m.p.h. and declared opened for public traffic on 6th May, 1962, by the President of Pakistan.

Detail of materials used in the Bridge:—

Cement	4000 Tons
Shingle (Hirok)	320000 Cft.
Sand (Bholari)	160000 Cft.
Steel Reinforcement	131 Tons
H.T. Structural Steel.	1000 Tons
Mild Steel	1907 Tons
Cast steel in Bearings	85 Tons
Pipe railing on Arch	5342 Lft.
Suspender strands galvd	9300 Lft. 76
Welded track	927'-6"

Contd. from page 39

(*ii*) Water supply Law and Sewerage Law, be enacted.

(*iii*) Regular training courses for Engineers and Technicians be started in Universities and technical institutes for those already in service and for the new comers to get specialised training.

(*iv*) Sanitary Engineering Degree course be started like other branches of Engineering.

(*v*) Sanitary Engg. research stations be opened in the country for sewerage disposal and night soil with garbage in particular.

SALINE WATER CONVERSION

By

Frank Schneller A.M.A.S.C.E. Associate Editor, Civil Engineering, New York.

Conversion of saline water to sweet usable water is as much a problem of interest to Pakistan as to any other country of the world. Its vast areas of alluvium formation comprising the Indus Plains possess pockets and zones of highly saline water. We are undertaking big schemes for utilization of underground water. If water is pumped only from sweet zones, its pollution from saline water pockets is expected sooner or later to flow into the good quality regions. As a remedy it is proposed to pump out this saline water also to check its intermixing with the sweet water. Disposal of this saline water is a problem. Water of low salt content can be mixed with river water and used for irrigation, but in large areas water is such as cannot be used even after dilutation. If this saline water is disposed of through natural drains, the spreading of this on the lands lower down is a real danger. It is even now said that small dozes of salts of irrigation water had a cumulative effect on raising the salts content of the agricultural land. Spoiling low areas at the cost of upper regions is an unwise policy. Pakistan shall have to consider the possibility of conversion of this saline water into good quality water on the spot.

Again vast areas of Baluchistan comprising nearly 80 million acres are thirsty dry lands when a source of fresh water can make them bloom. Perhaps a cheap method of conversion of sea water may help to change the conditions of the area in the near future.

All over the world intensive experiments are in hand to convert sea water into sweet water. We have been giving brief information of the world conferences being held to discuss the present status of the knowledge. In this article, which we have reproduced from December Civil Engineer, the present status of the saline water conversion is set forth for the interest of our readers.

U.S. needs more water

Water delivered to the consumer at a cost of $ 1.45 per thousand gallon will not seem like much of a bargain to most American Engineers. In nearly all areas of the United States, water is available for about 25 to 40 cents per thousand gallon. But to the people of Coalinga, California $ 1.45 is just about 15 per cent of what they formerly had to pay. Coalinga, in the San Joaquin Valley, midway between San Francisco and Los Angeles, previously hauled its water some 45 miles from Armona, California, by tank car at a cost of about $ 7.00 per thousand gallon. Delivered to the customer, the cost rose to over $ 9.00.

Our present water supply is not unlimited. Over 300 billion gallons of water is used every day in the United States. On a per capita basis this amounts to about 1,700 g.p.d. for every American. Domestic

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TABLE I

PLANTS IN DEMONSTRATION PROGRAMME FOR SALINE-WATER CONVERSION

Location	Process	Capacity Gpd.	End Product, Dissolved Salts in ppm.	Architect and Engineering Contract	Construction Contract	Remarks
Freeport, Tax.	Multiple-effect long-tube vertical type distillation	1,000,000 Sea Water	15-20	Sept. 24, 1960 W. L. Badger & Assocs. $112.000	June 8, 1960 Chicago Bridge & Iron $1,252,797	On line June 1961
Point Loma, San Diego, Calif.	Multi-stage flash evaporation	1,000,000 Sea Water	15-25	Sept. 24, 1960 Fluor Corp. $102,000	Nov. 5, 1960 Westing-House Elec. Corp. $1,608,000	On line Jan. 1962
Webster, S. Dak.	Electrodialysis	250,000 Brackish Well-water, 1,800 ppm.	250	Sept. 24, 1960 Sur, of Reclamation $50,000	Nov. 16, 1960 Asahi Chemical Co. Ltd., and The Austin Co. $482,000	On line Oct. 1961
Roswell, N. Mex.	Forced circulation vapor-compression	1,000,000 Brackish Well-water, 24,000 ppm	50	Oct. 28, 1960 Catalytic Const. Co. $96,700	Bid Opening, Dec. 5, 1961	On line Jan. 1963
Wrightsville Beach, N.C.	Freezing	250,000 Sea Water	Less than 400	Lummus Corp. $99,800	...	On line May, 1963

use averages less than 150 g p d. per person but industrial processes take prodigious quantities.

The Saline Water Act

In 1952 Congress passed the Saline Water Act providing $2 million for a 5-year study of economical means of developing fresh water from saline water. Research and development were entrusted to the office of Saline Water (OSW), Department of the Interior which formed out research and development contracts to institutions and industries. This Act was amended in 1955 by Public Law III which increased the appropriation to $ 10 million and extended the time to 10 years. Under these acts the Federal Government has worked jointly with state and local governments, private industry, and educational instituitions in establishing pilot plants to study the various processes of saline water conversion.

A law passed in 1958 added substantially to the already mushrooming developments. An additional $ 10 million was authorised to "provide for the construction, operation, and maintenance of not less than five demonstration plants for the production from sea water or brackish water of water suitable for agriculture, industrial, municipal and other beneficial consumptive uses."

One of the last things the 87th Congress did before adjourning late last summer was to pass Public Law 87-295, which authorized an additional $ 75,000,000 for further study (research and development) of saline water conversion between 1963 and 1967.

Five Demonstration Plants

Five processes have been selected for the first demonstration plants: multiple-effect long-tube vertical distillation for sea water conversion; multi-stage flash distillation for sea water conversion and electrodialytic process for brackish water; forced circulation, vapor-compression distillation for brackish water: and freezing process for sea-water conversion. Table 1 gives pertinent data for each of these plants and processes.

The largest sea-water distillation plant in operation today is on the Island of Aruba in the Dutch West Indies of the coast of Venezuela. This $ 10 million, multiple-effect distillation plant produces nearly 3 mgd for about $ 1.75 per 1,000 gallon delivered to the consumer. The largest complex of conversion equipment is found in Kuwait (on the Persian Gulf) with a daily production of 7.5 million gallons.

A LONG-TUBE VERTICAL DISTILLATION PLANT.

Last June the first of the five plants went into operation at Freeport, Tex. This multiple-effect long-tube vertical distillation plant has a design capacity of 1 mgd. Here saline water is passed through long vertical tubes in which it is raised to boiling temperatures by condensing water vapour or steam on the outside of the tubes. The feed proceeds to a separation chamber where the clean vapour is separated from the brine.

In a multi-effect plant, such as the one at Freeport, the outgoing fresh water preheats the incoming sea water, which then enters the first effect, where it is boiled by steam heat. The water vapour produced here goes to the shell side of the second effect, where it is maintained at lower pressure than the first. Here it condenses and yields heat to boil the feed, which is liquid carried over from the first effect. (See Fig. 1.) The condensed vapour is the desired fresh-water product. The cycle is repeated through all following effects at progressively lower temperatures and pressures.

A pilot distillation plant operating as described above was built at the International Nickel Company's Marine Corrosion Test Station at Harbor Island, N.C.

To apply the knowledge gained from the pilot plant to practical use, the OSW built its first demonstration plant with 12 effects, using long-tube vertical evaporators. The first-effect temperature is 250°F and the final effect temperature is 110°F. The final brine is concentrated about four-fold.

Scaling on equipment surfaces exposed to saline water is one of the main problems to be overcome in converting saline water to fresh. One method of preventing scaling, employed at Freeport, uses fine crystals (seeds) of the scale-forming material in suspension. When these are introduced into the evaporating liquor, additional scale forms on the seeds rather than on heating surfaces.

Half of the product water of this plant is being sold at $ 0.30 per 1000 gallon to the Dow Chemical Co. for industrial use and the remainder to the City of Freeport to supplement its present municipal supply of fresh water at a cost of $0.20 per 1000 gallon. Other objectives of the Freeport plant are :

(1) to make corrosion test, to find the most economical materials of construction for long-term use, and

(2) to enable the public to see saline-water conversion in operation.

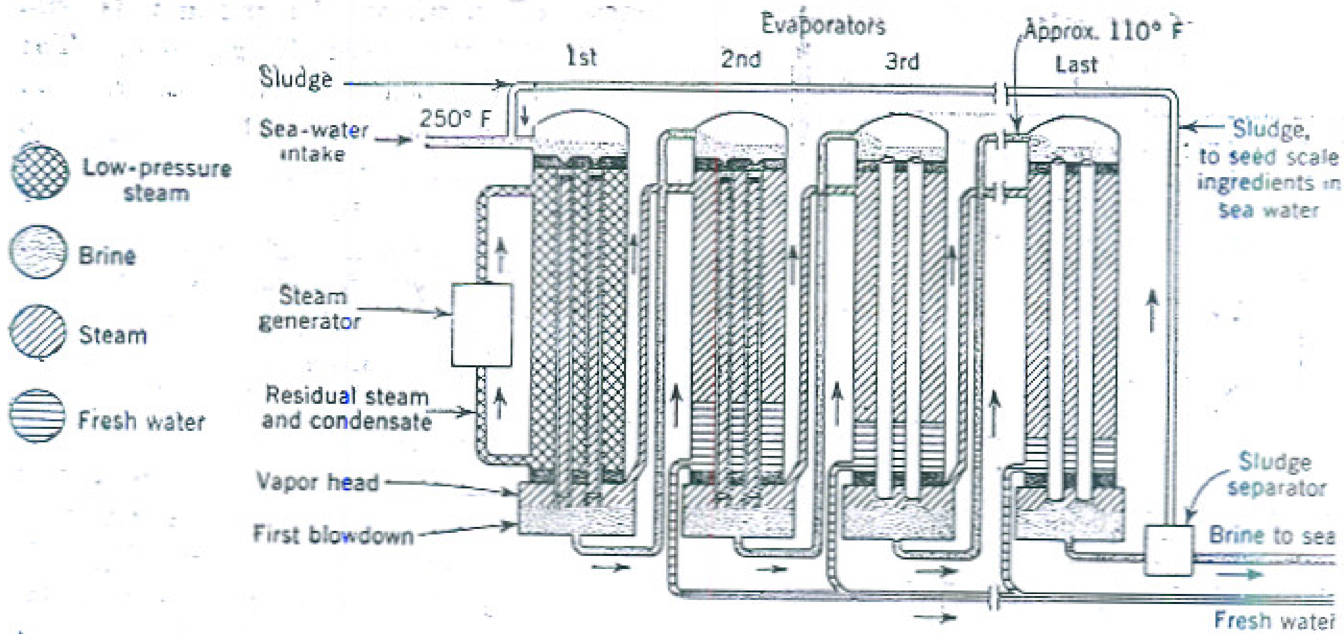
The Freeport plant, built by the Chicago Bridge and Iron Co., is reportedly producing fresh water at about $1.24 per thousand gallon including all expenses for demonstration and experimental purposes. OSW reports that the knowledge gained from this plant will make it possible to design a 20-mgd. plant that can produce fresh water for $0.50 per thousand gallon.

Flash distillation.

A multi-stage flash-distillation plant on Point Loma, San Diego, Calif, is designed for a capacity of 1 mgd. This plant will have 36 stages. A feature is prevention of scaling by flash evaporation. (See Fig. 2).

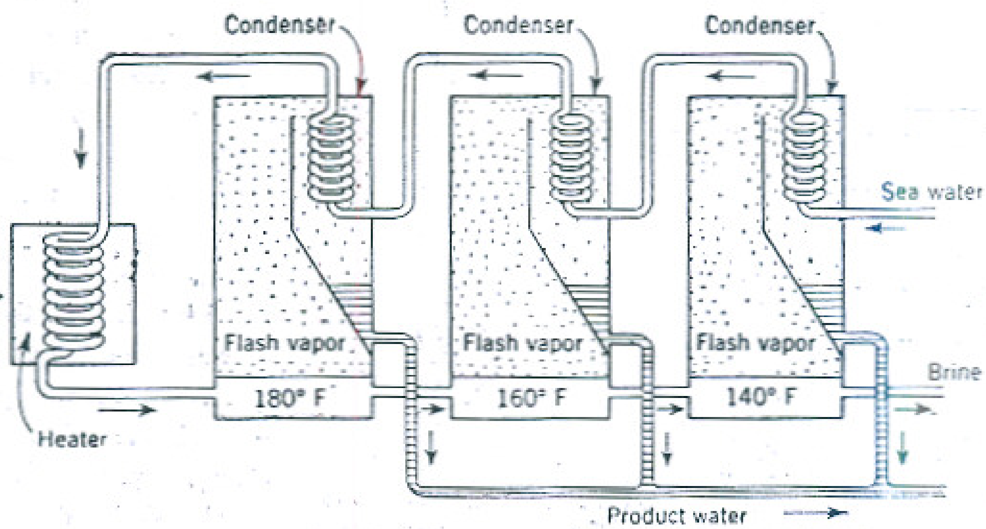
The essential unit of a flash evaporator is a vessel maintained at a suitably reduced pressure into which the heated sea-water is sprayed. The water boils instantly and the steam flashes off. Whatever scaling may result occurs in the flash vessel, where it does not interfere significantly with the operation of the unit. Such a flash evaporator usually consists of a number of flash vessels in series, maintained at progressively lower pressures. The sea water is first heated in a unit that is completely separate from the flash vessel. Because of the low operating temperatures and the use of additives, scaling in the unit's tabular heaters is not expected to be serious.

Flash evaporation is especially suitable for locations where warm water in large amounts is already at hand, as is waste



▲ **FIG. 1. In long-tube vertical-distillation process, saline water in the tubes is raised to boiling temperatures by condensing water vapor or steam on outside of tubes.**

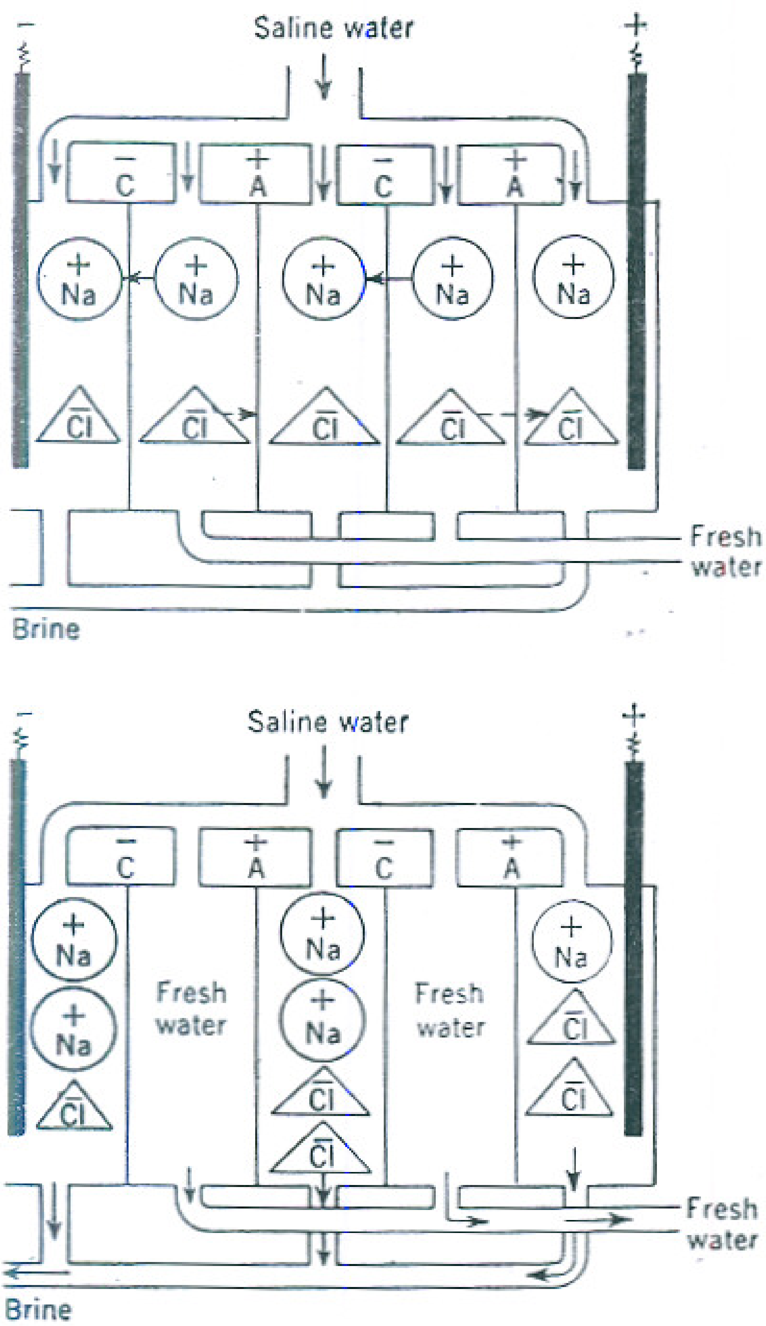
FIG. 2. In flash distillation process, sea water, sprayed into a vessel maintained at reduced pressure, boils instantly and steam "flashes off." ▶



De

cooling water in chemical plants or the surfaces layer of a warm sea. The steam produced can be used to drive a turbine and produce power, before it is condensed for use as fresh water. Such a flash evaporator has been operated successfully as a pilot plant at the University of California.

In the demonstration plant of the Office of Saline water at San Diego, being built by the Westinghouse Electric Corp., the sea water will be preheated under pressure and then introduced into the flash vessel, where the pressure is lower than the equilibrium pressure of the feed. As a part of the water flashes up in vapour,



g. 3. In electrodialys's, salts are removed from the water through memberanes that are one way permeable. Sodium ions (Na) move toward the c thode and chloride ions (cl) towards the anode.

the temperature of the liquid naturally drops. The vapour flows around a condenser through which the feed water is passing. The remaining liquid travels on to the next effect, where the pressure is still lower and the cycle is repeated. The plant is intended to operate at a feed temperature of 200°F but may go higher depending on the success of new scale-control methods.

3. **A plant for electrodialysis.**

Electrodialysis removes the salt from the water instead of removing a large amount of water from the saline solution, as in distillation. This method takes advantage of the fact that salts in water are in the form of negatively and positively charged ions. By applying an electrical potential across a vessel containing salt water, the ions are caused to migrate. Sodium ions move towards the cathode and chloride ions towards the anode.

Separation of the salt from the water takes place in an electrolysis vessel divided into compartments by means of membranes made of ion exchange resins. The simple three-compartment cell with two membranes shown in Fig. 3 illustrates the principle involved.

Materials for the two membranes are so chosen that one allows only cations (positively charged particles) to pass through it, and the other only anions (negatively charged particles). The membranes are so placed in the cell that when current is applied, the ions move from the central compartment through their respective exchange memberanes into either the anode or the cathode compartment. That is, the anions move toward the anode and the cations move toward the cathode. At the same time the two membranes act as barriers to prevent ions from moving back into the central compartment. The result is that the water in the central compartment is effectively desalted.

Since the amount of electricity needed, and the current density, are directly proportional to the salt concentration, the method is not at present considered suitable for the purification of raw sea water with its salt content of 35,000 ppm or more.

In some large commercial cells in use today, an electrolysis stack may contain as many as 300 membranes. Suitable manifolds continuously separate the exit-streams into fresh water and waste brine.

The OSW electrolysis plant at Webster S. Dak., began operation in October 1960 to convert brackish well water. It was built by the Asahi Chemical Co. of Japan in co-operation with the Austin Co. Its design capacity is 250,000 gpd and it will electrolyse starting water with about 1,800 ppm of dissolved salts, bringing it down to about 300 ppm.

4. A vapour compression plant.

Turning a large amount of water into vapour to separate it from a relatively small amount of dissolved salts is inherently expensive. Therefore distillation processes are eminently suitable for use near a source of cheap fuel. Failing that, more efficient vaporization processes must be employed. One such process is the forced circulation vapour compresssion distillation method. It is an outgrowth of the small distillation units much used to provide drinking water during World War II.

In this process the vapour produced by boiling sea water is not condensed but compressed. Compression increases its energy content enough so that it can be returned to the evaporator to serve as the the heating medium. After it has heated the incoming sea water, the compressed steam is condensed to provide the required fresh water. (See Fig. 4).

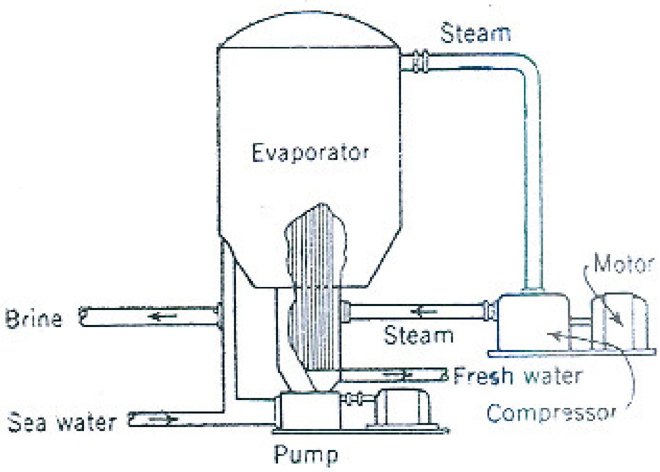


FIG. 4. In forced-circulation, vapor-compression distillation method, vapor from boiling sea water is compressed and made to serve as a heating medium. After heating the incoming sea water, the compressed steam is condensed to provide fresh water.

The costs of the process vary inversely with the temperature of the operation, that is, as the temperature goes up the area of the heat-exchange surface and the size of the compressor goes down. At high temperatures the old difficulty with scaling is intensified. Forced circulation of the feed increases heat exchange and decreases scale formation.

Roswell, N. Mex., is the site selected for the fourth demonstration plant planned by the OSW. It is to be a forced-circulation vapour-compression unit with a design capacity of 1 mgd of brackish well water. It is expected that the plant will be operated at above 212 deg F. The OSW feels that this type of distillation is capable of maximum fuel economy. Scale will be prevented by either an ion exchange pre-treatment system or the use of a calcium sulphate slurry scale-prevention system. Bidders can select either of the above.

5. **A freezing-process plant.**

Desalting of water by freezing has the natural advantage of an inherently low energy requirement. Also the process can be accomplished and on near atmospheric pressures and at low temperatures, which minimize scaling and corrosion. The basic simplicity of the process has the additional advantage that low-cost materials and equipment of reasonable size can be used in plant construction.

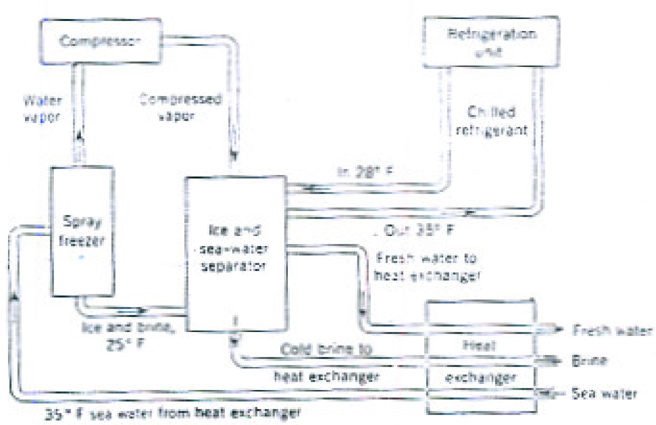
The fifth plant in the present OSW demonstratian plant programme will apply the freezing principle. Although direct freezing appears to be the most advantageous method, it has not been decided whether the direct or indirect process will be used. The OSW is preparing performance specifications for competitive bidding. With a design capacity of 250,000 gpd, the plant will treat sea water at Wrightsville Beach, N.C.

One of the first direct freezing process investigated was that developed by the Carrier Corporation. (See Fig. 5). Deaerated sea water is precooled by loss of heat to the brine effluent and the fresh-water product streams. The feed is further cooled to 25° F by evaporation, whereupon it is practically frozen. The ice-brine slurry is pumped to the bottom of a separation column, where the ice and brine are initially separated by a screen. The ice moves to the top of the column and the brine is recycled to the freezer and thence to waste.

Water vapour leaving the top of the freezer is absorbed in a lithium bromide solution. The diluted absorbent is regenerated by heat ; the steam produced is condensed ; and the condensated is used for washing the ice in the wash column. The concentrated absorbent is recycled to the absorber. Fresh water flows countercurrent to the ice rising in the column.

The ice is scraped into a melting tank where it is melted by recycled fresh water. The effluent from the melting tank is divided into three streams. The largest stream flows to the absorber, where it picks

FIG. 5. In direct freezing process, as developed by the Carrier Corporation, deaerated sea water is precooled, then frozen by chilled refrigerant.



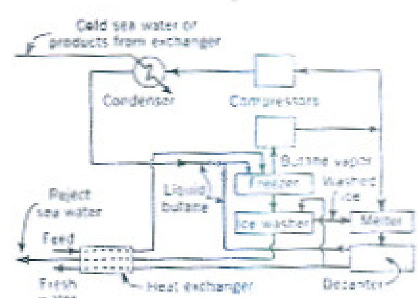


FIG. 6. In direct freezing process as developed at Cornell University, liquid butane serves as the freezing agent. Courtesy Blow-Knox Company.

up the heat of absorption. The same stream flows through a chiller to preserve heat balances and then flows back into the melting tank to melt more ice. The second stream is used for washing the ice at the top of the column and the third stream is product water, which is heat interchanged with incoming feed and thence goes to storage and distribution.

In the direct process developed at Cornall University the water is frozen by the evaporation of a refrigerant, liquid butane, directly in the brine. (See Fig. 6). The resulting ice-brine slurry enters a washer where the ice is rinsed and separated. The ice goes on to a melter where it is melted by compressed refrigerant vapours collected at the freezer. The refrigerant is of course insolube in water and is recovered for further use. It is reported that ice made with butane can be washed almost completely without melting.

Propane will be used in a somewhat similar way in a pilot plant now being designed by Koppers in co-operation with the Office of Saline Water. When sea water is cooled to 35° F and mixed with propane, hydrate crystals form around the propane molecules. The crystals are washed free of salt and pumped to a decomposing chamber to which the propane is also pumped under pressure. Here the condensation of the propane releases heat to melt the hydrate crystals. Since the resulting fluids, pure water and propane do not mix, they are easily separated as they flow out, and the propane is returned to the reaction vessel. Low cost, less than 50 cents per 1,000 gal. is predicted for this process when perfected.

Future Possibilities.

Although solar distillation was not selected as one of the processes for the first five demonstration plants, much has been learned about this process both here and abroad. While it is doubtful the large-scale solar distillation will ever be practical in the United States, it may well be successful in small units in warm, dry areas where there is plenty of sunlight.

Advances in solar distillation have been in the direction of lowering the cost of equipment and increasing the efficiency with which the solar energy is utilized. Valuable data have been obtained through the operation and development of basin solar-still prototypes and small pilot plants. Tilted-type and suspended-type stills are also being evaluated at test sites.

Several of the distillation processses are the farthest advanced to date. New large commercial installations in water-short areas have been announced, multistage flash distillation being the preferred process for the conversion of sea water. Methods of scale control have received much attention.

Progress has been in the development of the vapour-reheat,multiple-flash process through laboratory research, particularly in liquid-liquid heat-exchanger development. As a result of laboratory tests with the new wiped-film evaporator, a prototype is now being built. A phase of the rotary vapour-compression still has been completed and additional research has been recommended. The atomized suspension technique has been under investigation as a possible means of brine disposal.

Membrane process continues to show promise as an important means of converting saline waters. Commercial development of electrodialysis has continued, with considerable increase in the number of installations treating brackish waters all over the world. Research and development under way at the Bureau of reclamation's laboratories in Denver have been expanded and now include a field test site where brackish well-water is available. Several different types of membranes have been tested for electrodialysis. Four different types of electrodialysis units have been procured and are being evaluated.

Electrodialytic processes are related to ion-exchange technology, since ion-exchange types of materials are used in permselective membranes. However, interest is growing in other ways of using ion-exchange resins for saline-water applications. An example is the work initiated during the past year in the use of special ion exchange materials to remove scale-forming components before distillation, the concentrated brine effluent being used to regenerate the resins.

Solvent extraction, that is, the use of organic solvents to remove fresh water from saline, has been the subject of further study and laboratory research. It continues to show promise as a possible economical process for treating brackish waters in the 5,000 to 10,000-ppm range.

Present day cost of Conversion

In regard to costs it can be stated that just 10 years ago the conversion of sea water to fresh water by distillation processes produced fresh water in small quantities at costs of $4,000 to $5.000 per 1,000 gal. It is generally agreed that the lowest cost of fresh water produced from existing large sea-water distillation plants is approximately $1.75 per 1,000 gal. The OSW estimate costs for more advanced distillation process to be about $1,000 per 1,000 gal. for plants in the 1-mgd range.

This includes writing off the equipment but not experimentation expenses. Conversion plants of smaller size for brackish water using the electrolytic process can produce fresh water for about $1.75 to $1.00 per 1,000 gal.

OSW Director, MacGowan has been quoted as stating to a Congressional committee that some phenomnal new process would be necessary to bring conversion costs below 50 to 60 cents per 1,000 gal. Research is the answer. Time and money and manpower for additional research are the keys to economical desalinization.

Still in the Experimental Stage.

That saline water conversion is just coming out of the experimental stage is a fact conceded by all. The demonstration plants of the Office of Saline Water are just that—plants to demonstrate the validity feasibility of various types of equipment and techniques. There will be failures demanding new approaches, and there will be progress demanding money. The Government is ready to spend the money.

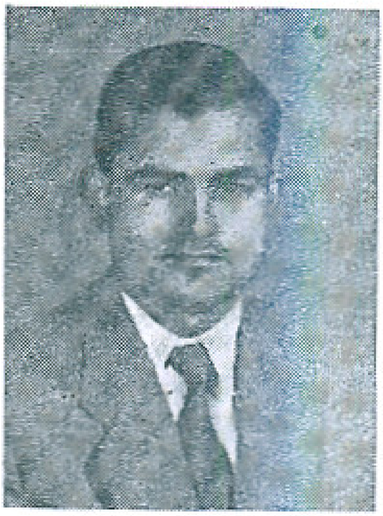
The $75.000,000 approved by the last Congress for further work in this field an amount equal to 3½ times the total spent by the government thus far—puts us in the saline-water conversion business all the way. More research and more plants are coming. Only the future will reveal our wisdom.

LINING OF LINK CANALS

By

Mazhar Ali, Section Officer, (Manuals)

A large number of link canals are to be constructed under the Indus Basin Replacement plan. These canals will be mostly feeder channels, running across the slope of the country to connect the Indus, the Jhelum, the Chenab, the Ravi and the Sutlej to distribute the available river supplies in summer. Their effect on the water-logging problem, their bed slopes and their stability with fluctuating supplies are hot issues The author has examined the suitability or otherwi·e of lining these link canals, and the economics of pumping out the seepage losses by tubewells. The Trimmu-Sidhnai Link has been selected as a typical example. The writer has been incharge of Trimmu Head Works and Haveli Canal and thus has studied the problem closely.



A large number of feeder channels, commonly known as Links, are to be constructed under the Indus Basin Replacement Plan. They will cut across the drainage of the country. They will generate mounds in the subsoil water-table. Their discharge will also be highly fluctuating over the year. Lining of these links to take care of a number of different factors is a controversial subject. It is considered appropriate to select one such link canal and study it to get representative results.

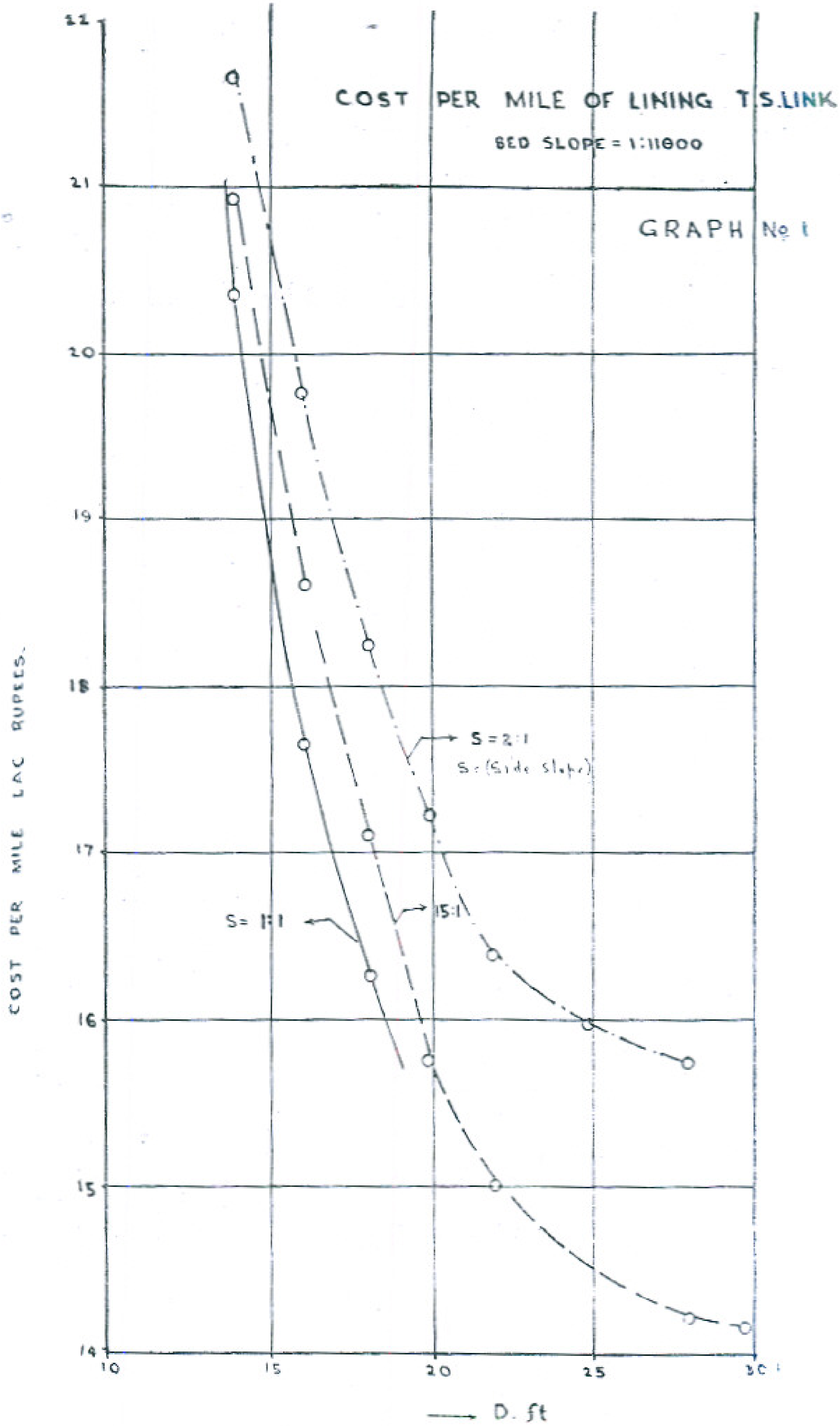
In the list of priorities, Trimmu-Sidhnai Link will be the first one to be constructed. It will take off from the Chenab at Trimmu and will fall in the Ravi 6 miles above the present Sidhnai Weir. It will run for 10 months in a year with a widely fluctuating hydrograph. This 44 miles long channel will have maximum designed discharge capacity of 11000 cusecs. Water levels in the two rivers at the head and the tail are almost fixed, and the water slope available is tight. There are zones of high sub-soil water in the head and the tail reaches. The link also runs parallel to the existing Haveii Canal, which is a perennial channel.

The original IBAD proposals envisaged lining the middle 28 miles, leaving the zones of high water table unlined. Slope accepted was 1 : 10500 all through. It has now been proposed to keep the entire link unlined, construct its work to a slope of 1 : 10500 but to keep free board to a slope of 1 : 9500 and to remodel the Trimmu Barrage to take care of the raised Full Supply Level of the Link at the head.

Cost of a lined canal

The discharge capacity Q of any lined section is determined by the bed slope S. as $Q \propto V \propto S^{\frac{1}{2}}$

The discharge carrying capacity of a section increases as the bed slope becomes steeper. For a given capacity, the cost is a


COST PER MILE OF LINING T.S.LINK
BED SLOPE = 1:11000
GRAPH No 1
S = 2:1
S = (Side slope)
S = 1:1
1.5:1
COST PER MILE LAC RUPEES.
22
21
20
19
18
17
16
15
14
10
15
20
25
30
D. ft

direct function of the cross-sectional area. Consequently as the slope becomes flatter and the capacity falls, the canal becomes more expensive.

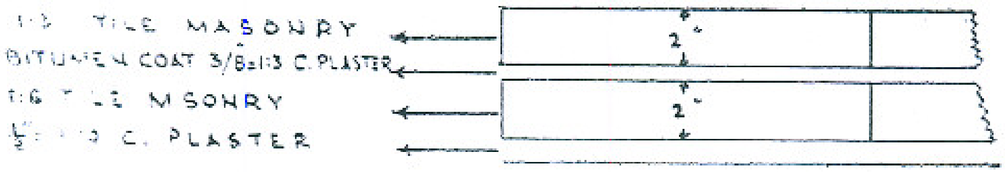
Table 1 gives the capacity ratio of any section with variations of bed slope from 1 : 9500 to 1 : 20000. This table also enables a preliminary comparison of the cost ratio of lined canals with variation of bed slopes. Cost ratios will be inverse of capacity ratios.

TABLE 1

Capacity Ratio of lined section with variation in bed slope.

Slope 1 in	9500	10000	105000	11000	12000	13000	14000	15000	16000	17000	18000	19000	20000
$S^{\frac{1}{2}}$	.01025	.01	.00975	.00953	.00913	.00876	.00845	.00816	.00790	.00766	.00745	.0725	.0070
Capacity Ratio	145	141.5	138	135.0	129.0	124.0	119.5	115.4	111.9	108.4	105.3	102.6	100.0

TYPICAL X-SECTION OF LINING

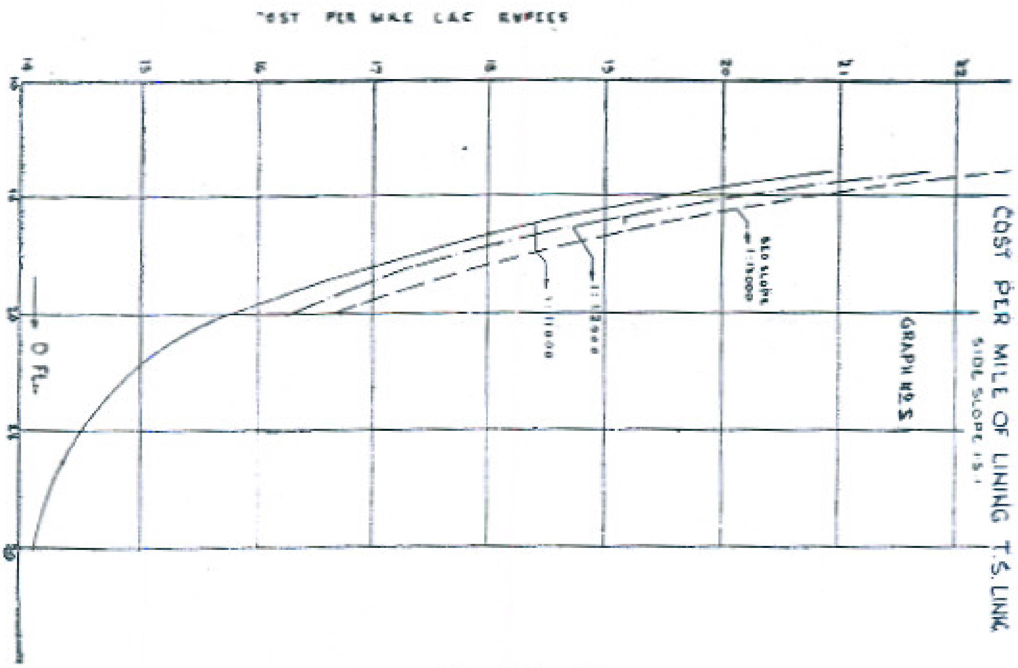


Typical section for double tile lining is shown in Fig. 1. A typical section of a lined channel is also shown. Cost per 100 sq. ft. of lining is accepted as Rs. 200.

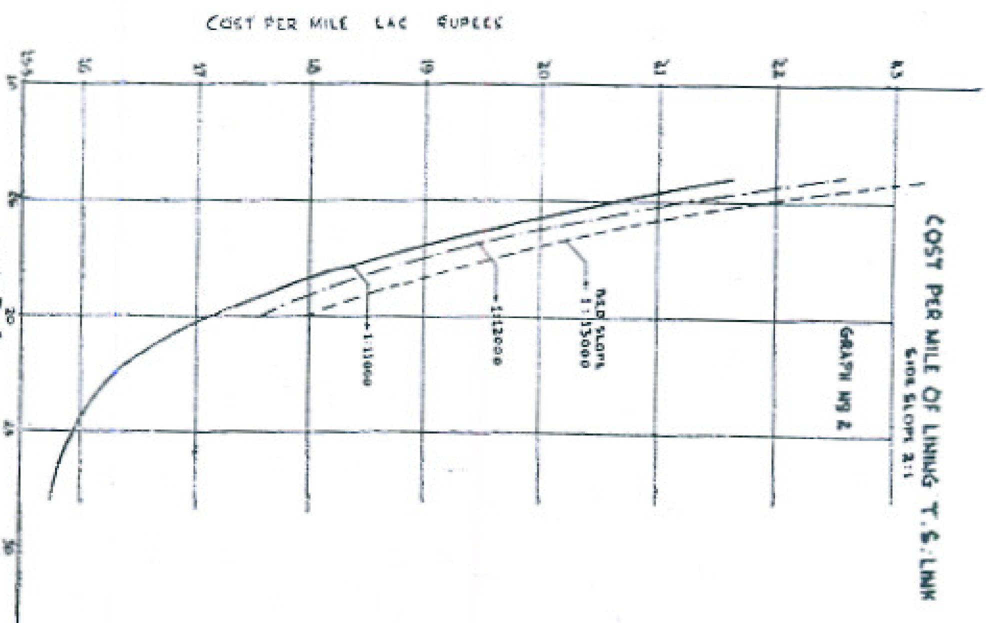
Assuming discharge to be equal to 11000 cs., N=0.016 and the specifications of double-tile lining at Rs. 200 per %sft, cost of lining T-S. Link has been worked out. If bed slope is kept at 1 in 11000, and side slopes varied from 1 : 1 to 1 : 1.5 to 1 : 2, the variations in cost per mile are plotted in Graph I. Between depths of 15 ft. and 18 ft., it shows a successive increase of about one lac per mile length. Variations in cost for one side slope but with different bed slopes of 1 in 11000, 1 in 12000, 1 in 13000 are shown in Graphs No. 2 and 3.

In a lined reach, the section is narrower and deeper, and there is reduction in cost on other items. This reduction per mile (5000 ft.) of a lined canal for earthwork, land and works is about Rs. 3.5 lac.

Average cost of lining per mile is Rs. 20 lac. Consequently the additional cost of a lined canal works out at Rs. 16.5 lac per mile. Essentially 99% of this additional cost is local currency expenditure and less than 1 % foreign exchange is involved.



Graph No. 2



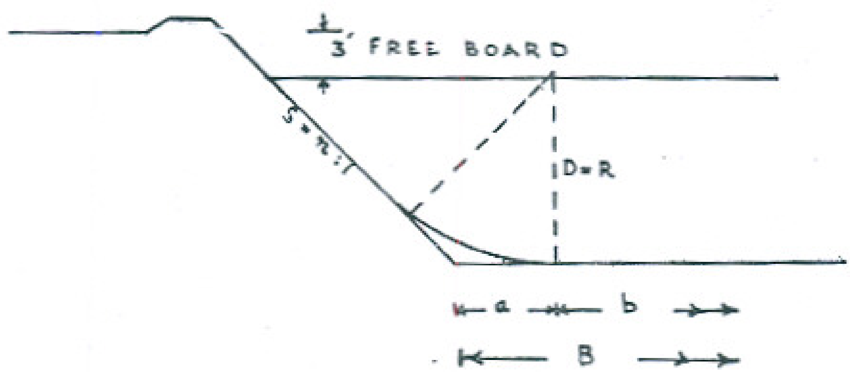
Graph No. 3

Seepage Losses.

In a lined canal, average seepage losses are assumed as 2 cs. per m. sq. ft. while for an unlined canal they are accepted as 8 cs. per m. sq. ft. These values may be comparative for supply and soil conditions.

The unlined link canal will not form berms due to highly fluctuating hydrograph and losses may be on the higher side. If supply levels are raised for steepening the slope in such a channel, comparative losses may be still higher.

TYPICAL X- SECTION OF CANAL



In case of T-S. Link, with 11000 cs. capacity :

Seepage losses per mile of		
(*i*) unlined reach	=	12.48 cs.
(*ii*) Lined reach	=	1.82 cs.
Difference	=	10.66 cs.
Period for which link will be run	=	300 days
Hence annual incremental losses per mile in case of unlining		300x10.66 cusec days or
	=	0.0064 MAF

Reclamat ion Tubewells

It is proposed to pump out the incremental seepage losses by 200 to 300 ft. deep, 2 cusecs tubewells with steel casing pipes and strainers. They will run 12 hrs. a day throughout the year.

Estimated capital outlay on a typical tubewell of 3 cusecs rated capacity, and cost of Electrical Transmission and distribution facilities (without cost of generation) is taken from tables no. 5 and 6 of "Lining of Link Canals" by Tipton and Kalmbach and reproduced as Tables II and III here.

TABLE II

Estimated Cost of a Typical Reclamation Tubewell

(Exclusive of cost of power supply facilities)

Depth-250 feet.
Capacity- 3 cusecs.
Pump setting - 50 feet.

Item No.	*Component of cost*	*Dollars*	*Rupees*	*Eq. Rupees*
1.	**Construction.**			
	(*a*) Drilling tubewell 22″	1,125	3,750	9,105
	(*b*) Electric Logging.	75	200	557
	(*c*) Gravel filling	20	40	135
	(*d*) Pump housing casing 14″	400	160	2,064
	(*e*) Tubewell casing 10″	723	340	3,782
	(*f*) Slotting tubewell casing	150	450	1,164
	(*g*) Gravel shrouding	312	1,500	2,985
	(*h*) Developing and testing	300	1,200	2,628
	(*i*) Concrete in pump base	50	400	638
	(*j*) Installation of equipment	200	600	1,552
	(*k*) Pumphouse & Operator's qtrs.	0	2,830	2,830
	Subtotal- Construction.	3,355	11,470	27,440
2.	**Equipment.**			
	(*a*) Pump, motor & controls	2,100	0	9,996
3.	Contingencies	545	1,130	3,724
4.	Administration and engineering	750	1,400	4,970
5.	Total Estimate cost	6,750	14,000	46,130

TABLE III

Estmiated cost of Power Supply Facilit'es for Tubewells

(Exclusive of cost of Power generation facilities)

Item No.	*Description*	*Quantity*	*Unit cost*		*Estimated cost*		
			Foreign	*Local*	*Foreign* $	*Local* Rs.	*Equiv.* Rs.
1	Construction equipment and Plant	...	...	...	200	200	1,150
2.	High voltage transmission Lines	0.03 miles	6,000	12000	180	360	1,220
3.	Major substation facilities	26 Kva	25	55	650	1,430	4,520
4.	Distribution facilities						
	(*a*) 11 Kv. lines	0.75 miles	2,000	5,600	1,500	4,200	11,340
	(*b*) 400 K v. lines	0.40 miles	2,600	2,900	1,040	1,160	6,110
	(*c*) Distribution transformers and services	35 Kva	15	30	525	1,050	3,580
5.	Contingencies engineering				205	600	1,580
6.	Administration and Engineering				500	1,000	3,380
7.	Total estimated cost				4,800	10,000	32,880

Note : Values represent estimated average quantities for one tubewell as derived from estimates prepared for the reclamation of Chaj Doab embodying 3,311 tubewells.

(*a*) **Energy Consumption.**

Power required = 7 KW per cusec rated capacity.

Average hydraulic efficiency of a tubewell = 70%

No of wells required per mile $= \frac{6400}{2} \times \frac{1}{3} \times \frac{1}{365} \times \frac{100}{70} = 8.35$

Annual energy consumption $= 8.35 \times 3 \times 7 \times 365 \times 12$

= 0.77 million KWH.

Power consumption per acre ft. = 120 KWH

(*b*) Abstract of Capital Outlay per tubewell.

Tubewell equipment	= Rs. 45130
Transmission etc.	= Rs. 32850
Offices and Residences	= Rs. 950
Total : ...	= 79930 Say Rs. 80,000

(c) Annual Charges per tubewell.

They will include depreciation charges, for the purpose of which useful average life of bore is taken as 15 years, of blind pipe 30 years, of iron strianer 15 years, of pumps etc. 15 years. Abstract of charges is as below :—

	Rupees
Operation staff	1500
Supervisory Staff	170
Deterioration of bore	1170
Depreciation of equipment	1060
Normal maintenance, repairs and lubricants	500
Total	4400
Electric energy @ Rs. 0.065/KWH	6000
G. Total : ...	10400

Allowing a rate of interest of 4%
Equivalent capitalised cost Rs. 2.60 lac.

Economic Comparison of lined and unlined canals.

It is quite reasonable to presume that the cost of maintenance and operation of a lined canal is not greater than a similar unlined canal. For correct economic comparison, the cost of a lined link canal should be compared with the cost of an unlined link plus the cost of tubewells needed for recovering the incremental losses and the capitalised cost of the operation of these tubewells.

To recover the incremental losses :—	
No. of tubewells required per mile	= Rs. 8.35
Capital outlay on tubewells	= Rs. 6.68 lac.
Capitalised cost of operation	= Rs. 21.71 lac.
Total : —	= Rs. 28.39 lac.
Compared to this, additional cost of lining per mile...	= Rs. 16.5 lac.

Special problems of T S link.

The ultimate total expenditure and the proportion of foreign exchange involved both tip the balance in favour of lining a link canal. The Trimmu-Sidhnai Link however, has some more complications. The slope available from Trimmu to Sidhnai is very small. Pond Level of Sidhnai weir will be R.L. 467.0, tail F.S.L. of link 469.0, present normal pond Level at Trimmu is 490.0 with emergency level equal to 492.0, F.S.L. of Haveli Canal at head is equal to 489.0. Levels at Sidhnai cannot be depressed without throwing large areas out of command.

The link is being constructed unlined, with a bed slope of 1 : 10500 in the hope that this will work. In case it does not, steeper w ter slope is needed, all the masonry works will be constructed with water line slope of 1 : 9500. For correct appraisal, the worst conditions have to be kept in view. The steeper slope, with tail level fixed requires Full Supply Level at head of the link as 493 0, about 3 ft. higher. As a consequence the pond level at Trimmu has to be raised by 4 to 5 ft.

Raising Pond Level at Trimmu will require either extension of U/S weir floor or construction of a subsidiary weir downstream, as it is not feasible to extend or strengthen the downstream raft floor. Upstream, floor extension will cost about Rs. 300 lac., while expenditure on subsidiary weir will be Rs. 200 lac. The chances of uncertainty in river works being great, these figures may be exceeded considerably. The rising unit rates of International Contractors may result in a further increase upto 50 per cent. About 60 sq. miles of riparian land will be a submerged, displacing about 15000 people. Their re-settlement will be a big problem and financial load may exceed Rs. 50 lac. It will also become problematic to hold the Marginal Flood Bunds against the raised flood heights due to deterioratian of river channel. Due to heavy shoal formation, the weir will get masked further and its flood discharge capacity will deteriorate. Raised river Pond Level and the Link water level will create water-logging in large areas.

Raising of Pond Level can be avoided by lining a part or whole of the Link. The entire length may be lined with a bed slope of 1 : 11000 and the zone of high water table may be tackled by constructing heading-up regulators, as is being done in the case of Haveli Canal running parallel. As canal lining is not fully impervious, these reaches can be fully dewatered without damaging the lining, if a controlled rate of lowering the canal water level is maintained. This is already being practised on Haveli Canal. Alternatively, the head and the tail reaches may be kept unlined with bed slope of 1 : 9500 and the middle portion lined with a bed slope of 1 : 12000 or 1 : 13000.

Conclusions

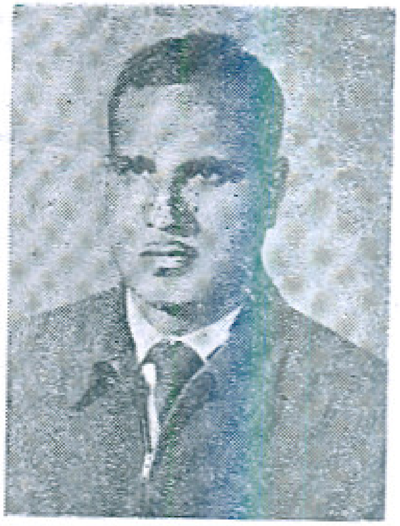
A lined channel is initially more expensive, but the additional expenditure involves 99% local currency. An unlined channel, on the other hand, creates serious water-logging. It leaks 4 times greater than a lined canal. Tubewells required to pump out the incremental seepage losses change the final economic appraisal. In case of T-S link, cost of lining is only 58 per cent of the expenditure on tubewells. Foreign exchange component forms a major portion of the outlay on tubewells while it is less than one per cent for lining.

All the link canals, will have big discharge capacities, and will run with highly fluctuating hydrographs. They will be nothing short of rivers. Suitably designed lined channels will take care of these fluctuations in a much better way. Unlined canals will never form berms, will meander and will have bed trouble.

In case of T-S Link, raising of Pond Level at Trimmu and consequent remodelling of the Barrage can be avoided if a suitable lined section is adopted.

RIVER SOUNDING
FOR
DISCHARGE MEASUREMENT—II

by
FAZAL KARIM KHAN
Assistant Design Engineer, Planning & Investigations, WAPDA, Lahore

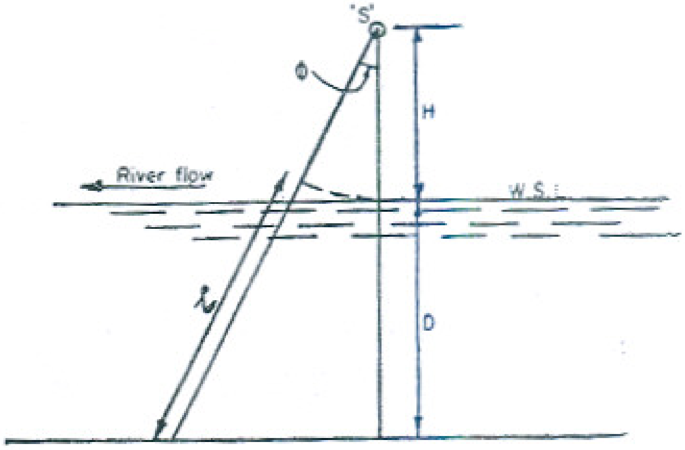


Accurate sounding of the cross section of swift flowing stream is important for discharge estimation. Haigh in 1943 developed a depth sounder which was further modified in the Irrigation Research Institute. In this article Mr. Fazal Karim Khan describes a sextant developed by him to sound the depth accurately. This is his second article. His first, on River Sounding for Discharge Measurement—I, appeared in the Pakistan Journal of Science, Vol. 13 No. 1., Jan. 1961.

Theoretical background and principle.

It is a matter of common observation that ordinary sounding weight even though it is streamlined, is considerably deflected from its suspension point when depth observations are initiated in a swift moving stream. The velocity impact of the current determines the final position in equilibrium of the sounding load when suspended. When it touches the bed it may rest somewhere considerably deflected from the dip point. Uncertainty of the magnitude of deflection is responsible for undependability of sounding observations. If, however, it be possible to measure its deflection from the vertical accurately, the sounding can be deduced with sufficient accuracy.

To consider the proposition, reference is invited to Fig-1. 'S' is the suspension or the release point which, in practice is the top of a lower pulley in a pulley block sliding over the stretched wire rope across the river over which the sounding load is lowered.



FIG—I

Theoretical considerations for depth observations of stream by sextant.

Let (H) be the altitude of point 'S' above water surface level (W.S.L.)

- (D) Depth of water below suspension point.
- (l) Additional release of line after the sounding load has just touched the W.S.L.
- (L) Total length of line released from its suspended position at 'S', (l+H)
- ϕ Final deflection of the sounding line when the load rests on the bed.

Then,

$$L \cos \phi = (H+l) \cos \phi$$
$$= H+D$$

Therefore

$$D = L \cos \phi - H$$

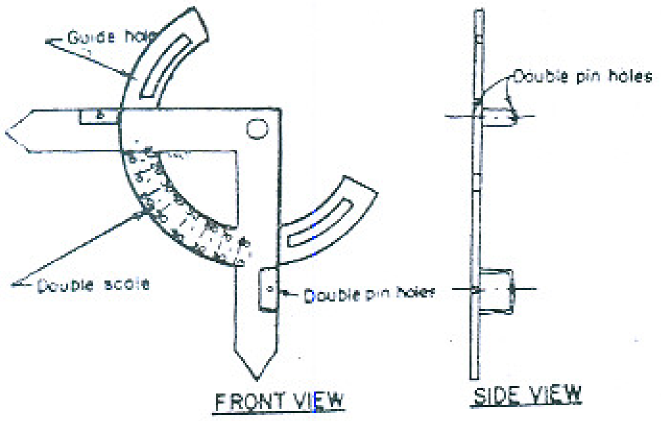


FIG-2
SEXTANT PLATE
(Drawing not to scale)

Thus, for a depth observation we have to make two linear observations; one for 'H' and the other for 'l' and a measurement for deflection ϕ. A special type of sextant was, therefore devised to meet the latter requirement. It may, however, be pointed out that certain assumptions have to be made in reconciling theoretical considerations actually obtained in the field.

Sextant—its construction and performance

It is essentially a brass plate with rectangular arms. A 90° double scale (direct and reverse) is fixed at a convenient radius from the junction point of the arms (Fig. 2). Further, each arm at its centre carries a special device of double pin-holes, one above the other, normal to the arm. This is the sextant plate. In order to clamp and set up the sextant plate on a stand, a hole is bored at the junction point of the axial lines of the sextant arms. In addition, two

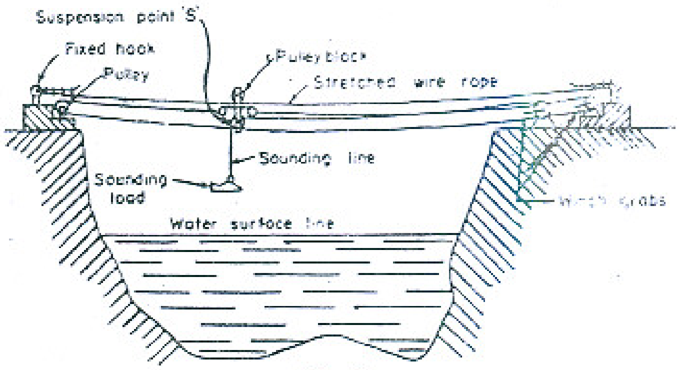


FIG-3

Stretched wire rope arrangements on stream for lowering depth sounder or currentmeter for discharge observations

circular metallic strips, with guide holes extending side ways, are fixed on both arms. This helps in vertical adjustment of the sextant plate. Its accessories include a long pointer; a plumb line, a supporting rod and a stand with a clamp. The parts are assembled as shown in Figure 4. The apparatus is used on the riverside where lowering arrangements of the sounding weight can be made over a stretched wire rope across the stream. To set the apparatus it is necessary that one arm of the sextant plate should be vertical and other normal to the section plane of the stream where soundings have to be made. Verticality is obtained by a plumb bob to which the centre line of the arm is set. The other condition is fulfilled by the use of sight holes in the sextant plate. A point is first selected on the opposite side of the stream to ensure that the line of sight is parallel to the line along which section has to be observed. The sextant plate is then manoeuvred to enable the object to be seen through the pin-holes. The sextant is now ready for use. When the sounding weight has actually been lowered and is resting on the bed, the angle of deflection is given by the pointer moving on the sextant plate, which is set parallel with reference to the sounding line by parallex.

Basic set up.

It is obvious that for making sounding observations on the pattern described, a stretched wire rope across the river is essential preferably at a discharge site. Over this rope is run a pulley block of two pulleys with the help of a winch grab worked manually on the river side (Fig. 3). Whereas the running pulley makes it possible to make observations at selected points along the river section, a second one (lower down) is helpful in lowering the sounding weight over which it is suspended. This lowering or raising of the weight is manoeuvred through another winch fixed on the same side of the river. These are the preliminary arrangements which have to be made at a discharge site. The stretched wire rope technique enables both the depth sounder and the current-meter to be used conveniently in a swift flowing stream.

Experimental procedure.

The sounding weight is hung by a

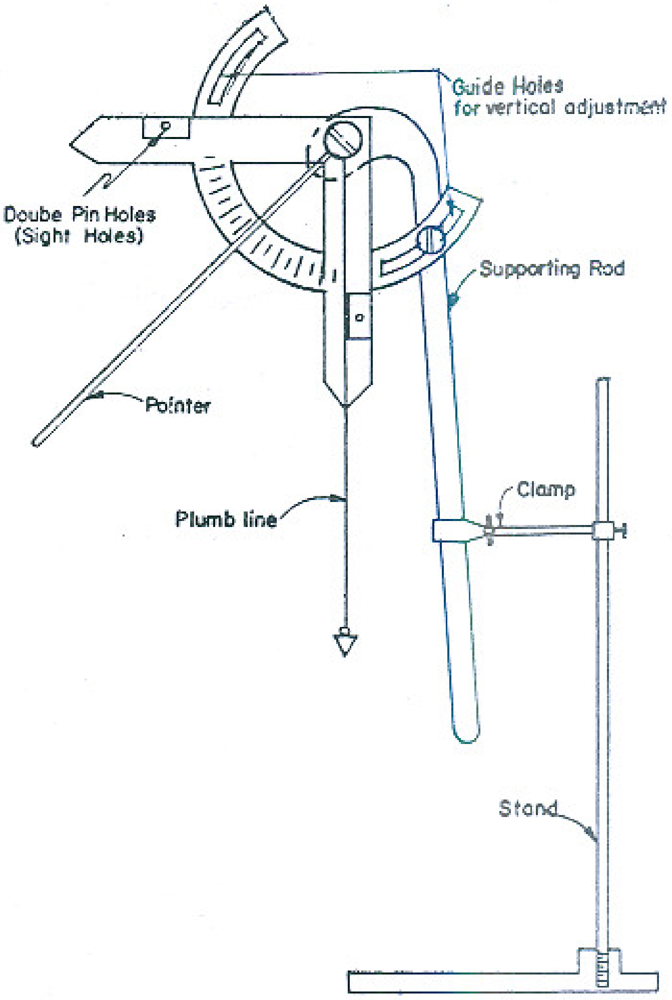


FIG. 4
SEXTANT SET UP FOR OBSERVATIONS

flexible wire rope over pulley No. 2 of the pulley block (Fig. 3) and its lift or drop is controlled from a winch grab. The pulley block is first run to a point over the river section where the water column below has to be fathomed. Simultaneously the other winch is manipulated so that the sounding weight is also carried along to the same point. The altitude 'H' of 'S' above water surface is measured by actual tape measurement of the line released while the weight is being lowered on to the water surface. On further lowering, it dips into the water. No sooner it does this, than it is swung away by the current action and is consequently deflected from its normal position. The angle of deflection gradually changes as the sounder sinks deeper into the water till it rests on the bed. In actual practice, the line is released with such a speed that the sounder touches the bed not far away from the section line. The sounder is then slightly dragged back on bed to make sure that the line is taut. But one has to be careful to make sure that the sounder is in contact with the bed. Any practising engineer or observer actually conducting the tests can easily judge this from experience. For recording deflection the sextant is set as already explained. Deflection angles on both sides of the pointer are read on the scale and mean value accepted. Usually, one or two extra observations are taken to confirm the results. This is done by further pulling up the sounder, rather dragging it up the bed, and one or two sets of new measurements are taken for sounding line and deflection. The deflection would naturally change, and also the length of the release line (l), but the results when computed have always shown remarkable uniformity.

Assumptions :

The accuracy of the results is based upon the following assumptions .—

1. The sounding line is taut, although there is a slight sag due to current action. At greater depths, 1 to 3% deduction has to be made from the overall length of the line (l) depending upon the weight of the sounding load and current velocity.
2. The river width and slope of the bed is practically uniform in the region considered. If, however, fall in the bed is appreciable, necessary correction can be incorporated from the slope gauges.
3. The sampler does not sink into the bed nor rests on a boulder, that is to say, that conditions of a firm and even bed are stipulated for the period during which the observations are in progress.
4. The sag between the release point of the sounding line on the river bank and the release point on the stretched wire rope is considered to be negligible.

Discussion of results and general review :

Table 1 presents a specimen of sounding observations made on one occasion on a river discharge site with the help of the 'Sextant'. The results are quite consistent, varying only by 3% from the mean figures. The instrument is rugged, reliable, efficient and well adopted for use in the field. One can proceed with the sounding observations right from one bank of the river across to the other without bringing the sounder back to the working side during the operations. Besides eliminating all risks to personnel, it makes river gauging possible when the stream is running at high discharge. Another aspect is its low working costs as compared with an electrically or hand operated cable way. In relation to the boat method, it is

RIVER SOUNDING FOR DISCHARGE MEASUREMENT—II

BY

Fazal Karim Khan, B. A., Jr. M. I. E. (Pak)

TABLE—1

Depth measurements with the help of SEXTANT

Suspension position (Distance from reference point).	'H' (in ft.)		l (ft.)	L (ft.)	Angle of deflection			Cos ϕ	D (ft.)	D (mean) (in ft.)
	Observed	Corrected			ϕ_1	ϕ_2	ϕ (mean)			
75	19.42	21.59	40	61.59	51.5	52.5	52.0	·616	16.41	
	,,	,,	35	56.59	48.3	49.3	48.8	·659	15.61	
	,,	,,	31	52.59	43.5	44.5	44.0	·719	16.21	16.08
100	18.67	20.84	50	70.84	58.5	59.5	59.0	·515	15.66	
	,,	,,	45	65.84	56.0	57.0	56.5	·552	15.46	15.56
125	18.17	20.34	55	75.34	60.3	61.3	60.8	·488	16.46	
	,,	,,	50	70.34	59.0	60.0	59.5	·508	16.86	
	,,	,,	45	65.34	55.5	56.5	56.0	·559	16.16	16.49
150	18.67	20.84	55	75.84	55.4	56.4	55.9	·561	21.66	
	,,	,,	50	70.84	53.5	54.5	54.0	·588	20.76	
	,,	,,	45	65.84	50.5	51.5	51.0	·629	20.56	
	,,	,,	40	60.84	49.2	50.2	49.7	·647	18.56	20.39

NOTE :— Letters H, l, L, D and ϕ have their significance as explained in the text.

Correction H = 2.17ft.

decidedly superior, as it is impossible to keep a boat stationary in a swift mountain stream.

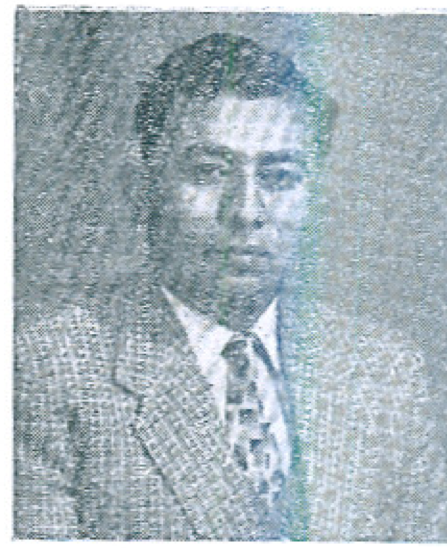
The author, however, does not lay claim to its finality. It is a newly introduced instrument and has a scope, as is the case with almost all new appliances, for further improvement and refinement. For example, the parallex method needs improvement so that the deflection is more accurately read and personal error eliminated to the minimum extent. Similarly, sight holes can be replaced by small lenses in order to give a more exact view of the line of sight. The instrument has been devised and introduced and it is now for the research minded engineers to perfect it.

The article will be incomplete without a word on the sounding weight. Deflection and linear measurements of the sounding line are apt to yield incorrect results if a light sinking load is used. In that case it is likely to remain suspended or at the best may touch the ground far downstream of the dip point depending upon current velocity. The former condition does not lead us anywhere. In the latter case only grossly erroneous observations can be expected due to considerable sag in the sounding line. A stream lined load of hundred lbs. weight has practically been found to be suitable for a current velocity of 5 to 8 ft/sec. For higher velocity of flow, a load of 150 lbs. or more may be preferable.

Acknowledgements :

My grateful thanks are due to Dr. Nazir Amad, Physicist, Irrigation Research Institute, Lahore without whose direction, guidance and encouragement it would not have been possible to devise the 'Sextant'. The author has had the honour of working under him as a Research Assistant. Indebtedness has also to be expressed to the officers of the defunct Dams Investigations circle under the Ministry of Industries, Government of Pakistan, who were kind enough to provide all facilities for work and research. Thanks are also due to the writer's friends and colleagues in Irrigation Research and Dams Investigation Circle for their co-operation and helpful attitude in devising the instrument.

PROGRESS MADE IN THE FIELD OF SANITARY ENGINEERING IN JAPAN



By

IQBAL AHMAD Executive Engineer, Rawalpindi.

Mr. Iqbal Ahmad who had been on a five weeks study tour under Colombo Plan, describes present facilities of sanitary engineering in Japan. He discusses the existing sanitation law in force in that country. He gives some suggestions to be adopted in Pakistan.

A—Water Supply

1. Development of Water Works.

(a) *History.*

It was in the early period of the Meiji Era, in the seventies and eighties of the last century, that modern water works technique was introduced and practised in Japan along with other developments in the country under the influence of Western civilization. The first primitive water supply channel was laid in 1590 in Kanda and the second followed in 1653 as Tamagawa Water Supply Channel made of non-pressure type wooden and stone ware materials, but it was in 1885-1887 A.D., when the first Water Works on modern line was constructed in Yokohama Port by a British Engineer, Col. Permal. For the first time in Japan pressure type iron pipes were used, which served slow sand filtered without chlorination. This Water Works was designed for population of 70,000 with maximum supplying capacity of 1.5 million gallons per day, at an expenditure of 1,075,000 Yen (*i.e.* £ 1075 or about Rs. 14,000/-).

Water Works were later installed by other important towns, like Hakodata and Nagasaki. Then the First Water Supply Law was enacted in 1890, and Osaka, Kobe, Okayma, Hiroshima and Tokyo followed suit.

(b) *Introduction of Rapid Sand filteration and Chlorination.*

Rapid Sand filteration technique was first introduced in the year 1912 in Kyoto the old capital of Japan, while chlorination was introduced in 1625 in Yokohama.

(c) *Postwar Development.*

After the impact of World War II, the Japanese Water Works development made considerable progress. The technique of " automation" or " remote control was introduced in Water Works Engineering.

II Present situation of Water Works in Japan

The Japanese Government issued official figures as of March 1958, which are shown in Table "A".

The Paper was read in 13th Pakistan Science Conference held at Dacca Jan. 11—16th, 1961.

TABLE - A

Population served with potable water supply in Japan.
(As per report of Ministry of Health Welfare)

S. No.	Description	Population served.	Ratio to population.	No. of water works.
1.	Large scale water works.	29,925,000	32.8%	900
2.	Small scale Water Works. (Population less than 5000 persons)	4,090,000	5.8%	4,000
3.	Private water works.	3,090,000	3.4%	3,600
	Total :—	37,105,000	40.7%	8,500

Thus 40.7% population was being served with piped water supply in March, 1958.

III. Ten Years Water Supply Programme.

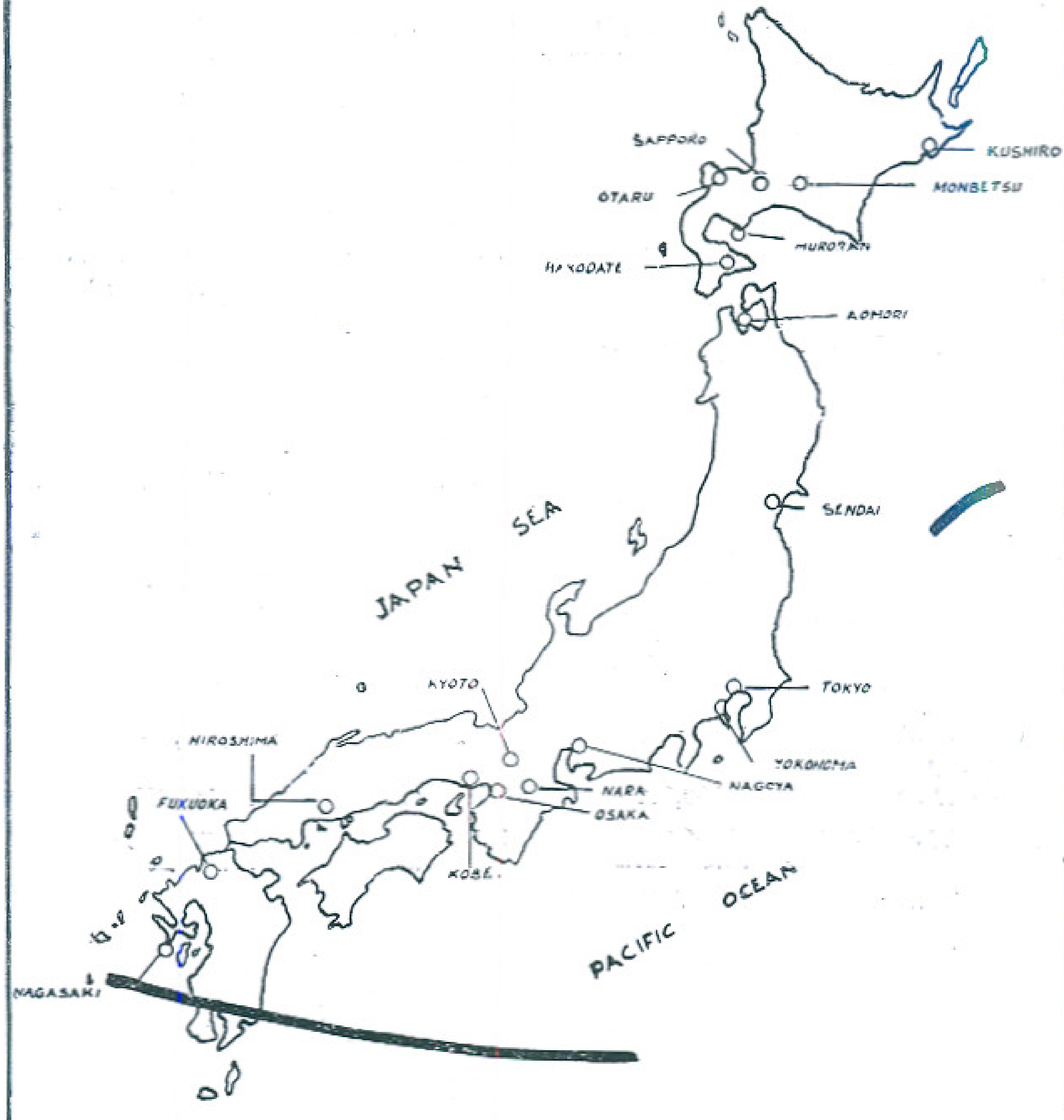
The Japanese Government has formulated a 10 years Development programme for the period 1958 to 1967, at an estimated cost of 545,900 million Yen (*i.e.* 545 Million sterling). The plan aims at providing potable water supply for 90% of the population. Breakdown of the programme for the served population is shown in Table "B".

Table B

Ten year Water Supply Development Plan.
(Framed by Ministry of Health & Welfare Govt. of Japan from April, 1958 to March 1967).

S. No	Description	Population served in March '58 i.e. start of Development plan.	Increase in population served at the Completion of Dev. Plan	Total population to be served on completion of plan.
1.	Large scale Water Works.	29,925,000	23,726,000	53,651,000
2.	Small scale Water Works	4,090,000	25,365,000	29,455,000
3.	Private Water Works.	3,090,000	1,640,000	4,730,000
	Total :—	37,105,000	50,731,000	67,836,000

PLAN OF JAPAN



Total estimated population of Japan in 1967.	97,615,000
Total population to be served with water supply in 1967.	87,836,000
% age of population to be served in 1967	90 %

Budgetary requirements of the plan have been shown below in Table 'C'

TABLE C.

Financial Requirements for the 10 year Water Dev. programme of Japan.
(in Million Yens : 1 £ = 1000 Yens)

S. No.	Description	Expenditure per annum	Local Bond or loan per annum	Subsidies per annum	Total expenditure of 10 years plan
1.	Large scale water-works	44,450	44,450	—	444,500
2.	Small scale water works	10,140	7,610	2,530	101,400
	Total :—	54,590	52,060	2,530	545,900

As shown in the table above, a yearly amount of about 55,000 Million Yen (*i.e.*) 65 million sterling) is needed but in the plan period 26,000 M. Yen or 26 million pound sterling have already been spent. This shows that progress is lagging behind for want of necessary funds. However, the Japanese Govt. is trying to find ways and means to overcome this difficulty.

IV. Method of Financing a Water Supply Scheme.

As a general practice, 25 to 35 % of the total funds are provided by the Central Govt. as subsidy, 40 to 50 % by local Bonds or loans and the balance by the community to be benefitted. The financial plan is based on NO PROFIT NO LOSS BASIS and is generally spread over a working period of 15 to 20 years.

It is worthwhile mentioning here that in matters of budgeting and financing, the Bureau or Deptt. of Water Works in a municipality is independent of the general budget of the municipality.

V. Water Supply Law of 1957.

The old Water Supply Law of 1890 was abrogated and a new Water Supply Law was enacted in 1957. This law laid hat down different standards of water works Engineering and has made it compulsory for a municipality to obtain permission and technical clearance from the Health and Welfare Ministry. An important aspect of this law is the chapter on awarding punishment which, in brief is as follows :—

Punishment.

1. Imprisonment up to 3 years and fine upto 300,000 Yen to Mayor and community.

(*a*) Water supply scheme is started without the approval of competent authority.

(*b*) Community does not stop the supply of water when ordered to do so by Prov. Govt. or Central Govt. on account of bad quality of water.

2. *Imprisonment upto one year and 100,000 Yen fine.*

(*a*) If additions and alterations in construction are made without approval of competent authority.

(*b*) If water supply stopped without any reason or prior approval of Government.

(*c*) If an application for grant of water supply from a person within the water supply area is rejected or extraordinarily delayed without any genuine reason.

(*d*) If maintenance and execution is not entrusted to a properly qualified Engineer.

(*e*) If removal of replacement of any construction or installation as ordered by Government is refused or inordinately delayed.

(*f*) If a neighbouring community facing shortage of water is denied supply of the excess water available with a particular community.

3. *Simple fine of 100000 Yen to Community.*

(*i*) When certain conditions as imposed by Govt. as a pre-requisite to start or before completion of work are not fulfilled.

(*ii*) Quality Examination and inspection of facility arrangement is not conducted before start of supply of water.

(*iii*) When a set procedure of water quality test is not adopted.

(*iv*) When officials employed on water works who are required to obtain physical fitness certificate are continued even without such a certificate.

(*v*) If no chlorination is done before supply.

4. For private water supply facilities, if prior intimation to Govt. is not conveyed before the start of work, a fine of 30,000 Yen would be imposed.

This law lays down minimum qualifications for the work Engineers who could be made responsible for construction or even maintenance. The qualifications required are :—

(1) A Civil Engineering degree with a minimum of 3 years experience.

(2) A Civil Engineering diploma with a minimum experience of 5 years.

(3) A Civil Engineering Certificate with a minimum of 7 years experience.

(4) An unqualified person with a minimum of 10 years experience, subject to conditions that he undertakes and qualifies the specialised course of Technical Manager. This course

was also specified in this water works law.

VI. Present and future Problems.

Like any other country, Japan too has its own problems of water supply.

1. *Financial Problems.*

A country of limited resources, Japan is faced with the problems of providing adequate funds for the 10 year Water Supply Development Programme. As mentioned above, against the annual requirement of 55,000 million Yen (55 million sterling) approximately 50 % has been spent during the plan period. This position if not improved in time, would affect the plan adversely.

The Government is thinking of floating an additonal public loan to meet this requirement.

(*ii*) **Technical Problems.**

(*a*) *Grouping*

Japan is an over-populated country with a high rate of increase in population. Due to rapid industrial development the cities are becoming more and more crowded and, being situated very close to one other, some have merged together. As the source of supply is common, it has now started creating water right difficulties in different cities. As a solution, the Government is thinking of grouping them and providing a joint control with a view to pool the resources and serve the areas with a balanced water supply. The more important grouping problems are :—

(*i*) Kanto District Group, consisting of Tokyo, Yokohama and Kawasaki.

(*ii*) Kansai District Group consisting of Osaka, Kyoto, Kobe, Etc.

(*b*) *Iron Problem.*

Iron is found in compound with silica as Fe Si O_2 in Shikiboku Island. Experts have recommended chemical treatment before sedimentation.

(*c*) *Tuberculation.*

The presence of iron is resulting in the formation of bacteria as "LEPTOTHRIX and GALLRONELLA".

(*d*) *Fluorosis.*

Although the fluorine and fluoride contents are only upto 0.8 PPM. as against WHO standard 1.00 to 1.5 PPM yet the effects in Japan are as of 2 to 2.5 PPM. Research is being conducted but there is no solution as yet. According to one theory Japanese Tea is mainly responsible.

(*e*) *Pollution of surface water.*

Industrial waste and over population is causing contamination of surface water. A water pollution control law has been enforced.

B. Sewerage System.

1. Development of sewerage system in Japan.

Japan's first under-ground sewerage was constructed in Ginza-Tokyo in 1872. It was only a covered drain made of bricks or clay. Such drains were then constructed in the Kanda area of Tokyo in 1883 with some improvement *i.e.* the section of the drain was changed to nearly circular. In 1900 the old sewerage law was issued by Meiji Govt. which marked the beginning of the Japanese sewerage development.

2. *Introduction of treatment plants.*

It was in 1922 that the first sewerage treatment plant, based on trickling filter method, was constructed in Tokyo and named Mekawashima Treatment Plant. The next plant, named Haridome Plant, was constructed in Nagoya City in 1930, based on activated sullage process.

This modern method of sewerage treatment is growing fast.

3. *Sewerage Law 1959—Like Water Supply Law.*

The Government revised the old sewerage law, and a new sewerage law was enacted in 1959. The aims and objects of this law were to fix standard of planning, designing, construction, financing and maintenance of sewerage schemes including sewerage treatment plant. An important feature of this law is that the city cannot get water closets connected to the underground sewerage system unless and until the sewerage treatment plant has been provided at its disposal work. With the enforcement of this law there is a growing tendency among the Japanese to provide treatment plant with each disposal work within their financial limitations.

4. *10 Years Development programme of sewerage.*

This programme was started in 1958 and is to be completed in 1967. In this plan 160 cities will be equipped with modern treatment facilities of sewerage, at an estimated cost of 150,000 million Yen (150 million sterling).

5. *Subsidies.*

According to sewerage law, 25 to 30 % of subsidy is to be provided by Government. The subsidy for the development sewerage system under 10 years development programme as distributed in last 3 years is as below :—

1958.	381.25 million Yen.
1959.	460 million Yen.
1960.	710 millions Yen.

6. *Present condition of sewerage system in Japan.*

There are 65 cities having a total of 88 treatment plants which are either equipped or in the advance stage of completion of equipment with treatment plants spread throughout the country. The smallest treatment plant is Mishitozaki Sewerage Treatment Plant at Shinga town in Kyushu for a population of 6300, while the biggest treatment Plant in operation is at Tokyo, known as Shibouron Treatment Plant designed for a population of 2.1 million. The breakdown of these plants and designed population is given in Table D.

TABLE—D

Present position of Sewerage treatment plants in Japan already completed or nearing completion.

S. No.	Population		No. of plants
1.	Less than 10,000	persons.	3
2.	From 10,000-20,000	persons	10
3.	From 20,000-50,000	persons	14
4.	From 50,000-1,00,000	persons	23
5.	From 1,00,000-200,000	persons	19
6.	From 2,00,000-5,00,000	persons	11
7.	From 5,00,000-1,000,000	persons	6
8.	More than 1,0000,000	persons	2
		Total :	88

7. *Methods of Treatment for these plants.*

They are as follows :—

(*i*) Treatment based on sedimentation only. 6 Numbers.

(*ii*) Treatment based on trickling filters on sprinkling filter process. 39 No.

(*iii*) Treatment based on activated sludge process. 43 Numbers.

Total : 8 Numbers

8. *Utilization of Sewerage Disposal.*

By-products of the sewerage system are being utilized as follows :—

(*i*) **Effluent.**

The treatment effluent from the treatment plant is being used for industrial requirements. The importance is seen in the Mekawashima Treatment Plant in Tokyo where the effluent is being used for water industry.

(*ii*) **Sludge.**

The sludge is being used as fertiliser. Their importance can be seen at Tempakai Plant at Nogoya, which yields an income of about 7 million yen ($7000) per annum.

9. *Research on by products of sewerage disposal.*

In Nagoya city laboratory, research has been successfully completed and it has been discovered that Vitamen B-12 could be obtained from activated sludge waste. It is hoped to obtain Vitamin B-12 from the wasted for commercial use.

VII Educational and Professional Developments.

(I) Japan Water Works and Sewerage Associations.

Since 1932, a recognised body of Sanitary Engineers has been formed as "Japan Water Works and Sewerage Association." Membership is over five thousand. Important activities of the association are :—

(*i*) Holding training courses for technical managers.

(*ii*) Compiling and editing histories and census of all water works and resources in Japan.

(*iii*) Providing quality check on water works and sewerage industrial material.

(*iv*) Working as consultant and designer at no profit basis for the betterment of the community and poorer municipalities.

II. Sanitary Engineering Degree Courses and Post Graduate refresher Courses.

Japan has developed full-fleged Sanitary Engineering degree courses in Hokkaido and Tokyo Universities. A Post graduate refresher course for Engineers in service has been established in the Institute of Public Health in Tokyo.

III. Industrial Development.

With practically all raw material imported Japan has made itself fully self-sufficient in all material required in Sanitary Engineering Development.

Suggestions for Pakistan.

(*i*) A regular association of Sanitary Engineers of the country be formed to develop the available talent and harness the resources.

Contd. on page 6

background has been proven to provide an excellent foundation for administrative leadership. Those engineers who have risen through the ranks to the positions of the administrative control have generally been outstanding men who have successfully fulfilled the requirements of their administrative positions'. He exorted the Pakistani engineers to develop the characteristics necessary for becoming administrative leaders. He deplored the position whereby qualified engineers in this country were not being put to jobs where they can serve to their fullest capacity. This situation was not only resulting in 'dissatisfaction to the individual, but also detrimental to the country as a whole.'

The organisers of the Sargodha Chapter were congratulated for their venture by Mr. Latif Mirza on behalf of the Executive Council of the West Pakistan Engineering Congress. He hoped that the lead given by the Sargodha Engineers would be followed by the engineers at other places and thus the long unfulfilled desire of the central Executive to have a net work of the local organizations would be fulfilled.

The guests were entertained to a light refreshment and to a show of a technical films by the USIS.

International Symposium on the methodology of Plant ECO— Physiology

Botanical Institute of the University of Motpellier (France) held a symposium from 7 to 12 April, 1962 under the presidency of Professor L. Emberger, Director of the Institute. It was attended by 120 specialists. Fifty-six papers were presented which UNESCO will publish under its Arid Zone ReSearch Series. These papers are to be grouped into 15 sub-heads dealing with radiation, wind, evaporation, transpiration, water potential, water saturation deficit, water consumption, soil moisture, temperature, precipitation and interception etc. This publication will be useful addition to the Arid Zone publication of UNESCO. In the June, 1962, issue of 'Arid zone', a UNESCO'S Major Project, details of these papers are given.

The Problem of the Arid Zone, Proceedings of the Paris Symposium

" A New Unesco Publication "

The Unesco arid zone programme was started in 1951, and after nine years of activity on the many facets of arid zone research, it was felt that an examination of the results achieved would be of value both as a means of preventing possible duplication of effort, and as an opportunity of suggesting new directions of useful activity.

An equally important consideration was that some overall evalution of Unesco's arid zone programme was required. At the end of 1962, the six year period during which the arid zone programme was one of Unesco's Major Project was due to terminate ; a broad evaluation of the work achieved and a genereal review of the situation had therefore to be made in good time so as to allow the necessary steps to be taken for the continuation of international action in arid zone research after 1962. With these objectives in mind and following a recommendation of the Unesco Advisory Committee on Arid

Research at its fifteenth session, a general symposium on arid zone problems was held in Paris from 11 to 18 May 1960. It was attended by 250 scientists from many scientific discipline and from 33 countries.

The proceedings of this symposium, Volume XVIII in the Arid Zone Research series, have just been published.

The volume comprises of 494 pages and costs $ 15.

Central Arid Zone Research Institute India

The Australian Government has agreed that approximately $360,000 from the Australian Colombo Counterpart Fund be allocated to the construction and fitting of the main laboratory and the office block at the Central Arid Zone Research Institute, Jodhpur (India).

Furthermore, arrangements are being made for the training in Australia of certain staff members of the Central Arid Zone Research Institute, whilst certain Australian expert will make short term follow-up visits to India.

Symposium on Advances in Arid Zone Ecology

A symposium on Advances in Arid Zone Ecology sponsored by the Arid Zone Research Association of India, will be held in Jodhpur (India) in the last week of December 1962, to coincide with the Golden Jubilee Celebrations of the Indian Science Congress.

The general subjects which will be treated at the symposium are: (*a*) Basic Ecology of the Arid Zones, including plant ecology, animal ecology and human ecology; (*b*) Applied Ecology, including wind and water erosion and their control, range management and conservation, animal production, salinity and its control, etc.

Regional Training Course in Arid Hydrology

A training course was organized jointly by the Pakistan Government and the Unesco South Asia Science Co-operation Office. It was held at the Water and Soil Investigation Division (WASID) of the Water and Power Development Authority(WAPDA) at Lahore from 26 March to 20 April, 1962, and was attended by 25 trainees from Burma, Ceylon, India and Pakistan.

The course was directed by Mr. S.M. Said, Deputy Chief Engineer of WASID, who also gave the opening address at the inaugural ceremony. The closing session was presided over by Mr. Ghulam Ishaq Khan, Chairman of WAPDA, who presented certificates to the participants.

Professor G.V. Bogomolov of the Section of Geographical Geology, Academy of Sciences of the U.S.S.R., Mr. W.T. Staurt, Staff Engineer, Water Resources Division, U.S. Geological Survey ; and Professor G. Filliat, Professor of Applied Geology, Conservatoire National des Arts de Metiers, France, the three visiting professors, each delivered eight lectures during the course. The participants also visited the Pakistan Irrigation Research Institute, the Land Reclamation Laboratory and the WASID Laboratories, and field trips were made to pumping sites, the Balloki Head works and an area where rig-drilling is practised.

UNESCO—USSR—Holds A Symposium in Tashkand of Secondary Salinity of Irrigated Soils.

Academy of sciences of Uzbek SSR and Unesco, Arid Zone Division held a symposium at Tashkand from 6-9 August 1962. The subject of discussion was the relationship between irrigation, salinity and ground-water. In addition to Soviet specialists, participants at this seminar included scientists invited by Unesco and also the 12 Unesco fellowship holders studying hydro-geology and salinity problems in USSR. The seminar was followed on 10-12 August by field trips in the irrigated areas of Samarkand, the Ferghuna Valley and the Hunger Steppe.

Symposium on Geomorphological Mapping

A symposium on the geomorphological mapping of arid regions with problems of utilization of land with a Mediterranean type arid climate was held in 19 to 26 September 1962. The symposium took place in Crete and was directed by Professors Jean Dresch, Director of the Institute of Geography and Dr. David Amiran of the Hebrew University Jerusalem.

Wind and Solar Energy Research at Brace Research Institute Canada.

Under the terms of the Brace Bequest, funds were put at the disposal of the Faculty of Engineering of McGill University, Montreal, Canada, for the purpose of conducting research work aimed at the eco-

conversion of saline water to fresh water with particular reference to the application of such research to conversion of some of the arid areas of the world into fertile agricultural land. A programme has now been drawn up which comprises four phases. The first of these covers basic research carried out in the Laboratories of the McGill University in Montreal. The second phase consists of applied research and development on an engineering scale at the new Brace Experiment Station in Barbados. The main current research activities of the Station are the design of solar distillation units and the development of small scale devices to produce power from the wind and from the sun. The third phase entails extension work and the setting up of demonstration and testing centres in newly-developing areas, in co-operation with local authorities and with the support of the United Nations organisations. The first such centre will be at Jodhpur in India. The aim is to introduce equipment suitable for local manufacture which will desalizine brackish water and pump irrigation water, using the power of the sun and the wind. The fourth activity of the Brabe Research Institute is in the educational field. In order to encourage already increasing interest in the application, in arid areas, for solar and wind energy to saline water conversion and water pumping, and to provide the necessary specially trained personnel to staff the development and demonstration centres, a post-graduate diploma course in "The engineering aspects of arid land development" has been instituted and the first course will be inaugurated at McGill University in October 1952. This course will be attended by specially selected graduates in engineering and physics from newly developed countries, who will at the end of the course return to their home countries and form a nucleous of specialists in the field of saline water conversion, solar and wind energy. All requests for further information concerning the activities of the Brace Research Institute should be addressed to Dr. G. T. Ward, Director, Brace Research Institute, McGill University, Montreal 2, Province of Quebec, Canada.

Saline Water Conversion Report.

The United States Department of the Interior announces the publication of the Saline Water Conversion Report for 1961. This Report is a non-technical review of programme activities of the Office of Saline Water for the year 1961. It contains a summary of the developments during 1961 in the several major process groups on which research and development work was conducted, as well as a report on the status of the demonstration plant programme. Copies of the report may be obtained without charge from the Office of Saline Water, Department of the Interior, Washington 25 D.C., U.S.A.

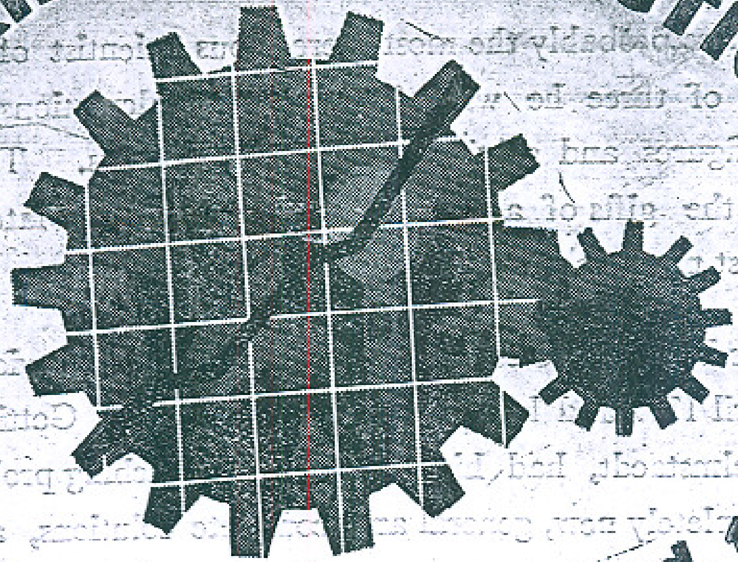
INDEX TO ADVERTISERS

Gauss was probably the most percocious scientist of his era : at the age of three he was already doing calculations, drawing geometric figures and solving numerical problems. These were portents of the gifts of a man whom Laplace was later to call "the greatest mathematician in Europe".

Charles Frederick Gauss who was born in Brunswick on the 23rd of April 1777 and held professorships first at Gottingen and then at Helmstaedt, had his own way approaching problems and finding completely new, general and complete solutions, applicable in all cases : in this his motto was "Pauca, sed matura". Almost simultaneously with Legendre he discovered the method of least squares and probability theory owes to him the law of the frequency of errors, known as "Gauss's curve", which has since become an essential tool of the statistician. The Disquisitiones arithmeticae which he published in Leipzing in 1801 represents the full flowering of his talents. His style can sometimes, however, be accused of being excessively obscure and hermetic, in keeping with his often intractable and reserved character. The inventor of the heliotrope and the magnetometer, his work on magnetism which has since acquired such importance in the industrial use of electricity, led later to the choice of his name to describe the unit of intensity of a magnetic field.

Gauss died in Gottingen on the 23rd of February, 1855. He had been an associated foreign member of the Paris Academy of Science since 1820.

MAXIMUM PRODUCTION



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