nowhere, until very recently, was the whole analysis of the occurrence, circulation and distribution of waters on the earth, their physical and chemical properties and their interactions with the environment, which constitutes the science of hydrology given a unified discipline.

Water specialists have not been very well treated up to now, and hydrology has not really been considered as a proper science, perhaps because it has more of an applied character and, unlike physics or biology, does not offer much opportunity for unravelling fascinating mysteries of nature. This has not raised much enthusiasm among the brightest young men in the various countries.

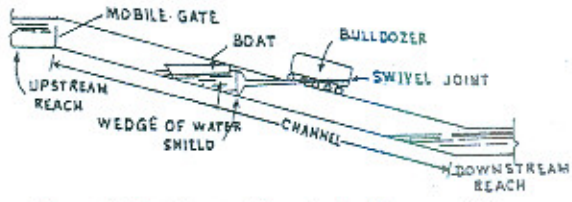
As regards the trainee every nation should progressively build up its own institutions and facilities for training specialists.

Structures, an Institutional Aspects

We briefly underline some mutual relationships between these structures and the problems of research and training. It is necessary to conduct a survey of meteorological survey in the world. Everywhere in the world, Planning and Development of Water Resources required first thorough scientific analysis of water balance and hydrological situation.

Most of our present habits and thinking in relation to water still seem to be based on a situation which occurred some fifty years ago in the temperate zones where there was plenty of good water available at very low cost for easy delivery to all users and for harmless dilution of wastes. This is no longer the case any where and we must change our habits and our thinking, which is inevitably a difficult process. Yet we should remember the attitude of the ancient Egyptians, the Romans, the Arabs and of all those who by necessity have long learned the value of water. For the first time—and surely once and for all-modern civilization must now become water conscious. It must, through proper education, create the will to scientifically develop, manage and conserve the water resources on which its survival depends.

Inspector-General J. Aubert, of France's Department of Highways and Bridges, noted that "for a long time, the lock alone has been used to enable ships to circumvent the difference in level resulting from the presence of a dam. However, the lock has many disadvantages. In particular, its cost is excessive, if the difference of levels approaches 20 to 30 meters. One is, therefore, led to consider use of other facilities". Among the ideas he discussed are the "Water slope" (see Fig. 1), the first full-scale example of which is soon to be built in France.



French Engineers Plan to build soon this alternative to lock.

Donalt J. Belcher

Of the Centre for Aerial Photographic Studies, Cornell University reported that it is now possible to locate fresh-water underground streams that flow into the sea, and to tap the streams on shore. Free-flowing underground streams flow into the sea from such places as Iran and Saudi Arabia, many Mediterranean countries, the Pacific Coast of Central and South America, and such islands as Jamaica, Puerto Rico, Cuba, the Azores and Canaries, Sardinia,

Sicily, Crete and Cyprus. In the Mediterranean basin alone, he reports, losses to the sea have been estimated in the order of 130 million cu. ft. per hr.

John S. Gottschalk

Director of the U.S. Bureau of Sports. Fisheries and Wildlife, reported enthusiastically about developments since 1958, when the U.S. Fish and Wildlife Coordination Act granted fish and wildlife full partnership with irrigation, flood control and navigation, hydro electric power, municipal and industrial water as a consideration in water-project design. Gottschalk noted that the 1965 authorization of the Garrison Diversion Unit of the Missouri River Basin Project in North Dakota will not only provide irrigation water for one million acres eventually but will also provide for acquisition and development of some 147,000 acres dedicated to the conservation and development of migratory water-fowl. Because they provide a drought-proof water supply, the project will enhance North Dakota as a most productive water-fowl area.

Municipal Sewage Treatment

The city of East Chicago, Ind., has a twin-pronged problem of major proportions—a combined sewer system with its concomitant discharge of untreated water during heavy storms, and serious industrial pollution of the Grand Calumet River and Lake Michigan. (The area has the highest per capita concentration of industry in the world). Tackling both problems at once, the East Chicago Sanitary District proposes this four-element solution, reported Ernest R. Hamilton, of Ernest R. Hamilton Inc.

—Acceptance of industrial waste into the municipal treatment system

—Collection and discharge of storm waters into a 200-million-gal detention basin

—Tertiary treatment of secondary effluent

—Renovation of combined storm-water and treatment-plant effluent, for industrial reuse

DESALINIZATION

President Johnson speaking at the meeting, noted that he had just signed an Act of Congress to help finance the huge nuclear power-desalting plant to be built in the ocean off Los Angeles, (*Civil Engineering*, Aug. 1965, page 105), "which will more than double the world's present capacity for desalting water. A decade ago the best plant design could produce only 50,000 gpd at a cost of $5 per 1,000 gallons. This new plant . . . . will eventually produce 150 million gallons of fresh water per day at a cost approaching 20 cents per 1,000 gallons. That is 3,000 times as much, at 1/25 the unit cost." Desalted water will be relatively less expensive, partly because the process will utilize the heat in the waste cooling water from nuclear power plants.

Reported James. T. Ramey, of the Atomic Energy Commission, Research and development programs in desalting and nuclear technology point to the future possibility of producing desalted water at costs of 8 to 15 cents per 1,000 gallons, which may permit more general use for agriculture. However, Dr. R. B. Sen, Director-General of the UN's Food and Agriculture Organization, appeared to disagree with Commissioner Ramey. He said, "Only very intensive high-value crops can bear a (water) price of 10 to 12 cents per 1,000

gallons. Large-scale irrigation from desalinized water will not be economically feasible for normal agricultural operations till the price falls below 4 cent per 1,000 gallons. Research must, therefore, be intensified, by use of nuclear energy or otherwise."

An entirely different approach was reported by R. N. Morse, of Australia's Commonwealth Science and Industrial Research Organization (CSIRO). This is the solar still, a logical approach in arid regions. A 4,500 sq. ft. still operated there for three years, unattended except for minor servicing at three-month intervals, Morse reported. Peak summer output was 400 Imperial gallons per day, and yearly average output was 200. The world's largest solar still is now being installed in South Australia. The first stage, with an area of 38,000 sq. ft., was completed last November, and is now supplying 2,500 Imperial gallons per day. Cost is in the range of $3 per 1,000 gallons.

Evaporation Control Sprinkler Irrigation

Conventional or gravity irrigation, though the predominant technique in use today, is less efficient than sprinkler irrigation, reported Dan Goldberg, of the Benrew University of Jerusalem, Israel. He listed these disadvantages of gravity irrigation:

—More water needed per unit area (light applications hardly possible)
—Accumulation of water in the subsoil, causing waterlogging and salinity
—Need for extensive underdrainage systems (adding to cost)
—Costly and time-consuming surveying, scraping and levelling of land
—Detrimental, though temporarily, to vitality and soil properties of scraped area

And he listed these advantages of sprinkler irrigation:

—Easy and quick to install on large areas, and unlimited by topography
—High irrigation efficiencies in terms of water use (80 per cent and above) compared with 20 per cent by gravity irrigation.

M. D. Bester, of South Africa's Department of Water Affairs, reported on what he termed the World's largest operational program of reservoir evaporation control through use of monomolecular films. Some 3 tons a day of cetyl-stearyl alcohol was spread by modified crop-dusting airplanes over 30,000 acres of reservoir surface above Vaal Dam. The project started last September and ran for several months. The annual gross evaporation rate of 60 in. was reduced by an estimated 16 percent.

Harvesting Rainfall

Catching rainfall before it percolates into the ground or reaches streams was the topic of several papers. Giorgio Nebbia, of the University of Bari, Italy, reported on one such project on the arid island of Lipari, off southern Italy. Some 28 acres of hillside have been paved with concrete; 13 million U.S. gallons of fresh water are collected yearly.

Lloyd E.Myers, of the Agricultural Research Service, U.S. Department of Agriculture, noted that 4,000 years ago farmers in Israel and Jordan harvested rainfall to successfully irrigate crops though rainfall was only 4 in. a year. He believes that "wide-scale application of precipitation harvesting seems certain to develop within the next decade. Treatments now under investigation should produce water for about 38 cents per

(*Continued on page 79*)

Institute of Engineers (Pakistan) Lahore Centre

Annual Meeting

The Third Annual Meeting of the Local Centre of the Institute of Engineers, Pakistan was held on 11th November 1967. Large number of members, graduates and student members were present.

Mr. H. J. Asar, Chief Engineer, Remodelling Organization (now retired), relinquished the charge of the office of the Chairman, Lahore Centre in March 1967. The members paid glowing tributes to Mr. Asar for he excellent work done by the Lahore Centre during his tenure.

Sheikh Ahmad Hassan, Secretary, Government of West Pakistan, Irrigation and Power Department, was elected as new President of the Lahore Centre from April 1967. In his speech he apprised the Council of three very important issues facing the Centre, namely,

(*i*) Increasing the membership,

(*ii*) Organising a programme for the construction of Lahore Centre building and

(*iii*) improving the quality and expanding the circulation of technical papers.

He also stressed the role of engineers in nation-building and said that Lahore had the proud privilege of having the largest collection of eminent engineers and a large number of Consulting and Contracting firms as are located here. The engineers in Lahore can, therefore, play a prominent role in building up the profession and in raising their status and looking after the well-being of the engineers in the country as a whole. He said that the engineers in Pakistan were not properly organised. As such, they were steadily losing their places in society and in the administrative machinery of the Government. Every engineer should give a serious thought to this state of affairs. He also emphasised the need for building up consulting firms of high standard, so that the works now being conducted by many foreign Engineering firms, are handled by eminent engineers of the country.

Mr. Asrar Ahmad Qureshi, Honorary Secretary, read out the Annual Report of the Lahore Centre. Speaking about the membership, the Secretary reported that the present membership stands at 338 corporate members which included 21 life members,

80 members and 237 associate members. The Organization has to announce with regret that 678 persons have seized to remain members for non-payment of their subscriptions for more than three years. This has resulted in a loss of about Rs. 63,571.

During the year, six technical meetings were arranged in collaboration with other Engineering Organizations of the country.

The construction of building for Lahore Centre has been receiving the attention of the Senior Members. The work of design and plan has been entrusted to National Consulting Engineers, Lahore. Recently, a notice in an important newspaper was issued inviting Architects to offer designs and plans for the Centre. A reward of Rs. 5000 for the best selected design was also decided to be given. There is urgent necessity of constructing at least three or four rooms to effect a saving of nearly Rs. 300 per month which is being paid as rent for an inadequate small four-room rented quarters which are quite inadequate for the activities of the Centre.

This meeting was addressed by Syed Mohsin Ali, retired Chairman, Central Engineering Authority, the oldest member of the profession. He was the Chief Guest.

Syed Mohsin Ali advised the engineers to wake up to their great responsibilities. He said :

Mr. Chairman and Brother Engineers

As is right and proper, I shall begin my address with a couple of verses from the Quran the English translation of which is, "O Believers, fear God, and speak the truth, He will impart excellence to your works, and forgive your misconducts. Those who obey God and His Apostle are bound to attain a high order of achievement."

It is my singular good fortune, and a privilege which I value most dearly, to have been asked to inaugurate this annual meeting of the Lahore Centre of the Institute of Engineers (Pakistan). As this is probably the last time that I shall address you (I am running in the 80th year of my life), this is going to be my swan-song. I shall soon be facing my Creator, and propose therefore to go straight to the points and speak the truth home truths, if you like. They shall come out of the depths of my heart and my absorbing love for the profession of Engineering.

It was my ill-fortune, some years ago, to head the High Powered Committee, appointed by the Central Government for, among other things:

"Devising a fool-proof system to reduce to the minimum the dishonesty of the contractors as well as of the Pakistan Public Works Department Officer and staff."

It is not for me here to divulge our findings and I must refer the curious to our Report, dated August 15, 1959. My object in referring to it is to emphasize our firm resolve never again to allow the breath of calumny or scandal to pollute the fair name of our profession. Come heaven, come hell, we shall defend its honour to the last drop of our blood.

It is not enough to say that corruption is rampant in other services also as some wag described : "Under the table, over the ceiling, through the nose"! We must prove to the world that the Engineer's is the noblest profession in the world, as it is, indeed, the most ancient as well as the most important for the development of a country in particular, and for the onward march of civiliza-

tion in general. We must present to the world an image of integrity and not of "dishonesty"—the actual word used in the terms of reference to the Committee.

The engineer's career is peculiarly broadening. He is thrown into contact with almost every type of business and profession. He must work with men of other professions : the lawyer who must advise him on legal documents, water rights, land acquisition, mining laws; the doctor who safeguards the health of his men; the journalist who keeps the public information of the importance and progress of his projects; the chemist; the statistician; the economist; the school teacher if he is in charge of a large project like Mangla; and last but not the least, the politician.

You have probably guessed that I am leading you on to a realization of the fact, that the engineer, who has been in charge of public works involving great responsibility, is specially fitted for statesmanship and the public life generally. He knows men of every kind.

Why then, and how, has he missed the bus? Some of the causes are the fault of the Engineers themselves, some due to public misconception. One, at least, which falls within the latter category, is a lack of appreciation of the real service of the Engineer. Compared with the politician or the successful author, his fame and reputation are small indeed. Compared to the lawyer or the physician, his remuneration is poor. Compared to the C.S.P. Officer or the Diplomat, his status is very, very low.

Very little newspaper space is given to the Engineer. He works quietly, and while the public enjoys the result of his labours, it seldom troubles to ascertain his identity.

The Engineer has hitherto laboured under the disadvantage of a one-sided education. Thrown in contact with Government officials like the C.S.P., or his legal, financial, educational or business associates of the highest culture, he has frequently been unable to hold his own and has suffered in consequence.

It must never be forgotten that general information is extremely valuable to the engineer. He never knows where it will prove invaluable. Spare time spent in reading books, magazine articles, newspapers, no matter what the subject, is seldom wasted. If the engineer can manage to get away from his own speciality for the time being, so much the better.

To complete the education of the engineer, however, it is desirable to put him through a course of training at the proposed Engineering Academy, more or less on the pattern of the Swiss Academy at Zurich, which is meant exactly for the purpose of giving technical people a finishing education, or of our own Civil Service Academy. I have had the pleasure of discussing the subject with the Director of the Academy, and he has promised to give me a broad outline of studies that should be taken up. This could form the basis of project which the Institute of Engineers could work out and put up to Government for implementation.

Our own President, Field Marshal Muhammad Ayub Khan, is always stressing the virtues of the strenuous life in all his addresses to the nation, for there is a tendency in our country also to rest on our oars, having achieved that herculean task of winning Pakistan, and building it up to what it is today. But the strenuous efforts

will have to continue. The life of ignoble ease is not for us, and in this it is the Engineer who should set the pace. If we are tempted to become mere armchair engineers and sleep at our desks, we must wake up and resist the temptation. There must be more field work than office work, more inspections than introspection more elbow-grease than being mere lookers on, more perspiration than inspiration. You know the famous definition of genius. As Carlyle said, genius is the capacity for taking pains.

Although we have done much, we have a long way to go. Not all the water which a benevolent Providence has given us has been put to use either for agriculture or power production The whole of Baluchistan—a country in itself—is virgin soil. The Arabian Sea litteral, along the Makran coast, offers immense possibilities of development, with the help of thousands of cusecs of water running down the coastal streams and rivers. The extensive marshes, Hamun-i-Mashkel and Hamun-i-Murgha still remain to be drained like the Pontine marshes near Rome, which Mussolini drained and turned into rich agricultural country-side. If he had not made a fool of himself, his name would have gone down to posterity by this one act alone, as a benefactor of mankind. Then we have to reclaim the immense areas of saline and waterlogged land, which as sins of our fathers have visited on the heads of their children. The floods have yet to be tamed, and many more rivers "for to cross". The immense mineral wealth buried in our country has yet to be assayed and developed. Wind power has to be exploited.

All this only the Engineers can do. The Engineers can set an example of the strenuous life to the other services and professions. If gold do rust, what should iron do? When we have taken the initiative in our own hands, and put our shoulders to the wheel, we shall automatically come to the fore, as engineers have done in America and other countries. No one can then deny us our role as the leaders of the nation or cheat us of the reward of our efforts.

Gentlemen, I give you the slogan "Wake up, Engineers," and salute you with another verse from the Quran :—

"Nothing comes to man except what he strives for."

Mr. Ahmad Hasan's,
Annual Inaugural Address

As President of the Lahore Centre of the Institute of Engineers, Mr. Ahmad Hasan, Secretary to Government of West Pakistan, Irrigation and Power Department, addressed the members on eleventh November, 1967. He said, "It is a matter of great pleasure for me to welcome you, Syed Mohsin Ali, on behalf of the Members of the Institute at the 3rd Annual Meeting of the Institute of Engineers, Pakistan, Lahore Centre, this evening. I must thank you for accepting our invitation to be the Chief Guest on this occasion. We are proud to have with us at this meeting, the company of the oldest and one of the most eminent and distinguished living Engineers of the country. Your presence here, I am sure, will inspire all the Members of the Institute just as your work and dedication in the past half a century has been a source of inspiration to the fellow engineers in this part of the world.

The role of the engineer to-day in developing economy of Pakistan is significant from the fact that almost 75% of the project provisions in the Third Five Year Plan will be converted into reality by direct or indirect

association of the Engineers with this stupendous task. Therefore, this Institute which is the only organization representing engineers from both wings of the country, must strive to produce such ethics, ability, calibre, capacity, knowledge and efficiency, among the engineers of this country, that they become, one and all, worthy of discharging the responsibilities that have been placed on their shoulders by the Nation. For this purpose the activities of the Institute have already been decentralized by opening local centres at suitable places both in East and West Pakistan. With this decentralization greater and greater responsibilities devolve on the effective planning and operation of the local centres. It is my firm conviction that our best professional interest requires that the local centres such as this one, be always active, vital, even aggressive and ready to meet each of its challenges. To-day the Engineer feels a lack of recognition and identification by the society which he continuously serves in so many important ways. We can struggle for achieving this recognition and identification only through the success of our own efforts in creating an awareness of what we do and how we do.

As the membership of the Institute increases day by day with Lahore centre alone having over 1000 Members, it becomes more and more incumbent on the Members representing various local centres of the Institute to struggle for ensuring a proper place and status for the Engineer in our society by perfecting our professional conduct and engineering skill. With proper encouragement from the Government, this Institute can perform a vital role towards this objective.

The foremost problem facing the country at present is to attain self-sufficiency in food production and saving our precious lands from the menace of waterlogging and salinity and the onslaught of floods. Our Engineers are already actively engaged in meeting this challenge and have met with considerable success is taking this task to completion. The undertaking of Indus Basin works, the drainage and tubewell projects, production of thermal and hydro-electric power for domestic, agricultural and industrial use, the embarkation of flood control projects, the development of water potential both surface and underground and putting it to optimum usage, the setting up of vast network of highways and railroads, the provision of adequate pubilc health facilities in cities towns and villages, and the setting up of light and heavy complex industrial units are some of the major problems which are currently being handled by the engineers.

Under the guidance of the PRESIDENT OF PAKISTAN, the country has already launched an open war against poverty and hunger. The engineers and scientists are the persons who would be directly concerned with the eradication of these evils. While the scientist explores to enhance the boundaries of knowledge, it is the engineer who puts this knowledge to practical use by accomplishing a new feat of engineered construction.

I would now like to refer to the problems of the engineers both in the public and the private sectors. Sometime back, the PRESIDENT OF PAKISTAN was pleased to direct that a committee be appointed to look into the problems of the Engineers and come up with its recommendations. Since then some thought has been given to this question by Institute's headquarters at Dacca and the local centre at Lahore and others. It

has been brought out that the problems relating to the engineers are of a technical, educational, administrative or a social nature. To groom the engineer from the start to the last, it is felt that our Engineering Universities should be fully equipped with teaching staff, laboratories and workshops according to Internationally acceptable standards, and compulsory training of the student engineers must be arranged prior to their recruitment in services or with private firms and industries.

Among the in-service engineers, a need has been felt for a long time for a full-fledged training establishment for those who join the engineering service in the Departments of the Government. Mostly this stems from a realization of the fact that the developing needs of the country and the objectives of creating progressive technological industrialized society have confronted the engineers with a challenge where they have to train themselves, not only in the technical know-how of engineering works but also to understand the aspirations and goals of an affluent society. The need is not only to impart professional training to the officers in their particular practical field of pursuit but also to inculcate in them the discipline to build the personality and outlook that is essential for the discharge of the duties and obligations of a professional service man. Some academies exist for many other services and it is very essential that an academy for the engineering services is also created by the Government. Such an Institution apart from training the young engineers would impart the serving engineers both in the public and private sectors with refresher courses with a view to keeping their technical knowledge up to date. The necessity for such refresher courses would be clear if I quote the saying of an American Engineer in this context; "Engineer's education has a half life of 10 years. In 10 years one half of what he knows now will be obsolete and one half of 10 years is not yet known."

The presence of Syed Mohsin Ali, here, this evening makes me recall some of the recommendations from the report of the high powered committee appointed by Government in 1959 to suggest improvements in the working of the engineering departments. This report which later came to be known as Mohsin Ali's report-expressly provided that a service of engineers on an all-Pakistan basis, like that of the C.S.P., should be created and there should be periodical changes of Engineer officers between the Provinces and the Centre. This report further recommended that the engineers should be associated more closely with the general administration in policy formulation and decision-making as recommended by the Planning Commission and those with special talent for administration should be eligible for inclusion in the administrative pool or appointment to higher administrative posts as they will bring new knowledge and aptitude to such a pool or post. As Chairman of the Lahore Centre, I could not agree more with Syed Mohsin Ali's recommendations narrated above. In fact it had been further recommended by you, Sir, in this report that the syllabi of engineering colleges should be so revised as to include a certain number of cultural subjects such as English Composition, General-knowledge, etc. to educate the future engineer to be able to put across his ideas to the Administrator, Financier, the Industrial magnet, the public and the Government. I am happy to inform you that the Government, if not at the University level, has included these subjects in the syllabi of the

competetive examination, for admission to the provincial engineering services.

Side by side with the engineers in the services of Government, those in the private sector constitute a vital segment of the engineering manpower resources of the Nation. The latter group needs to be boosted up with proper encouragement and effective planning and organization of the local firms of engineering consultants and the firms of contractors in Pakistan. A positive support from the Government is required to build up the local consultants and contractors in the national interest. This would also give an opportunity for utilizing the experienced senior engineers who may retire or wish to retire after completing their qualifying service, from the heavy administrative routine of Government Departments, to continue to give their benefit of lifelong experience in national engineering problems. Since bulk of the engineering talent in the country has in the past been directed towards the Government service, it might be difficult in the beginning to find suitable personnel to develop and enhance the standards of the local firms of consultants. For this purpose the Government may well consider the possibility of temporarily deputing some of its engineer officers to work with various firms of consultants, in the larger interest of the country just in the same way as the Government officers are now deputed for service to the semi-autonomous/autonomous bodies. Similarly the Pakistani contracting organizations can grow only with the support of Government and further provided that such contractors engage only qualified engineers to construct and supervise works entrusted to them under a contract. Unfortunately a lot remains to be done in this country both for the engineering consultants and the contractors. To provide them with some incentive, the Government may consider to form a National body for Consultants and Contractors.

Much strength can be derived by the engineering profession by strengthening the Institute of Engineers in a manner that it is recognized Internationally as a Member of the world-wide Engineering organization for which a plan for world-wide Federation for Engineering Societies is said to be underway and may materialize in the near future.

But this Institute of ours can be made an effective organ truly representative of the aspirations and calibre of our engineers only if all brother engineers play their part. The key stone of professional conduct is integrity, courtesy and professional skill and this constitutes the foundation of all codes of ethics. We need more Members of this Institute to come forward and express opinions when it is founded on adequate knowledge, through technical papers, articles based on the experiences acquired by them on various projects or research assignments. There is a dire need for constructive criticism but no room for destructive one. The senior engineers must patronize and encourage those comparatively younger in the profession and establish practices and precedents that may be quoted as an example by the young ones. The use of the indigenous material and the necessity for eliminating costly materials in construction has also been stressed by the PRESIDENT OF PAKISTAN. It is important that our Research Institutes and Laboratories make concerted efforts towards the utilization of newly discovered indigenous materials which may prove to be more

economical though equally durable. Our resources are limited and the engineers have to find ways and means to make best use of them; let it not be said that we did not live up to this challenge.

In the end I once again thank you, Syed Mohsin Ali, for having accepted our invitation to become the Chief Guest on this occasion. I am obliged to Mr. B. M. Abbas, the Institute's President for his presence here and his unabated encouragement to the Lahore Centre. I am also grateful to the office-bearers and the Council Members of the Institute, Lahore Centre and the Chairmen and Conveners of the various committees who assisted me in discharging the duties assigned to me as Chairman of the Lahore Centre. Soon we would Insha-Allah be having a building of our own at Lahore and it may well be that the next annual meeting of the Lahore Centre or the one thereafter may be held in our own building.

PAKISTAN PAINDA-BAD !

(Continued from page 71)

1,000 gallons. "Water costs low enough for irrigated agriculture may not be possible in the near future, except under particularly favourable circumstances. Costs will certainly be low enough for certain domestic supplies, livestock and some recreational uses."

One of the most imaginative proposals was made by Wyndham H. Roberts, of the Illinois State Water Survey. He proposes floating on offshore waters an extensive sheet of reinforced plastic. It would be surrounded by a floating barrier. Beneath the water surface would be a nylon-fabric storage tank of 400,000 gallon capacity to the bottom. Rainfall caught on the plastic sheet would run into the tank, later to be pumped to shore for use. He notes that a 1-in. rainfall on a water-borne sheet 40 acres in area would mean 1.09 million gallons of water, assuming 100 percent runoff.

Groundwater Recharge

*A. Amramy, Israeli consulting engineer, reported that construction began this spring on a project to reclaim the waste water of the Tel Aviv Metropolitan Area. First, the waste-water will get full treatment : anaerobic lagoon, secondary anerobic, aerobic (two stages), and finally "polishing" ponds. Effluent will be pumped to an adjacent dune area into prepared, levelled sand basins, for recharge by surface spreading. The reclaimed water is to be withdrawn from this aquifer through wells situated around the spreading basins; this water will be pumped into a large pipeline of the National Supply System, and reused in the south of Israel (not in Tel Aviv itself). First-stage construction is to be completed in 1970.



Late Mr. R. J. Tipton,

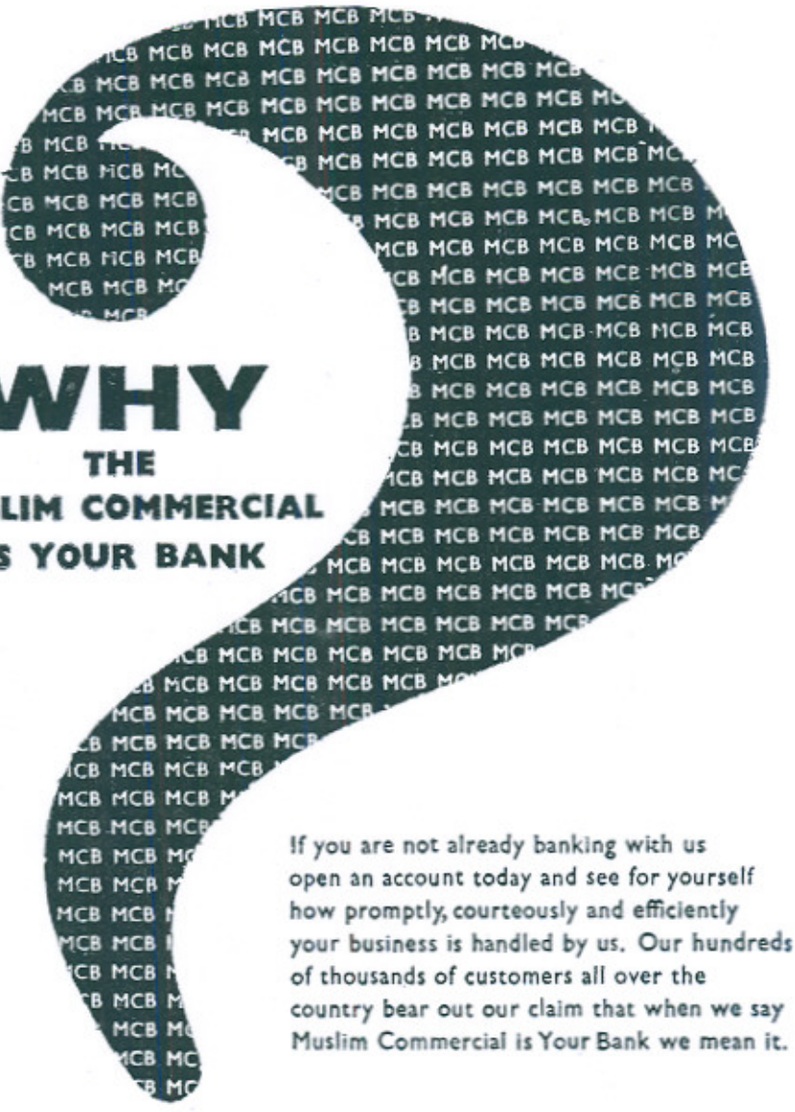
It is with great sorrow that we have to report the death of Mr. Tipton who died on 23rd December 1967. He died due to massive cerebral haemorrhage. Mr. Tipton was born in Litchfield, Ill, on March 23, 1893 and was educated at Cripple Greek, Colorado, and graduated from the University of Colorado.

Mr. Tipton had been in private practice since 1922. He conducted studies for U.S. Bureau of Reclamation on water supplies for the Boulder Dam. At the time of his death he was Chairman of the Board of Tipton and Kalmbach, a Consulting Engineering firm of world renown. His firm is helping West Pakistan not only in the completion of Indus Basin Water Project but with all groundwater and reclamation project undertaken in the Northern Region of the area. His Organization has put forth seven or eight Scarp schemes for West Pakistan. It is a consulting firm for all the link canals being constructed in the area under Indus Basin Water Treaty.

Mr. Tipton at the time of his death was President of the International Commission on Irrigation and Drainage. He was Vice-President of the American Society of Civil Engineers. He was a past President of the Colorado Section of the American Society of Civil Engineers and a member of many other Engineering Water Organizations. He has an impressive record of achievements in the field of water engineering for more than 50 years. He has been planning and constructing projects throughout the world. He had in him the rare quality of understanding and appreciating other's points of view and of making others understand the opposite view.

Mr. Tipton's commendable services for the betterment of Irrigation and Drainage, in the interests of humanity at large will always be remembered.

We pray for his soul to rest in peace.



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compared to a single strainer equal to their combined length.

(c) A multiple strainer system makes the pumping set to work at its maximum efficiency

A few instances of the increase in yield of multiple strainers with small additional input power are put forth to show the efficient performance of a multiple strainer tubewell. At Niazbeg Field Station a number of shallow tubewells are installed in fine sand formation. These are located close together along the circumference of a circle of 75 feet diameter and are operated by the same centrifugal pumping set. The strainers are of different materials such as brass, coir string, pre-packed gravel type, and of 'munj' string.

The yield of these tubewells together with the input power is shown in table 13.

It is apparent from this table that it was possible to obtain 20 to 70 percent more yield by 7 to 25 per cent additional power.

In Figs. 21 and 22 is shown the output discharge being obtained by working a single and multiple strainers by the same pumping set.

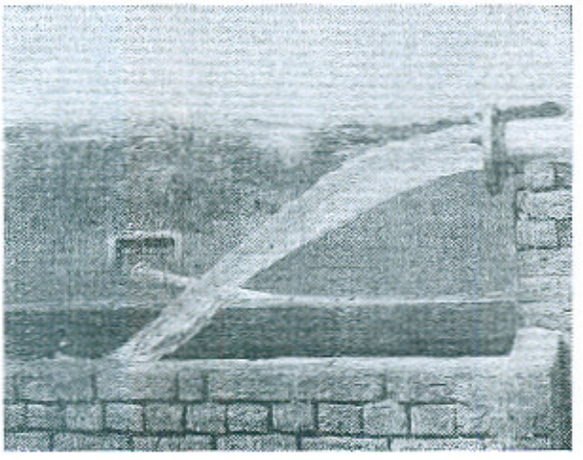


Fig. 21.—Yield of a single strainer pumped by a pumping set

A similar experiment was conducted in the Gaja area of Ghulam Mohammad Barrage. Here the groundwater is generally saline. At a few places the top 60 to 80 feet layer of water is less saline, so that tubewells were installed to pump top water only.

These tubewells were provided with two or three strainers and pumped by the same centrifugal pump operated by a low speed diesel engine. The result of their performance is given in table 14.

Such experiments of multiple bores are now being tried at many places in West Pakistan. The result of yield making the pumping set work efficiently are fully established.

If a tubewell shows a fall in discharge after long operation as is the case with Rasul Tubewells which are operating for the last 13 to 20 years, (up to 1967) addition of a strainer is now being done to renovate the tubewells to bring their yield to the original designed discharge.

Shrouding of a tubewell

Shrouding is a term which is used for providing a layer of coarse sand or fine gravel round a tubewell to work as a filter

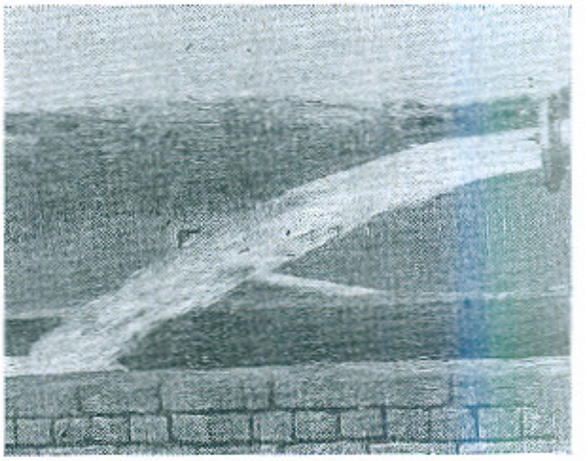


Fig. 22.—Yield of two strainers pumped by the same pumping set

TABLE NO. 13—*Performance of Multiple Strainers tubewell installed at Niazbeg.*

S. No.	Type of Strainer	Symbol	Depth of bore ft.	Length of strainer (ft.)	Appx. Distance between strainers (ft.)	Dis. in cusecs.	Dep. head in ft.	Power consumption (KWH)	% increase of Dis.	% increase of power	%increase of yield and power is worked W R T
1.	Coir string	C_{11}	130	100	..	1.3	18	8.88	..	..	..
2.	Brass	B	80	50	..	0.97	18	7.5	..	..	..
3.	Coir string	C_1	80	50	..	0.89	18	7.8	..	..	..
4.	Munj string	M_1	80	50	..	0.78	18	7.2	..	..	..
5.	Ghafoor	G	80	50	..	0.95	18	7.5	..	..	..
6.	$C_{11}+B$	..	..	..	37	1.73	19.0	9.5	43.0	7.0	C_{11}
7.	C_1+B	..	..	..	40	1.5	19	9.23	68.6	17.0	C_1
8.	C_1+M_1	..	..	..	75	1.21	19	8.1	36	3.8	C_1
9.	G.+ B	..	..	..	127	1.52	19	8.42	60	12.3	G
10.	$G + C_{11}$	..	..	..	100	1.6	16.5	9.1	23	2.4	C_{11}
11.	$B+C_1+C_{11}$	..	..	..	..	1.86	1.6	10.2	91.7	36.0	B
12.	$B+C_1+G$	..	..	..	..	1.76	17	9.4	60.8	25.6	B
13.	$C_1+C_{11}+G$	..	..	..	..	1.81	17	9.8	39	10.3	C_{11}

TABLE 14.—*Performance of Multiple Strainers Tubewell of Gaja Area.*

T. Well No.	Strainer No. 1				Strainer No. 2				Strainer No. 3				No. 1 and 2 combined		No. 1, 2 and 3, combined	
	Depth of bore ft.	Installation period M/Year	Yield cus.	Depression head in ft.	Depth of bore ft.	Installation period M/Year	Yield Cus.	Depression head in ft.	Depth of bore ft.	Installation period M/Year	Yield cus.	Depression head in ft.	Dis. cus.	Dep. Head ft.	Dis. cus.	Dep. Head ft.
4	70	7/1960	0.58	11	105	7/60	0.64	15	72	2/64	0.5	15	1.13	19	1.6	16
5	62	11/60	0.65	16	62	11/10	0.7	21	62	1/64	0.66	19.5	1.22	17.5	1.8	18
14	77	9/60	0.86	11	74	9/60	0.76	12.5	76	3/64	0.4	15	1.4	16	...	...
1	60	3/64	0.5	15.6	70	2/64	0.5	17	70	3/64	0.5	19	...	...	1.2	16.3

The material of the filter should be made up of round, hard, non-reactive particles of grit. If the particles of the material are round and of a uniform grade, their pores space is the maximum.

The work of Graton[11] and Fraser with regard to the size of perfect pround articles, their packing and pores space has already been mentioned. The size of pores can be worked out for ideal round particles with reference to their packing but in nature particles are very often angular and determination of the size of pores offers some difficulty. A filter of the size will be suitable which gives the biggest size of pores—not the porosity percentage—and yet do not allow the fine

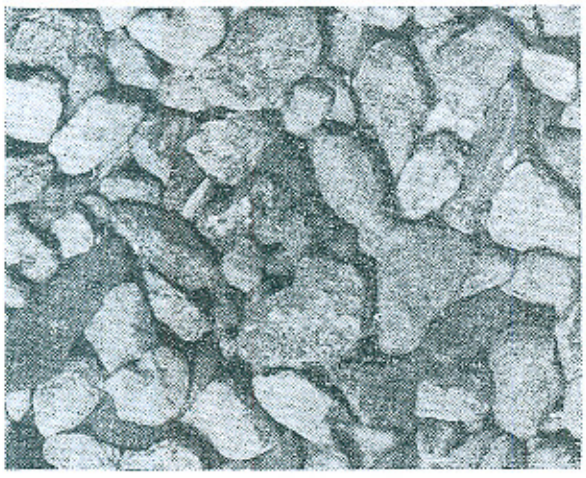


Fig. 23-*a*.—Coarse grade of shrouding material

formation to pass through. If an improper size of a filter material is used, the formation moves into the pores of the filter and makes it a compact mass with reduced pores size and decrease in permeability. Referring to the three photographs No. 23 *a*, *b* and *c*, two of these represent a coarse type of gravel and a fine type of the formation and the third is when these two are mixed together. The pores space of the gravel is generally between 25 to 30 percent whereas that of the sand is about 40 percent. If the fine forma-

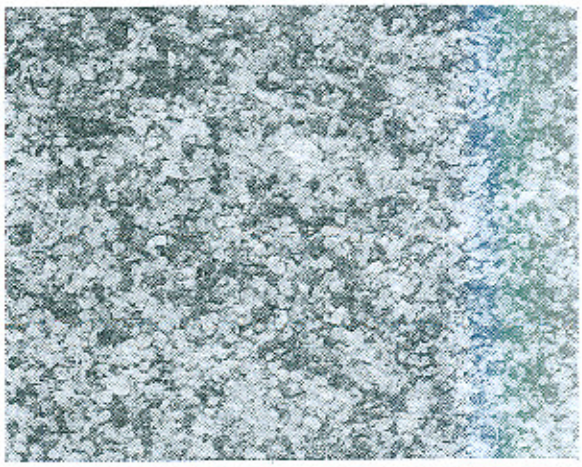


Fig..23-*b*—Fine sand grains of the formation

tion moves into the pores of the coarser grade of the filter, the pores are blocked by solid particles of sand and the effective porosity is considerably decreased. This



Fig. 23-*c*.—Fine sand grains filling the pores of shrouding material

forms a compact mass, which has a high density, less porosity and low order of infiltration. Thus selection of a proper size of the filter material is very essential.

We have also seen that the space between the boring pipe and the strainer varies between 2 to 6 inches depending upon the

size of the bore. The full depth from water-table to bottom is full of water, so that the possibility of installing the graded filter is out of question. This small space can only be filled by a filter of one grade.

Selection of a suitable size of the filter

The design of the filter was suggested by Tarzaghi. According to this method, a gradation curve of the sand to be protected is prepared. The diameter of the sand particles corresponding to 85% and 15% pass are determined. Suppose size of sand particles of 85% pass is x and 15% pass is y. These are then multiplied by 4 so that $4x$ is a coarse grade of the shrouding material and $4y$ is a fine grade of the same. These two grades of the shrouding material correspond to 15% pass. A curve as shown in Fig. 24 is then developed for higher grades to correspond to the shape of fine sand to be protected.

The Irrigation Research Institute suggested a simpler method. Plot the sand gradation curve and determine its mean size *i.e.*, D_{50}. That filter gradation curve will be suitable which will have the mean size seven times D_{50} of the sand to be protected. The gradation curve of filter will be similar to the sand formation. A proper filter grade curve is an envelope curve having the mean grade between 5 times D_{50} and 10 times D_{50}.

For practical purposes one has to use two sieves of square holes. With this end in view in table 13, the sizes of shrouding materials passing a certain sieve and retained on other, suitable for protection of a given type of formation are put forth.

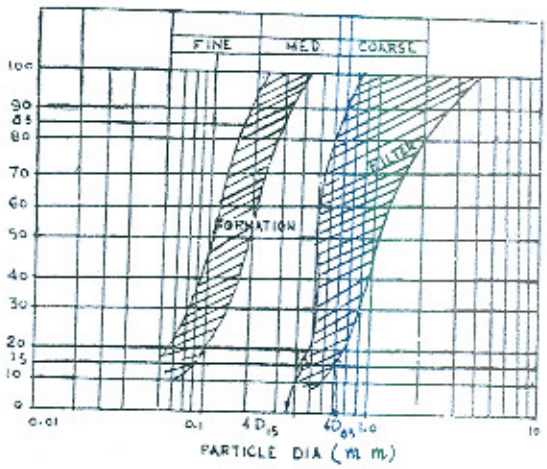


Fig. 24.—Filter Design Curves Reproduced from "Soil Mechanics in Engineering Practice" by Terzaghi and Peck

TABLE 15

Mean grades of sand to be protected	D_{50} in mm	Grades of filter material in inches		Actual practical grades in inches	
		Pass	Retained	Pass	Retained
Coarse grade of medium sand ..	0.35	3/16	1/16	1/4	1/16
Fine grade of medium sand ..	0.3	3/16	1/16	1/4	1/16
Fine sand ..	0.2	1/8	1/32	1/8	1/32
Very fine sand ..	0.15	1/16	1/64	Harrow Sand should be used	

Use of non-reactive particles of gravels

It is very important that the material selected for shrouding should be non-reactive. There are some areas in West Pakistan where calcarious sands and gravels are found. These are formed from disintegration of limestones. In Hyderabad, Kotri and near Hassan Abdal such material is found in certain natural streams. This type of material may be avoided as it is likely to be reacted by the salts contained in the ground-water. The best shrouding materials are hard, round particles of quartz, silica or shale.

Thickness of shrouding

Many workers have experimented to determine the minimum thickness of the shrouding envelope. It is found that the minimum thickness of 1/2 inch filter material of a suitable size is sufficient but in practice on account of variation of sand occurring in nature, it is preferable to fix the shrouding thickness to 3 inches. Addition of too thick a shrouding is not very helpful, the limit may be between 3 to 6 inches.

Installation of the shrouding material

The installation of shrouding is a very difficult job. After fixing the strainer, the whole surface between the strainer and the casing pipe has to be filled but it may not be done all at once. This often creates difficulties with extraction. The skin friction offered by this material is considerable, so that the extraction of the casing pipe becomes a problem. It is very necessary that shrouding may be added in small layers say up to one foot at a time and after each addition, the casing pipe may be pulled out slightly less than the thickness of the shrouding material added. Dropping a large volume of shrouding results in segregation or sorting of the particles, the bigger particles falling first followed by the fine ones. The best counter-measure against segregation is to pour it through a pipe of about 2 inches in diameter which may be lowered through the space between the strainer and the casing pipe and brought close to the site of pouring. This will avoid the possibility of segregation of particles. Bit by bit after filling the space with shrouding the pipe is pulled out.

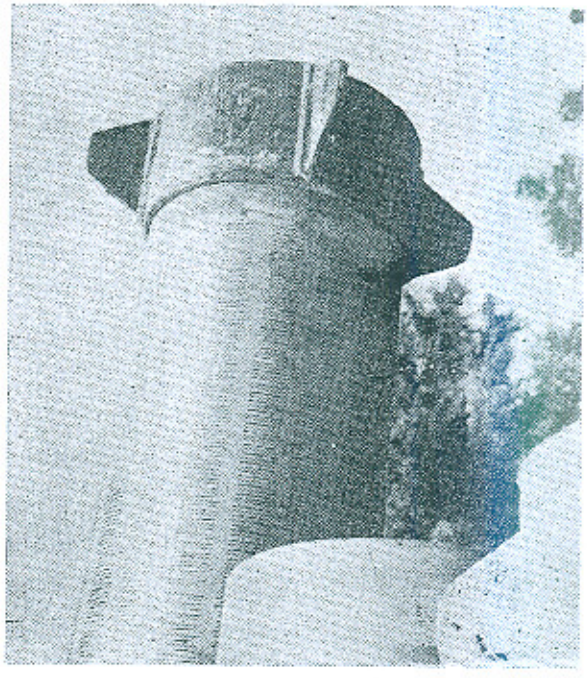


Fig. 25.—Stays cast along with socket to keep the strainer equidistant from the casing pipe.

Uniform pouring of shrouding

It is very necessary to keep the strainer equidistant from the casing pipe so as to have a uniform thickness of shrouding all round. Originally iron spikes used to be welded with the strainer or sockets to keep it equidistant. Recently these have been cast along with the sockets as shown in Fig. 25. This precaution is possible only if the boring is done using a casing pipe. In

case of drilling by Rotary method stays are not useful. One has to rely on the careful straight lowering of the strainer. In this case shrouding can be added continuously, preferably through a pipe.

Precaution against settlement of shrouding

It sometimes happens that after a tubewell has been completed and it is being developed, some readjustment of the shrouding material takes place. If some source of additional shrouding material is not available at top, then some of the slits of the strainer may face the formation without the protection of this device. In order to avoid this discrepancy it is preferable to shroud right up to the top covering the blind pipe portion also, so that if any settlement of the shrouding occurs, the material available in the blind pipe region may slip down and avoid the defects pointed out above. Sometimes one or two pipes are left fixed in the shrouding zone so that in case shrouding is to be fed it can be done through the pipes. Several failures of tubewells have occurred only due to non-availability of the excess shrouding material to feed the zone emptied by readjustment of the shrouding. This has often resulted in damages to the tubewell, breaking of the strainer, sinking of the pump house etc.

If precautions are undertaken to install the shrouding material carefully then the advantages of increase of the effective diameter of tubewell can be had.

Shrouding a coir string strainer

It is a common practice that a coir string strainer is left unshrouded. This strainer thus loses the advantages of the increase in its effective diameter. There is another point which makes it necessary to shroud a coir string strainer.

A coir string is made by twisting and winding coir fibres which lie between 0.2 to 0.4 mm. Coir string generally used in strainer is 1/8 to 3/16 inch thick. When two strings are laid close together at certain places the two windings face such as to form a big space in between. Its size is much bigger than the particles of sand formation. Coir has another property. It expands on wetting. Its expansion under no load is about 1% but with a tension of 20 lbs. it elongates by 10 to 15 percent. A dry string also expands by about 5% under a tension of 20 lbs.

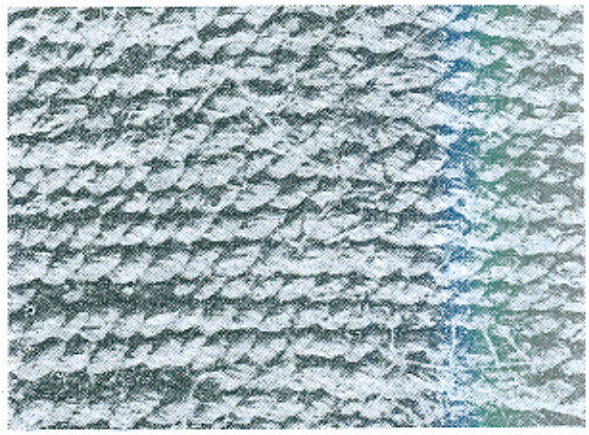


Fig. 26.—Opening and holes between the twisting of coir string

If a wet elongated string is allowed to dry under similar conditions the recovery is only 2 percent. The winding is done with dry string under tension of about 20 lbs. On saturation, it lengthens by 5 to 10 percent so that the winding loosens slightly and under certain conditions, the space between two adjacent strings become still bigger. These become a potential source for movement of sand through the coir string strainer.

This defect has often been avoided by double winding of the coir string. This reduces the overall porosity resulting in 10

to 15 percent fall in yield.

Another method to overcome this defect has been to use loose unspun coir fibres on the windings. These are held in position by a covering of a wire gauze.

It is thus concluded that shrouding of a coir string strainer is also required. The practice of unshrouding a coir string strainer has been adopted by local farmers to reduce the cost of installation. While using 4 to 6 inches diameter strainer, boring up to 6 or 8 inches diameter is carried out. The small size boring is cheaper. The extra cost of shrouding material is also avoided and there are some defects of shrouding as already discussed. When high capacity tubewell is to be installed for deep boring casing pipe of 12 to 18 inches has to be used. Sometimes shrouding has been avoided for fear of damaging the string while pulling out the casing. This can be remedied by due care and using fine grade of shrouding such as Harrow sand. While boring with a big diameter pipe, the shrouding will improve the effective diameter and will be of advantage. The string can be protected by a thin galvanized iron wire gauze and suitable shrouding material like coarse sand from Harrow river with approximate grade between 1/8 or 1/16 inch pass and 1/32 inch retained can be used as a suitable shrouding material.

Development of a well

There are two types of strainers being used in the country. One is a coir string strainer. It is generally left unshrouded. The second type is a slit strainer. It is always provided with a filter layer all round.

During shrouding of a tubewell some sand always gets mixed up with it. It fills the pores of the filter material resulting in the formation of a compact mass having low order of porosity. It is the aim of the development to take out this sand from the pores and leave them empty so as to yield a large volume of water at a low suction head.

While drilling with a rotary system, a mud made of bentonite or fine colloidal clay is used. This lines the excavated portion and reduces its permeability. This process also stabilises the sand formation which remains in position and does not cave in. The washing of this mud is very essential otherwise the yield of the formation is considerably affected. In modern practice with the use of reverse rotary no mud is used to line the excavated portion as it was found most difficult to remove the gell of the mud.

The development of well after its completion is thus essential. It improves the porosity of the shrouding by removing fine particles and leaves the pores empty. The removal of drilling mud, if used, is very necessary to improve the yield.

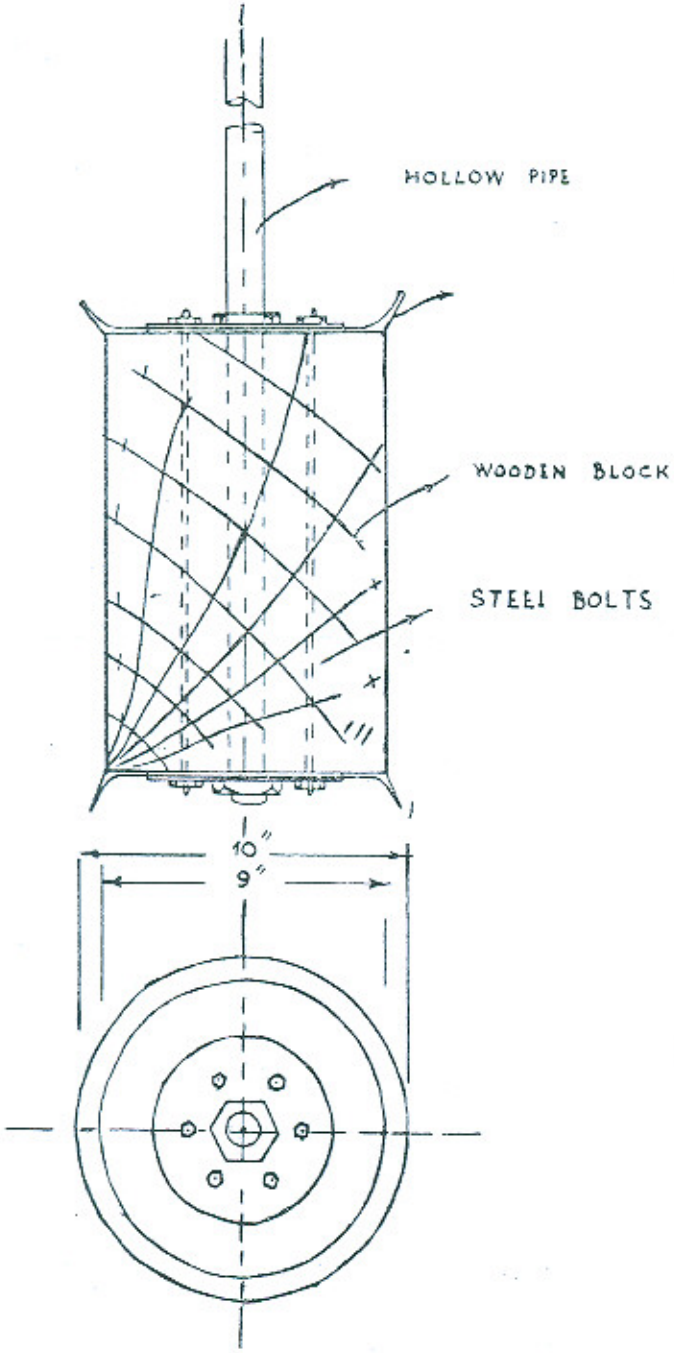
Method of development

(*a*) *Over-pumping*—Over-pumping is the simplest method used to remove the fine particles from around the strainer. In this case a pumping set of a larger capacity than the one to be fixed ultimately on the strainer is used. The pumping is done by creating surging. A tubewell is worked to a full capacity of the pump.

It is suddenly stopped so that the water column moving up through the pipes stops at once. It exerts a pressure wave, a sort of a hammer blow causing disturbance to the sand formation. The pump is restarted to capacity. Repetition of this method is carried out for a number of times usually for about 6 to 10 hours. The fine sand

particles are brought out with water tills and-free water is obtained. The measurement of depression head pumping the designed discharge is a measure of completion of the development. The tubewell is then provided with the normal pumping set.

(*b*) *Mechanical surging*—This method is based upon the use of a plunger or a piston which is forced down through the strainer. It pushes out water through the strainer into the formation. It is then raised up again, so that water is sucked in. This causes a disturbance to the formation close to the screen. In this way some of the finer particles are removed from the pores of the filter. A surge plunger can be made of a wooden piece slightly smaller than the internal diameter of the pipe or the strainer. It has two pieces of leather one at top and another at bottom nearly equal to the internal diameter of the pipe. These are fixed on the wooden block with the help of two iron plates as shown in Fig. 27. The surge block is fixed to a strong iron rod or a pipe. It is manually operated. Another type of surge plunger[6] provided with two rubber packing is shown in Fig. 28. The water is pushed with the plunger. It is forced to pass through the screen and the shrouding. When it is pulled up, it brings sand out of the pores of the shrouding.



PLUNGER FOR WELL DEVELOPMENT

Fig. 27

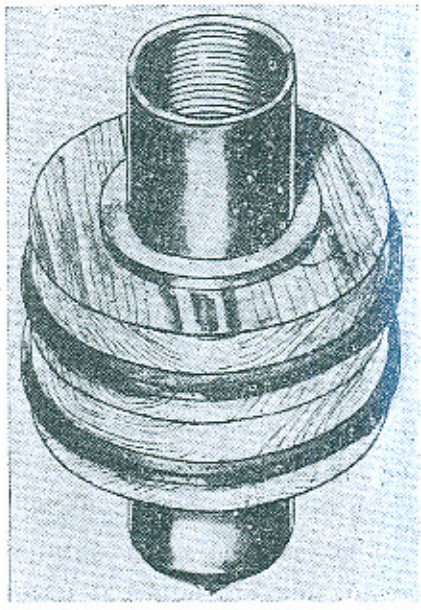


Fig. 28.—A plunger for developing a freshly installed tubewell strainer.

This process is repeated several times. The sand which is drawn into the strainer collects at the bottom of the well. It is pumped out. Usually this process is continued for one or two days to get the maximum yield at a low depression and without pumping of sand.

(*c*) *Development by air compressor*—Development of a well is also carried out by air compressor of 100 to 150 lbs. per square inch capacity. Air pressure is allowed to develop in a tank which is provided with a quick opening valve. The air is let in through a pipe which reachesc lose to the bottom of the strainer. This pipe has air outlet holes at its bottom to a length of 6 inches or a foot. This is $1\frac{1}{2}$ to 2 inches diameter pipe and can be easily raised or lowered in another pipe of a bigger diameter. When the back surging is to be attempted, the air pipe is lowered to face the screen. (See Fig. 29 from Johnson). This back surging with high pressure air is carried out at different positions of the air strainer from the top to bottom. After this treatment, the air pipe is raised up by a few feet in the outer pipe. The air pressure starts pushing out the water and some of the formation particles which have been drawn into the well are also taken out. The suitable size of the pumping pipe and the air line are adjusted according to diameter of the well. For an 8 to 10 inches diameter strainer, 4 to 6 inches of covering pipe and $1\frac{1}{4}$ to 2 inches of air line is suitable. The capacity of air compressor has to be selected according to the length of the strainer or the water pressure to be encountered in the well.

This method is neither so simple nor so cheap as the first two foregoing methods.

(*d*) *Chemical treatment or jetting by high velocity water*—The removal of mud is fairly difficult and for this purpose some chemicals which disperse the mud have to be used. These are of polyphosphates group such as sodium pyrophosphate, sodium tripolyphosphate, sodium hexametaphosphate or sodium sephtaphosphate etc. which disperse the clay particles and break the jell property. After the chemical treatment, the well is again subjected to surging and back-washing.

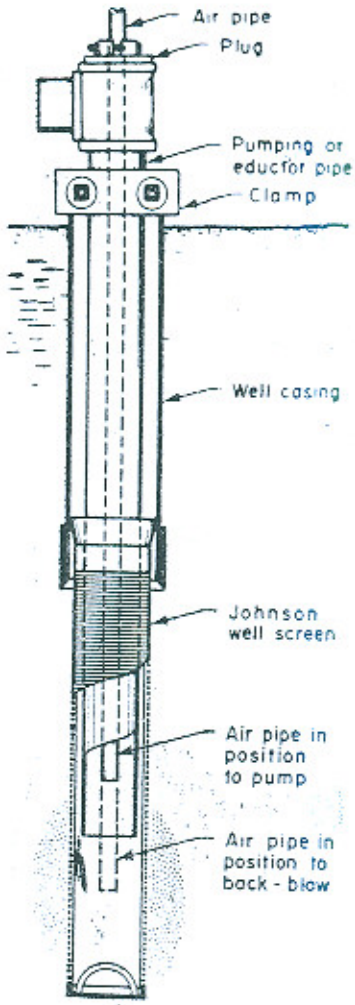


Fig. 29.—Developing tubewell strainer by air line.

A system of high velocity jet impinging on the walls of a strainer is also attempted. This can even be useful for a strainer like coir which has a continuous slot. The strainer with slit having more blind portion

do not respond to jetting so effectively.

Gravel feeding during development

When a tubewell is being developed, readjustment and repacking of the shrouding material occurs. It often becomes necessary to feed additional shrouding at top. An arrangement to feed the shrouding materials during development of the well is necessary.

Maintenance and the yield of a tubewell

In West Pakistan, twenty tubewells were installed in the Karol area in 1938-40. About fourteen hundred tubewells were installed between 1946-1951 under Rasul Tubewell Scheme. A recent (1967) survey conducted to check their performance has revealed that about 65% of the undamaged tubewells are still yielding about one cusec of water although these were designed for two cusecs.

During these thirteen or twenty years of operation the tubewells have continued to incrust, so that the present yield is being obtained with a depression of about 17 feet per cusec although originally it was about 7 to 8 feet per cusec.

These tubewells have brass strainers, 8 inches in diameter, 140 feet in length, shrouded to make the effective diameter equal to 12 and 15 inches. The strainers are put in medium sand only, the fine sand and clay zones are blinded with iron pipe. The depth of tubewells extends from 200 to 350 feet, so that a considerable depth of water-bearing medium is available. These are operated with centrifugal pumps designed for two cusecs. The tubewells work with a low order of suction, have long length of strainers, sufficient thickness of water-bearing medium and are located close to the main canals pumping very good quality water. A few tubewells in Chaj Doab along Lower Jhelum Canal below Sargodha and some in Rechna Doab along Lower Gugera and Burala Branches pumped ground-water of high salinity. Other tubewells installed after 1954-1957 are those in Dera Ismail Khan, Central Rechna and under Scarp-1 Scheme.

A study of performance of all these reveals that a fall in yield of about 2 to 5 percent per year has been noticed in all tubewells and in many cases 40 to 50 percent deterioration has occurred within 10 years of their operation.

This is due to the incrustation of the strainer which blocks the water inlets with time. Some information about the nature of materials found in the incrustation, its chemical analysis and the causes of its formation is explained further.

Incrustation is due :

(*i*) to the deposition of precipitation of carbonates of calcium and magnesium. Some sulphates of these radicals also get deposited. This is a chemical deposition from soluble bicarbonates which are changed into insoluble carbonates when carbon dioxide gets removed on account of the working of a tubewell producing low pressure. Deposition of sulphates also occurs under similar conditions. The deposition of carbonates entraps aluminium silicates and iron compounds along with the particles of the formation. The release of carbon-dioxide also causes the precipitation of compounds of iron and manganese.

Some of the soil silicates can also be sparingly dissolved in the presence of alkalies. These also get deposited with the conversion of bicarbonates into carbonates.

(2) Iron bacteria live in ground-water and are supposed to feed on carbon compounds. Another class of bacteria is that of sulphate reducing organism.

During the life cycle of these organisms, slime which is a sort of slippery jell is produced. The slime entraps particles of the formation, augmenting and quickening the incrustation.

3. All alluvial deposits contain some clay material so that in the presence of alkalies some clay minerals get dispersed into small particles often of colloidal size and which can pass through the pores of the formation and being electrically charged add to the deposition taking place around a strainer.

The combined effect of these chemical, biological electrical changes, is the deposition of materials blocking the slits of the strainer, filling the pores of shrouding and the formation.

The occurrence of these changes is a must. So far means of preventing the incrustation have not been found. No doubt certain action can be undertaken which can delay this defect and make it less serious.

In fact in all the tubewells installed in this country, maintenance has never been given much consideration. A tubewell once installed has not been looked after to maintain its performance.

Apparently to delay the incrustation,

(*a*) a screen with wide opening, of sufficient long length with a proper shrouding and carefully developed, can be helpful.

(*b*) The pumping load and the inflow velocities should be kept as low as possible. A low order of suction will cause less conversion of bicarbonates to carbonates, and less inflow of clay colloids etc.

It means that a low yield and a low depression head prolongs the period of incrustation.

(*c*) Pumping a high discharge with a high depression head from a single strainer quickens the incrustation. The best solution is to reduce the depression head and the discharge. It is thus advantageous to employ multiple tubewells or increasing the number of tubewells with a small output.

(*d*) The most important aspect of maintenance is the periodic cleaning of the well screen. The various methods adopted for this purpose are explained briefly.

Removing of carbonates by Acid Treatment

(*a*) *Use of Hydrochloric Acid*—The carbonates of calcium and magnesium are reacted by Hydrochloric acid. It has a tendency to attack steel and brass. This action can be slowed down by the addition of an inhibitor in the acid. This acid also dissolves to some extent, the oxides and hydroxides of iron and manganese. This needs a high concentration of the acid and it is often necessary to add Rochelle salts to stabilize the acid. This treatment needs a large volume of strong acid, sometimes $1\frac{1}{2}$ to 2 times, the volume of water contained in the well.

The acid is poured through a pipe either of plastic or black iron but not galvanised. The pipe is lowered close to the screen and the acid is poured to replace the water of the screen. The acid is agitated for a few hours. It may be forced out through the screen by a plunger. The outflow and inflow of acid water will react with the incrustation of the screen, in the shrouding and even in the formation.

It is preferable to collect samples of water containing acid to check its concentration and be assured about the action of the acid. In certain cases it may need additional dose of acid and longer periods of treatment after which the acid may be bailed out and tube-well put to operation.

The chlorine content of this acid is helpful to remove slime of bacteria as well. This treatment for a country like Pakistan will be costly as the tubewell strainers to be so treated are 200 to 350 feet deep and contain about 100 to 200 cu. ft. of water. All of this water cannot be replaced by strong acid.

In fact in order to reduce the reaction of the acid on the metallic portion its concentration is reduced to about 20% which is the minimum for a proper reaction.

One acid treatment may cost about Rs. 4000 to 5000 which includes the cost of acid, pouring pipe and operational treatment.

Hydrochloric acid is also injurious to coir string which burns out and loses its strength.

(*b*) *Using Sulfamic acid*—Another acid which has a strong action on removing the carbonates and organic materials is sulfamic acid.

It is quite edifferent from sulphuric acid which is used very occasionally for this type of treatment. Calcium and magnesium carbonates are changed into sulfamates which are highly soluble.

This acid is much less reactant with metals and has little corrosive effect on well casing and other metallic equipment.

It is also solid and does not give off fumes. It has no irritation on dry skin. Its solubility changes with temperature, so that at 60°F it is about 17% soluble. If a large quantity of the acid is added, some of it remains unreacted. When its concentration decreases after reaction, some additional quantity gets dissolved.

This acid has also to be mixed with water by agitating and stirring. It is, forced out through the screen for proper action.

This acid has many more advantages as compared to hydrochloric acid. It is, however, costly than hydrochloric acid but due to its better cleaning qualities its use is preferred.

(*c*) *Chlorine Treatment*—Bacteria form slime which deposits along with iron oxide. Although acid can kill some of the bacteria but it does not remove the slime. Even iron oxide is not easily removed.

The chlorine kills bacteria and also burns out the slime.

Chlorine is obtained from sodium or calcium hypochlorite which is more stable. It loses its chlorine slowly, under a dry state but when added to water it loses its chlorine quite rapidly. It is also available in solid state. Sodium hypochlorite, however, is liquid and it loses its chlorine content very quickly. If this material is to be used it must be very fresh.

It is necessary to have at least 100 to 200 ppm of free chlorine. This concentration can be had by using 0.14 to 0.3 lb of dry calcium hypochlorite giving 0.1 to 1.2 lbs. of chlorine in about 100 gallons of water. Working on this basis the quantity of the salts needed can be estimated. This treatment has to be spread on 12 to 24 hours and also needs surging of solution through the screen.

(*d*) *Use of Polyphosphates*—It has already been stated that polyphosphates such as sodium pyrophosphate, sodium hexame-

taphosphate, sodium septaphosphate etc., are used to disperse the bentonite jell of the drilling mud. Their use in tubewells has the same effect. It disperses the incrusted materials and hence vigorous surging of the solution is very essential.

(*e*) *Use of explosive*—Sometimes it has been found helpful to use the force of explosion to remove the incrustation. Explosive called *Prima Card* has been used to remove the incrustation of iron strainer of tubewell installed in Scarp No. 1. The method was found effective but not lasting. Nearly six months after the treatment, the same conditions appeared.

This technique could be used in strainer made of seamless pipe. It is doubtful to be successful on welded brass strainer or coir string strainer.

(*f*) *Electrolysis for removal of incrustation*—It was found in the laboratory that electrolysis action produced by keeping a central electrode in a brass strainer and passing high current at low voltage, in the presence of oxidising salts, was very successful to remove the incrustation formed after several years of operation of tubewell. After the treatment of some hours exertion of slight pressure was found necessary. This was effected by filling under pressure oxygen and acetylene in a football blader. The explosion was effected by electrical spark. This treatment was found to be very effective in the laboratory.

(*g*) *Addition of strainer to a choked tubewell*—All the treatments are effective to some extent. In fact these should be applied after every year and their timely treatment will not allow the incrustation to become very hard and difficult to be treated. The treatments are also fairly costly and in case of those tubewells like that of Rasul Project which have been kept in position any treatment for years, will now difficult problem.

A simpler and a sure treatment extra strainer to a choked one and it to the centrifugal pump. This is now being tried on Rasul tube yield of which has decreased more percent. With the development coir string strainer and the use materials like plastic, cement asbe technique of renovation appear better and less costly.

Sand Model and Analogic Techniqu

There are many problems of gro flow and tubewell hydraulics which solved by model experiments in a la A common technique is that of san

usually construc of various sha of the problem rovided on one omena with reg r, depression h roper size of the source into a we

tank representin t the apix of inds can be inst At the side of meters are prov ariation. A con rvation combine is often used to arge of a well, etc.

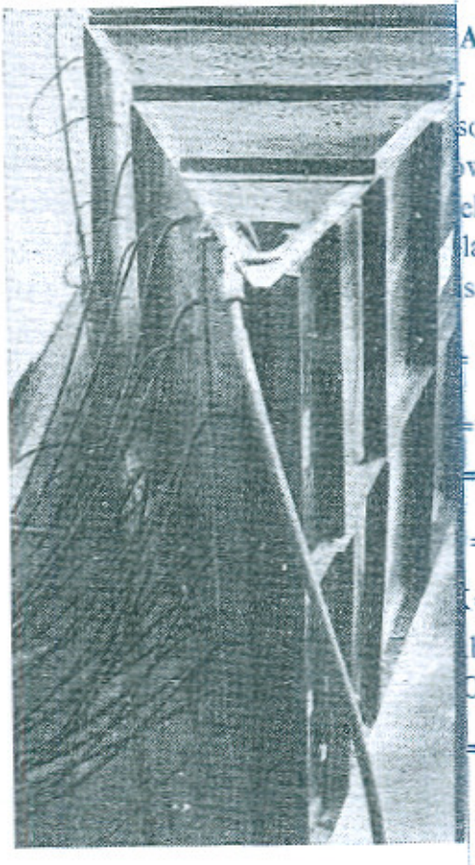


Fig. 30.—Triangular Tank.

Analogy Method

method very c soil flow proble w through a mec electrical potent lates velocity o s expressed as :

$$= K\frac{dH}{ds}$$

=the seepage velo

=piezometric hea

=is the hydraul

=the hydraulic

he flow of el Ohm's law which

$$=\sigma\frac{dE}{ds}$$

=the electric cu

=the pressure the voltage.