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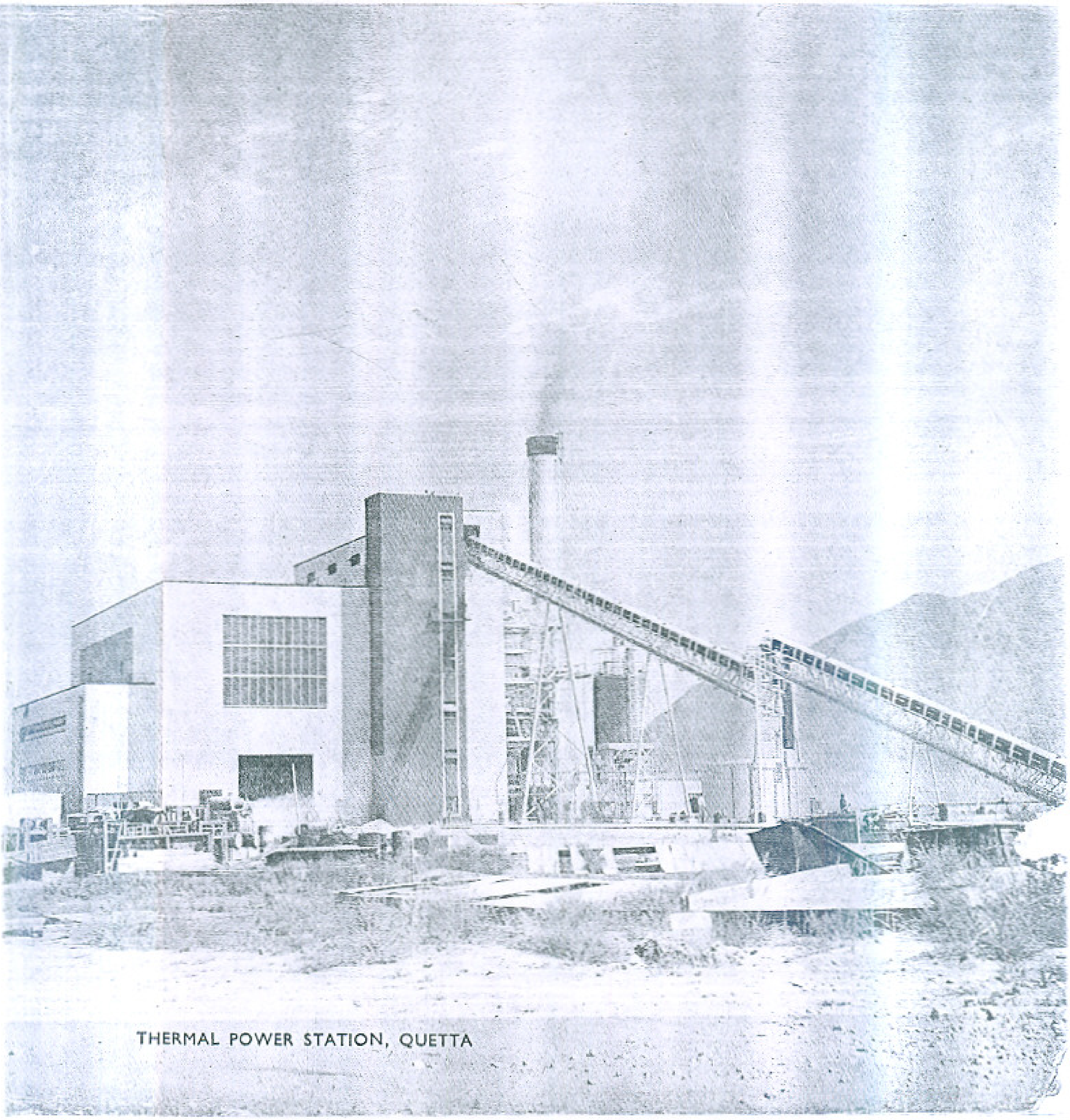
Engineering News



THERMAL POWER STATION, QUETTA

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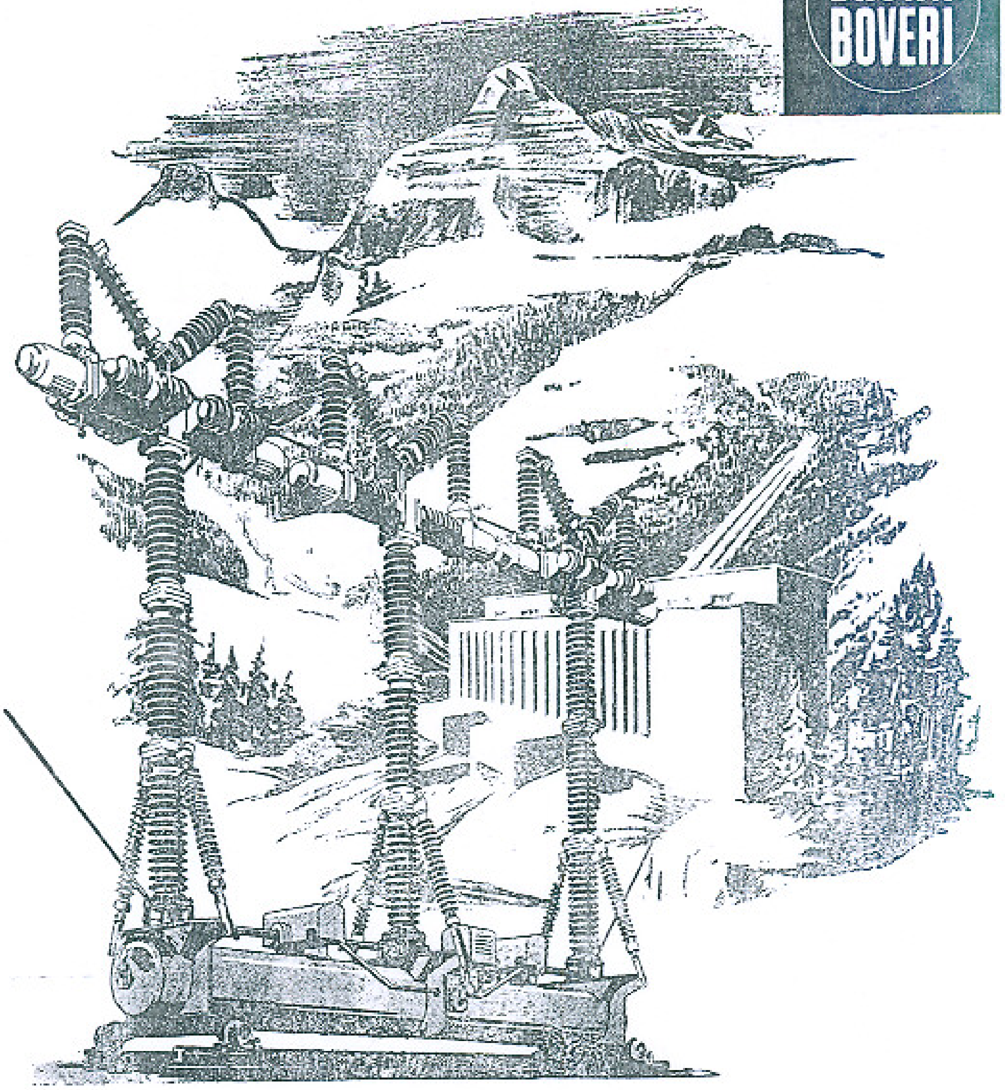

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Vol. IX September 1964 No. 3

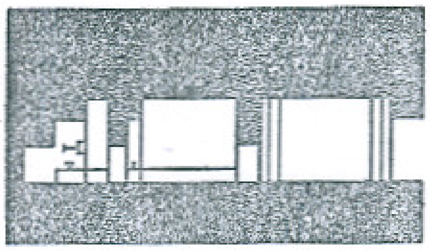
In this issue

Page

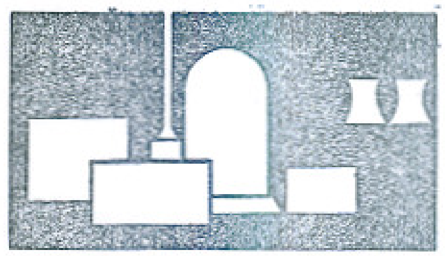
AEG

Electrical Plant and Equipment of all Kinds

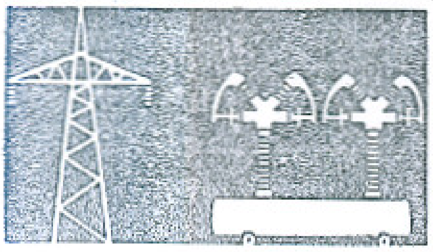
Erection
Manufacture
Design



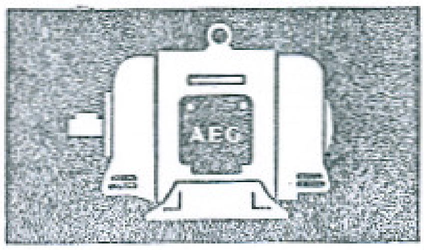
Power Generation



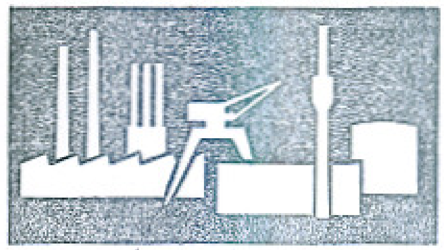
Nuclear Power Plant



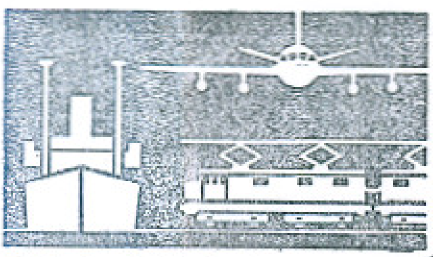
Power Transmission and Distribution



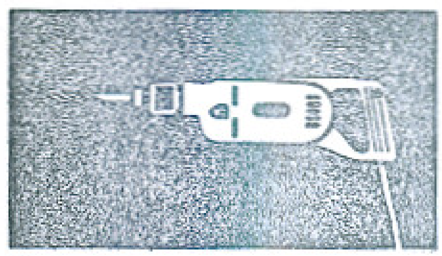
Energy Utilization Equipment



Industrial Plant



Electric Traction Engineering
Marine Engineering
Airfield Equipment



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WAPDA EXPANDS POWER

AS a result of the efforts of West Pakistan Wapda, the country has seen a tremendous expansion of its electrical potential during the last six years. Those who experienced the aftermath of the last Great War, know well the great difficulties one had to face to get a connection for the load of even a few k.w. Whatever meagre power production sources existed in the country, were run on coal, which too was not available in the country. The only hydel power plant in existence was at Joginder Nagar on the Uhl River. This went over to India, and supply from it depended upon the goodwill of India, in spite of an agreement to supply power on cost.

In some other towns of what is now West Pakistan, there existed, before Independence, worn out and dilapidated diesel power plants. The total hydel power generation in West Pakistan was only 20360 k.w., of which 9600 k.w. were being produced at Malakand from the Upper Swat Canal since 1938 and 660 k.w. at Renala from a branch of the Lower Bari Doab Canal. Even with the combined efforts of private companies and the Government, the capacity for power production was only 36324 k.w., which existed at the six cities of West Pakistan *viz.* Shahdara (17450), Sukkur (1241), Quetta (2984), Hyderabad (1600), Multan (6270) and Rawalpindi (6780).

Karachi produced another 24,000 k.w., so that the total power capacity in West Pakistan at the time of Independence was about 70600 k.w., of which 10260 k.w., was from hydel power.

The conditions at the time of Independence became still worse as most thermal stations were coal fired, the fuel supply of which depended upon the discretion of India, or on import from other countries.

The electricity department laboured under numerous handicaps. There was shortage of funds, materials, foreign exchange and personnel. In spite of the concerted efforts of 12 years, before Wapda took over the Electricity Departments in 1959, power production stood only at 116,000 k.w. In these years, the electricity department extended the Malakand Station to produce another 10,000 k.w. in 1951: the Dargai Station was commissioned to produce 20,000 k.w. (1952), the Rasul Power Station started working in 1952 with an output of 20,000 k.w. The three hydel stations raised power production to 52,000 k.w. Another 42,000 k.w. were produced by the thermal stations located at Sialkot (1160), Burewala (1600), Lyallpur (24200), Montgomery (11000), Bhakkar (2200) and Liaqatabad (2120).

This was the condition when the dynamic Wapda came into action in 1959. It is gratifying to find that in less than six years, the power potential has been raised by Wapda to 616,000 k.w. and hydel power has been increased to 205,000 k.w. Hydel Stations of different power potential, like Chichoki Mallian (13200), Shadiwal (13500), Kurram Garhi (4000), Nandipur (13800), Warsak (160,000), and Renala extension (440) have been completed. Thus hydel power has been increased four times since Wapda took over.

Wapda's greatest achievement is the extension of thermal stations, a large number of which have been completed during the last five years. At present, thermal power to the tune of 192,000 k.w. is in production. This is produced at Multan (135,000 k.w.), Hyderabad (21,000 k.w.), Quetta (15,000 k.w.) and Sukkur (25,000 k.w.).

By 1970 Wapda will be producing 620,000 k.w. from thermal stations. This will be after the extension of the Multan Power House by another 132,000 k.w., Lyallpur thermal station producing 132,000 k.w., Hyderabad (23,000 k.w.), Sukkur (25,000 k.w.) and Quetta (7500 k.w.).

Two phases of a thermal station are proposed at Moro/Mari, with a capacity of 299,000 k.w. This will increase the present thermal power production three times.

As for hydel power, Mangla will start producing 300,000 k.w. by 1968 and after the raising of the dam by 50 ft., the power potential will rise to 1100,000 k.w. When Tarbela starts working, it will produce 2100,000 k.w. and its off channel storage will have a power potential of 4000,000 k.w. Thus power planning has been successful and power production satisfactory. The distribution of electricity is another aspect with which Wapda has dealt successfully; but that is a different story. Wapda's achievement in village electrification, extension of transmission to vast rural areas in connection with the tubewell programme, renovation of the obsolete transmission system, are the works of which any organization can justifiably be proud.

Wapda has certainly placed us in the forefront of developing countries. We have extensively expanded our thermal stations. God gave us the free gift of gas, but it is limited in quantity and will be exhausted sooner or later. We should make use of this gift wisely till we tap our permanent resources of hydel power. At present, our hydel production is only 200,000 k.w., just equal to that being produced by thermal stations. By the time we add another 400,000 k.w. of thermal power, Mangla will be ready with 300,000 k.w., and if we are successful in raising Mangla lay another 50 ft., and complete Tarbela, then hydel power will far exceed thermal power. That is how the country should develop. Thermal power plants are easy to construct. They need little engineering skill. It is like a factory to be transplanted. There are no Hydraulic works, no civil works and no serious problems of construction involved, whereas multipurpose projects entail tough engineering problems. However, the country must be prepared to face these. So far we have been getting help from foreign consultants, foreign contractors, and foreign advisers. They have been investigating for us, advising us on machinery and have been helping us in construction and installation. Even transmission towers have been erected under their expert advice.

These conditions must change. After construction of so many thermal stations and completion of hydel generation works, some of our own engineers must have acquired sufficient knowledge and confidence. Let them be entrusted with the responsibility. Let them pool their resources of talent, intelligence and training, and Pakistan will be able to say with pride "Here is an engineering work conceived, designed and constructed, all by Pakistani engineers."

We certainly have such engineers in the profession. They have had the same type of training, they are the products of the same institutions, and they have been taught by the same teachers as foreign experts and advisers, whom Wapda sends for to help us to carry on our development. We look upon Wapda to give our own engineers their due, and entrust to them the planning and execution of all works. This will instil confidence into them, and there is no doubt that they will come up to our highest expectations. And it will be cheaper too.

President of Pakistan Inaugurates Quetta Thermal Power Station

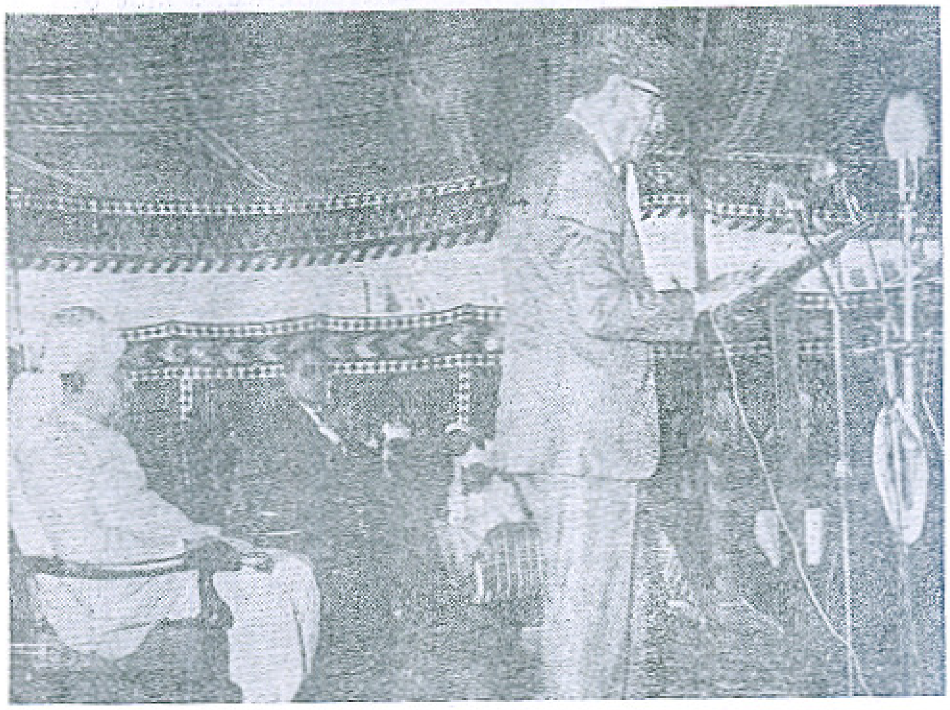
On the 13th of September 1964, Field Marshal Mohammad Ayub Khan, President of Pakistan inaugurated the Quetta Thermal Power Station. He wished the Power Station to have a long and useful life in the service of the people. The President commended the achievements of WAPDA, which "will reshape the economy of the country". Earlier Mr. Ghulam Ishaq Khan, Chairman WAPDA, presented an address of Welcome. We have reproduced below both, the reply of the President and the address of the Chairman.

THE PRESIDENT said, "Mr. Chairman, ladies and gentlemen, Assalamo Alaikum. I am happy to be here to inaugurate the Quetta Thermal Power Station. May it have a long and useful life in the service of people of the this region.

The importance of power in a developing economy needs hardly any emphasis. Its availability and rate of consumption constitute a universally recognized index of economic progress and prosperity of a country. The supply of adequate power at reasonable prices is a prerequisite to any programme for the accelerated development of the economy of an area—especially an under-developed one.

Power is an important infra-structure for the development of industry, exploitation of mineral resources, expansion of agriculture including lift-irrigation, besides its consumption for domestic purposes. The Quetta region is fortunately blessed with an excellent climate and soil suitable for growing of fruits and nuts. The scarcity of water has, however, been a limiting factor. The answer to this problem may be in tapping the underground water reserves on which increasing attention is being focussed by the Government. This region is also rich in mineral resources like coal, chromite, etc. the economic exploitation of which has been handicapped hitherto for want of adequate power. The thermal power station which is being inaugurated today will go a long way to meet these long-felt needs. From now on, this station will supply power for lighting and warming up the homes, development of industry, mechanisation of the collieries and exploitation of the mineral wealth.

My Governor is wedded to the policy of early removal of the economic disparities in



President Ayub Khan delivering his Inaugural Address

the various regions of the country. This project is a step in that direction by way of improving the living standards of the people of Quetta and Kalat divisions, along with the rest of the frontier belt. For the first time the people of this region would enjoy the benefit of power supply at considerably reduced rates. The lower tariff has been made possible by a unified approach to development —a natural corollary to administrative integration.

It was with the intention of formulating sound policies for the development of power in the country that my Government set up a Power Commission. One of the important tasks assigned to it was to suggest measures for the rationalisation of electricity tariff with special reference to the needs of the under-developed areas. The Commission has already submitted its report which is receiving the close and urgent consideration of my Government.

Wapda has been entrusted with a role which will reshape the economy of the country. I am glad to note that the Authority has been discharging this heavy responsibility in a creditable manner. I am also pleased to know that this power station will use indigenous coal. This is as it should be.

I appreciate the generous assistance given by the Agency for International Development which has made it possible for the Government to launch this scheme and bring it to fruition.

Power facilities are now being made available and it will be for the people to make the best use of them to make themselves, as well as this country, happy and prosperous. The people of this area are hardworking who have so far toiled under primitive conditions.

The provision of electric power ought to accelerate their progress and facilitate their achievement of a healthy and prosperous future.

Mr. Chairman, I accept with thanks the fine replica of the Power House you have presented me.

With these words, I have great pleasure in switching on this thermal power station.

Pakistan Paindabad"

Earlier **Mr. Ghulam Ishaq Khan, Chairman Wapda,** presented an Address of Welcome to the President of Pakistan while requesting him to inaugurate the Power Station.

The Chairman said, "Mr. President, it gives me great pleasure to welcome you on behalf of the West Pakistan Water and Power Development Authority, at the formal inauguration of the Quetta Thermal Power Station. For us in Wapda, as also for the people of Baluchistan, this is an occasion for celebration and rejoicing. The Quetta Thermal Station is the first major development project to have been completed in Baluchistan and its commissioning today should usher a new era of economic development and progress into this region. We are happy that by completing this project we have been able to carry another step forward of your programme to improve the living conditions of our people inhabiting the under-developed areas of the Provinces. Their cause has always been closest to your Governor, Malik Amir Mohammad Khan ever since his assumption of stewardship of the affairs of the Province.

Sir, you would be glad to know that this is the eighth power generation project that we have brought into commission since we were entrusted, a little over five years ago, with the responsibility for generation, transmission and distribution of power in the Province, outside Karachi. With the switching on of this power house, the total installed capacity of the Wapda system which was barely 119,000 kws representing an increase of over 400 per cent. During this very period we have also :—

* added 9714 miles length of transmission and distribution lines to the then existing length of 4682 miles;
* connected to the system another 331,000 coasumers—more than the total number we inherited at the time of transfer of the electricity operation to us;
* electrified 1013 new villages raised the total number from 587 in 1959 to 1600 at the close of last financial year;
* increased the total annual energy output from 698 million kwh to 2105 million kwh; and
* increased our earnings from the sale of power from Rs. 4.2 crores in 1959 to Rs. 19.4 crores by the end of last year.

A significant development during this period which is worth a special mention is the change that has been brought about in the pattern of power utilization. Electricity is no longer the twentieth century wonder and luxury to be witnessed in large cities and towns alone; electric power has been and is being taken to the remotest rural areas of the Province and increasing use is being made of it in the long neglected agricultural sector. While five years ago industrial consumers accounted for over 70 percent of the power sold by Wapda system, with general consumers, mostly concentrated in urban centres, coming next with about 16 percent and agricultural consumers trailing behind with 11 percent, agricultural consumers today, even without counting the rural household consumption, are using about 29 percent of the total power sold. In fact, the rate of consumption in the agricultural sector has increased by 670 percent compared to the overall increase of 249 percent in the consumption of electricity since 1959-60.

These developments represent a rate of accomplishment in five years practically in all departments of power generation, transmission and distribution which is equal to or greater than what was achieved cumulatively during the previous 40 years. It is no more chance, Sir, that this period of phenomenal growth in the power industry should coincide almost exactly with the period of your administration of the country. What we have been able to accomplish is the direct outcome of the conscious emphasis you have been placing on economic development as a national endeavour and the active support and encouragement that the key infrastructure sectors have received under your guidance at the hands of your Government, both at the Centre and in the Province.

The Power Station which you are going to inaugurate, Mr. President, has a total installed capacity of 15,000 kws and inclusive of the cost of, for the time being limited, transmission and distribution system has been completed at a total cost of Rs. 4.12 crores. The project was engineered by the Kuljian Corporation of Philadelphia, U.S.A., and its foreign exchange cost was met out of a 6 million dollars credit afforded by the Development Loan Fund (now Agency for International Development) of the United States Government. The Loan is repayable over a period of 25 years and bears a rate of interest of 3.5 per cent per annum. I would like, Mr. President, to avail of this opportunity to express our gratitude to the United States Government for the generous assistance we have received not only for this but for a large number of our projects.

On this occasion it might also be of interest to recall that although this project, reckoning from actual job site construction to commissioning, took us less than two years to complete, despite two winter seasons with temperatures as low as 5 degrees Fahrenheit and despite the fact that one of the ships carrying the last consignment of vital equipment and machinery was impounded for months in the New York harbour in connection with some insolvency proceedings taken out against the shippers, it took us much longer to complete the preconstruction location and design studies and to establish the technical feasibility and economic viability of the project.

Steam power stations of the conventional design require enormous quantities of water for condenser cooling and make-up to locate which it was necessary to undertake extensive groundwater studies and drilling. The only source of relatively inexpensive fuel on which we could base a thermal plant was the local coal but here again limited development of the coal mines at that time handicapped accurate, appraisal of the quality and quantity of the available fuel.

The water problem was finally solved by discarding the conventional open circuit cooling in favour of the "dry cooling" method which, using a closed system, utilizes the same water over and over again. Such a system can be easily sustained by the 350 gallons per minute yield of the two tubewells which we have successfully drilled at the Sheikh Mandah site exclusively for this purpose. The dry cooling system as adopted at this power house is the only one of its kind in the whole of Asia and the fourth in the entire world.

The equally formidable problem of efficient utilization of the low grade sub-bituminous local coal, which has a high sulphur content and is subject to slacking and spontaneous combustion, was solved by designing the furnaces with spreader-type stokers and travelling grates, and by providing for a re-injection system which can return the unburnt coal particles and soot to the furnace before the furnace gases pass out into the stack.

As other important features of the plant, centralised automatic controls have been installed to ensure efficient, reliable and safe operation of all important equipment under all conditions and loads. A completely co-ordinated combustion control system, for example, regulates stoker operation, furnace-grate travel speeds and enforced and induced draft fan output for efficient combustion at all loads. The coal and ash handling system are similarly safeguarded by co-ordinating controls and interlocks to prevent damage or hazard to property and persons in the event of any malfunctioning. No safety feature has been overlooked in the design of the plant.

Sir, the Quetta Power Station is a small station and is one of the smallest that Wapda has built. In power starved Baluchistan, however, it would be a veritable giant. The region, as you know, Sir, is rich in mineral and agricultural resources. The Quetta Valley in particular is noted for the excellence of its fruits and nuts and the mountains skirting the valley have rich deposits of coal. For want of reasonably priced electrical energy, however, these resources are, for the time being, only partially and rather inefficiently exploited. For the first time in the history of this region a plant will be available which will be transmitting energy to other than strictly local areas making it feasible not only to replace the meagre supply of high priced energy provided by the small, obsolete or obsolescent diesel units of the Quetta Electric Supply Company, but also to provide adequate power desperately needed for the mechanization of the coal mines, for increased industrial uses in the grid area and, what is perhaps of still greater importance, for operation of irrigation pumps.

For the time being our 66 kv grid extends to the sub-stations, one near Quetta City, another in the irrigation belt near Pishin, towards the north and the third in the coal mine area towards the East from where 45 miles length of 11 kv distribution lines will supply power to villages, industries, coal mines and irrigation pumps. During the course of the next year or so, we intend to extend power supply to Mastung in Kalat Division and a number of other local areas.

In the interest of general economic development of the region and in order to confer on the people of Baluchistan the same degree of benefits as accrue to consumers from the availability of reasonably priced power in the rest of West Pakistan we have devised, by reducing our profits to the minimum, a special tariff for the Quetta Thermal Project. Under this tariff power will be supplied to domestic consumers at the average price of 23 paisa per unit (30 paisa for the first 20 units and 17 paisa for the balance) against the current price of 44 paisa for lighting purpose and 20 paisa for small motors; at 11 to 14 paisa to industrial consumers and at 10.5 paisa to agricultural consumers against the present rates of upto 19 paisa per unit. It gives us in Wapda a sense of happiness that we should be able to supply thermal power to agriculturists in this region at a price which is almost comparable with the very low price at which power is sold to agricultural consumers in the rest of West Pakistan, where the main generation is hydel. In the context of tariffs, I might also mention that the present price of coal on which we have based our tariff is unconscionably high. If coal prices are brought down, and with the mechanization of coal mines it should be possible, we may be able to reduce the power rates still further.

According to the power market survey that we carried out sometime back it was estimated that the initial energy output of this power house will be sufficient to meet the requirements of the people of this region until 1969. Power, however, creates its own demand, and the demand for power throughout the country is growing so rapidly that hardly we complete a power project when the need for its extension begins to be felt. Judging by the number of applications that we have already received for power supply, this, we are afraid, is exactly that is going to happen at Quetta. We have accordingly put arrangements in train for adding at least another 7500 kws capacity to the station by 1967.

Sir, the successful completion of this project has been the result of the untiring efforts of our staff in the Power Construction Wing and the Engineers of our Consultants, the Kuljian Corporation and the Contractors, Messrs Motherwell Bridge Co., Gustav Hersch, Herman Mohatta and Interhoms, who had to labour against heavy odds in a difficult terrain and in extreme climatic conditions. The Authority wishes me to avail of this opportunity to publicly acknowledge our appreciation of the good work done by them all. In particular we would like to bring to your notice the outstanding performance of Mr. Lewis E. Hussain, our Deputy Chief Engineer, Power Construction, but for whose knowledge of thermal power plants, and his unremitting zeal this project would not have been completed within the time in which it was done.

And finally, Mr. President, I would like to express on behalf of the West Pakistan Water and Power Development Authority our deep sense of gratitude for the great interest that you have always taken in our work. Much of what we have accomplished would not have been possible but for the support that we have received from your Government and the benign guidance and encouragement that we have been getting from the Governor, West Pakistan. We are grateful that on the present occasion, as on many past ones, you were gracious enough to find time, in spite of your preoccupations with the affairs of the state, to preside over this function.

May I now request you, Mr. President, to honour us by switching on this power house and to permit me to present to you as a humble token of our regard and esteem and as a memento of this day dedicating yet another of Wapda projects to the service of the nation a small replica of this power house.

Power Needs Planning Ahead

By **CH. ABDUL HAMID,**
General Manager (Power) WAPDA.

In 1959 the power demand of Grid area was 100 MW which after five years rose to 274 MW and the present peak demand has gone up to 374 MW. By the end of Third Five Year Plan, the power in the main Grid area of Northern zone is expected to go up to 929MW. The demand for power always lends to outpace availability. Wisdom lies in catching time by the fore-lock and our future plans must ensure that at no stage in our growing economy, there will be shortage of power. This was stated by Ch. Abdul Hamid, who is planning ahead for our Power needs.

Power Needs Planning Ahead

In the Third Five Year Plan, special emphasis has been laid on the development of heavy industry in Pakistan. Prior to independence, West Pakistan was an area known mainly for its agricultural produce. Therefore on the birth of Pakistan a great void suddenly appeared in so far as the existence of industries of any description was concerned. However, it was not long before the Government took cognizance of the situation and realised the urgency of establishing certain basic industries in the country.

In order to infuse interest and create confidence among those who were in a position to invest money in setting up industries, the Government initiated the building of certain type of industries in the public sector, through the agency of PIDC. The measures were crowned with great success and soon private capital began to be employed in industries of various kinds. At this juncture some people started expressing doubt on the advisability of pursuing a policy of industrialisation in the country. They counselled that more stress should be laid on agricultrual development instead. There is no doubt that since bulk of our population is dependent on income from land, agriculture had of necessity to remain the mainstay of our economy. At the same time if the country was at all to bring up its standard of social and economic development to a reasonable level and thus gain a respectable place in the comity of nations, it was imperative that not only should it become selfsufficient in the production of certain basic goods but that it should also be able to trade with foreign countries in the export of our own manufacture. This would on the one hand reduce our foreign currency expenditure and on the other enable us to earn more foreign exchange, which would enable us to purchase such capital equipment and plants, from abroad, which we were not able to manufacture ourselves.

During the Second Five-Year Plan, through sound and farsighted policies, adopted by the Government our trade balances improved considerably and each day saw more and more of our requirements of goods and materials, hitherto imported, being fulfilled through indigenous production. This encouraging state of affairs led to our thinking in terms of local manufacture of even heavier goods and equipment during the Third Five-Year Plan period. Hence the stress on heavy industries envisaged during this period.

Economical Supply of Fuel and Power

Industrial development is inseparably linked with abundant and economical supply of fuel and power. No industry can survive, let alone thrive, if these essentials are wanting. While focussing our attention and efforts on the development of heavy industry, simultaneous development of electric power cannot therefore but receive a high priority. It is often said that the economic and social standard of a country can be measured through its consumption of electricity. This has in fact come to be quite universally accepted. Our experience in the past few years has shown beyond doubt that whenever and wherever adequate power has been made available rapid expansion in all sectors of development has taken place. The benefits of this facility have encompassed not only the industrial establishments but also in a very large measure the agricultural activities.

The part which electricity is playing and will continue to play on an ever increasing scale, in the reclamation and development of land, is so outstanding and important that it is bound, one day, to revolutionise our entire agricultural economy. Electricity will always be the key-note of our national advancement whether in the field of agriculture or industry. Not very long ago there was school of thought that the power requirements of the country were being overstated and that valuable capital was going to be unnecessarily locked up in schemes from which full advantage could not be derived, as power would actually not be used in the quantities anticipated by those responsible for the initial planning of such schemes. Such reservations of opinion can still be heard at times but it needs to be carefully and objectively examined whether there has in fact been any lop-sided thinking in the planning of power development schemes.

Limitation of Warsak

Way back in the years 1953, 54 and 55, opinions were being expressed in certain quarters that with the completion of Warsak Hydro-Electric Scheme all the power needs of at least the Northern region of West Pakistan would be satisfied for the next 10 years or so. PIDC was at the time engaged in promoting a scheme for installing a 135 MW Station, Multan. After a good deal of discussion and arguments the Scheme was finally approved for only one 60 MW unit and one 30 MW unit. When the tenders were received, however, it transpired that within the sanctioned amount of the scheme two 65 MW units could be purchased.

Consequently the first phase of Multan Power Station was completed with two units each of 65 MW plus a house-set of 5 MW Gas turbine. With the creation of a generating capacity of 135 MW at this Station and the installed capcity of 160 MW at Warsak, it appeared that we were all set for a number of years to come. But events began to move differently and we were soon roused out of this complacency. Warsak power in winter was found to be limited to 90 MW. At the same time the demand in the Northern Zone began mounting up in an unprecedented manner. A quick appraisal of the situation resulted in WAPDA'S initiating the scheme for duplication of Multan. Vigorous efforts on the part of WAPDA enabled the scheme to be approved and two additional units of 65 MW each were installed at Multan which went into commercial operation a few months back. Meanwhile, the load curve continued bulging upward till a maximum demand of 374 MW was registered last month on the Northern Grid. As against this the aggregate safe firm capacity of all Power Stations connected to the Grid is only 379 MW, so that even with the duplication of Multan and the contribution of Warsak, Dargai, Malakand, Rasul, the 3 canal-fall Hydel Stations, Montgomery Thermal Station and other odds and ends, we are today dangerously approaching the safe firm capacity of the system. The Scheme recently sanctioned for locating 130 MW Thermal Station at Lyallpur is scheduled to be completed towards the end of 1966. Thus it will be over two years still before any additional generation becomes available on the Grid. Obviously the situation is fraught with uncertainty till then. Some corrective measures are being planned and it is hoped that it would become possible to tide over the period till Lyallpur is commissioned and later on till Mangla comes in.

In recapitulating the power position on the Northern Grid what is actually meant to be conveyed is that very rapid increase in power demand is being evidenced throughout the country. People are clamouring for new connections. Commercial establishments, industries—big and small—and large number of private tubewell owners are striving to get power, so much so that it is becoming difficult to keep pace with their demand. A similar story is being repeated in areas other than those served by the Northern Grid such as Hyderabad, Sukkur and even the out-of-the-way place like Quetta where the newly built 15,000 KW Power House is. In all these places plans have had to be taken in hand to augment the existing generating plants although at Sukkur and Quetta even the initial units have not been commissioned as yet. These developments leave hardly any doubt in our minds that for many years to come the demand for power will always tend to out-pace availability. Wisdom lies in catching time by the forelock and our future plans must ensure that at no stage in our growing economy there will be any shortage of power. If at any stage we are constrained to resort to such restrictive measures as load shedding it is bound to give a rude and unpleasant set-back to our progress and will cause frustration among those who are investing their capital in projects with the hope that they will be able to operate them uninterruptedly. Their production must not be allowed to suffer due to prolonged power rationing or shortages of supply.

Greater Demand for Power

The next five years will see our local industry assume bigger proportions. This would necessarily call for the laying of larger electric supply installations, enabling more power to be given to a larger number of consumers and over widely spread areas. Large blocks of power will be required for the various salinity and reclamation schemes presently being planned for execution in the next five years throughout West Pakistan. For the uplift of rural areas a village Electrification Scheme is being launched for supplying power to some 5,000 villages during the course of five years. A scheme for electrification of a part of West Pakistan Railway system is also being planned by the Railway authorities. All these developments point to large requirements of Power. WAPDA has carried out a projection of probable demand in future years as realistically as possible which indicates that by the end of the Third Five-Year Plan our requirements of power in the main Grid area of Northern Zone alone will go up to 929 MW. Comparing this with the peak demand touched in the last month of the year of 374 MW can give an idea of the extent of expansion that needs to be carried out to meet the anticipated future demands. The rapidity with which the demand has increased is evident from the fact that in the year 1959 the maximum demand of grid area was only 100 MW and in a matter of just under five years has increased by 274 MW. The country is very well placed so far as natural resources are concerned. In the North there is a very large potential of hydro-power and in the South the gas fields discovered so far can meet our requirements of fuel for a long time to come. This happy combination of hydro and thermal would make our electrical system both stable and flexible. Investigations are already underway to have an inter-connected system throughout the length of West Pakistan. With careful and advanced planning the country can be well equipped with the facilities of electric power so essential for the development and prosperity. Necessary provision has been made in the 3rd five year plan for Generation, Transmission and Distribution schemes to meet the anticipated power needs during this period and with the availability of adequate funds at the appropriate time there should be no problem in the way of achieving the desired objective.

Engineering Features of Quetta Thermal Power Station

By I. A. S. BOKHARI,
Planning and Development,
Sunny View, West Pakistan, Wapda.

Quetta Thermal Power Station was formally switched on the 13*th of September,* 1964 *by the Field Marshal Mohammad Ayub Khan, President of Pakistan. This station with the present installed capacity of* 15,000 *k.w. which can be doubled later on, is the only one of its kind in Asia and the fourth in the world. It is a coal fired and steam utilizing power plant yet consuming the least amount of water.*

In this article Mr. I. A. S. Bokhari of Pakistan Wapda has described the engineering features of the station.

Quetta had Power in 1891

Apart from the fact that Quetta had the first Power House in the entire Province of West Pakistan installed as far back as 1891, (Lahore had its Power House in 1910) this area seems to have relapsed into a state of "lightlessness". But now Quetta is very much on the power map once again as a new Thermal Power Station has recently been set up and commissioned. Here follows an account of the Project explaining its scientific and engineering aspects, its salient technical features and economic benefits.

History of Investigations

Pakistan Industrial Development corporation was initially entrusted with the task of investigating and preparing a feasibility report and the cost estimates for the Quetta Thermal Power Project but till the transfer of Electricity Department to Wapda in April, 1959, very little had been done by the executing agency. Wapda had thus to start from *ab initio*.

Investigations had, therefore, to be carried out before taking concrete action. M/s Kuljian Corporation of Philadelphia, U.S.A. were appointed Consultants in 1959 for this job. Their immediate task was to prepare a feasibility report and estimates of foreign exchange requirements necessary for the execution of the project. This firm remained associated with the Project from the beginning to its completion and initial operation.

Sheikh Mandah Site Selected

The selection of the site proved to be a tedious task. A site was chosen on Sariab Road, eight miles from Quetta where two tubewells were sunk, but the yield of water was inadequate. This site had to be rejected. Another one was chosen near Sheikh Mandah Railway Station. Investigations carried out justified its selection because of the suitability of foundation soil and adequacy of water. An additional advantage of the site was that it was very close to the load centre and was accessible by rail and road, so that heavy equipment could be transported easily.

Design of Structures

The project is spread over an area of 63 acres in which the colony for the maintenance and operating staff is also located. The buildings are designed to withstand the earthquake shocks which are frequent in this part of the country. The power station sub-structure and the plant foundations are supported on spread footings on reinforced concrete. The superstructures are fully encased in steel frame. Winter in Quetta is severe. As a precaution against it, the outer walls are made of hollow concrete blocks tied-in with steel bars at 5 feet intervals. On the roof, precast concrete blocks have been used. These are made waterproof with bituminised felt followed by a cushion of 6 inches foam concrete and a layer of concrete. The foam concrete is again for protection against severe winter.

Boiler structure is outdoor type except for the operating tower which is enclosed the main building consists of the turbine room, control room, water softening and battery charging rooms, a gallery for boiler appurtenances and coal silos. The 11,000 volts switch-gear is housed in self-contained console. Other structures like the cooling tower and the switchyard are placed adjacent to the main building.

Design Features

This power house is the only one of its kind in the whole of Asia and the fourth in the world. It has been designed to utilize the local resources, and works with the scarcity of water. Coal locally available is the main fuel for the station. Its present installed capacity is 15,000 k.w. There is a provision in the design for extension to 30,000 k.w. at a later stage when power demand will increase.

Steam Turbines

There are two turbo-generator sets of 7500 k.w. each. These are manufactured by the Delaval Steam Turbine Company and run at a speed of 3000 r.p.m. The turbine has 18 stage horizontal shaft and 3 stage extraction for feed water heating. It is designed to operate on a steam pressure of 600 P.S.I.G. at a temperature of 825°F, exhausting to a direct contact type of condenser. A centrifugal governor, hydraulically operated, adjusts the speed of the turbine. It is a steam admission valve and it maintains the speed within ±5 per cent under sudden load throw or shut off. An independent over speed trip is also provided to guard against failure of governor control. It shuts off the main throttle valve, if the speed of the turbine reaches 3300 r.p.m.

Alternators

The alternator has a continuous capacity of 9375 K.V.A. at unity power factor. It is of Electric Machinery manufacture. It delivers 3 phase, 50 cycles per second alternating current at 11,000 volts. The generator is fully enclosed and the cooling is done through ventilating fans attached to both the ends of the meter. The fans suck cool air through water tube coolers mounted horizontally by the sides of the stator.

Steam Boiler

There are two steam boilers manufactured by Riby Stoker Company, each having a capacity of 80,000 lbs of steam per hour at a pressure of 625 P.S.I.G. and temperature of 835°F. The fuel used is the coal. This is fed by means of an automatic coal conveying system. It is capable of delivering coal into the overhead silos at the rate of 50 tons per hour. The silos can store 720 tons of coal which is sufficient to feed the boilers for approximately one week. The accessories provided are the boiler feed pumps, induced and forced draft fans, soot blowers and steel stacks. These are common auxiliaries of a boiler. Bailey Meter Control System caters for instrumentation and automatic control of fuel and air.

An ash hopper is provided immediately underneath the boiler for the removal of ash. It is removed with the help of an ash conveyor system which has a capacity of 15 tons per hour. A water spray is applied to the ash, to eliminate the danger of air pollution before removing it.

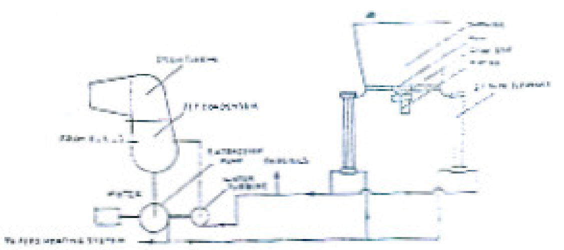
In this region water is scarce.

A steam power plant ordinarily requires huge quantities of water for the cooling system. For this reason the station site is selected proximate to a river, lake or any other perennial source of water required cheaply for condensing the exhaust steam for reinjection into the boiler.

In tropical countries like Pakistan, the quantity of water required for carrying away the rejected heat through the conventional surface condenser is considerable. In a medium sized steam generating station the optimum efficiency that can be achieved under most favourable conditions is in the neighbourhood of 33 percent which means that out of the total heat that is released by bringing fuel for generation of electricity, 67 per cent has to be carried away. The requirement of cold water is, therefore, high and it is not always possible to run into locations where this requirement can be met easily; often water has to be pumped over long distances for the purpose, which is expensive and recurring expenditure on maintenance can also become formidable.

Quetta being water scare area the setting up of the station depended upon assured ample supply of water. This problem was attached from two angles, by exploration a site was determined about a mile from the station wherein two tubewells each giving 2.5 and 1.5 cusecs respectively were installed. Secondly, a device of condensing steam called dry cooling system was adopted to restrict water quantity.

The dry cooling system was first introduced by Dr. Lazlo Heller, Professor, Budapest Polytechnical University and is known as "Heller System".



The process of this system is explained in Figure 1. The turbine is exhausted in a low pressure jet condenser which is fitted with nozzles to spray cold water against the flow of steam and thus forms the condensate by direct mixing.

The condensate is withdrawn from the condenser by means of extraction pumps wherefrom a portion needed for cooling is piped to air cooled heat exchangers and the remainder to feeding system. The heat exchanging elements constitute of aluminium tubes, designed specially to transfer heat at high rates to the air and for this purpose are located at the base of natural or air draught cooling towers. The water from heat exchangers after it is cooled re-enters the spray nozzles of condenser completing the cycle. Throughout this process the cooling water remains confined to a perfectly closed circuit and thus all evaporation losses are eliminated which are inherent in the conventional type of cooling systems.

The requirements for water are worked out on the basis of temperature and pressure of steam and the desired cooling.

The quantity of water needed for boiler is 360 gallons per hour. This estimate is based on the quantity of stream needed to be fed to the boiler and its output.

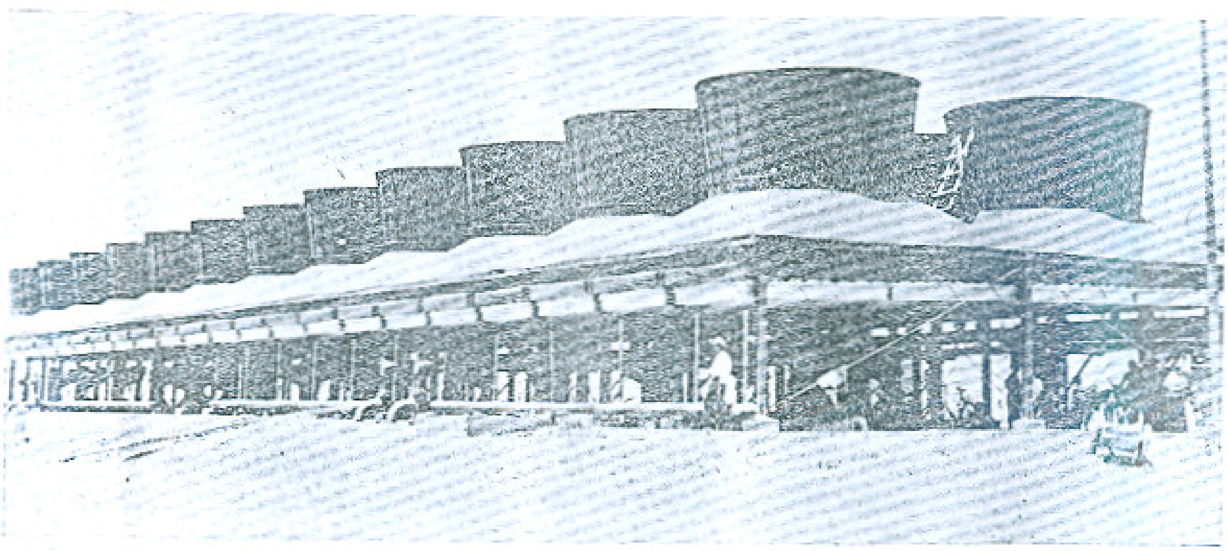
The quantity of steam fed to the boiler is 78130 lbs per hour and the output is 76299 lbs per hour to Turbine and 300 lbs per hour to condenser air ejector so that the loss is 78130 – 76299 = 1531 lbs per hour.

When two boilers are working to produce 15,000 k.w. then the steam to be made up is 3062 lbs per hour or 360.2 gallons per hour. This is the quantity of raw water needed.

Similarly for cooling water as the weight and temperature of exhaust steam is 60053 lbs per hour at 114°F and the temperature of cooling water at spray nozzle is 104°F. The quantity of water to be handled is 66143 gallons per hour and if 2% water is lost by evaporation, the water to be made up will be $2/100 \times 66143 = 12322$ gallons per hour.

The water needs for the two systems of boilers a conventional type and the dry cooling type is shown below.

Thus in this system the water consumption has been brought down from 453.2 gallons per minute to 20 gallons per minute.



Dry cooling system, specially adopted at Quetta for the first time in Pakistan

By this method there is no danger of pollution of water, atmosphere is not humidified etc. The jet sprays condense the steam as it is discharged downward, after cooling from the turbines into the condenser. The combined condensate and cooling water is then pumped back into the two systems, greater amount going to the cooling towers and smaller to the boiler heating system. At the cooling towers water passes through a series of horizontal heat exchangers. Air is drawn through these exchangers by inverted fans and exhausted through steel stacks specially designed to regulate the draft in order to avoid freezing damage in the event of a shut down.

Devices have also been laid to drain the water to an underground tank. This way the treated water is not allowed to go waste. Precautionary devices have also been installed to avoid the freezing of water during operations.

Generation and Transmission System

Power is generated at 11,000 volts. The auxiliary power is supplied at 380 volts on unit system through directly connected unit transformers. The 11 KV station bus is connected through air circuit breakers placed in an enclosure outside the station building. Two 11 KV feeders are branched off for supplying power to nearby areas and to two International General Electric Power Transformers having a capacity of 12 MVA each installed in the station yard. The transformers step up the voltage to 66,000 volts for transmission purposes. This stepped up voltage of 66 KV is transmitted on lattice steel pylons in two directions to Yaru on Chaman Road and to Quetta town and onward to Coal mines. Step down sub-stations are provided at Quetta, Yaku and Coal mines. Quetta sub-station is meant to supply power to Quetta town through the Quetta Electric Supply Co. by stepping down 11,000 volts to 3300 volts. The coal mines sub-station caters for power supply to PIDC, Habib Ullah, Mir Qadir Bukhsh and a number of other coal mines. Sub-station at Yaru is meant for supply of power to Pishin town and the surrounding irrigation tubewells.

Costs

The cost of the entire project including roads, paths, and housing facilities for the operational staff, transmission and distribution network has been worked out at Rs. 4.12 crores of which the foreign exchange component is Rs. 2.04 crores. The foreign currency cost has been partly financed thorugh a loan of 6 million sponsored by the U.S. AID.

The major items of expenditure on the full project are worked out in percentages and actual cost in lacs as below:—

	Percentage of total	Cost in Lacs
1. Colony and Preliminaries ..	6	25
2. Civil Works ..	12	49
3. Cooling Towers ..	3	12
4. Boiler Plant ..	9	36
5. Coal and ash handling system ..	1½	6
6. Turbine Plant ..	12	49
7. Electrical gear ..	6	28
8. Erection of the plant ..	7	29
9. Transmission and Distribution System ..	13	54
10. Freight and Insurance ..	6	25
11. Interest charges ..	6	25
12. Consultant's supervision ..	8	32
13. Departmental supervision ..	½	2
14. Audit and accounts ..	1	4
15. Government levies ..	9	36

Contractors

The contracts for the civil construction and mechanical erection of the Power House were awarded to Messrs. Motherwell and Bridge of Pakistan. The contract for the electrical installation in the Power House was awarded to Gustav Hirsch of U.S.A. and for laying the transmission lines and sub-stations to Inter-home Traders and Construction Ltd., Lahore, Pakistan. The date of completion and commercial operations of the power house was originally fixed for December, 1963, but on account of unavoidable circumstances it was delayed by about seven months. The power house has been supplying power to Quetta Town since 14th August, 1964.

Benefits

Both Agriculture and Industry will boost in the region due to power supply from this Project. Domestic consumers will also benefit from this on account of regular stable and adequate supply of current. More avenues of employment will appear. Production of coal is also expected to increase manifold.

Below we have added the technical data pertatining to each aspect of the construction.

TECHNICAL DATA

(a) Turbo-Generators

Turbines

Manufacturers	Delaval Steam Turbine Co.
No. of units	2
Speed	3000 RPM
No. of stages	15
Steam Inlet Pressure	600 PSIG
Exhaust Pressure	2.3" Hg (Obs)
Rotation	Counter clockwise
Over-speed trisetting	3300 to 3360 RPM
Steam to Auxiol Pump	490 Lbs/Hr. at 600 PSIG. and 825°F

Generators

No. of units	2
Manufacturers	Electric Machinery
Power rating	7500 KW
Volts	11,000
Amps. (Stator)	492
Amps. (Field)	170
Power factor	0.8
Cycles	50 c/s
Speed	3000 RPM
Cooling	Air cooled by suction through water tube coolers

Exciter

Type	Shunt wound
Capacity	50 KW
Speed	3000 RPM
Operating voltage	350 volts
Max. amps.	200
Main field resistance	90 at 28°C

Voltage Regulator

Manufacturer	Westinghouse
A. C. operation voltage	120 volts

Heat Exchangers

Total fluid entering each unit	6,250,000 lbs hr.
Temp. in.	114 °F
Temp. out.	104°F
Operating pressure	30 PSIG
Heat exchange	62,500,000 btu/hr.
Fans	12 ft. dia.-9 blades.

Boilers

Manufacturers	Riley Stoker
No. of units	2
Type	Spreader Stoker
Fuel	Indigenous coal
Operation Pressure	625 PSIG
Temperature	825°F at Superheater outlet

eed water temp.	360°F
Heating surface	645 sq. ft.
Maximum drum design pressure	700 PSIG

Boilers equipped with Turbular Air Heater with By pass, mechanical dust. Collections, Spreader Stokers, F.D.I.D. Fans totally enclosed Fan cooled motors.

Boiler Feed Pumps

No. of units	2
Capacity	200 g.p.m. at 259°F.
T.D.P.	850 PSIG
Motor	150 H. P.

Condensate Pumps

Capacity	150 g.p.m.
Speed	3000 RPM
Motor	15 H. P.

De-Aerating Evaporators

Manufacturers	Griscom Russel
Rating	5000 lbs. Vapour/Hr. for water at 80°F

Cooling Towers

Manufacturers	Baldwin Lima
Sections per unit	Hamilton 12
Total surface per unit	398,736 sq. ft.

Condensate Circulating Pumps

Rating	6325s gallon per minute
Speed	750 RMP
Motor	150 H.P.

Deep Well Pumps

Manufacturers	Byron Jackson
Capacity	100 g.p.m.
No. of stages	13
Motor	10 H.P.

Condensate Tank

(Bothlehem Steel)

Diameter	26 ft.
Height	15 inches

Condensate Transfer Pumps

Capacity	25 gpm.
Motor	20 H.P.

Power House Crane

Manufacturers	Whitting Corporation
Capacity	40 tons.
Span	51 ft.
No. of hoist	one.
Bridge speed	125 ft/min.
Hoisting speed	13 ft/min.
Trolley speed	120 ft/min.

Coal Handling System

Manufacturers	Link Belt
Capacity	50 tons/hr.
Belt speed	250 ft/min.
Coal bunker	720 tons
Coal crusher	Rolling ring type
Belt feeder	20 ft. per minute

Ash Handling System

Manufacturers	Allen Sherman Hoff
Capacity	15 tons/hr.
Silo size	50 tons drig ash.
Rotary ash conditioning unit	2.5 tons/hr. (unloader) revolving drum type with drive and water spray nozzles 3000 lbs. Steam/hr. at 150 Psig.

Diesel Generators

Manufacturers	Cumins
No. of units	2
Capacity	250 KW each

Reducing Evaporation with Monomolecular Films

By **NAZIR AHMAD AND MOHAMMAD SARFRAZ**

West Pakistan is faced with a problem of conserving water resources. Its millions of cultural acres need water. All its present sources of river waters are fully utilized except those which run off to the sea during flood season. A large volume of water is at present being wasted either as evaporation from free water surface or by evapotranspiration by plants grown in high water table or from land kept fallow.

In this paper attention is drawn by the authors on the possible saving of water lost by evaporation from free surface by using chemicals which spread like a film on the water surfaces reducing evaporation. Although no original work is quoted but experience of other countries is discussed for reducing evaporation.

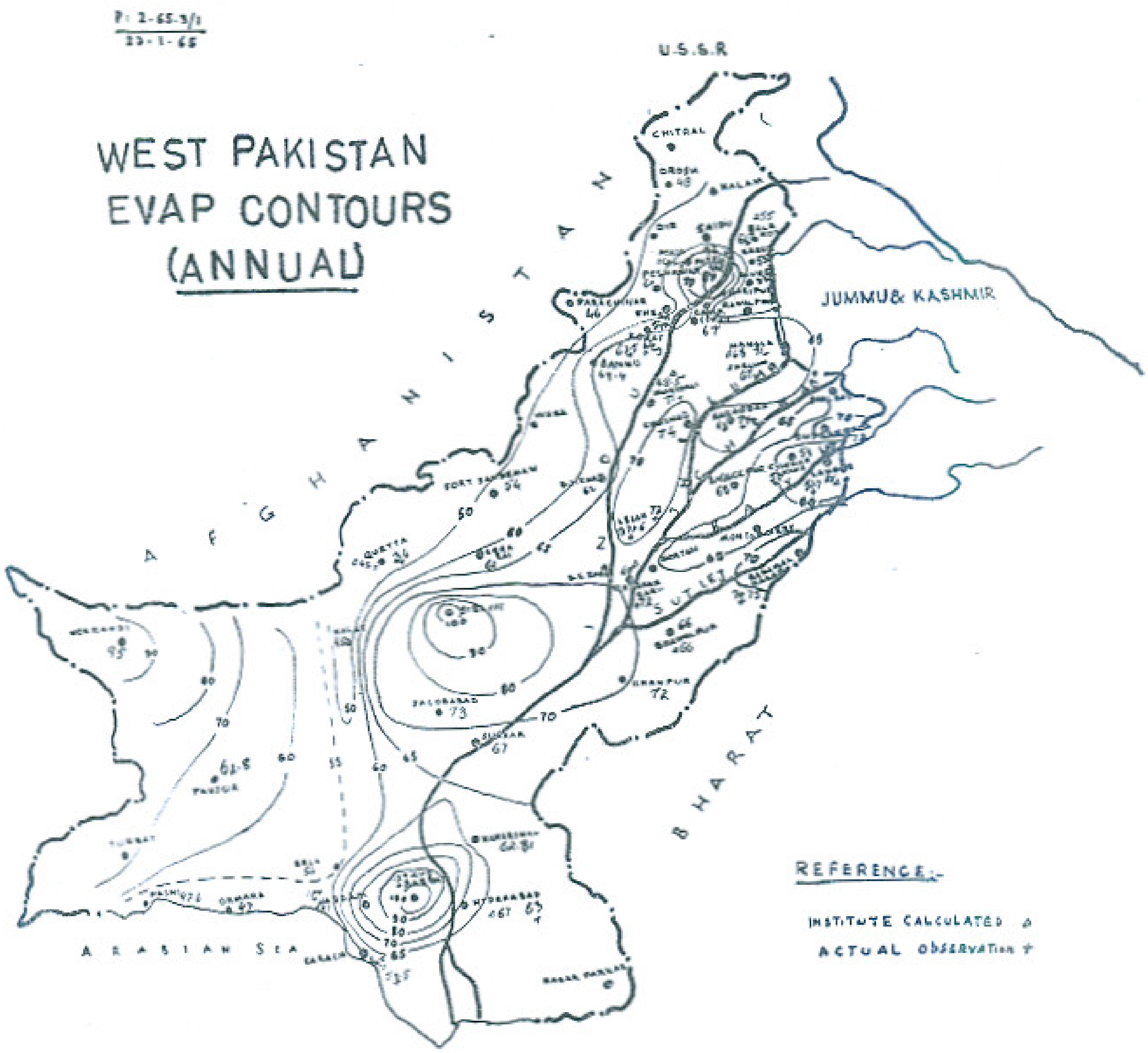
Introduction

It is estimated that in the West Pakistan an average of about 5 cusecs of water is lost from a square mile of the free water surface area. The range of variation of this loss is 3.7 to 8.0 cusecs from a square mile of its surface. Drawat and Hub Dam Sites near Karachi are the zones of highest evaporation—108 inches per year, about 8 ft. more than the annual precipitation, Sibi follows it at 100 inches, Nokandi at 95 inches and Tarbela at 93 inches per unit area. It is estimated that 60 sq. miles surface area of Kalari Lake is losing about 400 cusecs of water. Mangla reservoir when constructed will lose about 600 cusecs from its 117 sq. miles of surface area and 650 cusecs will be lost from 94 sq. miles of surface area of Tarbela reservoir. If the surface area of Warsak storage is assumed 5.7 sq. miles and that of Baran Dam 3 sq. miles, the loss of water will be 22 and 15 cusecs respectively. A cusec of water costs about Rs. 5,000 so that from Kalari Lake we are losing water worth Rs. 20,00,000 in one year.

There are 17 Headworks with pond of one to 3 sq. miles. There are going to be more small dams like Rawal, Gulkutch, Tanda Banda etc.

The amount of water being lost from the exposed surface is fairly large.

Recently an estimate of f.w.s. evaporation from West Pakistan has been carried out. Maps No. 5, 6 & 7 show evaporation contours giving the water lost annually or bi-annually. On the basis of these evaporation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REFERENCE:-
INSTITUTE CALCULATED
ACTUAL OBSERVATION

Fig. 5

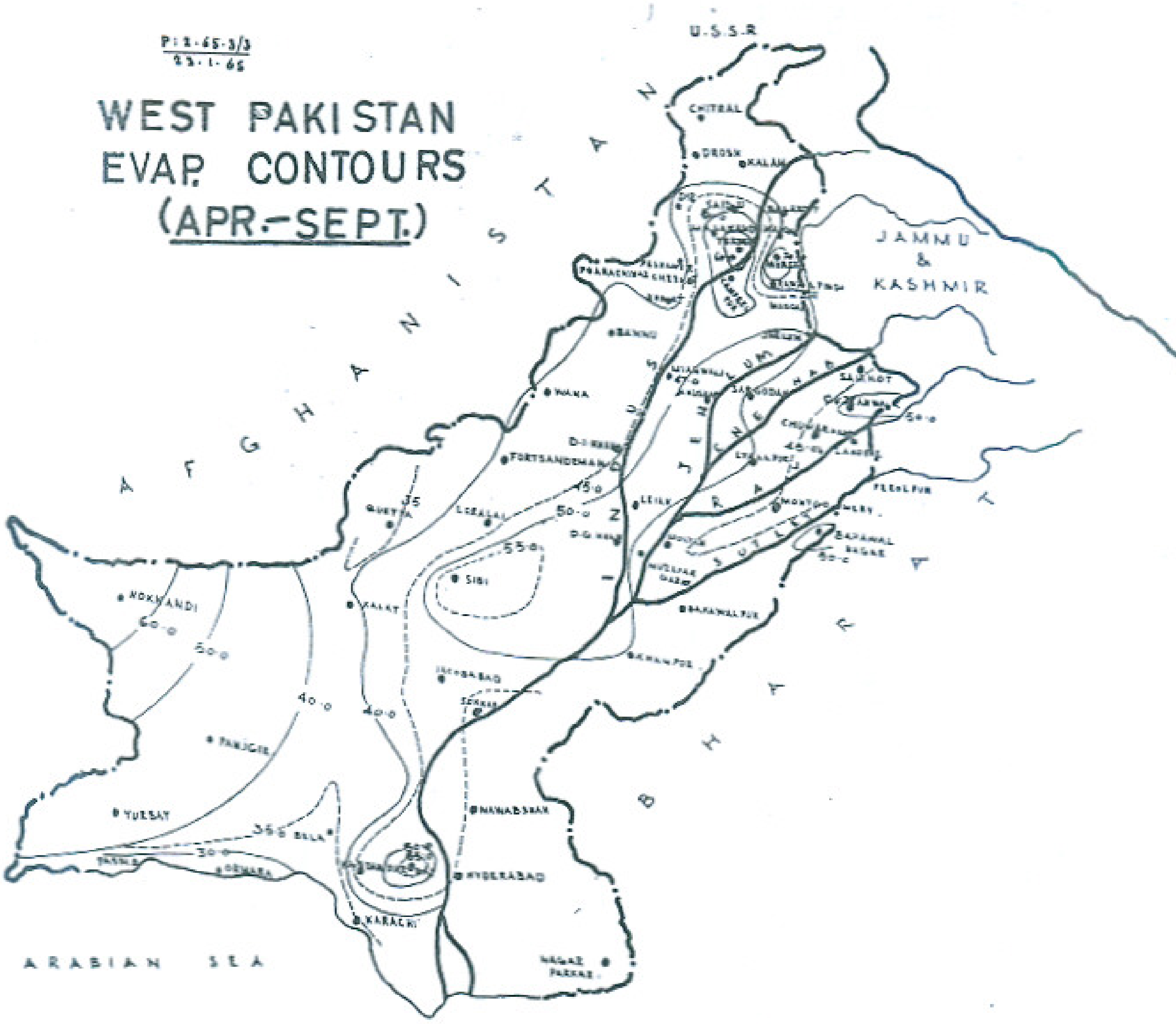
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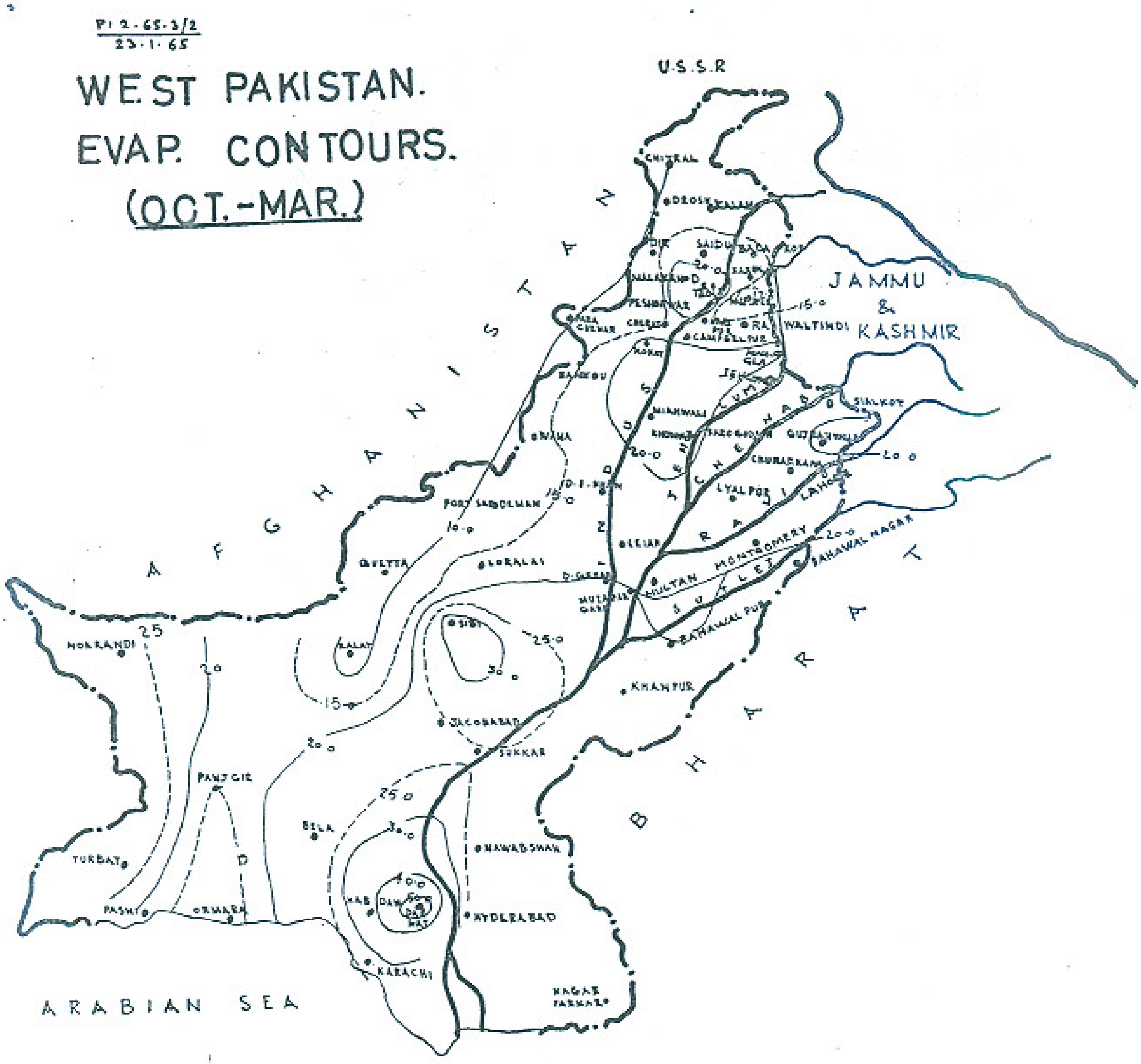
Fig. 6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SUKKAR
MULTAN
MONTGOMERY
LYALPUR
SIALKOT
KHANPUR
NAWABSHAH
HYDERABAD
KARACHI
BELA
PANJGUR
TURBAT
PASNI
ORMARA
MIANWALI
LEIAH
FORT SANDEMAN
BAHAWALPUR
BAHAWALNAGAR

Fig. 7

contours, water lost from any storage constructed anywhere in West Pakistan can be estimated. These maps have been utilized to prepare tables 2 & 3 which give the order of water lost from a sq. mile.

TABLE No. 2

Evaporation losses from the water storages in West Pakistan.

Name of storage	Annual loss in inches	Kharif/Rabi in inches	App. surface area in miles	Loss in cusecs/sq. miles
Warsak ..	53	38/15	5.682	22.22/3.91
Baran Dam ..	69	50/19	3	15.3/5.09
Rawal Dam ..	65	19/16	1	4.79
Kalari Lake ..	90	50/40	60	397.80/6.63
Bolan Dam ..	90	53/35	1	6.63
Mangla ..	68	47/21	117.19	587.12/5.01
Terbela ..	93	67/26	93.75	642.19./685
Hub Dam ..	87	47/40	One sq. mile	6.41
Gulkatch ..	60	42/18	,,	4.42
Kalam ..	50	38/12	,,	3.69
Kalargi ..	65	50/15	,,	4.79
Bunda Tunda ..	62	39/23	,,	4.57
Sargwal ..	67	51/16	,,	4.94
Naran Dam ..	50	40/10	,,	3.69
Dhok Pathar ..	67	50/17	,,	4.94
Mokhad ..	67	50/17	,,	4.94
Darwat Dam ..	108	57/51	,,	7.96
Dam near Turbat ..	70	40/30	,,	5.16
Dam near Pasni ..	50	30/20	,,	3.69
			Mean	5.16

Any measure designed to reduce the loss will directly pay off the cost of the treatment.

Research on Reducing evaporation

Much work has been done for reducing the losses from free water surface in many countries of the world such as America, Canada, Australia and Russia etc. Scientists have found that oily and fatty films when spread on water surface reduce the evaporation. The thickness of the film is close to molecular dimension. Mansfield,[2] Rideal[3] and Langmuir[4] for instance have found that a thin monomolecular film when spread on the surface of water can reduce the loss by more than fifty per cent of the total evaporation from water surface. Mansfield saved 200 million gallons of water at Broken Hill using cetyl alcohol dissolved in Volatile petroleum. At Rio Tinto Mines in Spain, solution of cetyl alcohol spread with two large floating dispensers saved 35% of the total evaporation. MacArthur,[5] Sklyaranko,[6] Baranaer, Glozov,[7] Kheimman,[8] Langumuir and Schaeffer[9] have shown that there are various substances forming monolayers which exhibit considerably large resistances to the transfer of water molecules to the atmosphere.

These are low in cost, non-toxic to wild life and human. These are also insoluble in water.

TABLE No. 3

Evaporation losses from water surface of the barrages in West Pakistan

Name of Barrage		Annual loss inches	Kharif/Rabi	Loss in cusecs per sq. mile.
(*i*) **Indus River**				
C. M. Barrage	..	75	45/30	5.53
Sukkur	..	67	43/24	4.94
Guddu	..	75	52/23	5.53
Taunsa	..	70	52/18	5.16
Kalabagh	..	64	45/19	4.72
(*ii*) **Jhelum River**				
Rasul	..	67	51/16	4.94
Trimmu	..	69	51/18	5.09
(*iii*) **Chenab River**				
Marala	..	65	46/19	4.79
Khanki	..	65	46/19	4.79
(*iv*) **Ravi River**				
Balloki	..	65	46/19	4.79
Sidhnai	..	63	46/17	4.64
(*v*) **Sutlej River**	..			
Panjnad	..	71	49/22	5.23
Islam	..	72	48/24	5.31
Suteimanki	..	75	50/25	5.53
			Mean	5.07

Nature of films

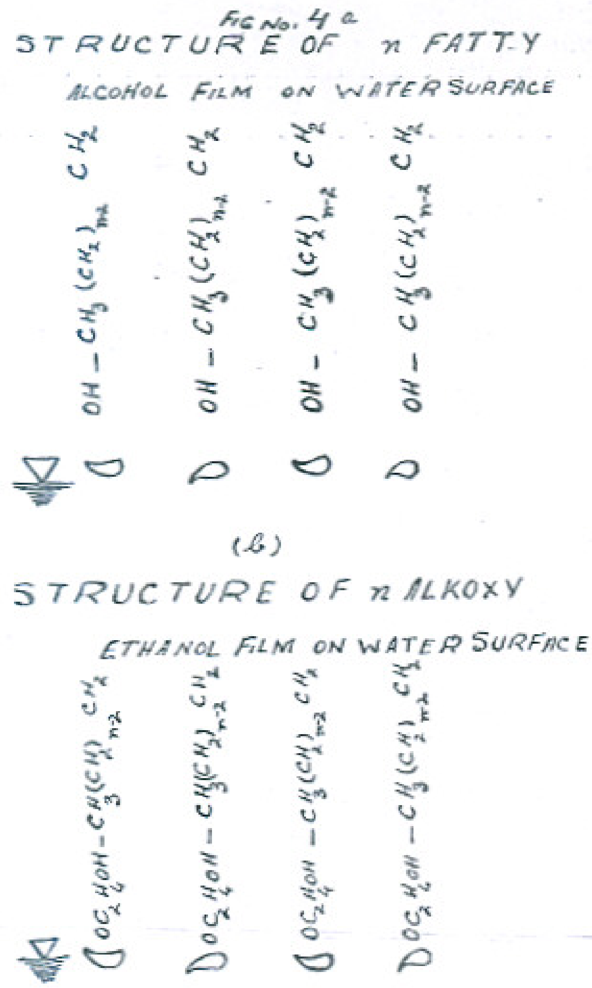
There are certain alcohols which have fatty nature. The general formula for fatty alcohols is:—

$$CH_3\,(CH_2)\,n{-}2{-}CH_2OH$$

where for hexamecanol alcohols, the value of n is 16 and for Octadecanol alcohols n is 18. The OH group in this compound is known as hydrophilic which means it has an affinity for water. When this compound is placed on the surface of water, OH, molecule is attracted to the water and the molecule orient itself vertically as shown in Fig. 4.

Another group of compounds is such which is water repellent. It is called hydrophobic. Such compounds are CH_3—(CH_2) n—2—CH_2—$O_{62}H_4OH$. In these compounds, the structure $OC_2\,H_4\,OH$ remain close to water surface and the other portion is repelled upward.

As the work of adhesive forces between OH group of alcohol molecule and water is greater than the work of cohesive forces between alcohol molecules, the latter separates from the mass and move on the surface to form monolayer. These invisible monolayers can spread over the water surface under pressure and wind. The organic compounds having a water attracting portion and a water repelling portion in their molecular structure possess the property of spreading out on the water surface. The invisible film is non-toxic and retards evaporation while at the same time, it allows free passage



of rain, oxygen and sunlight. At pressure of 40 dynes cm. evaporation reduces to 70% and at of 10 dynes/cm. pressure, it is reduced to 2% only.

Evaporation Retardents

It has been found out by many research workers that fatty alcohols, having higher molecular weight, are best suited as monolayers. Out of many compounds which have so far been tried, cetyl alcohol —C_{14} and Stearyl alcohol —C_{18}, gave the best results. Cetyl alcohol is a white waxy solid substance. It floats on the water and its specific gravity is 0.85. Chemically cetyl alcohol is a mixture of hexadecanol and octadecanol in varying portion. Cetyl alcohol film is said to be effective up to a wind velocity of 50 m.p.h. The efficiency of C_{14} and C_{18} alcohol increases with the decrease of water temperature. A list of the various evaporation retardents, which have been tried so far in different countries of the world, is given in table (10*a*) No. 1. These compounds are harmless to animal and plant life. These monomolecular films can regain their original position after these have been broken by wind pressure and action of dust.

Dosage Rate

Fatty alcohol, having 250 molecular weight and two square Angstrom molecule area, requires 30 ounce to cover an acre surface area. The estimated thickness of the film is 24 Angstrom. However, for normal conditions, L/A should not be less than .0025 cm/cm² which has been calculated with Mansfield[11] formula:

$$\frac{L}{A} = \frac{\text{Exposed Perimeter of Solid particles.}}{\text{Exposed water surface area to be covered.}}$$

In case of very hot climate, the rate of dosage should be 5 lb/acre. It was evaluated that at the cost of 2.4 pence, thousand gallons of water are saved. The rate of application will, however, vary during summer and winter seasons. The film life is near about sixty or seventy days. At Rio Tinto Mines, 1000 gallons of water were saved by cetyl alcohol at the cost of 13 pence. Cetyl alcohol costs 2.4 pence per lb and 3 lbs per year per acre are required. Siro seal will cost 10 shillings per lb. and 8 lbs. per year per acre will be required. There are standard units of dosage called Constant Feed Submerged Dispenser (C.F.S.D.) which automatically provides effective film to 1 acre of area and lasts for a month. These units can be had from Price's agents, F.O.B.

TABLE No. 1

Evaporation Retardents

S. No.	Trade Name	Composition		Evaporation saving%
1.	Adol 63	1-hexadecanol 28% 1-octadecanol 70%		54
2.	Adol 62	1-octadecanol U.S.P.		68
3.	Adol 11	Saturated coconut		65
4.	Adol 13	55% C_{12}		60
5.	Siponol L5x	1-dodecanol 62% C_{14} 23% C_{42}		60.5
6.	Stearly alkenol	1-octadecanol		57.8
7.	Lorol 28	1-octadecanol industrial grade		55
8.	Cetyl-stearyl mixture	1-hexadecanol 50% 1-octadecanol 50%		
9.	Cetyl alcohol N. F.	1-hexadecanol		56.2
10.	Ceramol	Fatty alcohol mixture		52.2
11.	Siroseal	Hexadecanol	80	62.0
		Octadecanol	10	
		Tetradecanol and dodecanol	5	
		Alcohols drain length less than 10	.5	
		Unsaturated alcohol	4	
		Iodine value less than	3	
		Acid value less %	.3	
		Sponification value less than	.5	
		Hydroxyl value 225 to 230		
		Melting point 47° to 50°C		

Liverpool. The unit contains 4 gallon kerosine oil with powdered cetyl alcohol kept in a can with a constant feeding device.

Methods of Treatment

There are two main methods for the treatment of these chemical compounds. One is the solid method and the other is known as the solvent method.

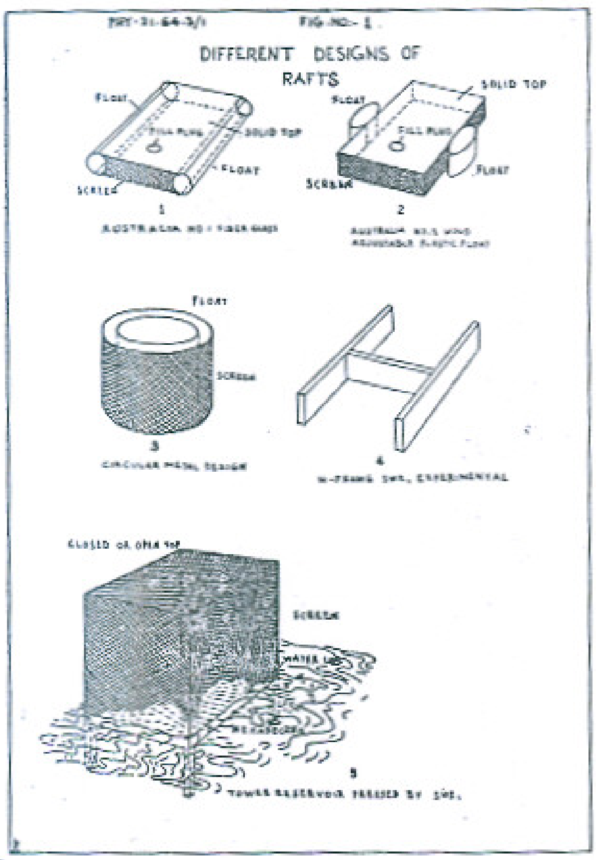
In the case of first method, beaded pallets of chemical compound such as C_{14} or C_{18} are contained in open mesh raft which is a floating container fitted with gauze windows. As the use of gauze windows needs a compromise with the diameter of beaded pallets, many workers have made use of the containers of 3 sq. ft. having beads of C_{14} of 4 mm. diameter. Siro seal has generally uniform beads having diameter 2.4 mm. Copper bronze is the material selected for mesh. The experiments with Siro seal were carried out using the material forming rafts of 2 ft. sq. made of 2′ and 4′ lumber put together in the form of an H and covered with a window screen. Different types of rafts used in various parts of the world are reproduced in Fig. 1.

At Nairobi dam in Africa gauze baskets were used enclosing an area of water surface of 9 sq. ft. A charge of 2 to 2.3 lbs. of cetyl alcohol was placed in the basket and this completely covered the surface. The gauze is made of bronze or aluminium with 14 to 16 mesh/inch. In fact cage rafts are so made that they maintain their centre of buoyancy. Small boats are used for placing the rafts at different places over the water surface.

At Loch Laggan, crystalline blocks of C_{14} were grinded by means of wire brush machine installed in a boat. The grinded fine powder was blown on to the surface of water through a pipe.

The solid treatment is, however, not recommended for very large surface.

In the case of solvent method, the fatty alcohols, which are insoluble in water, are dissolved in a volatile hydrocarbon Ethanol gasoline or volatile petroleum fraction, methylated spirit and kerosine oil have been used as solvents. The solution is contained



in a pot known as dripper. A hole is made in the bottom of 6 ounce can with a 4 d. nail. A small piece of iron tube ¼" (outside diameter) is soldered to the bottom of the can and a wick made of cotton or synthetic fibres is passed through the tubing. The dripper is fixed with a staff and installed around the side of the reservoir as shown in Fig. 2. The treatment becomes automatic. The drippers should be watched from time to time. This method has been best applied in Nairobi at Kenya.

Mr. Grundy[1] has applied another method in East Africa. Cetyl alcohol was dissolved in hydrocarbon solvent 10%C_{14}' 10% spirit and 80% solvent, and contained in various dispensers. Mansfield applied the siro seal units as floating dispensers where the annual losses were 2 ft. to 10 ft. Assuming 25% reduction in losses, he calculated the cost of saving water as below:—

Annual Evap. (Ft.)	Saving (Ft.)	Cost/1000 Gall. Saved (Pence)
2	.5	16
3	.75	11
4	1.00	8
5	1.25	6.5
6	1.5	5.0
7	1.75	4.5
8	2.0	4.0
9	2.25	3.5
10	2.5	3.0

There is another method of treatment used in Australia for large dams as shown in Fig. 3. A solvent is contained in a big drum, placed over wooden supports. A brass tube of small diameter is connected to the side of the drum near the bottom. A control valve and filter are fitted in the brass tube, to which is connected a rubber tube, the other end of which is dipping in water. The tube is tied with a float in order to keep its end near the water surface. This whole arrangement is shown in Fig. 3.

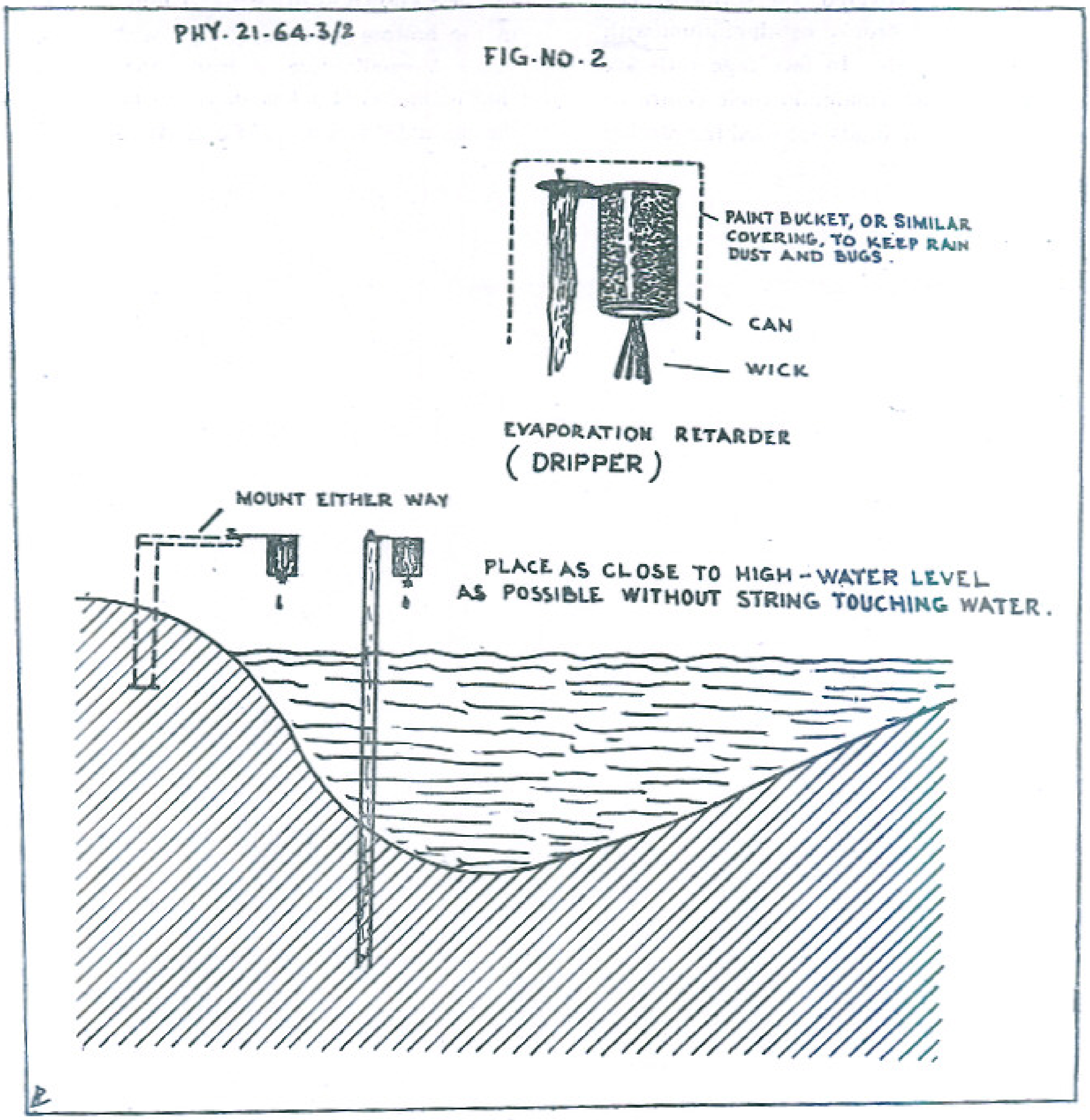
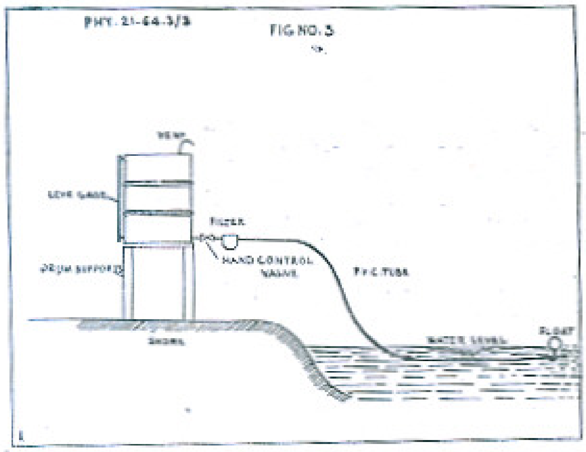


FIG-NO-2

Oil as evaporation retardent

The solvent treatment is recommended to be applied to canals[12] by injecting the additives at the Headworks.

Besides these described chemicals, we can also apply the film of cotton seed oil and its other derivatives. In India[13] at Poona, Dr. Ramdas and his co-workers have carried out these trials and found hopeful results. The application of an oil film preventing evaporation of water has been patented by Nelson[14] (1939) but this method has not been widely used. It has been found that in some instances, an oil film is damaged by both wind and dust. Moreover the oil film being rigid, does not heal itself if it is broken by wind or wave action. However, if the material is locally available, it can be put into trial where the wind velocities are not very high.



Detection of Monolayers

Monomolecular films are invisible. When, however, it becomes necessary to check their presence over the water surface, camphor crystals are used. These will gyrate on clear water surface but remain still when placed on film covered water. At the treated surface, ripple action becomes less due to the film tension. An oil drop will spread 3 times greater on film surface as compared to ordinary water surface.

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Brief Excerpts of Symposium on Sodic Soil in Budapest

8-16 August, 1964

Unesco and Hungarian Academy of Sciences cooperated to hold an International Symposium on Sodic Soils in Budapest from 8th to 16th August, 1964. The Symposium was represented by 54 persons from 26 countries of the world. Forty-two scientists from the home country and 4 from Unesco also participated. In all 34 papers were presented in the symposium. Two papers of these were from Dr. Kovda and Dr. Szabolcs, twenty from foreign participants and twelve from Hungarian scientists. As the subject-matter is of direct concern to West Pakistan about its problem of Waterlogging and Salinity, we have reproduced excerpts from the contributions for the benefit of the scientists of this country. The papers presented are being edited and will be published shortly by the Hungarian Academy of Sciences. In this very Journal we have reproduced the contributions of Dr. Kovda which contains very valuable information.

Important Subjects Discussed

There were four subjects on which many contributions were made. These pertained to :—

1. Action of sulphate reducing bacteria and the conversion of sulphates to carbonates.
2. Toxic effect of carbonates and bicarbonates.
3. Amelioration of Alkaline Soils.
4. General.

There were eight contributions on the subject of sulphate reduction into carbonates which make the soil alkaline. The contributing countries were Russia, Hungary and America. It was shown on the basis of data collected in the field and by actual laboratory tests that a soil when subjected to wetting and drying, with changes in temperature and in presence of organic material, the activity of the bacteria results in reduction of sulphate to change into carbonates which make a soil alkaline. Our Soil Chemists and Microbiologist can study these papers with advantage for checking the conditions in our country.

The toxic effect of the presence of carbonates and bicarbonates in water on the growth and yield of crops were presented in four papers. Recently C. A. Baver and

Masaland have also determined the same presence of highly toxic bicarbonates in groundwater of the Punjab plains. Perhaps this may be a cause for the low yield of crops in our area.

It needs more thorough examination.

The majority of the papers (nine) contained the results and experience gained in the field on the amelioration of alkaline soil by the use of chemical amendments. Gypsum is by far the most commonly used material practically in all countries. Lignite which is a coal dust and contains sulphur, lime sludge from cane sugar factories, brown coal, calcium chloride, waste from sulphuric acid factories, pyrite, phosphate, super-phosphate, ammonium fertilizers have been used at different places.

Nobody pointed to the method of reclamation of land by rice cultivation and green manuring with Jantar as is done in our country. Our method perhaps is cheaper and superior in some respect as compared to the rest of the world. With this brief introduction, brief excerpts of papers are put forth.

The main report was by Dr. V. A. Kovda on Alkaline Soda Saline Soil. It is a very informative document. It deals with the geographical distributions of Alkaline Soda Saline Soil existing in different parts of the World. Central Europe, Africa, North and South America, Australia, India and Pakistan have all Alkali-soda soils. The main property of Alkaline Soda Saline Soil are explained giving the extent of harmful salts occurring at various horizon. Several tables and figures

Members of Bureau of Sodic Soil Symposium presiding over the deliberations.

are added in the text explaining the view-points of the author. The process of formation of soda soils are also discussed and many chemical reactions are put forth. The conditions governing the continuous existence and accumulation of soda and its physieo-chemical property of formation of sodium carbonate are explained. Soda accumulation is the first stage in the process of salinization of soil and water. These items are discussed in three sections. The note also contains information on the utilization and reclamation of Soda Saline Soil. In fact the note is so informative that it needs to be studied as a whole. Some conceptions put forth in this note by Dr. Kovda will be appearing in the Unesco Resource Book which is also being edited by him.

1. ACTION OF SULPHATE REDUCING BACTERIA AND THE CONVERSION OF SULPHATES TO CARBONATES

(*i*) **P. Janitzky** described the natural leaching process in some salt-affected soils of California. He stated that complete chemical analysis of salt-affected areas of California Soils has never been conducted. The author carried out analysis of a few profiles and concluded that :—

* Leaching of salt-affected soils proceeds in regular and consistent manner irrespective of initial salt concentration and composition.
* Removal of sodium does not initiate the formation of sodium carbonate.
* Divalent cations are relatively fast solubilized especially magnesium and displace exchangeable sodium with no noticeable increase of soluble carbonate.
* True hydrolysis of sodium leading to development of sodium hydro-oxide and sodium chloride during leaching is possible only at complete absence of calcium and magnesium.

(*ii*) **Dr. I. N. Antipov-Karataev,** Professor of Soil Science in the Institute of Moscow, spoke on the genesis of Sodic Solenetz Soils and the methods used in their reclamation.

* He put forth the new biological theory which relates to the reduction of sodium sulphate to form sodic formation.
* Generally chemicals are used for amelioration of solonetz and sodic solonchaks soils. These are calcium polygalite, lime sludge of sugar mills and residual sulfuric acid. Their desage and the results are given in the paper.
* Use of ferrous sulfate and its by-product have been shown to give a high yield of wheat.
* It is said that where hydro technical drainage is not feasible for economic reasons bio-drainage by planting of trees and lawns should be restored to.

(*iii*) **R. Vamos** of the Institute for Plant Physiology of the University, Szeged, Hungary, put forth the results of his experiments on biological effects of sulphate reduction in water logged soils.

The author gave results of experiments on microbiological sulphate reduction. In water-logged soils, in paddy soils and in fish ponds, reduction of pressure and sudden cooling has been found to be helpful to produce sulphurate hydrogen and sulphur diaoxide.

(*iv*) **N. V. Orlovazkij** of U.S.S.R. spoke on the soil presently existing in the cold climate of Siberia are discussed where it is stated that on poorly drained land, chloride and sulphate form through the weathering of rocks which is liable to give rise to saline and alkali saline soils with accumulation of soda, which is said to form due to sulphate reducing bacteria. The presence of soda in West Siberia and the basins of Lena river is attributed to this process. In this paper amelioration and fertilization of the virgin alkali soil is also discussed by the application of amendments.

(*v*) **A. Hardan and L. D. Wittig.** Department of Soils and Plant Nutrition, University of California Davis, U.S.A. has tried to demonstrate experimentally the formation of alkali soil as a result of biological reduction of $Na_2 SO_4$ into $Na_2 CO_3$. Some relation has been attempted to be determined in presence of $Ca.CO_3$ and organic matter sulphate treatment on :—

* The rate of increase of exchangeable sodium percentage.
* Production of soluble carbonate and bicarbonate and the precipitation of calcium and magnesium.
* The rate of accumulation and mobility of soluble salts.

The experiments were carried out in wooden boxes of 50 cm. width and 78 cm. long containing air dried non-calcareous alluvial soil. Each box contained 26 kilograms of soil compacted to 1.3 gms. per c.c. D.B.D. The variables were the presence of calcium carbonate and organic matter. Salt solution of Na.Cl, Na_2CO_3, and Na_2SO_4 at a concentration of 50 millie quivalents per litre were delivered.

It was noted that :—

(*a*) in the presence of $CaCO_3$ the rate of increase of average exchangeable sodium content and percentage was greatly lowered with $NaHCO_3$, next with Na_2SO_4. In the presence of organic matter, the exchangeable sodium was greatly increased with Na_2SO_4.

(*b*) the precipitation of Ca and Mg. and soluble CO_3 and HCO_3 was significantly increased with organic matter treatment.

In the $CaCO_3$ treatments, however, soluble CO_3 and HCO_3 content was increased with $Na.Cl_2$, Na_2SO_4 but not with $Na.HCO_3$.

(*c*) The presence of $CaCO_3$ showed no effect on the ratio of soluble Na. to soluble Ca+Mg. with $NaHCO_3$, moderately increased the ratio with Na_2SO_4 and greatly increased with NaCl.

(*vi*) **E. Timar** is a micro-biologist working in Soil Science Institute of Hungary. Her paper gave an experimental verifications of the processes of sulphate reduction in soil, and its conversion into alkaline soil. Using soil having different percentage of Na_2SO_4, nitrogen gas was passed and production of H_2S was recorded. It was found that the amount of Na_2SO_4 substantially influenced the degree of biological sulphate reduction. It was stated that biological sulphate reduction and development of soda in the soil is largely connected with the amount and quality of organic matters present in the soil.

(*vii*) **N. N. Bolisev and E. A. Stina,** Department of Soil Biology, Moscow State University, put forth another paper on the part played by the Biological factors in the formation of Solonets soils. In the paper interrelations of different types of algae and presence of salts and their effects with regard to the biological effects were discussed. The author concludes that in semi-arid desert, sulphate reducing bacteria contribute to the formation of Na_2CO_3. In this formation the biological factors play a major role.

II. TOXIC EFFECT OF CARBONATES AND BICARBONATES

(*i*) Professor **V. V. Egoroy,** Institute of Pedology, Moscow, who had recently visited Pakistan, spoke on the sodic salinization of the soil in the Soviet Union and suggested some methods of overcoming it. He stated that the most common sources of sodium carbonate in groundwater and soils are :—

* Disintegration of rocks.
* Sodium hydrocarbonate under geological condition especially if the underground contained gas or oil.
* Reduction of a sodium sulphate into sodium carbonate and
* Utilization of sulphur of the sulphate by plants and forming sodium carbonate.

In fact these four hypothesis are completely new conceptions work on which is still being continued.

(*ii*) **B. Verhoeven** of Soils Department Zuiderzeepolders Development and Settlement Authority, Kampen, Netherlands put forth that it has been experimentally determined that the application of Gypsum on partly leached soil improved the leaching efficiency, and prevented the decline of soil structure. The previous conception was that dressing of Gypsum be employed when the bulk of the salts has been leached out.

(*iii*) **K. Darab** of National Institute for Agricultural Quality Testing, Budapest, wife of Dr. Szobloc, President of the Symposium, put forward her conceptions on the chemical and physical effects of sodium carbonate on soil. She stated that the presence of sodium ions in the liquid phase affects the physico-chemical and colloidal behaviour of alkaline soil. Dilute solution of sodium salt induces considerable alkalinisation and adsorption of sodium ions increases, and at the same time solubility of calcium and magnesium salt decreases. The excess of sodium salts also increases the swelling of the colloidal portion the soil.

Experiments using isotope of Na^{24} showed that maximum adsorption was connected with maximum colloidal swelling. The author stated that it needed further study to determine the changes in colloidal soils as effected by the sodium adsorption and nature of clay mineral, degree of soil alkalinization and composition of soluble salts.

(*iv*) **L. Gerei,** Director of National Institute of Agricultural Quality Testing, Budapest described the effects of Na_2CO_3 and other sodium salts on clay minerals. He used various types of soils and treated them with sodium salt like Cl, SO_4, CO_3 and HCO_3. Cycles of freezing and drying were also produced. He concludes that periodical drying and wetting is a pre-condition for the formation of soil alkalinisation.

* Carbonate, sulphate and cholride of sodium affected the crystal latices in the decreasing order.
* The most vigorous effect noted was that of reducing agent like sodium bi-carbonate.
* Several changes from micro-mineralogical point of view were also noted.

(*v*) **Gy. Varallyay** of the Research Institute of Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences described a peculiar case of sodic alkalinisation by water and soil eroded from the forest area. The soil accumulating at the foot hill was found to possess excess of carbonates and bicarbonates. At places where clay lenses and impermeable layers of colloids are wedged in the sediment, water rises to the surface and the presence of carbonate causes the soil to become alkaline. This paper describes the formation of horizon of lime accumulation within the soil.

III. AMELIORATION OF ALKAL SOILS

(*i*) **C. Sauberan and J. S. Moiina** from General Agriculture University of Buenos Aires, Argentina, described the reclamation of 440 ha. of alkaline low-lands in Argentina by the acidifying action of carbon dioxide produced by root respiration of salt resistant plants and by microbiological decomposition of plant residues added to the soil.

(*ii*) **G. Sandu, I. Kalibas, I. Vlas and M. Kalibas** were workers on soils in Rumania. They described the results of using soil amelioration substances on the decrease of alkalinity and increase of production. In one case lime sludge from sugar mills was used at the rate of 20 tons per ha. It reduced the presence of free sodium and increased the crops yield by 40 per cent for grass and 55 per cent for wheat.

Use of phospho-gypsum reduced the sodium alkalinity by 48 to 84 per cent and increased the yield of grass by 130 per cent and of wheat by 133 per cent.

Use of phospho-gypsum with superphosphate ammonium and manure reduced the sodium by 55-59 per cent and increased the yield of grass by 122 percent and that of wheat by 381 per cent.

(*iii*) **B. M. Agayev** of the Academy of Science of Azerbaijan, Baku, USSR gave examples of alkaline soil present in the alluvial cone close to Tartar River. These soils are compact with low permeability and contain high moisture, so that at a depth of one meter 50 per cent pore are full of water and at 2 meter depth 76 per cent pore are full of water.

It has been found that a local substance called Gaga which contains sulphuric acid and calcium sulphate is very effective to reclaim the alkaline land.

(*iv*) **K. B. Opera** belonged to Agrotechnical Institute, Timisoara, Rumania. His was a general paper giving statics of the salt affected soils of the country and the causes for the presence of alkalinity. He also described the genesis of alkali soils, their physico-chemical and agricultural characteristics and the method used for their amelioration.

(*v*) **L. Raikov and J. Kavirdgiev** of Puskarov Institute of Sofia, gave results of experiments conducted in Bulgaria on sodic solonets soils for their amelioration. The chemical used included gypsum which was most effective. Calcium chloride which was less effective and lignite waste which gave no significant results. Stable manure or peat showed no noticeable effect. In rice cultivation lignite mixed with gypsum gave good yields. Deep ploughing also gave satisfactory results.

(*vi*) **Dr. N. Miljkovic** of Faculty of Agriculture, University of Novi Sad-Yugoslavia, reviewed the extent of alkali soil in a part of the country called Vojvodina. The physical characteristics of the soils formation, their electrical conductivity of saturation extracts etc. was given. Existence of boron has been found out in alkali soils. Some aspects of reclamation and the possibility of secondary

Participants of Sodic Soil Symposium Budapest, August 8 to 16, 1964.

salinization as a result of over-irrigation is also discussed.

(*vii*) **S. Herke and I. Harmati** of the Agricultural Experimental Institute, Department of Soil Science, Szeged, Hungary, stated the results of amelioration of solonchak soils between river Danube and Tisza. In this region soda, salts of sodium and calcium carbonate exist in large volume. For amelioration of the soil, fertilizer and irrigation was attempted but great success was obtained by using gypsum and lignite dust. Both chemical amendment and irrigation were found to be a quicker means of reclamation. The N-deficiency which usually exist in alkali soil was made good by addition of fertilizer.

(*viii*) **I. Prettenhoffer** of Agricultural Research Institute, Szeged, Hungary, stated that east of Tisza river all types of soils are in occurrence, particularly the solonets. He stated that these can be successfully reclaimed by using lime or by spreading calcareous subsoil or by joint application of calcium carbonate and calcium sulphate. Due to shortage of gypsum in Hungary various by-products such as sludge from sulphuric acid, HCl, $CaCl_2$, $FeSO_4$, K_2SO_4, lignite dust and brown coal were tried.

In a soil having low calcium $CaCO_3$ best results were obtained by using gypsum, lignite dust, H_2SO_4 and $CaCl_2$. Large doses of nitrogen fertilizer were also very effective.

(*ix*) **L. Abraham** of the Agricultural Research Institute, Department of Soil Sciences Szeged, Hungary gave results of using small amounts of improving materials for reclamation of alkali soil. He was the first person to speak on the cost of amelioration. The quantity of material suggested for amelioration in many papers had sometimes amounted to 20,000 to 60,000 kg. per ha. The author used pulverised or granulated lime sludge from sugar mills and gypsum or their combinations. He introduced these in small amounts beneath the seeds or in furrows below the seed. It was found that 7,000 to 20,000 kg. per ha. have even much better results and increased the yield per unit of applied agent.

(*x*) **D. Gratzl, I. Harmati and L. Abraham** of the Agricultural Research Institute Department of Soil Sciences, Szeged, Hungary, put forth the results of their experiments to increase the yield of natural grasses. Puccinellia is a type of fodder plant which is resistant to alkali. It was found to give a very good yield by irrigation and by the use of ammonium-nitrate and superphosphate. Another variety of grass was also found to behave similarly.

IV. GENERAL

Besides the three subjects specified there were several papers of general nature. The important ones are mentioned below:

(*i*) Dr. S. P. Raychaudhuri of New Delhi India, put forth the practice of classification and management of saline and alkali soils of India. He said that saline and alkali soils are found in almost all normal soils of India. Their extent is about 15 million acres. Irrigation has increased unproductive areas to several thousands sq. kilometers. The author has classified these soils into three groups, saline, saline-alkali and alkali soils. These are further divided into five groups according to the degree of salinity. Reclamation methods for each group have been suggested. For ordinary deteriorated soils scraping of the surface and flushing with water is suggested. For advance deterioration flushing with trenching, improving underground drainage and deep ploughing is put forth. For alkali soils, the treatment with chemical amendment like gypsum, calcium chloride, sulphur, molasses, green manuring etc. are discussed.

(*ii*) Mr. J. C. Russel with other two contributors spoke on Sodic soils of Iraq.

In Iraq the soil is heavy, country is flat, drainage does not exist and so watertable is high. At many places, salts of sodium are in existence although at other places salts of calcium and magnesium are also found. Rainfall is hardly 150 millimeter. The possibilities of Iraq soils becoming non-saline alkaline at some time in the future as drainage programmes expanded and sodium salts are leached away, is discussed. It is stated that the water to be used for leaching contains an excess of divalent cations as compared to monovalent cations. Gypsum also exists in soil, and its resources in the country are enormous and easily accessible. For these reasons there is little possibility of the soils becoming alkaline.

(*iii*) **P. Buringth,** Professor of State Agricultural University, Wageningen, Holland spoke on the differences in salinization between the Mesopotamian Plains and the Nile Delta.

He gave very useful information on the nature of soil of the two deltic regions of the world *i.e.* Iraq and Egypt. He put forth that the soils of the Nile Delta are very heavy with capillary height hardly 10 to 15 centimeter. Soil is impervious and highly calcareous having 25-35 per cent of lime. Cropping is very intensive, so that two or three crops are sown in a year. Precipitation is very low being less than 20 mm. and upper layer of ground water is non-saline. These are the reasons for non-constance of the salinization problems in the Delta of Egypt.

In Central Iraq, the soil is used once after one or two years. It is highly calcareous, rainfall is up to 130 mm. soil is of less fine texture and groundwater is very saline. As a result of all these factors there is a serious problem of alkalinity and salinity in the country.

(*iv*) Dr. Nazir Ahmad of the Institute of Irrigation Research, Lahore, reviewed the salinity alkalinity status of irrigated soils of West Pakistan.

Soil surveys have only recently been taken up in the country. The soils of the Indus plain have been separated into six series for the northern region and into seven textural groups for the southern-region. The basis of salinity and alkalinity status is still the percentage of soluble salts. Maps depicting salinity are available but alkalinity status is yet to be exhibited. The various factors as causes of soil salinity are discussed. It is only recently that alkalinity status of soil is being studied with reference to exchangeable sodium, percentage and residual sodium carbonate. The paper gives the factual information on the salinity and alkalinity status of irrigated soils of West Pakistan.

(*v*) **M. M. Elgabaly** of Egypt Institute of Land Reclamation, University of Alexandria, U.A.R. sent this paper. He was not present so the papers were not presented. In this paper the effects of different degrees of salts on cotton and corn are discussed. The yield and the growth with different percentage of salts and exchangeable sodium percentage is shown in the form of a table given below:—

(*vi*) **M. M. Elagabaly and** Naguib had sent a second paper on the effect of depth and salt concentration of groundwater on salinization of soil. It was observed that concentration of Cl. and Na. increased within

Crops	E. C. Range	Average	Na. Exchangeable %		Yield	Remarks
			Range	Average	lb/Ac.	
Cotton	1100—7100	2700	24—68.4	48.1	525	Growth well.
(Karnak)	4900—11830	8100	49.7 —78.3	65.9	321	Moderate.
,,	10100—22600	15900	55.6 —75.4	69.3	164	Good.
,,	23000	23000		75.0	No yield	Not good.
Cotton can tolerate chloride concentration of not higher than 38 meq/litr. and the E. C. less than 16.						
Corn	2100—5800	4100	21.8—44.5	34.5	1137.5	Growth well.
,,	3500—5200	4400	42 —70.0	53.8	700.0	Moderate.
,,	9200—16800	11860	44 —78.5	66.5	233.0	Good.
,,	—	17000	—	78.0		Not good.
When the chloride concentration exceed 20 meq/litr. and E.S.P. of the soil is increased, growth of corn is greatly reduced.						

fallow period and in the top soil the concentration was increased if it was high in groundwater. In this paper great stress was laid on the critical depth with respect to the concentration of salts in groundwater.

(*vii*) **F. Mate** is a scientist of the Research Institute of Soil Science in Hungary. He put forth the results of experiments on mineral composition of soil colloids and on the formation of soda-alkalinity in sodic soils. He noted that the hydrolysis of the adsorption complex of soil had a dominant role. The mineral composition of soil colloids influence the composition of exchangeable cations. The most important role was played by the cations which constituted part of the lattice of mineral colloids.

(*viii*) **Amaro Zavaleta G.** of Agrarian University, La Molina, Lima, Peru described the nature and the extent of saline and alkaline soils of Peruvian coastal areas. It was stated that non-saline soils are 6.5 per cent, saline soils 29 per cent, non-saline alkali soil 3.3 per cent and saline alkali soils 61 per cent. A considerable detail about the genesis and the formation of a soil is given in the paper.

(*ix*) **I. Lal Kovices** is a worker of the Institute of Soil Science, Budapest. She put forth her conception on the importance of Nitrogen compounds in the Reclamation of Solonetz soils.

* By dressing with N. Fertilizers at the rate of 150 kg./ha and simultaneous

irrigation, the hay yields increased substantially.

* Use of pulverised limestone failed to ensure dependable increase of crop yield.
* Some crops like sun flower, broom and maize have not grown under the effect of powerful liming.

(*x*) A. M. Balba of the University of Alexandria, submitted results of his experiments conducted on soils of various texture having different salts content and which were leached by water containing different concentration of salts. Estimation of salts in the soil, and in the filtrate and those added to the solutions was carried out and a mathematical relation was attempted.

(*xi*) N. N. Bolisev of Moscow State University, Department of Soil Biology submitted that he had studied the character and composition of the adsorption complex of solonets soils. According to the author, the solonets soils consist of peptized fraction 'A', coagulated fraction 'B', colloids and pre colloid fraction 'C'. All these three fractions components were studied. The degree of solonets soils was determined on the basis of Ca+Mg and to the ratio Na+K of the aqueous extracts, its pH value and the ratio of fraction 'A' and 'B'. In addition to these studies the author has given some methods of soil amelioration also.

(*x*) J. Jasso of the National Institute for Agricultural Quality Testing, Budapest, Hungary put forth the results of his analysis carried out on soil samples during the last 4 years from 1959 to 1963. The effect of fluctuations of water table at a depth of 200 cm., the variation of salts content in the profile of different soil texture was put forth and very useful conclusions were drawn.

(*xi*) Don Kirkham of America did not submit a written paper but showed several slides pertaining to the determination of field infiltration which is an essential method for measurement of alkali soils.

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Alkaline Soda Saline Soils

By **V. A. Kovda**

Dr. V. A. Kovda is a world reknown expert on soils and their reclamation. He was the chief speaker in the Unesco-Hungarian Symposium on Sodic Soils. His address was very exhaustive covering many aspects of alkaline soda-saline soils. The present is an abridged version of Prof. Kovda's discourse.

Alkaline soils are widespread

Ample geographical data have now been accumulated showing that alkaline soda-saline soils are extremely widespread throughout the various continents of the world. In view of the high toxicity of carbonic alkalies and of the very unfavourable physical properties imparted by these salts to both soils and soil-forming sediments, alkaline soda-saline soils have very low natural fertility and can only with difficulty be used for farming. The upshot of all this is that the subject of the origins and reclamation of soda-saline soils constitutes one of the most vital problems of present-day soil science. This explains why the question of alkalinty of soils and in particular, of the origins of the soda they contain, has claimed the attention of many outstanding scientists (Hilgard, Sigmond, Glinka, Gedroitz, Kelley). The monographs of V. A. Kovda (1937), W. P. Kelley (1951) and I. N. Antipov-Karataev (1953) contain an account of contemporary theories on the origins of soda and the processes of formation of alkaline soils. The new generation of soil scientists—V. V. Egorov, I. Szabolcs, Shchyun-I Raychaudhuri, N. I. Bazilevich and others are now continuing the research on this subject.

Geographical distribution of alkaline soda-saline Soils

The soda-saline soils of Asia have been described by numerous scientists, including the author of this survey, on the territory of the People's Republic of China. Such soils are found on the ancient alluvial plains of the basin of the Sungari river (a tributary of the Amur); on the delta-alluvial plains of the Hwan Ho and Innumerable other rivers flowing into the Yellow Sea; on the alluvial terraces of the Hwang Ho and the tributaries along its middle reaches (in North Western China); on the sub-montane

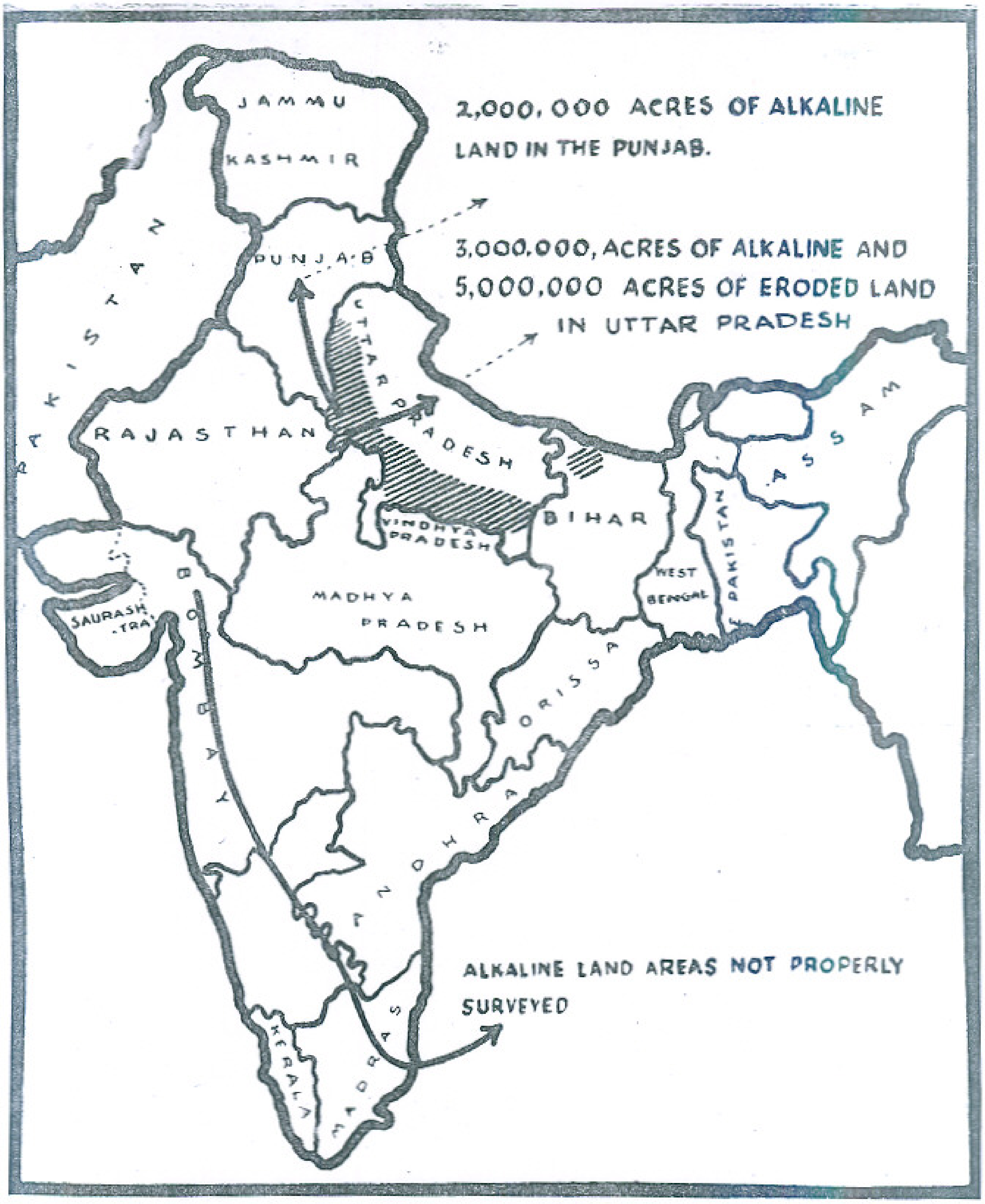


Fig. 1.—Distribution of soda soils in India (After K. N. Kaul—1961)

alluvial plains and lower terraces of the rivers of Western China which flow down from the Tien Shan and Kunlun mountains, including, in particular, the Tarim, Aksu, Kizil Su, and Manas; and lastly; on the alluvial terraces of the large and small rivers of Mongolia (Syun-1, 1936; Kovda, 1958; 1961; Egorov, 1961).

The existence of soda-saline soils (soda solonetz and soda solonchaks) on the alluvial plains and depressions of the Mongolian People's Republic has also been ascertained (Bespaloy, 1951). Saline soils of sodic salinity (often in combination with chlorides and sulphates) are widespread also on the alluvial and alluvial-deluvial plains of the Indian sub-continent (Raychaudhuri, 1954). Soda-saline soils are very often found, likewise, on the alluvial terraces of the river Indus (and its tributaries,) in Pakistan and India. Another extensive zone of soda-saline soils exists in North and North West India, on the alluvial-deluvial sub-montane plains formed by the numerous rivers flowing down from the Himalayas towards the Indian Ocean; on the alluvial plains of the middle reaches of Ganges and of its tributaries, West of meridian 80°, and there are varying alkaline soils on the alluvial terraces and depressions of the Deccan plateau amongst the black cotton soils of the monsoon belt. Lastly, large areas of soda-saline soils are to be found on the river terraces of South West and Southern India States of Bombay, Madras, where they exist in combination with lateritic soils of ancient surfaces.

Heavy alkaline soils, with groundwaters often at a depth of 1.5-2.5 m. were known to Indian farmers and scientists under the name of Usar from ancient times.

The phenomenon of secondary soda salinity following the installation of irrigation systems was observed in India and research was done on the subject.

Indians knew about the accumulation of free carbonates and bircarbonates of sodium in these soils, and were aware that they are strongly alkaline (pH9-11); and they made a study of reclamation methods, based on a combination of chemical, biological and hydrotechnical measures (Leather, 1897, Nasir, 1923; Puri and Taylor, 1937 Mukherjee, 1946; Raychaudhuri, 1952-1962; Kaul, 1961 and others).

The area covered in India by alkaline soils of various types amounts to some 2-2.5 million hectares (Fig. 1) B. Rozanov established the existence of black, highly alalkaline soils (pH-9) in Central Burma. Soda-saline soils are often found on fore mountain alluvial-deluvial plains in Iran (including the Teheran region); there are indications that soda-saline soils exist also in Turkey (round Lake Van and elsewhere) and various scientists have referred to alkaline soils on the alluvial plains of the Tigris and Euphrates, in Iraq (Buringh, 1960).

As regards the Soviet Union, soda-saline soils are found in both the Asiatic and the European part of the country. In Soviet Asia, the presence of soils of this type has been established on the alluvial plains of both large and small rivers in Eastern Siberia Yakutia, the Transbaikal region, the Baraba and Kulunda lowlands in West Siberia, several parts of the Urals region, the alluvial-deluvial plains of Transcaucasia, the boders of Azerbaijan (Karacakh steppe), and in Armenia (Araxes valley). The soda deposited in the lakes of Western Siberia has been used for industry for a very long time. Soda solonetz and soda solonchaks have also been noted in certain regions of the Caucasus, Moldavia, the Ukraine and the Great-Russian plain—where they occur always on the first and second alluvial terraces of steppe rivers and within the boundaries of clearly defined depressions. Sodium-saline soils have likewise been found on the alluvial plains of the rivers Don, Dnieper and Danube and their tributaries.

Similarly the existence of soda solontry and soda solonchaks soils in other continents of central and Western Europe, Africa, North and South America and Australia, is known to the soil scientists.

To sum up the following general conclusions may be drawn:

1. These soils are found in cold (permafrost), temperate, sub-tropical and tropical belts, *i.e.* all the way from the sub-arctic to the Equator and far south of it.

2. Gemoraphically speaking, alkaline soils most aften coincide with lake and river terraces, young and ancient alluvial plains, and deluvial and proluvial fore-mountain plains in depressions and also, occasionally, on high mountain plateau.

3. Climatically speaking, alkaline soils occur in regions which have a continental or arid climate at least part of the year (monsoon region, for instance), and therefore evaporation exceeds run-off either permanently or at least some of the time.

4. Alkaline soils are associated as a rule with black humus soils, chernozems, prairie soils, meadow soils, alluvial plains. They may, however, also occur amongst the podzol soils in the north, the brown and chestnut soils of the warm belt, the red earths and regurs (black cotton soils) of the monsoon tropics, the sierozems of the dry equatorial zone.

5. Hydrogeologically speaking, alkaline soda-saline soil are almost always characterized by the presence of relatively little saline, but always slightly alkaline waters, with concentration of between 0.5 and 5.0 gr./1. These waters may sometimes lie very deep down (tens of metres) but their level is much more often fairly high (of the order of 103 m.), so that they exercise a direct influence on the contemporary soil-forming process.

V. A. Kovda, in 1946, pointed out that there exist in the USSR specific provinces of soda and sulphate-soda accumulation occurring mainly in the extensive depressions of the Eurasian steppe and forest steppe zone. The present survey shows, however, that the area of contemporary soda accumulation in the world is both far more extensive and more varied in regard to climatic, hypsometric and soil conditions and also as to distribution throughout the world.

II-Main properties of alkaline soda-saline soils

In the vast majority of cases, alkaline soda-saline soils are characterized by a top horizon, extending down to a depth of from 50 to 100 cm., having dark, very dark or black colour, passing by gradual stages, into grey light grey or yellowish subsoil. Against the dark, grey profile of the soil, light coloured or whitish patches of calcium carbonate, brownish-rusty or dark blue patches of sesquioxides (particularly in the lower horizons) accompanied, sometimes by a grey sprinkling of siliceous dust are often observed.

As a rule, the top horizons of soda-saline soils are exceptionally unstructured, compact, and cemented. The humus horizons of the soil, in the dry seasons of the year, are strongly compressed, with the result that they are traversed by wide fissures, to a great depth. During the damp seasons, on the contrary the soil swells and all the soil lumps increase in size, with the result that the cracks are filled up and the soil becomes practically impermeable. The top part of the profile of alkaline soils comprises columnar, prismoid or cloddy strata, known as the B-horizon. This horizon may begin right from the soil surface; or it may be covered by a thin A-horizon, formed as a result of the action of the root systems of grasses. The deeper the ground water table the thicker, as a rule, the A and B-horizons of alkaline soils will be. Puddles of water on soda soils are usually turbid brownish-black in colour; when they dry up, there remains on the soil surface a shiny black crust or film of dry colloidal substance. The soil profile often contains small and large grains of newly-formed ferric and manganese oxides indicating the influence, present or past, of high groundwater table. The groundwaters in most cases lie at a depth of between one-and-a-half and three metres, although they may sometimes be found to be much further down.

There are a large number of transitional stages between dark alkaline soda-saline soils and slightly alkaline dark-coloured soils and cemented black soils of various types: meadow soils, terrace soils, prairie, valley smolnitzes, chernozems, black cotton soils, etc. Soils with fairly low alkalinity (pH 8.5-8.8) will have a specific plant cover adapted to these particular conditions; whereas strongly alkaline soils (pH 9, 10, 11) have, as a rule, practically no plant cover. Soil with strong sodic salinity-of the order of 1.5-2.0-3.0% lose their dark colouring owing to the coagulating effect of the easily soluble salts, acquire a false, friable structure and become-albeit only temporarily permeable.

The chemical properties of alkaline soda-saline soils vary very widely. The total amount of easily soluble salts contained in water extracts is not large usually between 0.2 and 0.5% though it may sometimes be as much as 0.7-1.0% and, on very rare occasions, even between 2 and 3%. In soil with a high groundwater table (1.5-3.0 m.) there is a definite pattern in the distribution of the easily soluble salts, with the maximum on the surface or in the B-horizon just below the surface; and a gradual decrease down towards the groundwater table (Fig. 2). In soils with a low groundwater table,

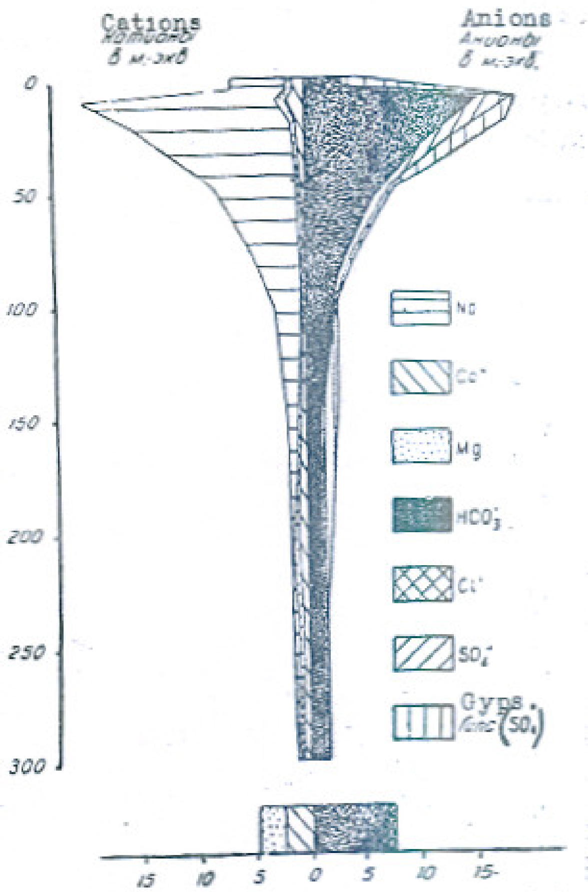


Fig. 2.—Salt profile of soda—solonetz—solonchak; 3rd terrace of the River Samarka, Section No. 23.

(5-10 m.), the maximum amount of easily soluble salts (including carbonates and bicarbonates of sodium) is found in the lower part of the B-horizon and in the C-horizon. As regards degree of salinity, alkaline soils are not, relatively speaking, very strongly saline-differing, in this respect, from sulphate and chloride-sulphate saline soils, which have a salt content of several per cent. As regards composition, analysis of the easily soluble salts contained in a water extract taken from alkaline soils shows that carbonates and bicarbonates of alkali head the list: the CO_3 content is 0.05-0.07% that of HCO_3 of the order of 0.1-0.2%. In soils with maximum soda salinity, the content of these ions may be as much as 1%.

The presence of free carbonates and bicarbonates of alkali, being accompanied by hydrolysis, causes the occurrence, in soda-saline soils, of a strongly alkaline reaction with the result that the pH value, in alkaline soda-saline soils is above 8.5-it varies between 9 and 11. Strong alkalinity is in fact one of the main features of the chemistry of soils of this group.

There exists, as between the total salt accumulation in the soil and ground-water and the degree of alkalinity (expressed by the concentration of HCO_3 anions or pH), a definite *albeit* complex dependence. The highest degrees of alkalinity are linked with certain relatively low values for the general content of easily soluble salts. Above a certain figure more than 5 gr./L in ground waters more than 1% in soils,) for the total quantity of salts, the degree of alkalinity begins to decrease noticeably, until reaches the minimum figure (Fig. 3 and 3-*a*). Bicarbonates and carbonates of alkali may be

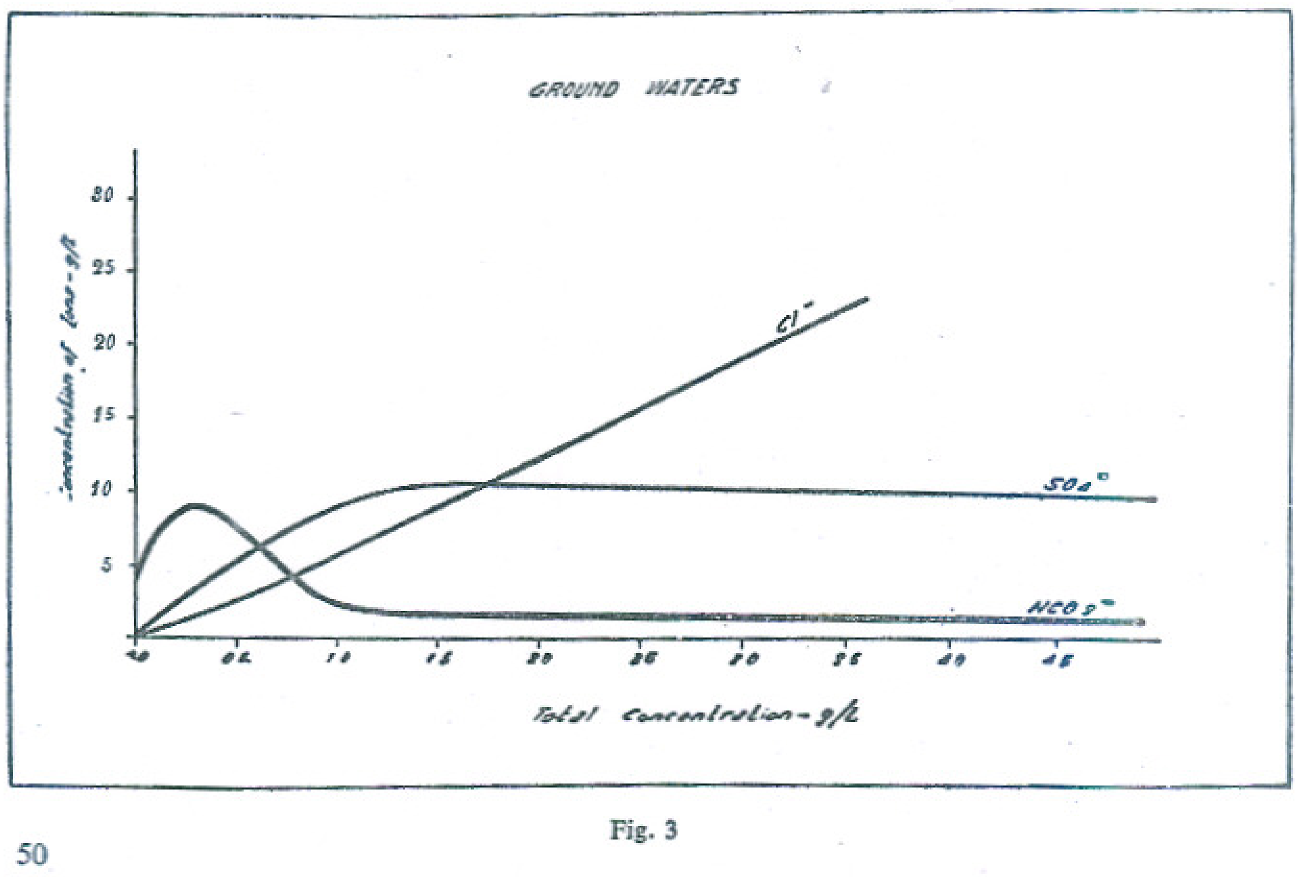


Fig. 3

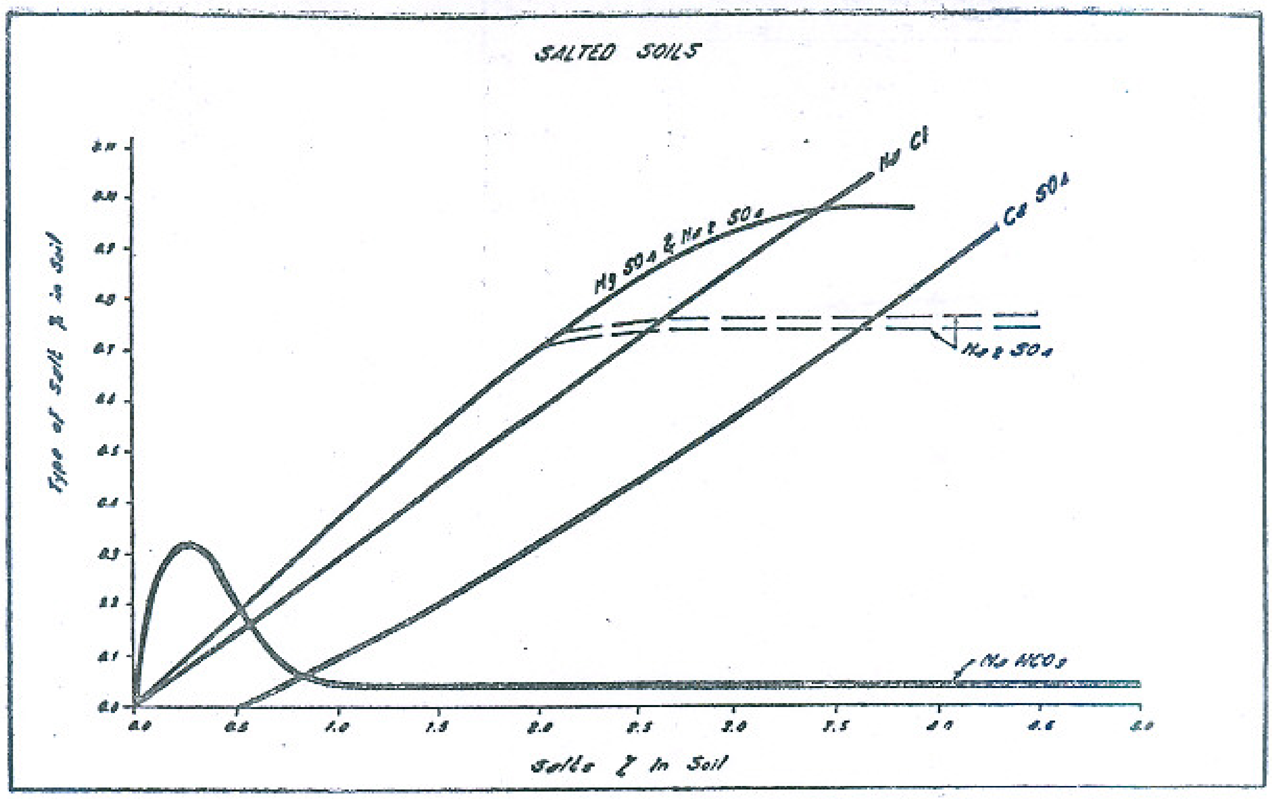


Fig. 3-*a*

contained in alkaline soil either in practically pure form or mixed with chlorides or sulphates. For this reason, a distinction must be drawn between two types of alkaline soils: soda-sulphate and soda-chloride. Table 5 contains analytical data for alkaline soils of different types of chemical composition.

Both soil solutions of alkaline soils and alkaline groundwaters almost always contain large concentrations of dissolved silica (60-80-100 mg./L SiO_2). These solutions are partly colloidal. The total quantity of mobile SiO_2 in a water extract obtained from alkaline soil may sometimes be as much as 0.05-0.1%. The quantity of mobile silica in soils increases with the growth of general alkalinity and pH values. There have been cases of the maximum formation of mobile silica in the soil profile of soda soils being located near the surface.

A constant feature of soil solutions and soil extracts from alkaline soils is the presence of mobile forms of organic substance (alkali humates). Indeed, it is these humates that give water extracts the dark coffee colour so characteristic of these soils. And lastly, water extracts and solutions of soda-saline soil are sometimes found to contain anions of aluminium (from aluminates of alkali). It is clear from the foregoing that alkaline-type saline soils contain, in addition to carbonates and bicarbonates of alkali, also silicates, humates and aluminates of the same alkalies (Fig. 4).

Thanks to the combination of intense alkalinity and extremely unfavourable physical properties, alkaline soils have

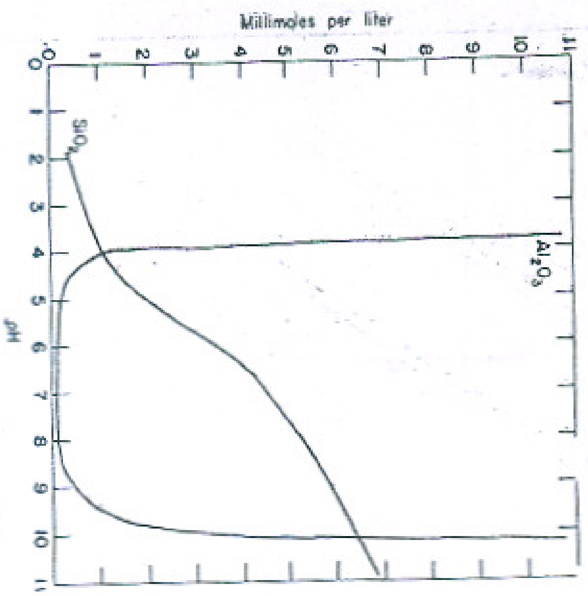


Fig. 4.—The solubility of salica and allumina as a function of pH.

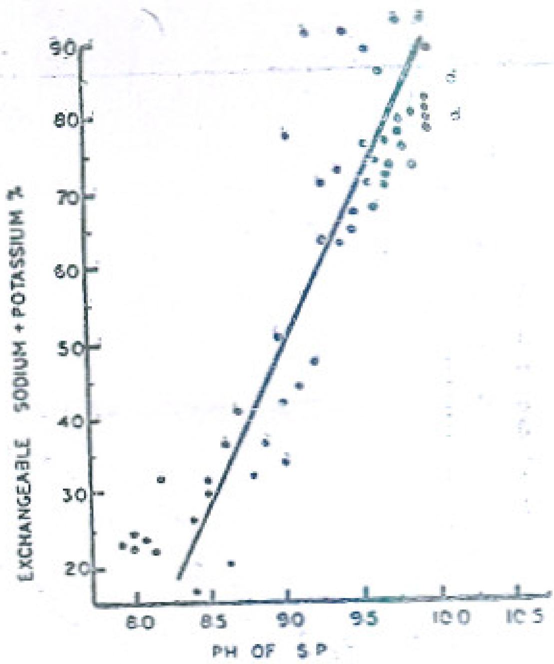


Fig. 5 Relation between pH & exchangeable sodium + potassium

exceptionally poor natural fertility. The physiological toxicity of soda is several times higher than that of chlorides and, more especially, of sulphates. Even on soils with total alkalinity of about 0.07% HCO_3 and pH 8.7, many cultivated plants fail to develop normally; and with total alkalinity of about 0.1% HCO_3, and pH 9.5, almost all cultivated plants die. The presence of exchangeable sodium has a similar effect; quantities of adsorbed sodium constituting 25-30% of the exchange capacity make soil barren for most agricultural crops and utterly unsuitable for tillage and irrigation.

In Table 1 data showing a close connection between the level of natural fertility of soils and the degree of their alkalinity.

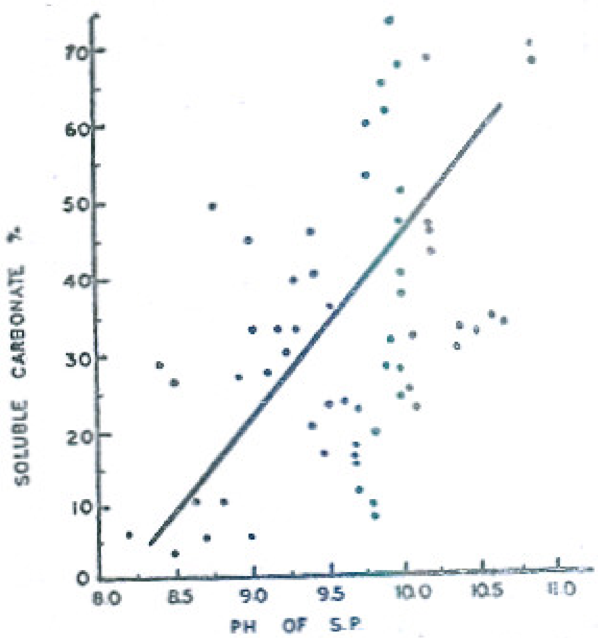


Fig. 5a Relation between pH and soluble carbonate

TABLE I

Connection between the alkalinity and fertility of soil.

Exchangeable Na in % of capacity ..	5	10.15	25.30	50
Total alkalinity of water extract in % of HCO_3 on weight of soil ..	0.02-0.04	0.05-0.06	0.07-0.08	0.1-0.2
pH of water extract or paste of soil ..	7.5-8.4	8.5-9.0	9.0-9.6	9.5-10
Relative fertility of soil (%) ..	100	60-75	20-30	0.00

III. Processes of formation of soda

The formation, migration and accumulation of compounds of carbonate and bicarbonates of alkali constitutes one of the oldest geochemical processes in existence, and one which is still taking place, all over the world, to this day. As we know, alumosilicate minerals represent by far the most important component in the mineral composition of the earth's crust, constituting 8.85% by weight of the rocks. Some of these minerals are highly stable whilst others have little stability and are easily weathered in the presence of water, particularly when it contains carbonic acid. The chemical weathering of sodium and potassium alumosilicate minerals—more particularly those like feldspars and feldspathodids—is accompanied by the formation of solutions of bicarbonates and carbonates of alkali, also of ionic and colloidal forms of silicas and aluminium oxides. The universal predominance of feldspathic minerals in the earth's crust in all climatic zones leads to the continuous formation, everywhere, of solutions of silicates, bicarbonates and carbonates of alkali, and alkali earths. It is for this reason that, when we analyse the chemical composition of natural waters in different climatic zones we invariably find that the lower the mineralization, the greater the relative quantity of dissolved silica, bicarbonates and carbonates of metal they contain. Special research was done on this question by Soviet and Chinese oil scientists in 1956-1957 in the basin of the Amur and Sugari rivers, with the author himself taking part. In the course of this work it was demonstrated, on a large quantity of material specially assembled for the purpose that, in the most diluted groundwater (50-100mg./L) silica alkalinity represented 70-90% of the total alkalinity. When the total concentration increases to 500-1000 mg./L, both the relative and the absolute quantity of dissolved silica decrease sharply, with a simultaneous marked increase in the content of the hydrocarbonate anion (Table 2).

The formation of bicarbonates and carbonates of alkali is particularly intensive in the case of rocks and minerals of recent volcanic origin Basalts, volcanic lava, volcanic ash and volcanic tuff, when exposed to the action of natural waters and carbonic acid, undergo intensive disintegration, forming large quantities of mobile silica, alumina and free bicarbonates and carbonates of alkali. This process is most marked when the pyrogenous material contains mainly nephelines or

TABLE II

Chemical features of the groundwaters of the Amur-Sungari basin.

Type of ground waters		Total dissolved matter mg./L	pH	SiO_3 mg./L	HCO_3 mg./L	CO_3 mg./L	SO_4 mg./L
Silicate	..	50-100	4.5-6.5	22-42	40-50	..	..
Silicate-hydrocarbonate	..	100-500	5.5-6.5	12-22	40-60	..	..
Sodium-hydrocarbonate	..	500-1000	6.5-7.5	6-12	60-70	5-10	..
Sodium-sulphate	..	100-3000	7.5-8.5	traces	40-50	20-30	20-30

svenites. The experiments which the author carried out parsonally some time ago (1935, Kovda and Bystrov), showed that the hydrolysis which nephelinic sevnites undergo, especially in the presence of carbonic acid, is so intensive that a simple water extract taken from pulverized svenite removes large quantities of mobile silica, and bicarbonates and cabonates of alkali are formed. The same thing was established by Stevens and Carron in 1948, by observing the hydrolysis reaction of alumosilicates subjected to intense frication in water. Similar phenomena are also observed in nature: spring, ground and subsoil waters, also lakes fed by streams in areas of recent volcanic deposits, contain large quantities of carbonates and bicarbonates of alkali and of mobile silica. In an arid climate zone, new volcanic areas will always be characterized by the formation of waters and soils containing soda.

IV. Conditions governing the continuous existence and accumulation of soda

We have examined, in the foregoing pages, the processes which lead to the formation of bicarbonates and carbonates of alkali, including soda. We shall next consider the conditions under which soda, when formed, is able to exist, migrate and accumulate, without passing into other compounds. One of the most important of the factors which restrict the ability of bicarbonates and carbonates of alkali to go on existing in solutions is the presence of dissolved salts of calcium—such as for instance calcium sulphate or calcium chloride: both these compounds when reacting with sodium bircabonates and carbonates, form calcium carbonate which is practically insoluble in an alkaline medium—as well as sodium chloride and sodium sulphate. The presence of calcium sulphate in landscapes—which is characteristic, for instance, of the territories of Soviet Central Asia, where there are almost always thick deposits of gypsum in Quaternary and Tertiary sedimentary rocks, and also in soils—causes the constant neutralization of bicarbonates and carbonates of alkali, and their transformation into calcium carbonates.

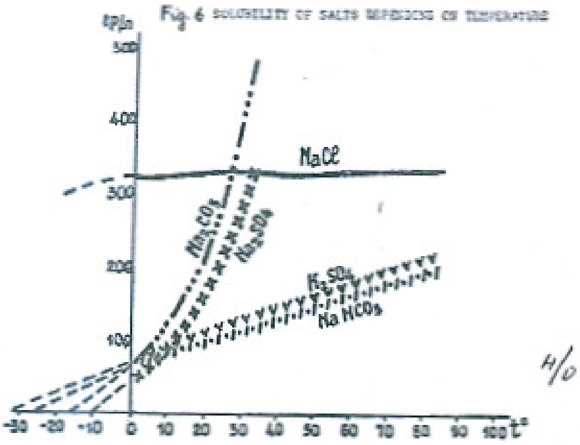
This is probably the reason why soda-saline soils are virtually unknown in Uzbekistan, Southern Kazakhstan, Tadjikistan and Turkmenia.

Free carbonates and bicarbonates of alkali cannot accumulate in substantial quantities until the whole of the calcium sulphate and calcium chloride reserves in any given territory have been transformed into carbonates. Only after this has occurred can soda exist and accumulate in free form.

V. Physico-chemical properties of sodium carbonates

The easily soluble salts which cause soda salinity in soils are composed mainly of the following water-soluble minerals: soda ($Na_2CO_3.10HO_2$) which crystallizes in soils with ten molecules of water, forming a mealy-fibrous mass; thermontrite ($Na_2CO_3. HO_2$) this is the same chemical compound but with one molecule of water only and a different crystal form, and it likewise accumulates in the form of mealy granules in soils and sedimentary rocks; trona—a salt containg two molecules of water, usually present in soda-saline soils and along the shores of soda-alkaline lakes in the form of pure salt, salt deposits ($Na_2 CO_3. NaHCO_3 2H_2O$); and lastly, nahcolite ($NaHC_2O_3$)—an anhydrous bicarbonate of sodium which is always present together with the three above components, being found in solution as well as in deposits in both soils and sedimentary rocks. Sodium carbonates are highly soluble in water; so in particular is soda which, at high temperatures, attain a concentration of nearly 500 gr./L—higher even than that of sodium chloride. The solubility of carbonates and bicarbonates of alkali depends to a very great degree on surrounding conditions, and varies within very wide limits. Most astonishing is the extent to which the solubility of sodium carbonates and bicarbonates depends on the temperature: at temperatures of zero and below, the solubility of soda and sodium bicarbonate, also that of sodium sulphate (but not that of sodium chloride) drops to as little as 3-5 gr./L. At temperatures of around 30°C, the solubility of soda is as high as that of sodium chloride, *i.e.* approximately 350 gr./L; whilst at temperatures of 40°C the solubility of soda is considerably higher than that of sodium chloride (Fig. 6). The

Fig. 6 SOLUBILITY OF SALTS DEPENDING ON TEMPERATURE



behaviour of soda in relation to temperature is similar to that of sodium sulphate, whose solubility also varies enormously with the temperature, being low in cold temperatures and many times greater in hot ones. The solubility of sodium bicarbonate is likewise much higher in warm temperatures, though it varies less than soda.

In the study of soil and geochemistry, this factor is of outstanding importance. It means that soda at atmospheric temperatures of the order of 10-15, and at 0° and below, will precipitate out into deposits in lakes and soils together with sodium sulphate: whilst chloride solutions will be carried away by ground, sub-soil and surface waters in the direction of the general geochemical flow. It is thus to be expected that, in regions with a cold climate and severe winters, saline soil will be characterized mainly by accumulation of sulphates and carbonates of alkali. In a dry, hot climate, on the other hand, owing to the fact that soda will then be more soluble than chlorides separation may occur and soda may accumulate in the areas of final evaporation of the solutions. Combined migration and accumulation of soda and sodium chloride will be comparatively rare, occurring mostly in places where there are deep, reducted underground waters flush with the surface. The solubility of sodium carbonates depends also in great measure on the salts contained in solution. Sodium sulphate in particular plays a very important part: when present in large concentrations, it lowers the solubility of soda and sodium bicarbonate and causes them to be precipitated out into deposits. For instance, saturated solutions of sodium sulphate, at concentrations of the order of 200 gr./L, transform soda and sodium bicarbonate into an insoluble deposit (Fig. 7). The influence of sodium chloride in this respect is similar to that of sodium sulphate, though not as strong. The soublility of sodium carbonates and bicarbonates decreases sharply with a total concentration of sodium chloride of the order of 260-270 gr./L

(Fig. 7*a*). In view of the fact that the solubility and migration capacity of sodium carbonates decrease in the face of high concentrations of sodium sulphate and sodium chloride, most highly concentrated natural brines will contain only small quantities of

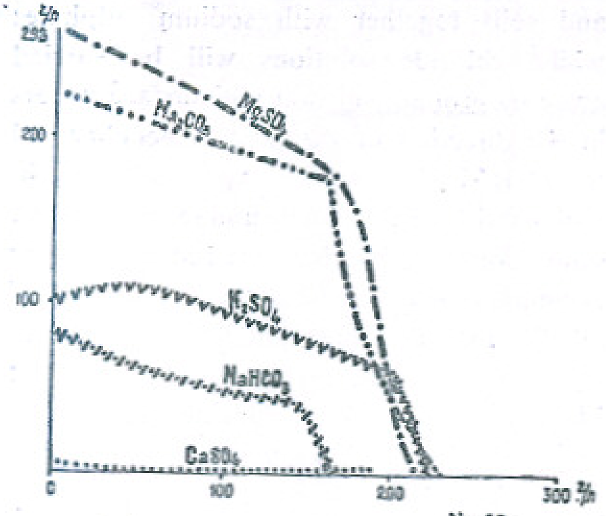


Fig. 7.—Solubility of salts depending on Na_2SO_4 concentration.

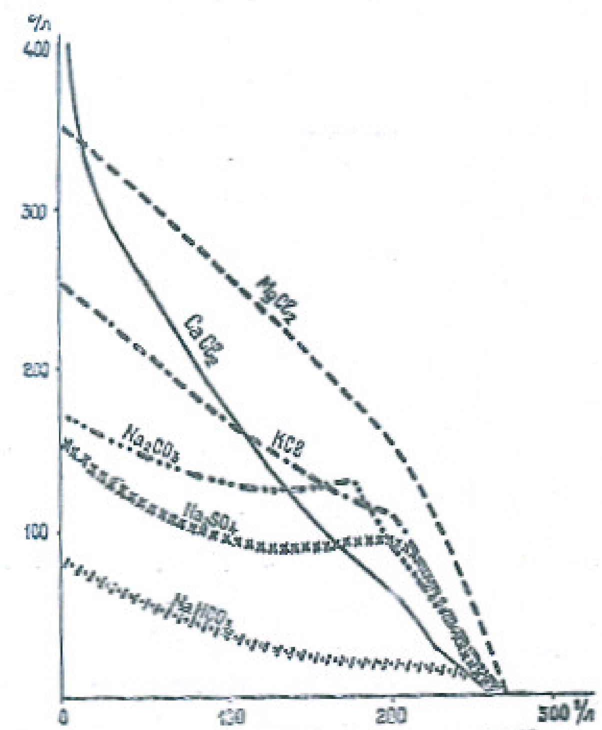


Fig. 7-*a*.—Solubility of salts depending on NaCl concentration.

sodium carbonates and bicarbonates.

A sharp distinction can thus be drawn, in the geochemistry of salt on land, between regions of carbonates of alkali and regions of accumulation of chlorides and sulphates: the potential areas of accumulation of bicarbonates and carbonates of alkali being much larger than those of chlorides or even of sulphates. Soda and sodium bicarbonates will tend to accumulate in regions where the general salt content is fairly small, *i.e.*, mainly in those at the initial stages of salt accumulation.

A high Soda concentration in solutions, in its turn, exercises a strong influence on the solubility and mobility of calcium carbonate, which is an extremely important compound in soil chemistry. Figure 8 shows that there is a very sharp drop in the concentration of calcium even in solutions with relatively low general-alkalinity. In the presence of sodium bicarbonate, calcium bicarbonate still retains some degree of solubility; but the presence of soda, even when the total alkalinity level drops to 0.1-0.2 gr./L, virtually eliminates the calcium from solutions. This explains why the groundwaters, in regions of alkaline salt accumulation, contain practically no dissolved calcium salts despite the presence of calcium carbonate in the rocks and soil horizons.

We have studied this phenomenon on the basis of numerous analytical data relating to soils of varying degrees of alkalinity. The data given in diagram 8 show that, after the alkalinity figure for water extracts reaches 0.05% HCO_3, these extracts contain practically no calcium salts.

When it comes to compounds of silica, aluminium and organic matter, it will be seen that normal and bicarbonate alkalies influence their solubility and mobility in precisely the opposite direction (Fig. 9): the greater the alkalinity of the soltion, *i.e.*, the greater the concentration of soda in it, the more compounds of silica, alumina and humus in the form of pure, molecular or colloidal solutions it will contain. The same applies to soils: the higher their alkalinity, the greater amount of mobile forms of silica and organic matter their soil solutions or water extracts will contain (Fig. 9). It is a well-known fact that rain puddles, surface streams and small brooks flowing through soda-saline soil areas are strongly tinted by

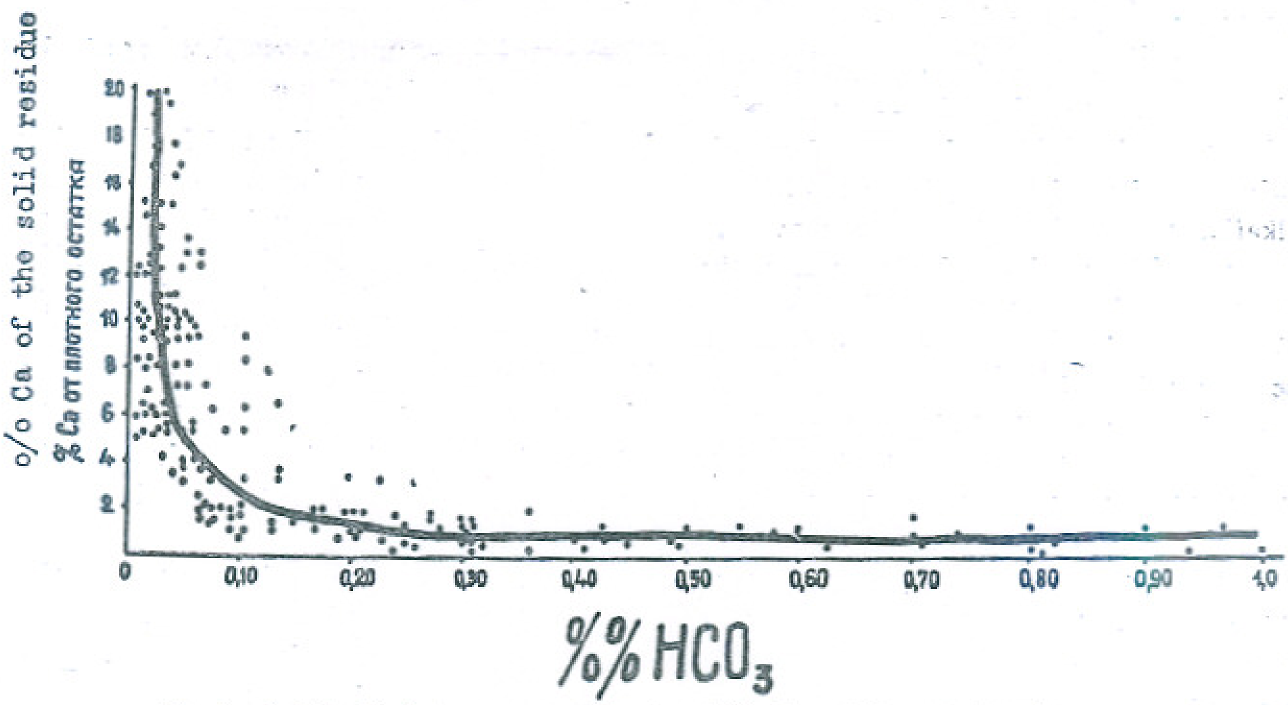


Fig. 8.—Relationship between content of water soluble Ca and the total Alkalinity.

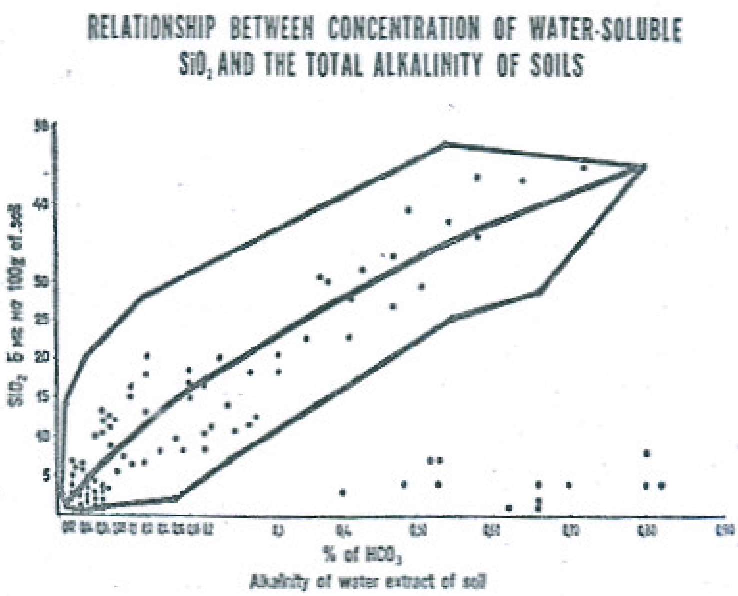


Fig. 9

organic matter. This capacity of alkaline soda solutions to turn compounds of silica, alumina and organic substances into mobile form has very far-reaching consequences in soil science and geochemistry.

Soda-salt accumulation areas will be characterized by more than the accumulation of bicarbonates and carbonates of alkali: there will also occur at the same time—though the process may not be visible—accumulation of compounds of silica, alumina and organic substances brought into the area with the alkaline water of surface or underground streams. Measured in absolute terms, the amount of these components brought into the area in this way will not at any one time be large; but these processes, continuing throughout long geological areas, culminate in the accumulation of considerable quantities of silica, alumina and organic substances, and the emergence of a highly specific type of soil-forming substratum. It is precisely this property—the capacity to transport silica and alumina compounds into areas of salt accumulation—that is, in our opinion, responsible for the formation in these areas of sedimentary rocks rich in secondary, amorphous minerals with marked predominance of silica over alumina and, more particularly, responsible for the formations, in these regions of montmorillonite-type clays containing a constant admixture of highly dispersed organic matter. Even kalolinite type clay deposits, under the influence of alkline groundwaters, containing dissolved silica, are inevitably transformed into montmorillonite, type clays. As a result of all these factors combined, the sedimentary soil-forming rocks of soda-saline regions will be dark in colour, be characterized by high dispersion, have a large swelling capacity when damp, and shrink and crack when dry. In other words, they will possess all the properties which distinguish soda-saline soils from the other soil types. The main reason for the black colour of meadow soda-saline soils is of course the accumulation of humus in hydromorphous soil-formation conditions.

VI. Soda-accumulation—the first stage in the progress of salinization of soils and waters

The results of studies which the author carried out over a period of many years, and reports on which were published at various times (Kovda, 1946, 1947, 1954, 1959), show that there exist certain specific relations between the quantity of the salts which accumulate in natural waters and soils and their composition. In the process of the growth of the mineralization of water, the following quantitative and qualitative stages occur:

1. Completely fresh waters of the tropics and of northern forest regions, containing silica and organic substances; total concentratin 0.01-0.1 gr./L;
2. Fresh hydrocarbonate-calcium water with concentrations of 0.2-0.3 gr./L.
3. Hydrocarbonate-sodium waters with concentrations of 0.5-0.7 gr./L;
4. Hydrocarbonate-sodium waters with salts concentrations of 0.5-3.0 gr./L, containing sulphates and, less often, chlorides;
5. Chlorido-sulphate waters with concentrations of 2.5-5 gr./L, containing soda;
6. Sulphate-chloride waters with con centrations of 20.30 gr./L and more, usually not containing soda in substantial quantities (Fig. 3).

The foregoing general pattern for the existence of hydrocarbonate-sodium underground waters with low mineralization (0.3-5 gr./L) was established by the author on the basis of a large quantity of geographical and hydrogeochemical data. The West Siberian depression, including the Barba and Kulunda plains, is a typical example of this phenomenon. In this immense soda-saline region (which we in 1946 called the Soda-salt accumulation area) it is established that in 80.90 % of cases, the first aquiferous groundwater horizon, and also the groundwaters, of the Quaternary, Tertiary and Cretacious strata, when they have concentrations of the order of 0.5-5 gr./L, are hydrocarbonate-sodium in type, with some sulphates or chlorides. With higher concentrations of salts in groundwater-10-20-30 gr./L-soda mixes as a rule with chlorides and sulphates. We established a similar hydrochemical pattern for the Hwan-Ho and Sungari basin in China, where, as mentioned earlier, there are large areas of soda-saline soils. The same chemical composition is found in the groundwaters of the Ararat Valley in Armenia, the Karabakh steppe in Azerbaijan in the subterranean waters of North Africa, California, Argentina, and so on. There are few known examples of deviations from this general pattern for the formation of alkaline hydrocarbonate-sodium waters. The most striking example of the complete absence of hydrocarbonates and

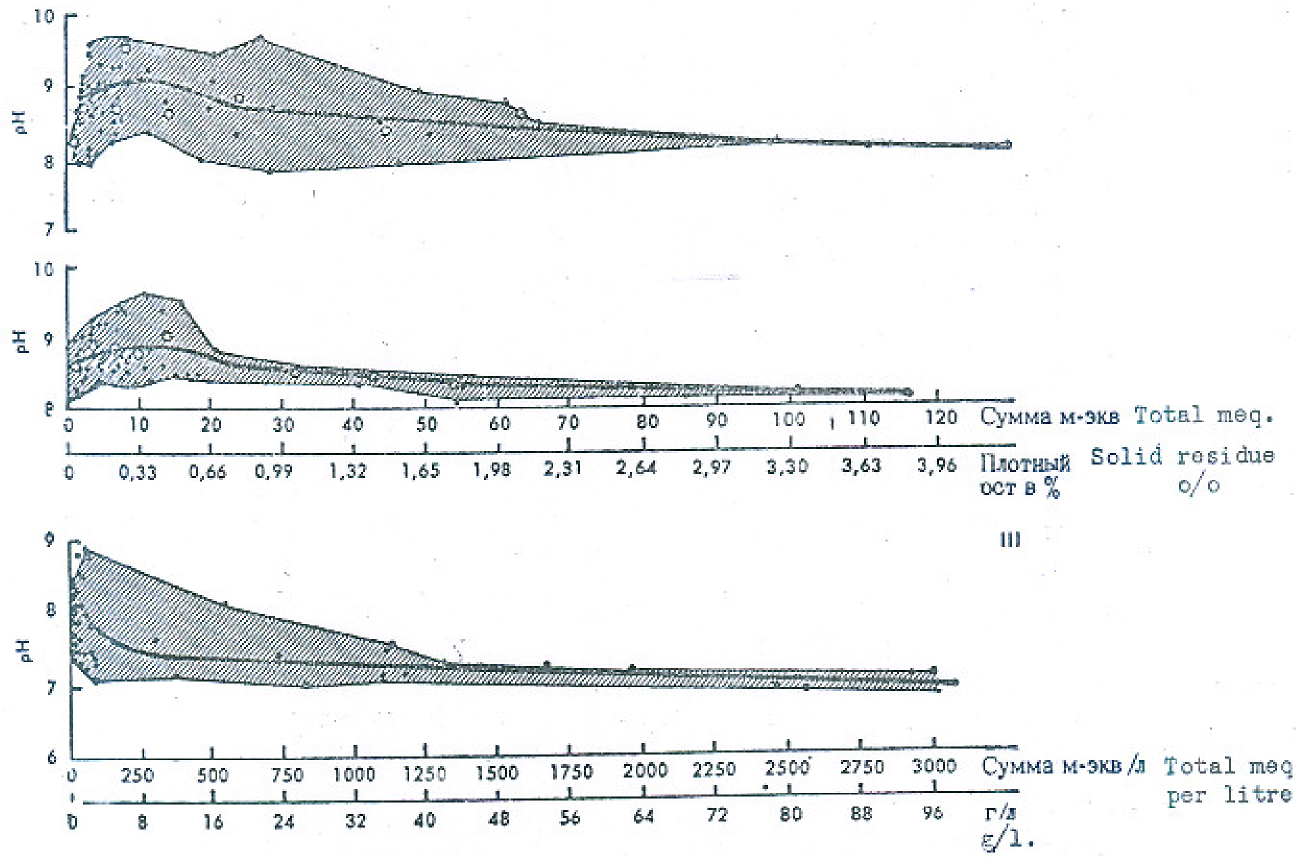


Fig. 10.—Relationship between the salinity and the pH value.

I. In top soil horizons.
II. In lower soil horizons.
III. In ground waters.

carbonates of alkali in groundwaters is that of the Ferghana Valley in Uzbekistan; here the rocks forming the valley basin contain abundant gypsum; and both the sedimentary rocks and the soils are super-saturated with this substance. In these conditions, it is impossible for bicarbonates or carbonates of alkali to form large concentrations or accumulation in solutions. Due to this, the Ferghana Valley constitutes a classical example of the absence of alkali accumulations and of the predominance of processes of accumulation of sulphate salts and, in particular, calcium sulphate. This is also characteristic, though to a lesser extent, of the Hungary steppe and the Bokhara region in Uzbekistan, the Vaksh river valley in Tadjikistan and the lower reaches and delta of the Amu-Darya. The fact that alkaline soda-saline soils coincide with the absolute minimum salinity figure explains why, when defining soil salinity by electro-conductivity, soda soils were not identified or recognized, but were considered as non-saline soils having poor water and physical properties. If a detalied analysis of the water-soluble salts contained in these soils had been made, on the basis of water extracts, and if their groundwater, which are fresh to the taste, had been tested for salt content, it would have been discovered that they in fact contain large quantities of sodium bicarbonates and carbonates, and the reason for their poor fertility and bad water and physical properties would have been explained. There is, in the author's mind, no doubt that many compact, impermeable, unstructured fissured dark-coloured steppe and meadow soils (so-called vertisoils) are in fact so many different types of soda-saline soils which not been identified as such beause their chemical composition has been analysed, if at all, by the electro-conductivity method.

VII. Utilization and reclamation of soda saline soils

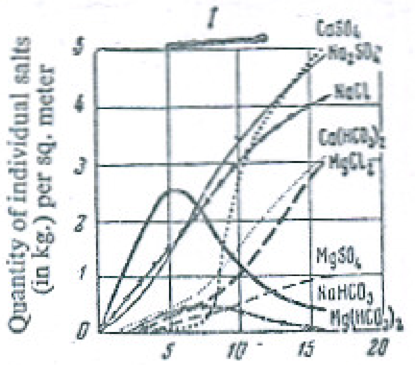
In view of the fact that sodium bicarbonates and carbonates are highly toxic for agricultural plants and also because of their extremely unfavourable agrophysical and hydro-physical properties, alkaline soda-saline soils are both difficult to reclaim for agricultural purposes and unrewarding. To reclaim such soils radically and permanently is a costly and complicated business. Before including alkaline soils in agricultural projects, therefore a thorough study of their genesis, and of their chemical, physical and hydrological properties methods for their reclamation and subsequent agricultural utilization. The reclamation methods selected in each case will depend on whether the soils are to be used for pasture land, as arable land under non irrigated (dry) agriculture or for irrigated agriculture. They will also depend on the particular type and regime of the alkaline soils in questions and especially their origin whether they are contemporary, active and linked with alkaline groundwaters; or whether, on the contrary, they are residual, relict and in the process of transformation into normal, non-alkaline soils.

From a purely economic view point it is preferable, provided that the country or region concerned possesses sufficient good agricultural land, not to plough up alkaline soda-saline soils, but to use them mainly as pasture land. When left, virgin alkaline soils do possess a certain plant cover, sparse though it may be, which can serve as fodder for horned stock. In soda-saline regions such as those located along the East African graben, the alkaline soils are covered with sparse grassy savannah vegetation, and are used as natural pasture by herds of wild buffaloes, zebra, antelopes, deer and other animals. Under good management, these animals provide enormous quantities of valuable meat, skins, wool and also numerous by-products of the meat industry. In Western Siberia in the USSR, livestock breeding flourishes on the natural pastures afforded by meadow-swamp and meadow soils, a large percentage of which are soda-saline. In Hungary too, the most intensely soda-saline soils are not ploughed up, but used for pasturing livestock; and the same is done in Argentina.

It must, nevertheless, be borne in mind that over-pasturing, with resultant degradation of the plant-cover and destruction of the soda intensifies the evaporation of soil moisture, increases the accumulation of alkaline salts and lowers the quality of the pasture. This is particularly serious in the case of alkaline soils with a high groundwater table. It is important, therefore, when using alkaline soils for pasture, to select suitable areas and regulate the number of stock per unit of area. As shown by the example of Australia, the quality of pasture on alkaline solonetz soils can be greatly improved by scattering.

Gypsum on the surface and using the simplest irrigation methods. Using alkaline soils (solonetz meadow soda solonchaks) for dry, non-irrigation farming is extremely complicated and frequently unsuccessful; besides which, agricultural crops grown in these conditions produce comparatively small yields. Much depends on the quantity of atmospheric precipitations, and how they are distributed throughout the year. In the Mediterranean climate with maximum rainfall in winter and spring, and also in the monsoon regions, with maximum rainful in summer it is possible—provided the total rainfall attains from 300 to 400 millimetres—to obtain yields from unirrigated crops such as barley and wheat. This applies, however, only to soils with very low alkalinity, having pH readings of not more than 8.5 on alkaline soils with pH readings of about 9 or, even worse, 10 and more, the cultivation of agricultural crops with dry farming methods, becomes impossible unless irrigation and reclamation measures are applied; though natural fertility is somewhat better and a certain amount of dry farming can be done in places where the alkaline, solonetz horizons instead of being right up at the surface, are topped by a humus or solodized A-horizon. Be this as it may, special reclamation work will always have to be done before alkaline soils can be used for dry farming. This will include: putting of gypsum in the soil in order to neutralize the free soda and exchangeable sodium; deep plantage ploughing in order to mix up the alkaline horizons with the subsoil horizons containing lime or gypsum; and application of large quantities of organic manure for the purpose of increasing the soil's content of carbonic acid, capable of neutralizing its alkalinity. Experience acquired all over the world in methods for improving alkaline soils shows, however, that the best results are obtained by irrigated farming, combined with radical measures of reclamation. Many years of research on this question has been done by Soviet soil scientists and agronomists in the Volga region. Western and Eastern Siberia, Central and Northern Ukraine, the Urals area and Transcaucasia. Also, extremely interesting observations have been made, and methods devised by Hungarian soil scientists, by U.S.A. specialists in California and Oregon, and by Chinese scientists in North-eastern and Western China. The combined experience of different countries shows that alkaline soda-saline soils can only be permanently improved by the application, simultaneously, of a whole series of soil-reclamation measures: chemical, physical, biological and phydrotechnical (watering, leaching, drainage).

Fig. 11.—Salt accumulation in soils Western Siberia.



Total quantity of easily soluble salts in the soil above ground water table (in kg.)]

The first step to be taken in order to ensure permanent improvement of soda soils is to eliminate the alkalinity caused by the presence in these soils of sodium carbonate and bicarbonate, and also of absorbed sodium. The general soil-alkalinity, as indicated by data obtained from a water extract, has to be reduced to about 0.05% HCO_3, the pH value to 8.4-8.5, and the quantity of exchangeable sodium in the arable horizon to about 5-10% of the total sum of exchangeable cations. The data obtained by Soviet, American and Hungarian experimental stations show that good results are obtained by applying large quantity of gypsum (40-90 t. ha.), sulphur (1-2 t./ha), sulphuric acid waste, ferric sulphide, raw calcium chloride, hydrochloric acid waste, and chlorine gas. With a sufficiently damp climate or good irrigation, satisfactory results are sometimes obtained, in experimental conditions by applying calcium carbonate together with large quantities of organic fertilizer, which leads to the formation, in the soil solution, of calcium bicarbonates and free carbonic acid. The optimal quantities of chemical substances to use, and also the best timing and methods of application, depend enormously on the specific geographical features of each area, the degree of soil alkalinity and the type of soda-alkaline soils to be treated. Soda solonchaks, being strongly saline, require leaching for removal of the surplus salts, in addition to gypsuming. Since these soils have poor water-permeability and since soda and sodium sulphate are difficult to leach out during the cold season, it will be advisable to put soda solonchaks under irrigated rice crops for a couple of years after treating them with gypsum. This "summer type" leaching is more effective and gives good results (experiments carried out in the Peoples Republic of China and in Hungary). The next stage in the process of reclaming soda-saline soils is to apply measures for improving their physical properties. All tendencies towards coalescence, loss of structure, peptization, impermeability to water, swelling when damp and cementation and crusting when dry must be eliminated. This will be achieved partly by the lamination of alkalinity and exchangeable sodium; partly also, by the introduction of calcium into the soil solution and the absorbing complex. A further means of improving the physical properties of alkaline soils is by deep heating (to 50-70 cm). and subjecting the soil surface to periodic drying and heating up simply by exposing it, under bare fallow, to the rays of the sun which will lead to dehydration and coagulation of the soil colloids, shrinkage of the crystal lattice of montmorillonite minerals, and fixation, in nonexchangeable form, of part of the absorbed sodium, with a consequent general improvement in the structure and physical properties of the soil. It has been shown both by our laboratory research in the 1950's and by investigations made in the field by Ukrainian scientists, that exposure to heat considerably improves the agrophysical properties of soils, even at temperatures of only 70-75°C.

The most important feature in operations for the improvement of soda-saline soils is the elimination from the soil itself of sources of renewal of soda solutions. This operation will, however, not be necessary in soda-saline soils of residual type, which have groundwaters, at a depth of more than 10-15 m. under these conditions, there is no longer any capillary flow of soda and sodium bicarbonate up to the soil surface, and on neutralization of the existing alkaline salts content with gypsum, sulphur or any other compound suffices for many years, especially if the fields are periodically hoed, manured and left under bare fallow. There are, however, many alkaline soils which are contemporary, not residual, and which have groundwaters, containing soda, close to the surface (1.5-2-3 m). In such cases, as shown by the observations of experimental stations in the Urals district, alkaline solids even when treated by chemical reclamation methods, become strongly alkaline again within 3-5 years, with all the attendant disadvantages. From the high alkalineg roundwaters, new reserves of alkaline carbonates constantly pass up into the soil horizons through the capillary fringe. Hence, when dealing with alkaline soda-saline soils which are hydromorphic in character *i.e.*, which have a high groundwatertable it will be absolutely essential, besides using chemical and physical soil improvement measures, to install artificial drainage for the purpose of lowering the groundwatertable and removing soda solutions from the soil cover. The drains used for lowering and removing alkaline groundwaters may be of various types: horizontal, open or closed; vertical with pumps; or combined. Further, they may be widely spaced out or laid close together, depending on the degree of alkalinity of the soil and groundwaters. Whatever the type used, drains provide the sole guarantee both against the intensification of sodium salinity in the event of the group water level rising. The Hungarian soil scientists I. Szabolcs and K. Darab observed the occurrence of secondary soda salinity in those areas of the Hungarian depression which were irrigated for rice growing. In this instance, it is essential to install drainage, in addition to applying all the other soil improvement methods enumerated above, as a means for preventing secondary salinity. In working out plans for improvement of soda-saline soils, the chemical properties of the irrigation water must always be taken into account for instance, prolonged irrigation of alkaline soils with irrigation waters containing calcium bicarbonates or sulphates will automatically improve the chemical, physical and biological properties of these soils. It was precisely this phenomenon which the American soil scientist Kelley observed at the Fresno experimental station in California. This is the reason, too, why gypsum in dissolved form, is poured into alkaline soils together with the irrigation water. This is the means Australian scientists use for achieving rapid and successful improvement of solonetz pasture land. Good results may also be obtained by irrigating with waters containing acids, as the waste waters from factories, coal pits or mining shafts often do. On the other hand irrigation of alkaline soils with waters which contain neither calcium salts nor acids but have even minute concentrations of bi-carbonates and carbonates of sodium will increase the alkalinity of the soil and provoke further deterioration of its chemical, physical and biological properties. For example, the waters of Lake Sevan, in Armenia, are strongly alkaline. In such cases, the quantity of chemical substances required for soil improvement will be much greater; and moreover, when alkaline irrigation waters are used, the chemical reclamation process will have to be repeated after several years.

Another important factor in the radical reclamation of alkaline soils is the improvement of their biological activity. Alkaline soils with high pH readings are characterized by low biological activity. They contain little microbiological life, and few insects, and in particular, worms, are found in their soil horizons. The root systems are not very highly developed, so that the production of organic matter and of carbonic acid is small. All this conduces to making the fertility of alkaline soils low, so that it is extremely important to apply very large quantities of ogranic fertilisers in order to increase their biological activity: manure, organic residues, peatcompost, etc. This gradually increases the microbiological activity and vitality of the soil, and increases the production of carbonic acid.

It is clear from the above that the methods for improvement of alkaline soda-saline soils are complicated vary according to conditions and to the type of soil, and include many costly operations, some of which have to be repeated after the elapse of several years in order to maintain the improvement achieved. Scientifically speaking, and on the strength of both laboratory and field experiments, it may be confidently affirmed that the problem of the reclamation and development of alkaline soils has been solved. We are now able, on the basis of a whole system of theoretical and practical research data, to draw up plans for the reclamation and development of any type of alkaline saline soils. Economically, the question is somewhat more complicated. In each specific case, before deciding to plough up alkaline soils for use in dry or irrigated farming, and before embarking on these operations, it will be essetial to make a general assessment of the economic aspects of the question.

KARL TERZAGHI
1883—1963

By **ARTHUR CASAGRANDE**
(*Abridged from Geotechnique, Vol. XIV, March* 1964, *No.* 1)

On October 25, 1963, the Engineering Profession lost one of its most eminent members who revolutionized design and construction practices in foundation and earth work engineering.

It was Karl Terzaghi, born October 2, 1883 in Prague, Austria. He studied Mechanical Engineering at the Technical University in Graz and graduated in 1904.

After graduating, Terzaghi served one year in Army and during this period he translated Geikies outline of "Field Geology into German".

During the next three years he worked with a contracting firm on variety of bridges. He had a chance to work on Foundation problems of a large building in St. Petersburg (now Leningrad). At this time Terzaghi had gained an impression that earthwork engineering was most advanced in the United States, where he managed to go and worked in various capacities as an engineer, boring foreman, time keeper, and even as a driller. He returned in 1913 not quite satisfied with his American visit.

On the recommendations of Professor Philip Forchhemier he went over as a Professor of Foundtion Engineering at the Imperial School of Engineering, Constantinople (later Istanbul). During his 10 years sojourn in Turkey he conducted a systematic study of Soil Mechanics. In 1924 at the first International Conference on Applied Mechanics in Delft, Holland, when he presented his paper on consolidation of clays, Forchheimer congratulated him saying 'this is the day of your birth into the scientific world." Next year he completed his classic work in Soil Mechanics literature, entitled "Eardbaumchanik auf bodenphysikalischer Grundlage." In the autumn of 1925 Terzaghi came over to America again to work at M. I. T. Now his fame found a sharp accent. Casagrande, author of this biographical sketch, started working with him as his assistant. At that period some of Terzaghi writing were so salty that these were sometimes refused for publications and only those appeared which had extensive editorial changes. In those days any foundation engineer who had doubt about the foundation conditions, followed the rule, "In case of doubt, drive piles". In case of settlement it

Late Mr. Terzagi in the bloom days

was concluded that piles were overloaded and these needed more piles. Terzaghi told them to omit piles. It was a great surprise for the engineers but the construction made under his suggestions without piles stood much better than those with piles.

In 1930 he again went back to Vienna, and during the second World War in 1939, he returned to Hardward Graduate School of Engineering. During this period he wrote two major books, over 100 papers and countless reports in connection with his consulting activities. His reputation spread throughout the world. In 1954, he was Chairman of the Board of Consultants for high Aswan Dam in Egypt. Until late in life he was favoured with a rugged health and physical stamina. Young geologists accustomed to field work hardly could keep up his pace in the mountains when he was 70.

In last year of his life, Terzaghi used his energy and vision trying to protect the young generation of soils engineers from pitfalls, and to guide them wisely.

Terzaghi created Soil Mechanics and retained undisputed leadership in this field to the end of his life. His eminence can be reflected by nine honorary doctors degrees confered upon him and by many awards and prizes from engineering and scientific societies. He was the only man to receive the Norman Medal four times. He was a genius of his time and will ever be remembered as the creator of a new science, science of Soil Mechanics so important in engineering construction.

News and Notes

SCIENTIFIC RESEARCH FOR ARID ZONE OF SAUDI ARABIA

At the request of the Government of Saudi Arabia Unesco invited Mr. Baumer to make a study of scientific research needs arising in connection with the problems of the arid zone of Saudi Arabia, and to suggest what steps should be taken to organize scientific research aimed at developing these arid regions.

Mr. Baumer has recommended preparation for the foundations of an Arid Zone Research Institute in Saudi Arabia. It will undertake basic or applied research with a view to solve problems of development. A national Arid Zone Committee of Saudi Arabia will also be set up to prepare projects and programme for the research. An information and Documentation Centre is to be set up to make available the research publication to the research workers, experts, teachers, etc.

Saudia Arabia is a country of about 1.6 million sq. km. inhabited by 6 million persons. It has a mean annual precipitation of 100 mm. only although in the region of Assir it rises to 300 mm. and in some cases to 600 mm. It possesses the largest sand desert in the world, Rud'al Khali, measuring 1000 k.m. East to West and 500 k.m. North to South.

LACK OF SCIENTIFIC INFORMATION

There is a great lack of data on Flora. Vegetation, Soil, Climate, Hydrology, Agronomy and such other subjects. The author has suggested ways and means to collect information on all these items. It is suggested that the Institute may be housed in the premises being provided for the University of Riyadh. It has been stressed that setting up of the Institute will considerably add to the store of knowledge essential for over all developments.

NTERNATIONAL HYDROLOGICAL DECADE

In Paris United Nations agencies and international scientific organizations and 140 delegates from 57 countries met from 7 to 17th April 1964 to recommend a programme for International Hydrological Decade. These recommendations will be considered in the

Unesco General Conference to be held in October-November 1964.

It was felt necessary to create a co-ordinating council composed of eighteen member states of Unesco and it will be responsible for supervising, from the organizational and scientific points of view, the implementation of the entire Decade programme; studying proposals concerning developments and modifications of this programme; recommending scientific projects of interest to all or to a large number of countries; co-ordinating international co-operation in the framework of the Decade; and assisting in the development of national and regional projects.

In this connection the meeting took note of preparation and organization of International symposia and seminars on special topics. The meeting being proposed by Unesco for 1965 and 1966 on the subject of Hydrology, Soil Moisture and a symposium on experimental and representative basins were taken note of with approval of Member States which have expressed their willingness to participate in the decades.

POST GRADUATE COURSES IN VARIOUS COUNTRIES

University of Nottingham

The University of Nottingham England is running a course on water relations of plants. It will also include lectures on Irrigation, Drainage, Salinity and Dry Land Management, etc. Those interested may apply to the Secretary, University of Nottingham School of Agriculture, Sutton Bonington, Lough-borough, Leices, England.

Technological University of Delft Netherlands

This University is running a course on Hydraulic Engineering which will include threotical and experimental hydraulics, foundation engineering, and water resources inventory. Requests for application should be addressed to the Netherland University Foundation for International Co-operation, 27 Molenstraat, The Hague, Netherlands.

University of Southampton, England

University of Southampton England is running an International course on Irrigation and Land Drainage Engineering. Application Forms can be obtained from the Academic Registrar, the University, Southampton, England.

Ontario Agricultural College, Canada

Department of Engineering Sciences Ontario Agricultural College is running a course on Hydrology on surface and ground water hydrology, soil physics and hydraulics engineering. Applications to be obtained from the Chairman of the Graduate Studies, Ontario Agricultural College, Guelph, Canada.

Brace Research Institute

Brace Research Institute is running six months course of specialized theoretical and practical training for research work in arid and semi-arid area. The subjects of studies will include utilization of wind energy, solar energy, saline water conversion, engineering hydrology. Inquiries to be addressed to Dr. Gerald T. Ward, Director of Research, Brace Research Institute, McGill University, Montreal 21, P. Q. Canada.

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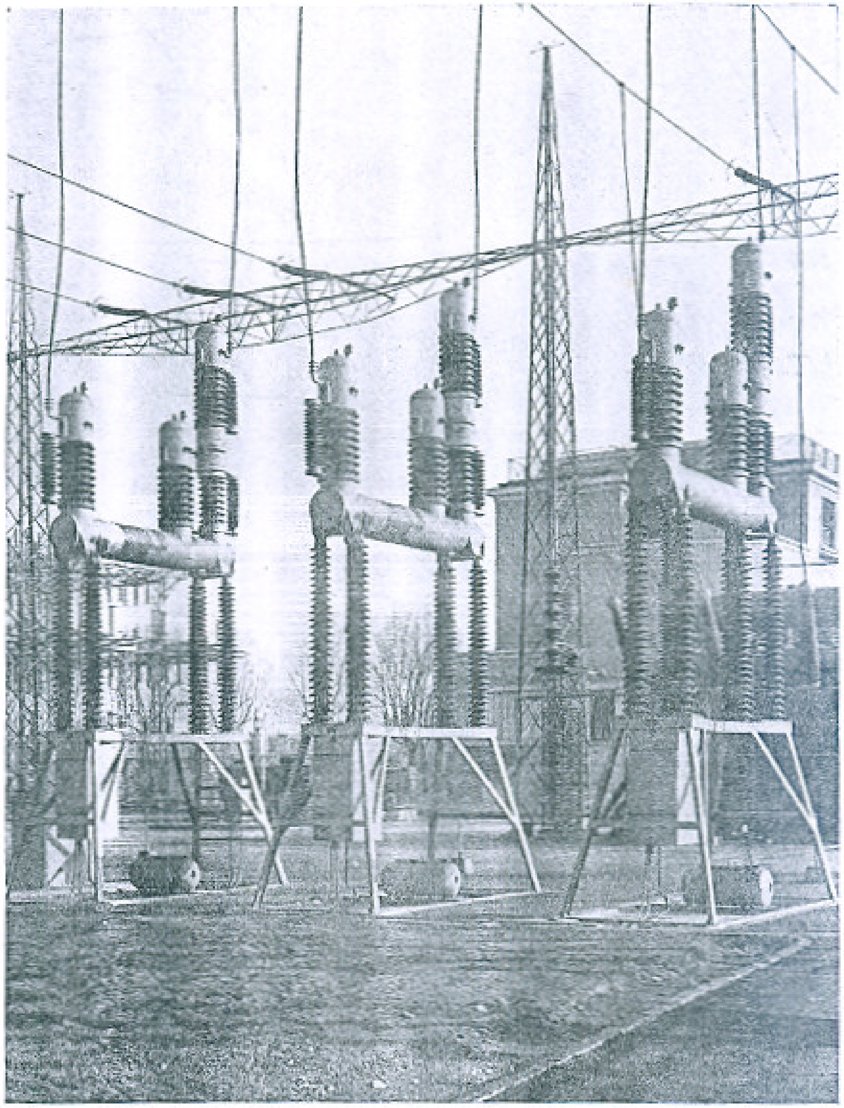
220 KV CIRCUIT BREAKER TYPE 220/245

MTM 10,000, 1200 AMPS

Low Oil Content Type High Speed Autoreclosing



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In this issue