SYPMPOSIUM

on Utilization of Manual Labour in Major Civil Engineering Projects.

The Institute of Engineers (Pakistan) during its Twelfth Annual Convention at Lahore in May 1966, held a symposium on Utilization of Manual Labour in Major Civil Engineering Projects. There were nine papers contributed by various authors. Mohi-ud-Din Khan as Convener of the Symposium opened the Symposium with a brief introduction. Brief excerpts from each contribution are given in this volume.

Mohi-ud-Din Khan opens the Symposium

In his introduction he invited the attention of the participants to the directive of the Executive Committee of the National Economic Council, dated 15 January 1964 on the importance of making use of manual labour for Major Civil Engineering Projects. It stated :—

"The attention of the Central Ministers and Provincial Departments concerned should be drawn to the fact that the earthwork except in the case of "Treaty Works" should always be done by manual labour which is cheaper. In case an exception from this clause is required it should be specifically mentioned in the Project Report bringing out the reasons why it was proposed to use machinery for earthwork. The projects already approved and under execution should be reviewed in the light of this decision.

Mohi-ud-Din Khan brought out the importance of using manual labour in comparison to the machinery. He compared the cost of the machine with the rate of wheat, cement and other commodities. The change in rate of manual labour over the year was nominal as compared to the price of trucks or machines. Even big countries like Japan and China are converting the large manpower into a great asset instead of being a liability. With efficient and sensible use of manual labour and simple implements, Pakistan can effect considerable economy in its Civil Engineering projects.

Role of Manual Labour in Indus Basin Works

By RIAZ NAZIR TARAR,

Technical Officer to Chief Engineer, Indus Basin Project, West Pakistan, WAPDA, Lahore.

The author in his long and detailed article discussed, the Indus Basin dispute or the Negotiation leading to the treaty funds agreement, mode of execution of the projects and the appointment of WAPDA as agent for the execution of the projects.

The author then explained the status of execution of the project, role of Pakistan manual labour and its limitation. He worked out the employment statistics and their training programme at Mangla Wages and other benefits, etc. His main conclusions were:—

It is a general impression, specially amongst the engineers, that by agreeing to the execution of the Indus Basin Project through international competitive bidding Pakistan denied itself a very good chance of utilization of the manual labour and other skills usually require for doing such jobs through conventional methods. However, his exposition has demonstrated beyond any doubt that it was a wise decision of Government to place the execution as explained in the text otherwise the limited manual resources of

the country would have made the timely completion of the Project very uncertain.

Actual examination of one of the major forces, the donkey labour, has indicated a likely shortfall of 2,300 for carrying out only the dry earth work of Phase I and II link Canals. If the country was to face such a situation by hasty decision or sentimenta pressures then a delayed deferred completion of the project was imminent. Therefore the National Economic Council was fully justified in directing that the Indus Basin Works should be exempted from compulsory employment of manual labour through conventional methods.

In spite of the fact that the Indus Basin Works were exempted from the employment of conventional methods, the role of manual labour towards its execution so far has been most outstanding. The future is, in fact more promising than past or present. The wages and other fringe benefits allowed to the labour. Management-Labour relations on the construction sites, environments and working conditions provided to the labour have actually set in a pattern which should be taken as a guide for all future works, through local or foreign contracts in Pakistan.

Up till December 1965, when all the Phase I Link Canals and Barrages had been completed, Mangla was more than half-way through and all the Phase-II works were under active construction, the actual labour employment on the Indus Basin Project totalled over 12 million Man-months with more than 50 per cent skilled labour. The gross earnings in the corresponding period are estimated at about Rs. 258 million and are expected to go up to about Rs. 600 million by the time the construction of the Indus Basin Project is over.

In short, the foregoing discussion and analysis lead us to the unmistakeable conclusion that, although the number of labour employment on the Indus Basin Project as being executed now would be half than if it were constructed through the conventional methods, the country would still not lose anything in monetary terms. The greatest, but not the last, benefit of this type of execution will be in the form of addition of a large number of skilled and semi-skilled competent manpower to the hitherto meagre source and would go a long way towards meeting the ever-increasing demands imposed upon the country for continuous development through successive Five Year Development Plans.

The Role of Manual Labour in the Construction of Balloki-Sulcimanki Link

By SARDAR ALLAH BAKHSH, P.S.E.I.,
Deputy Chief Engineer, Northern Zone Salinity Control and Reclamation Projects WPADA, Lahore.

In this article the author has worked out the importance of donkey labour for earth work as compared to Machine. He has put forth that out of 869.2 c.ft. of earthwork to be done during construction of Balloki-Suleimanki Link Canal. 710.3 million c.ft. was done by donkey labour, giving an average of 4800 c.ft. per donkey per month or 200 c.ft. per donkey per day. As against this the work done by imported machine was only 10 per cent of the total. This was done with an imported machine costing Rs. 100 million. He stated that some people believe that the donkey is an animal of the past and we are living in the machine age. No doubt machines will gradually replace donkeys but not in the immediate future, not till the machinery is manufactured in this country. At present machinery has to be imported from abroad.

It requires foreign exchange, long delivery period, spare parts, trained mechanics and operators, whereas donkeys do not require all the above items and at the same time give employment to a large number of labour in this country. Each donkey provides for nearly 10 persons. A donkey does all the work of an excavator, bulldozer, tractor and roller. It takes the eath from the pit to the spoil in one shift. Banks thus made are stronger and leak-proof, and as good as those made by tractors.

On B. S. link earth-moving equipment worth one crore of rupees was imported from abroad and the total work done by these machines was only 10 per cent, of the work done by the donkeys during the same period from which it could be imagined how far donkey is useful.

A judicious employment of machines and manual labour can certainly reduce the unemployment in the country. This can only be done if machines are not employed for that class of works which can be handled effectively by the manual labour available in West Pakistan. To achieve this object, the labour force in West Pakistan needs to be organized and maintained properly on various projects.

Role of Manual Labour in Link Canals Project

By S. M. RIZWAN ABIDI,
Asstt. Director, WAPDA, Lahore.

The author of this paper started his discourse with the brief history of the earth moving technique. The modern construction features are very complicated where one has to handle a large number of construction plant, machinery and equipment. He has to arrange for supply and transportation and look to the hundreds of thousands of employees. The author has put forth a chart explaining the modern set-up of an Engineering organization. He has explained the manpower on link projects. He has given a table in which the labour employed on various projects of WAPDA are explained. The total and the ratio of the expatriate to the local is explained in Table on next page.

The peak number of expatriates employed by any of the contractors closely resembles each other when compared for every crore of rupees of bid price, and is between 4 to 5 expatriates per crore of rupees.

The Consultants employ about one expatriate for every twenty Pakistanis. Cost-wise, this works out to a result that for every one rupee spent on expatriates about two rupees are spent on Pakistanis. This should, however, not be construed to mean that WAPDA is in any manner paying more than the normal due salary to the expatriates if they are to proceed outside their country.

The author has concluded that the successful completion of the first phase of the Link Canals Projects is a classical example of the fostering of the best Employer-Engineer-Contractor relationship. Almost all the contractors on the first phase of the Link Canals Project have earned bonuses for early completion of their jobs—thereby establishing their superiority of planning and, amongst them are Pakistani contractors also which is a good omen. With the present high standard of planning it will not be out of place to hope that the second phase of the works of the Link Canals Projects will be similarly completed ahead of schedule, thus speaking volumes for the foresight of those

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E=Expatriates L=Local

Month	WAPDA		M/s. T & K Cons. Engg.		T-S-Link M/s. Kaiser Engg.		S-M-Link M/s. Cogefar Astaldi		M-B-Link M/s. Aslam Khan & Hastam Khan		Q-B-Link M/s. Canal Construction	
	E	L	E	L	E	L	E	L	E	L	E	L
Total ..	—	16,816	1,429	30,750	1,467	77,371	2,275	154,836	—	35,315	1,186	36,502
Av. per month ..	—	480	35	715	40	2,091	62	41,85	—	1,009	74	2,281
Ratio of Expatriates to Local Labour ..			1 : 20.43		1 : 52.28		1 : 67.5		&		1 : 30.8	
Max. No. of Expatriates at anyone time			43		62		96				102	

responsible in WAPDA for setting the pace and policy. It is not wrong to presume that the association of the Pakistani contractors with the foreign contractors has refined and advanced some of the local techniques in Pakistan, where labour is cheap as compared to machinery. The experience gained in Pakistan in this manner may provide ideas for planning and handling of similar jobs in the Afro-Asian countries where conditions may be nearly similar.

Road Construction in East Pakistan

By AZIZUR RAHMAN,

Superintending Engineer, Roads and Highways, Rajshahi Road Circle, Rajshahi, East Pakistan.

The author has put forth the information about the roads constructed since Independence in East Pakistan. This constitute about 1,650 miles which apparently is not encouraging for a population of 55 million living an area of 55,000 square miles. It is due to the peculiar position of the country which is a land of rivers and innumerable smallstreams. The interesting information put forth by the author is that in 1957-58 as Executive Engineer with the help of I.C.A. under Highway Training Programme Organization obtained all the machinery such as dump trucks, scrappers, bulldozer, tractor, grader, etc. He made genuine efforts to utilize the machinery and his cost worked out to be Rs. 207 per 1000 c.ft. of earth work. Compared to this cost of manual labour including the cost of land compensation worked out to be Rs. 35. Thus there was excess of Rs. 172 per 1000 c.ft. of earthwork.

The author has given an example of construction of 40 miles length of road to which he has employed 35,000 labourers. The cost

of this worked out to be Rs. 25 per 1000 c.ft. against Rs. 172, by man working already mentioned. If the machinery was to be used the local labour force of 35,000 persons will be eliminated at the cost of Rs. 7.62 million of foreign-exchange as machinery's expenditure. No doubt the cost of manual labour in other countries is comparatively high only because the machines are constructed in their countries they are much cheaper and the labour is very costly.

I, therefore, believe that the country's prosperity depends on utilization of our labour force and in discarding heavy equipment in construction of road embankments. We may need only equipments like rollers, concrete mixers and small finishing tools to add efficiently to the works of manual labour.

Professional Engineers may feel a bit discouraged with my analysis. I would present to them an extract of a letter published in the STATESMAN on August 7, 1965.

"A recent British Publication has worked out in terms intelligible to the common man, the cost of a new prototype bomber with full equipment. The money required for such a bomber, it is estimated would suffice for a year's salary of 250,000 teachers in scientific research, it could meet the expenditure on 30 science faculties each with a 1000 students, in terms of medical relief of 75 fully equipped 100 bed hospitals or for agriculturists it could provide 50,000 tractors or 15,000 harvestors.

Role of Manual Labour on Irrigation Works in the ex-Sind Area

By MAZHAR ALI, PSE I,
Superintending Engineer, Irrigation Deptt., Sukkur.

The author has analysed the availability of manual labour for the ex-Sind constituting about 47,000 sq. miles in Sind. There is large construction of flood embankments, silt clearance of canals and such other works connected with three barrages. In this province the earth-moving machinery found favour much earlier than in the rest of the country. The primary reason was no spare population and the absence of sizeable organised labour. After detailed analysis he has concluded that earthwork rates for machines are invariably higher than the corresponding rates through manual labour, but unfortunately the comparison has always been confined to the face rupee value. The manual labour involves no foreign exchange while the machines consume about 50 to 60 per cent of the rupees in foreign exchange.

The labour potential of a country is a vast reserve of energy, and needs exploitation to the maximum. It is like any other indigenous reserve of gas, oil or coal and cannot be matched against any imported stuff, however attractive it may seem. As the labour force of the Indus Valley gets busy on the irrigation works, it will usher in an era of prosperity and plenty for the common man. The impact will be clearly and surely felt on the economy as the gold reserves of the nation start bulging. It will provide a face lifting, hitherto unknown and unheard of.

Role of Manual Labour in Masonry Dam Construction

By MOHI-UD-DIN KHAN, PSE I,
Deputy Secretary (Development), Irrigation and Power Deptt.

The author has exhorted the magnificent traditions of masonry structures left by Muslim rulers in the Indo-Pakistan sub-

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continent. He has mentioned some of the earlier structures. A recent example of the use of masonry works is Nammal Dam in Mianwali Distt. 88 ft. high and 130 ft. long which was constructed as far back as 1907 when even the irrigation system in West Pakistan had not yet started. He has given the example of the use of masonry structures even in Scotland where several dams in the high lands are constructed by this material. He gave a table in which the masonry dams were shown to be very economical as compared to the earth fill dam which are very expensive. He has put forth the example of Tungabhadra Dam of India and Krishna-raja-Sagar Dam in Madras. These structures are much cheaper when compared to the later structures constructed in the country.

Each hundred cubic feet of masonry laid at Tungabhadra actually cost, on the average Rs. 128 or Rs. 132. Lime soorke mortar permitted the cheaper rate. D.V.C. has at Maithon Dam the most completely rationalized, scientifically planned concrete laying plant (until Bhakra) in India. But its product cost Rs. 145 to 150 per unit. Bhakra with its huge volume of production is another story; its estimated cost of Rs. 100 per cubic feet is not available by any method on lesser dams. And remembering that both the Damodar Valley Corporation's Maithon cost and Bhakra's cost are advance estimates, in 1956 whereas Tungabhadra's figure is actually attained, it is certainly clear that, rupee for rupee, big automatic machines have not been able yet to do more work than men working with the simple machines. This fact should not be lost sight of by developing countries who have more labour than capital.

Role of Manual Labour in the Construction of Coastal Embankment Projects in East Pakistan

By SHAFIQUL HAQ,
Chief Engineer, EPWAPDA.

The author has put forth the figure of non-employed labour in the country. According to his survey in 1955-56 about 2.7 and 3.9 per cent of labour force was looking for jobs in West and East Pakistan respectively. The seasonal under-employment in the country about 4.7 and 17 per cent in West and East Pakistan respectively. On the basis of this estimate with the growth of population on 2.7 per annum, there will be about 6 million unemployed workers. The author has given the example of coastal embankment project of East Pakistan in which 3,300 miles of embankments have to be completed by 1975 by moving earth equivalent to 350,000,000 cubic yards. At a cost of about Rs. 113 crores and by employing 150,000 labourers every year during short construction period from January to April. In these projects the author has explained that machinery work was impossible and the employment of such large manual labour in the project has helped in several organizations to establish local big industries and cottage industries on account of their increased per capita income.

In the end the author has concluded that the use of manual labour in major Civil Engineering Projects wherever possible in developing countries helps to improve the economic condition of common people of the project area. It also cuts down foreign exchange component of the expenditures to a great extent and hereby reduces dependence on foreign aid and loans. Employment of manual labour in Civil Engineering

Projects increase the circulation of money in the area which in turn help in formation and mobilization of domestic capitals.

Role of Jail Labour in Civil Projects

By BRIGADIER SARDAR ALI,

Joint Secretary and Adviser Jails, Govt. of W. Pakistan, Home Department, Lahore.

In this short article the author has put forth figure about the number of the prisoners employed on various public works during 1955-1963. This has been done mainly on the directive of the President of the Pakistan to employ a large population of prisoners on productive work.

Census of Civilian Labour in Pakistan.

By TAHIR ABBAS MIRZA, M.A.

Statistical Officer, Hydrology Directorate, West Pakistan, Lahore.

This is a brief paper in which analysis of the sensus of Pakistan is carried out to show the percentage of Civilian Labour Force of above 10 years age, which can be available in the country. His analysis is explained from the table given below :—

		East Pakistan Males	*West Pakistan* Males
Total population	No.	263,48,843	211,68,047
of East Pakistan	%	100	100
Population 10	No.	169,00,392	144,11,941
years and over	%	64.14	68.08
Civilian labour	No.	148,02,472	116,41,016
force	%	56.18	54.99
Civilian labour force 10 years	No.	—	—
and over	%	87.58	80.77

AIMS AND OBJECTS OF THE INSTITUTE

The Institute of Engineers was founded by the late Qaid-e-Azam Mohammad Ali Jinnah in 1948. This Institution is successor to the Institute of Engineers India registered under the Indian Act 1930 and incorporated by the Royal Charter in 1935. This Institute had its jurisdiction throughout India and at the creation of Pakistan and Bharat, the jurisdiction of the Institute of Engineers India remained limited to the territories of Bharat and Pakistan created its own Institute of Engineers. Its headquarters was established at Dacca. The front page photograph is that of the Dacca Centre which houses the main office, a library and a half for meetings. The Institute has since established nine local centres, four in West Pakistan at Rawalpindi, Lahore, Karachi and Peshawar and five in East Pakistan at Dacca, Khulna, Rajshahi, Comilla and Chittagong.

The Institute was created :—

(*a*) To promote and advance the science, practice and business of engineering in all its branches throughout Pakistan.

(*b*) To promote efficiency in the engineering practice and profession.

(c) To regulate the professional activities and assist in maintaining high standards in the general conduct of its members.

(d) To lay down professional code of ethics and to make it mandatory for its members to abide by the same in their professional conduct.

(e) To help in the acquisition and interchange of technical knowledge among its members.

(f) To promote the professional interest and social welfare of its members.

(g) To encourage original research in engineering, and to economical utilization of the country's materials and resources.

(h) To foster co-ordination with similar institutions in other countries and engineering universities, institutions and colleges in Pakistan and in other countries, for mutual benefits in furthering the objects of the Institute.

Besides these broad functions, the main aims of the Organization are to promote engineering knowledge practices and every thing connected with the engineering as a science.

Promotion of Engineering Practices

In order to promote the Engineering knowledge, the Institute holds examinations twice a year. The syllabi and other conditions are similar to those as already in vogue in its mother Institution, *i.e.* Institute of Civil Engineers, London. Candidates who are successful attain the Associate Membership of the Institute and are considered equivalent to engineering graduates for employment purposes. The Central and Provincial Governments have recognized these examinations.

The Organization publishes a Monthly Journal named the "Pakistan Engineers". It is issued from the headquarters and is distributed to all members. The present membership of the Institute is 290 full members, 1354 associate members, 470 graduate members and 5655 student members.

The Institute holds annual meetings at different places in Pakistan. The meeting recently held in Lahore was the Twelfth Annual Convention. For about a week there was a considerable activity of the Engineers of Pakistan who had gathered in Lahore. There were papers reading, discussions and presentation of new ideas in the Symposium. In this volume we have reproduced brief activities of the Institute during its Lahore Convention.

Water Requirement for Forest Crops

By

GHULAM AHMAD*

INTRODUCTION

Following the annexation of the Panjab by the British in the year 1848, it was found necessary to raise Irrigated Forest Plantations to produce fuel for locomotives which were run on this source. A scheme was initiated in the year 1864 to establish a forest plantation. Water of Bari Doab Canal, now the Central Bari Doab Canal, was utilized and the forest plantation of Changa Manga was started in 1866. It would be interesting to mention Mr. Ribbentrop's description of its formation (Page No. 572, Volume II).

> "It was established in the centre of the dry forest area, where the long-rooted bar trees alone can exist, but is now, under the influence of irrigation, covered with a complete crop of sissu and mulberry. The plantation was begun in 1866, but no success could at first be obtained. In 1868, Mr. Amery, then incharge, had the idea of employing a trench and ridge system. When I took over the division, though but a comparatively small area had been stocked, I felt convinced the correct principle had been ascertained, and within a few years the whole area was planted. The plantation had been a silvicultural and financial success in spite of the high rate for canal water charged against it. Under the working plan it is treated as coppice with a few standards, and we are already occupied in reaping the crop of a second rotation."

Subsequently more irrigated plantations were raised. In the wake of Independence, the population of West Pakistan increased due to the influx of refugees and so did the demand for fuelwood and timber. The forest Department wanted to meet the increased demand through raising irrigated forest plantations. But the independence also brought in new problems. Head-works of very important canal systems, due to delineation of international boundaries went over to India and water supply became uncertain. The increase in population also needed an increase in argicultural production and it became necessary to assess all available water resources and have a proper water

*Conservator of Forest, Peshawar.

budget. It was found that the existing water resources were not enough for agricultural production and therefore, the flood water had also to be stored. It becomes a matter of paramount importance to mustor all the available water in West Pakistan for agriculture, and fix a water budget for forest crops. It was for this reason that an idea was concieved by Mr. M. I. R. Khan, in 1957 to submit a scheme to food and Agriculture Council of Pakistan to undertake experimental study on the subject. The experimental details were drawn up by the author with the help of Dr. Mushtaq Ahmad and the experiments were laid out in the field in September, 1958, in co-opeative with the assistant conservation of forest Mr. Muhammad Asghar Qureshi.

EXPERIMENTAL DESIGN

A split plot experiment was designed to test application of flow irrigation water at five different depths. These depths of water called delta, were $1\frac{1}{2}$, 3, $4\frac{1}{2}$, 6 and $7\frac{1}{2}$ feet for the entire growing the season. This water was delivered in frequency of fortnightly, three weekly and monthly. It was delivered either through trenches 10 ft. apart, 13.5 inches wide and 27×8 inches deep or through the flooding. The lay out of the irrigation system as well as the experiment is shown in Fig. 1. There were three replicates.

In the design of the experiment the delta and the frequencies were the important variables. Each individual experimental sub-plot was 300 feet to 78 feet. In between the sub-plots a strip of 20 feet wide was left out as a non-experimental strip to prevent border effects of the roots, shade etc. of the plant extending on to the other sub-plot. Around the experimental area, a deep ditch was dug to prevent cattle trespass.

THE IRRIGATION SYSTEM

Two brick lined feeder channels indicated as B & C in Fig. (1), run through the experimental area. These take off from the lined channel 'A' which draws its supply from a forest irrigation channel called a main.

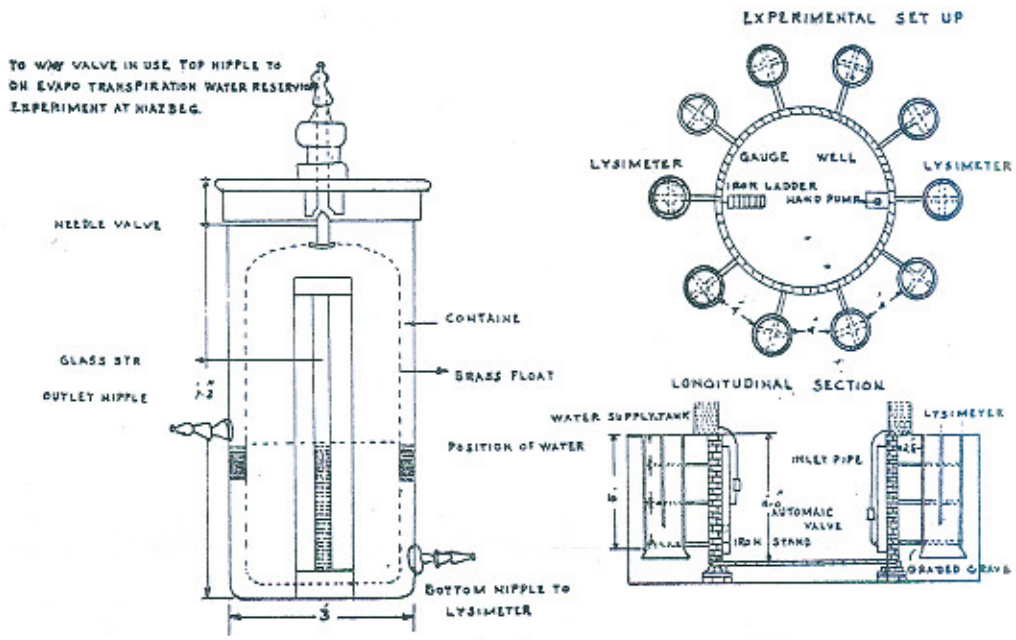

Fig. 1

Their direction of flow is also indicated in the layout plan.

A head regulator is provided at the head of channel 'A' where it joins the forest main. This has an adjustable shutter to regulate the head of water at the head regulator 'A'. The intention is that a steady flow of water be maintained in the experimental area, so that the quantity delivered may be accurately measured. The shutter is kept at a minimum height so that any decrease in water supply in the forest main does not effect the discharge of 'A'. This arrangement eliminated the fluctuation of discharge in the channels, B & C and the flume outlets. The channels B & C are lined to prevent seepage of water. The water is applied to the field plots through the outlets which can discharge upto 4 cusecs. In the beginning metallic flumes were provided which were later on changed to masonary flume outlets forming a standing wave to record accurately the discharge. A gauge measured the head above the crest and the time of flow was recorded by a stop watch.

PLANTING SYSTEM

In individual sub-plots, trenches were dug 10 feet apart and were of the standard size as already mentioned. *Dalbergia sisso* (Shisham) stumps were planted 6 feet apart along these trenches. In flood plots they were planted 10 feet × 6 feet apart Planting was done in September 1958 and failures beaten up in April, 1959.

METHODS OF MEASUREMENT

Since there are too many plants in each sub-plot a plant was selected from each line using the table of random numbers. Its height was measured every month. The average height for each sub-plot was then found. This is set out in table below. The data for height growth ending 1962 has been analysed.

HEIGHT OF PLANTS

(*Measured in* 12/1962) (*in feet*).

		D_1	D_2	D_3	D_4	D_5
F_1	M_1	15.03	18.76	21.36	23.36	25.63
	M_2	12.33	18.93	21.46	20.7	24.63
F_2	M_1	15.56	17.86	20.9	23.2	24.33
	M_2	13.4	16.00	20.8	23.23	22.73
F_3	M_1	13.43	19.00	20.5	23.83	24.7
	M_2	15.66	19.43	21.66	23.26	24.16

The means delta or depth of water applied is represented by D_1 equal to $1\frac{1}{2}$ feet, D_2 equal to 3 feet, D_3 equal to $4\frac{1}{2}$ feet, D_4 equal to 6 feet, and D_5 equal to $7\frac{1}{2}$ feet.

The frequency of irrigation was expressed as F_1 being fortnightly, F_2 being three weekly, F_3 being monthly.

The Method of irrigation was M_1 for Trench and M_2 for Flood Irrigation.

ANALYSIS OF THE RESULTS

Results were subjected to analysis of variance for the split-plot design (Appendix-I).

It was found that the amount of water delivered did result in significant increased growth, but beyond 4½ ft. depth, the increased application of water did not result in proportional increase in growth.

Thus economic application is indicated in 4½ feet delta. This is shown by the following table:—

	D_1	D_2	D_3	D_4	D_5
Means	109.49	141.86	160.69	167.15	182.80
Difference in Means		31.37	18.83	6.46	15.65

Critical region is 5.775

Frequencies of irrigation did not give any significant difference. This is clear indication of the fact that within the depth of water delivered, it is the total quantity applied which matters and not the doses that one gives. This is in consonance with the results obtained in agriculture crops, provided adequate moisture is kept in the soil between the two irrigations.

It was also inferred that trench irrigation was more beneficial than the flooding.

EXPERIMENT-II

An experiment was laid out in Niaz Beg near Lahore in March 1964, in conjunction with Irrigation Research Institute, to find the consumptive use of water for poplar (Populus xeuramericana) and Shisham (Dalbergia sissoo). The experiment was tried in lysimeter design whereof is given in the Fig. II.

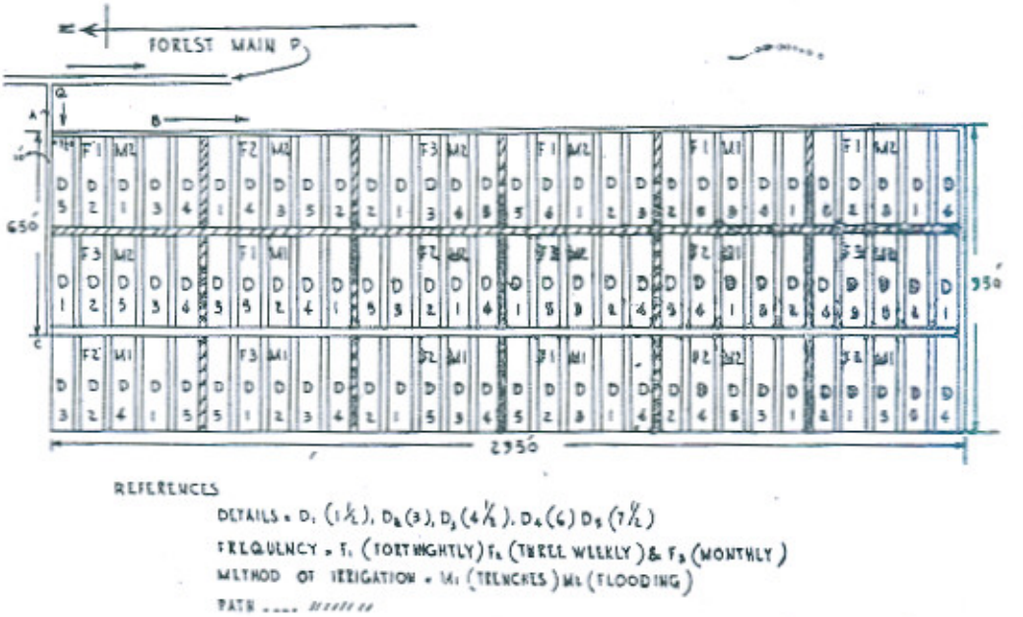

Fig. 2

The meteorological parameters for Niaz Beg for 1960-64 are given in the following Table 3.

Measured quantity of water was given as surface irrigation from time to time while

Latitude 310 *39feet N N.S.L.* 711 *Ft.*

Maximum F°	Minimum F°	Mean F°	Relative Humidity
66.60	42.90	54.70	78.60
73.50	46.60	60.10	78.60
82.33	57.30	69.80	73.80
94.33	63.30	78.80	65.20
104.40	75.00	89.70	52.85
106.50	81.00	93.70	61.00
98.00	80.70	89.30	61.00
95.60	79.70	87.70	73.00
95.00	75.40	85.20	74.94
91.00	64.30	77.70	74.65
81.50	50.50	66.00	76.53
71.00	43.60	57.30	79.94

the water table was maintained at 8 feet. Lysimeter was connected through a pipe fitted with a value to a drum full of water so that if the water table fell below 8 feet the valve would open and let in water to maintain the water table. "Lysimeter was also provided with a drainout valve so that any water in excess, be through rain or otherwise, was drawn out into a jar. Quantity of water so drawn was measured. The 8 inches long poplar cuttings were planted 2 feet 1 foot and Shisham stumpe were planted 10 feet by 6 feet which is normal spacing in irrigated plantation. Plantation was done on 22nd March.

METHOD OF ANALYSIS

The amount of water applied was measured. The rain-fall during the period was also registered, from this the percolation if any, was found out, and the amount of water consumed calculated. The data for poplar and Shisham is given in Table-II respectively.

The tables also give the average height, growth of plants rounded to the nearest inch. The values of water used were then plotted on the graph paper and a smooth curve drawn as given in figures III & IV.

From these curves the values were read out for each month which are:—

TABLE-IV

Months		Poplar	Shisham
March	..	9.5	5.90
April	..	11.25	6.88
May	..	12.5	7.38
June	..	13.37	7.75
July	..	14.0	7.97
August	..	14.32	8.00
September	..	14.25	8.00
October	..	14.12	7.87
November	..	13.50	7.5
December	..	12.00	7.00
January	..	9.37	6.25
February	..	5.2	5.2

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Shisham
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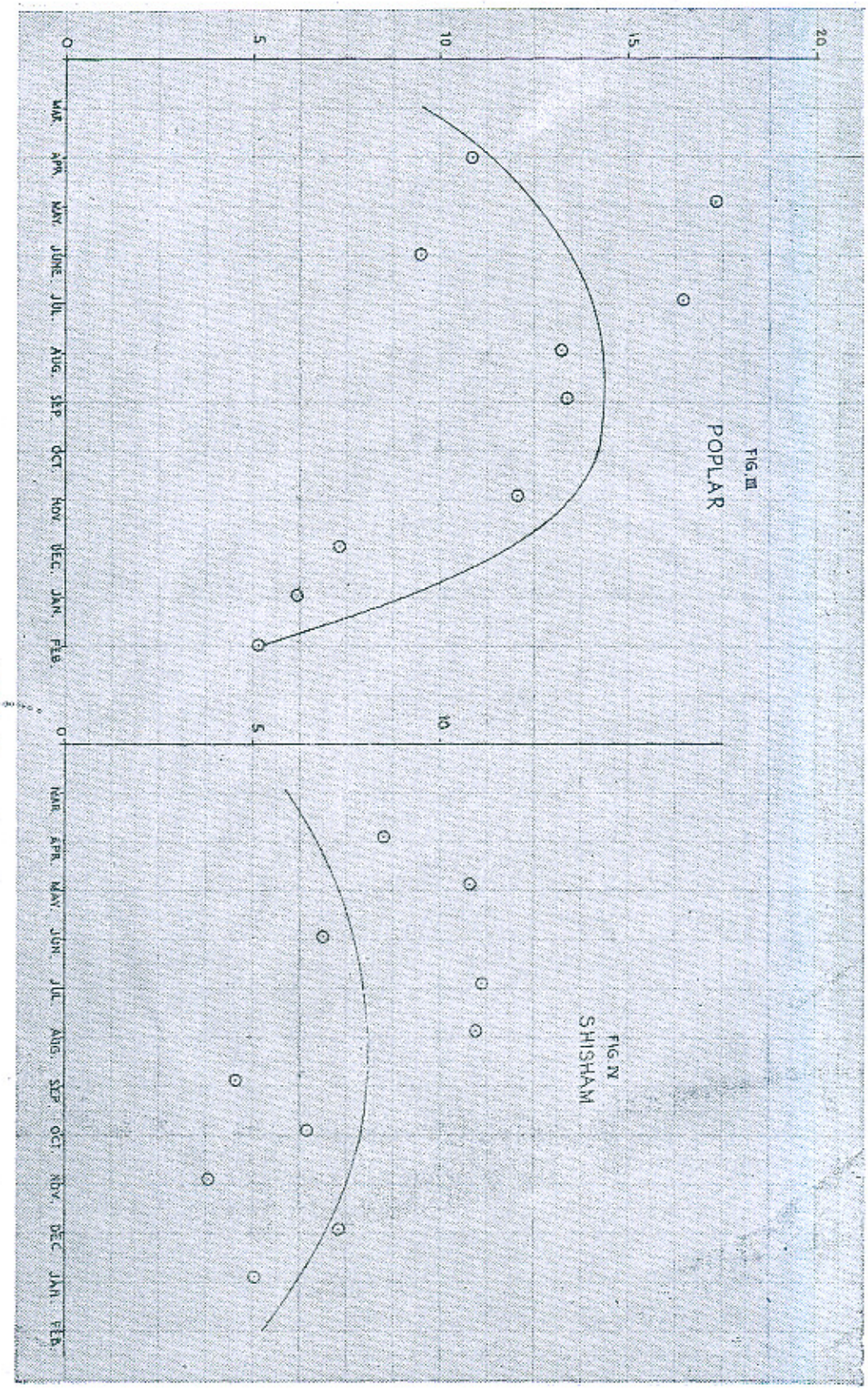


Fig. 3 &

TABLE I.—*Consumptive use of water for poplar & Shisham Plants Observed at Field Research Station Niaz Beg Irrigation Research Institute Lahore.*

(All figures are in inches except when mentioned.)

Soil — Clayey
W. Tab. — 8′-0

POPLAR

Month	Sub-Irrigation	Surface Irrigation	Rain fall	Percola-tion	Total Consump-tion	Height in feet & inches
1	2	3	4	5	6	7
March	.. 4.478	5.0	..	..	9.478	..
April	.. 4.406	6.0	0.495	..	10.901	1—5
May	.. 7.07	10.0	0.226	..	17.296	2—0
June	.. 3.125	6.0	1.3	0.9	9.525	7—0
July	.. 6.029	4.0	6.489	0.005	16.513	8—0
August	.. 3.772	..	17.915	8.469	13.218	12—0
September	.. 9.936	3.0	0.435	..	13.371	13—0
October	.. 13.7664	6.0	..	..	19.7664	14—0
November	.. 8.928	3.0	0.046	..	11.974	14—3
December	.. 1.224	6.0	0.124	..	7.348	..
January	.. 2.5056	3.0	0.624	..	6.1296	..
February	.. 1.6992	3.0	0.465	..	5.1642	..

TABLE II

SHISHAM

1	2	3	4	5	6	7
March	.. 0.864	5.0	..	..	5.864	..
April	.. 1.987	6.0	0.495	..	8.482	6—6
May	.. 0.59′	10.0	0.226	..	10.816	2—0
June	.. 0.317	6.0	1.3	0.7	6.917	5—0
July	.. 0.705	4.0	6.489	0.007	11.187	6—6
August	.. 0.345	..	17.915	7.347	10.913	7—5
September	.. 0.9648	3.0	0.435	..	4.3998	8—2
October	.. 0.3888	6.0	..	..	6.3888	8—5
November	.. 0.720	3.0	0.016	..	3.766	9—0
December	.. 1.4256	6.0	0.124	0.20	7.3496	9—6
January	.. 1.3616	3.0	0.624	..	4.9856	..
February	.. 1.7565	3.0	0.465	..	5.2218	..

TABLE V

POPLAR					
Months	U	Mean Temp: (t)	% Sunshine hours	tp / 100	k
1	2	3	4	5	6
March ..	9.5	69.80	8.37	5.84	1.62
April ..	11.25	78.80	8.75	6.89	1.61
May ..	12.5	89.70	9.61	8.62	1.45
June ..	13.37	93.70	9.57	8.96	1.49
July ..	14.00	89.30	9.76	8.71	1.60
August ..	14.22	87.70	9.26	8.12	1.75
September ..	14.25	85.20	8.34	7.15	1.99
October ..	14.12	77.70	7.95	6.17	2.29
Novermber ..	13.5	66.00	7.12	4.69	2.87
December ..	12.0	57.30	7.06	4.04	2.97
January ..	9.375	54.70	7.22	3.95	2.31
February ..	5.175	60.10	6.96	4.18	1.23

It is always customary to use emperical formula to work out the water consumed by crop to assess the water requirements in any valley project. The above data has been used to fit in such an emperical formula. The most widely used formula is given by Henry. F. Blaney and W. D. Criddle. Their formula known as Blaney—Criddle formula connects the consumptive use of water with the average day-time hours and mean temperature. The formula can be written down as:

$$u = k\ pt$$

where k is an emperical co-efficient, p, the total monthly day time-hours and the "t" is the average temperature. The p was found out from the tables for the latitude of Niaz Beg which is 31°—30′ North and t was found out through averaging the average daily temperature for the month. The values of U in table-IV, were then devided by tp/100 and results are given in last column.

The k has been found to vary from 1.46 to 2.50 in case of poplar and from 0.83 to 1.44 in case of Shisham and the total U has been found for Poplar and (*b*) for Shisham. It can also be seen from tables I & II, that though Shisham and Polar both use water in months following November there is no increase in height and, therefore, in actual practice it is not necessary to give them any water.

Based on this effective U values are:

Poplar .. 101.57

Shisham .. 58.21

and the seasonal 'k' values are:

Poplar .. 1.70

Shisham .. 0.98

INDICATION FOR FUTURE

So far there has been no yard-stick to determine the water required for various forest crops and trees to help in the drawing of water budget for different projects. With the help of these co-efficients, thus found out above, it is possible to project with some degree of accuracy the water requirement for a project for forest plantations.

PRACTICAL USE

Immediate practical use can be made of the iterim observations given in the tables above, even now by arranging delivery of above given quantities of water every month to field crops in general and nurseries in particular with reasonable chances of success. In the past nurseries have failed due to heavy watering, which has resulted in the wastage of an important resource which is in limited supply. We can therefore have more equitable distribution of water in an irrigated plantation.

SUMMARY

Two experiments have been laid to find out the water requirement of forest crops. The first one was at Pirowal in 1959 to determine for *dalbergia sissoo*. The efficicy of different depths of water delivered (1½′, 3′, 4½′, 6′, 7½′), fortnightly, three weekly and monthly in accordance with trench and flood methods. The analysis of the results show that an application of water upto 4½ ft. in trenches gives significant results. Application of additional quantities of water does not result in proportional increase in growth. The three frequencies of application did not give significant results.

The second experiment was laid out at Niaz Beg to determine the consumptive use of water for populus *euramericana /CV.* 1.214′ and *dalbergia sisso* with water table maintained at 8 feet depth, it has been found that *growth for both the spp., stopped* towards the end of October and application of further water produced no growth. The order of water consumption (U) and (K) values were found as under:

	(U) Water consumption in inches	(K) Seasonal	(K) Monthly
Poplar ..	101.10	1.21	1.26-1.44
Shisham ..	56.41	1.47	.87-2.51

ACKNOWLEDGEMENTS

I am grateful to Mr. Amir Ahmad Khan, Secretary, Agriculture, Government of West Pakistan, Agriculture Department, for the keen interest which he had taken in the experiment.

I thank Messrs Ghulam Mohammad and Mohammad Akram Sehgal, Forest Rangers and Mohammad Akram Research Assistant, Irrigation Research for the pains which they had taken in the conducting of the experiments and the interest they have shown in it.

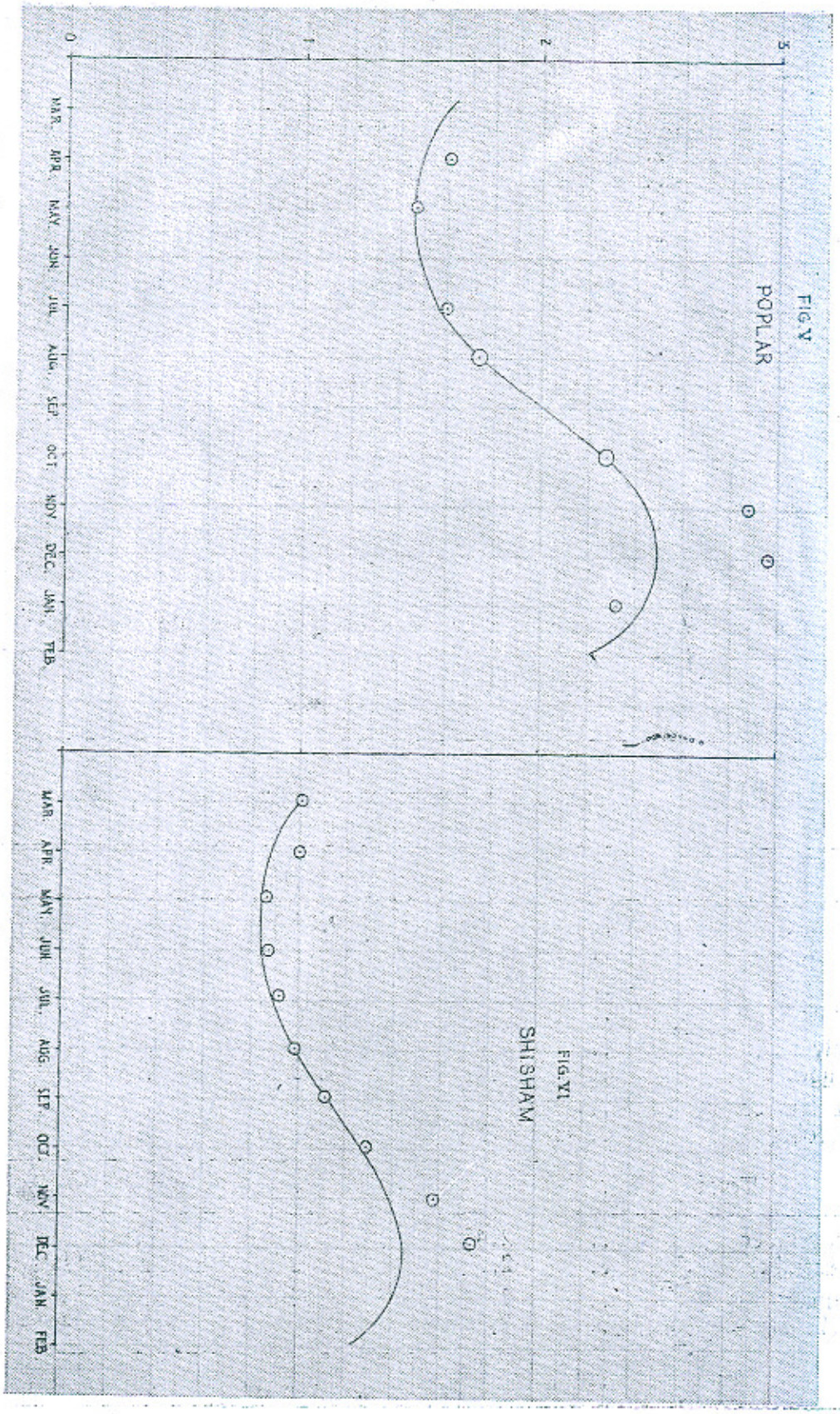


FIG.V
POPLAR
0
1
2
3
MAR.
APR.
MAY.
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
FIG.VI
SHISHAM
MAR.
APR.
MAY.
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.

Fig. 5 & 6

TABLE VI

SHISHAM

1		2	3	4	5	6
March	..	5.9	69.80	8.37	5.84	1.01
April	..	6.87	78.80	8.75	6.89	0.99
May	..	7.37	89.70	9.61	8.62	0.85
June	..	7.75	93.70	9.57	8.96	0.86
July	..	7.97	89.30	9.76	8.71	0.91
August	..	8.0	87.70	9.26	8.12	0.98
September	..	8.0	85.20	8.34	7.15	1.11
October	..	7.87	77.70	7.95	6.17	1.28
November	..	7.5	66.00	7.12	4.69	1.59
December	..	7.0	57.30	7.06	4.04	1.73
January	..	6.25	54.70	7.22	3.95	1.58
February	..	5.2	60.10	6.96	4.48	1.24

The values of k so found were then plotted and a smooth curve drawn as shown in figure V & VI. The values of k were read out and are given in columns' 2 & 4 of table VII, given below. Using Blaney Criddle's formula the consumptive use of water for Poplar and Shisham was determined, the results are given in the same table. (See also Figure VII & VIII).

TABLE VII

Month		k value	U	k value	U
		POPLAR	POPLAR	SHISHAN	SHISHAM
1		2	3	4	5
March	..	1.60	9.34	1.00	5.84
April	..	1.49	10.27	.88	6.05
May	..	1.46	12.59	.83	7.16
June	..	1.48	13.26	.84	7.53
July	..	1.57	13.67	.89	7.75
August	..	1.74	14.13	.98	7.96
September	..	2.00	14.30	1.13	8.06
October	..	2.27	14.01	1.27	7.84
Total	..		101.57		58.21
November	..	2.45	11.49	1.38	6.47
December	..	2.50	10.10	1.44	5.82
January	..	2.44	9.64	1.40	5.53
February	..	2.20	9.20	1.24	5.15
Total	..		142.00		8.18

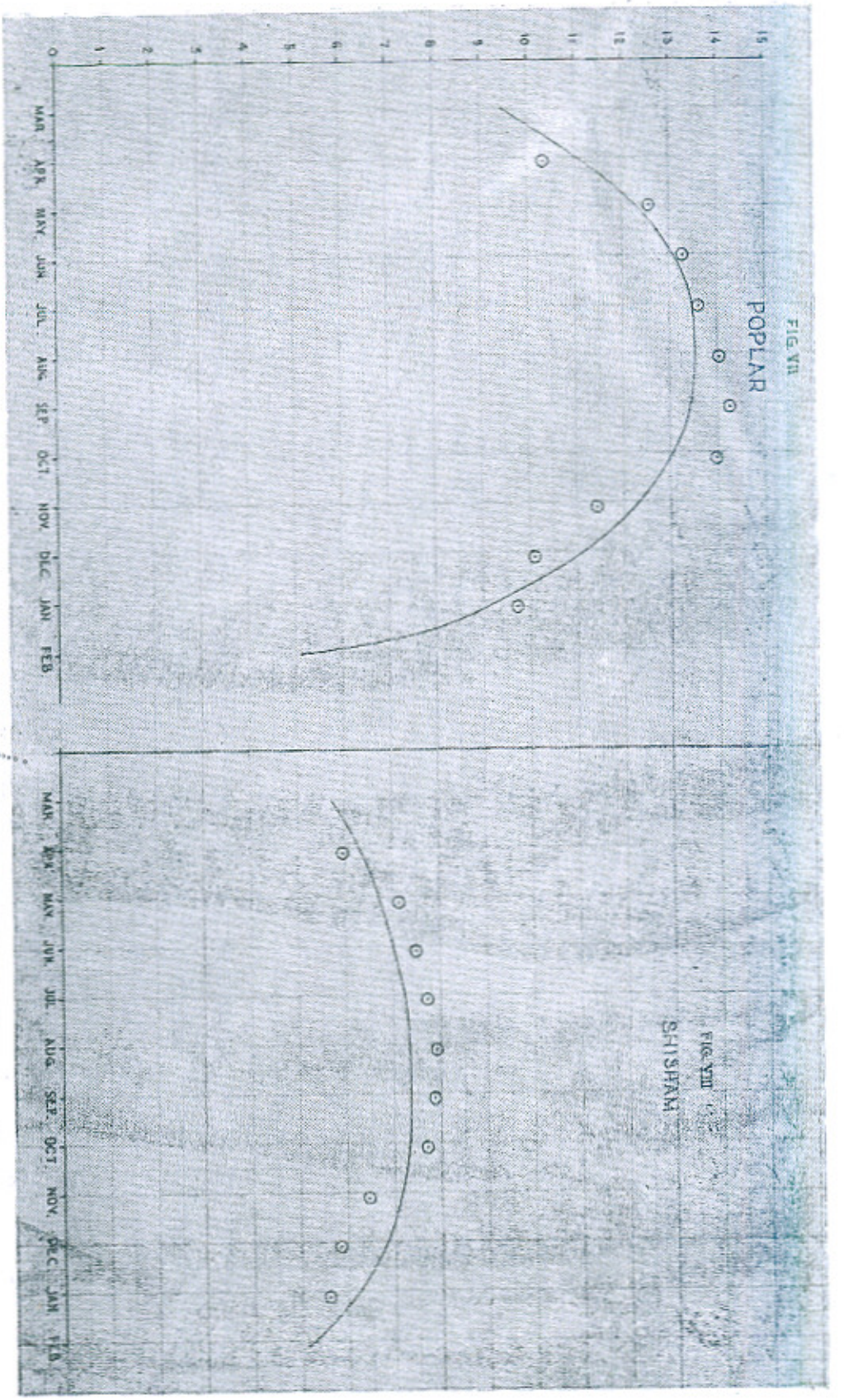


FIG. VII
POPLAR
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MAR.
APR.
MAY.
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.
FIG. VIII
SHISHAM
MAR.
APR.
MAY.
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
FEB.

Fig. 7 & 8

APPENDIX-I

ANALYSIS

	Degrees of Freedon	Sum of squares	Mean square	F. Value	F. at 5% level.	Result.
Replicates ..	2	5238.6	2619.6			
Delta ..	4	55268.2	13817.05	$\frac{13817.05}{28.12.}=491.36$	(4.8)=3.84	Significant
Error 1 (DXR)	8	225.0	28.12			
Frequency	2	285.8	142.9	$\frac{142.9}{165.7}=.8638$	(2.20)=3.49	Insignificant.
DXF.	8	1479.6	184.95	$\frac{184.95}{165.7}=1.116$	(8.20)=2.45	,,
Error 2.	20	3313.33	165.67			
Method ..	1	4102.8	4102.8	$\frac{4102.8}{277.019}=14.88$	(1.30)=4.17	,,
MXD ..	4	709.8	177.45	$\frac{177.45}{277.019}=.6405$	(4.30)=2.69	,,
MxF. ..	2	677.2	338.6	$\frac{238.6}{277.019}=1.223$	(2.30)=3.32	,,
M.D.F. ..	8	3195.26	399.41	$\frac{399.41}{277.019}=1.448$	(8.30)=2.27	,,
Error ..	30	8310.57	277.019			
Total ..	89	82806.16				

Measuring Discharge of Irrigation Water–Part I

By

DR. NAZIR AHMAD*

Measurement of Irrigation water is important both for the engineers as well as for the farmers. There are many standard methods to measure the discharge. These are known to a qualified engineer. Recently with the development of groundwater, the measurement of small discharges has become very important. Farmers are interested to know the order of the discharge being pumped out from their tubewells. It is the intention of this note to put forth some simple methods which even a farmer can use to estimate the discharge of a tubewell. Formulae, tables and other details of the methods are put forth. This is reproduced from Chapter 3 of the book on Tubewell Practice in West Pakistan, under print by the author, so that the number of figures and tables are kept the same as in the original text.

Units used to record the flow

The discharge of a tubewell is measured in cubic feet per second. Another common measure is gallons per minute. Sometimes the discharge is measured in acre inches per 24 hours or acre feet per 24 hours. All these units of measurement are inter-related. Below in Table 1 is given the inter-relation of the various units of measurement. It may be noted that:

One cu. ft. per second	= 449.83 (approx. 450) American gallons per minute.
One cu. ft.	= 7.48 (approx. 7.5) American gallons.
	= 62.5 lbs.
One acre foot.	= 43560 cu. ft.
	= 325851 gallons.

Imperial gallon is bigger than American gallon so that one cu. ft. per second=6.25 Imperial gallons.

Measuring discharge by a container

A simple method to estimate the discharge is by using an empty bitumen drum. Its capacity is 45 gallons and a discharge of one cu. ft. per second will take six seconds to fill it (see Fig. 1). If the discharge is less than one cusec, it is possible to measure it by this method. Recording time of filling an empty bitumen drum gives the discharge.

*Principal Research Officer, Irrigation Research Institute, Lahore.

TABLE I

Conversion units of flow—Data are in American gallons.

Units	Cubic ft. per second	Gallons per minute	Million gallons per day	Acre ins. per 24 hours	Acre ft. per 24 hours
Cubic feet per second ..	1.0	448.8	0.646	23.80	1.984
Gallons per minute ..	0.00223	1.0	0.00144	0.053	0.00442
Million gallons per day ..	1.547	694.4	1.0	36.84	3.07
Acre-inches per 24 hours ..	0.042	18.86	0.0271	1.0	0.0833
Acre-feet per 24 hours ..	0.504	226.3	0.3259	12.0	1.0

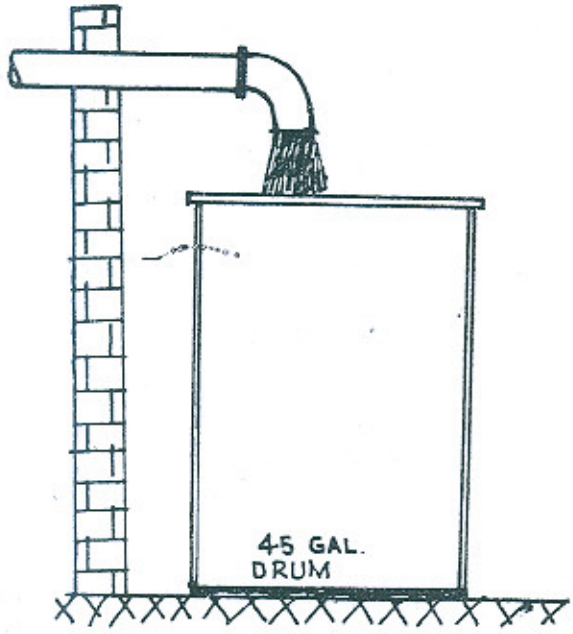


Fig. 1.—Direct Method of Discharge measurement.

Sometimes at the site of discharge outlet, a masonry tank is constructed. It can also be used for recording the discharge by noting the time to fill this tank of known dimensions.

Estimation of discharge through an outlet channel

If the water of a tubewell is allowed to flow through a straight small channel of uniform cross section, estimation of surface velocity of flow can give the discharge.

In a straight uniform section, select two points at 50 to 100 ft. apart. Take a wooden piece and drop it in the centre of the channel about 10-15 ft. upstream of the first reference point. Note the time, the float takes to cover the distance between the selected points. It is explained in Fig 2.

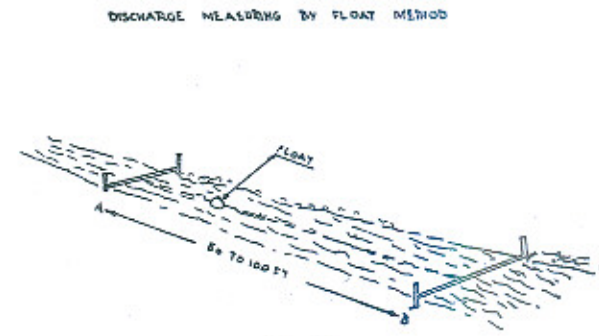


Fig. 2.

The surface velocity is given by dividing the distance travelled by the time taken. To determine the mean velocity, multiply the surface velocity by 0.8, if the channel is shallow and wide. If it is narrow and deep, the factor to be used is 0.85. The area of cross section is the mean of bed width and

surface width multiplied by the depth of water measured at two or three points to find the average. This area multiplied by the mean velocity, gives the discharge.

Use of a V-notch

A very accurate method for discharge measurement is by the use of a V-notch. Take an iron sheet, 1/8 inch thick. Cut a 90° V-notch on its one edge. Fix this plate vertically in the brick masonry tank preferably at its end.

Fill the tank with water and let it stand up to the level of the apex of the V-notch without flowing. Assure that there is no leakage of water. This is the zero level of a gauge fixed 2 or 3 ft. upstream of the notch on one side of the tank. Be careful that there is no grease or oily material on the apex of the notch as it will hold up the water and will give a wrong indication of the zero level. The foot scale will record the water head above the notch. Operate the tubewell and allow a free fall of water below the notch. Record the water level when conditions are steady. The main arrangement of tank with stilling wall and notch is shown in Fig. 3.

The discharge is measured in cu. ft. per second or in gallons per minute. In Table 2 the discharge in the two units for a given gauge reading is given. The formula used for computing the discharge through a 90°

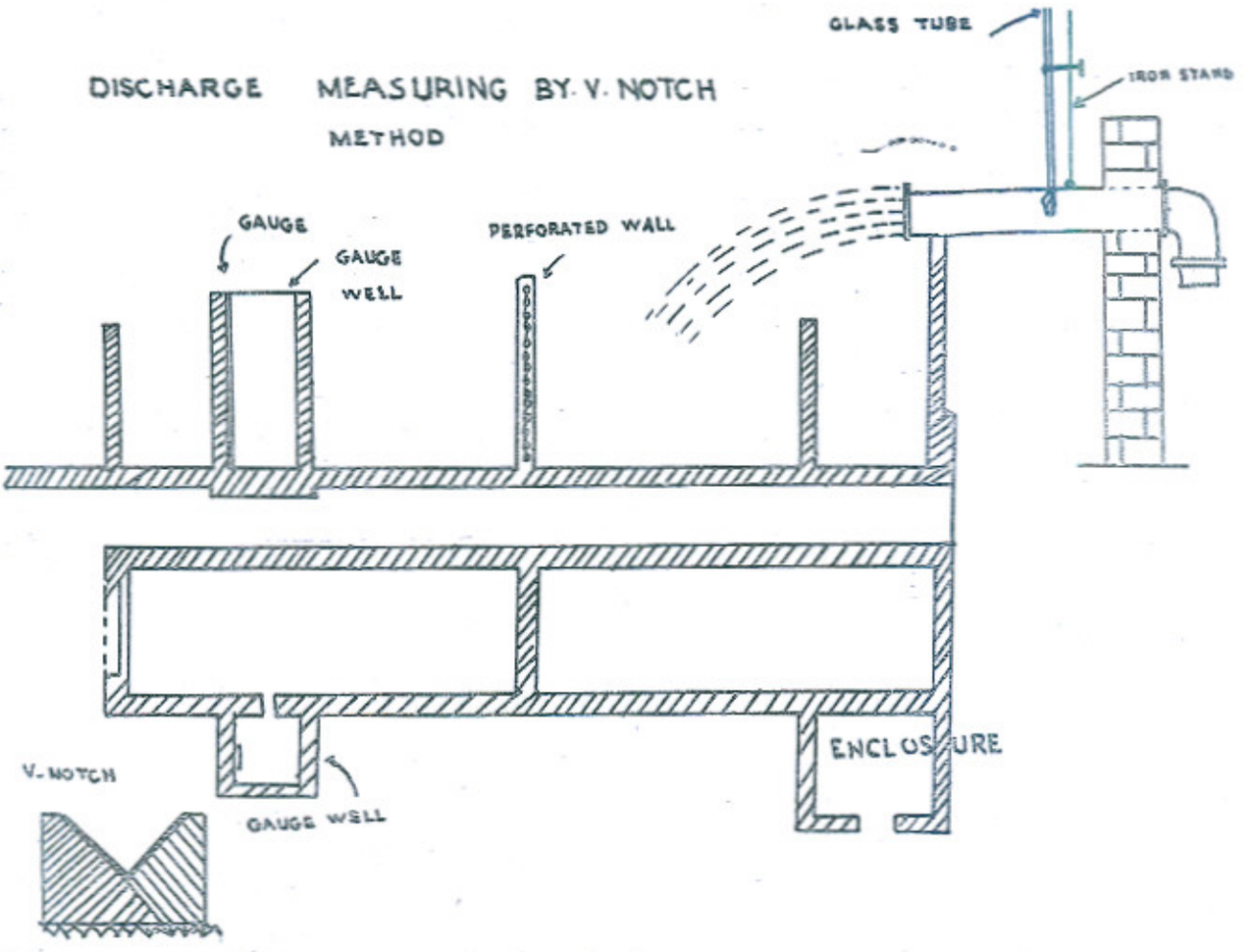


Fig. 3

V-notch is $Q=2.5\ H^{2.5}$ though in he Table 2, the calculations are based upon the formula $Q=2.47\ H^{2.5}$.

TABLE 2

Flow over 90° V-notch weir in cubic feet per second and gallons per minute

Head in feet 'H'	Head in inches approximately	Flow in cubic ft. per second	Flow in gallons per minute
0.10	1-3/16	0.008	3.6
0.15	1-13/16	0.022	9.9
0.20	2-3/8	0.046	20.6
0.25	3	0.080	35.9
0.30	3-5/8	0.125	56.1
0.35	4-3/16	0.184	82.6
0.40	4-13/16	0.256	115
0.45	5-3/8	0.343	154
0.50	6	0.445	200
0.55	6-5/8	0.564	253
0.60	7-3/16	0.700	314
0.65	7-13/16	0.854	383
0.70	8-3/8	1.03	462
0.75	9	1.22	548
0.80	9-5/8	1.43	642
0.85	10-3/16	1.66	745
0.90	10-13/16	1.92	862
0.95	11	2.19	983
1.00	12	2.49	1,118
1.05	12-5/8	2.81	1,261
1.10	13-3/16	3.15	1,414
1.15	13-13/16	3.52	1,580
1.20	14-3/8	3.91	1,755
1.25	15	4.33	1,943

This is a very accurate method and can even be used in an earthen channel as shown in Fig. 4 provided it is straight and water is allowed to fall freely below the notch.

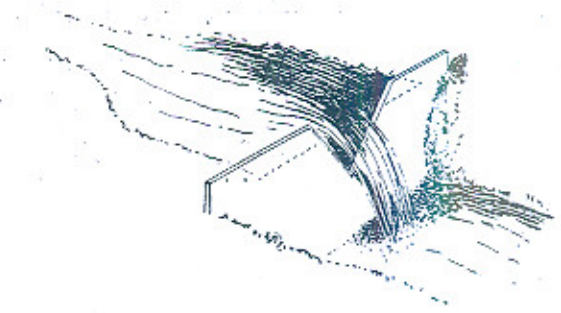


Fig. 4—A V-notch fitted in a Channel

There are a few precautions which need be adopted while constructing a V-notch. The surface of the plate facing the flow need be smooth. It will be preferable to fix brass strip on the V-notch edges to avoid rust.

Discharge measurement by a sharp plate weir

For a high discharge or when the head of water is not to be allowed to rise too much on the upstream side, providing a straight iron plate can also be used to record the discharge. In a straight masonry channel a sharp plate usually 1/8 inch thick is fixed as shown in Fig. 5. The zero level of the crest of the plate is recorded as before and a gauge is fixed about 3 feet upstream of the plate.

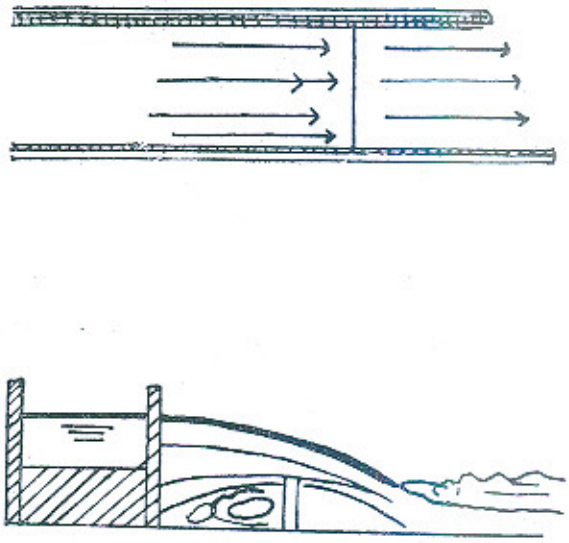


Fig. 5—Rectangular Weir without Contraction

Precautions for installing a weir plate

The following instructions are important while installing a weir of any type or shape. It includes even a V-notch.

Set the weir structure in a channel that is straight for a distance upstream from the weir equal to at least ten times the length of the weir crest.

Place the weir at right angles to the direction of water flow.

Make sure the face of the weir structure is perpendicular, and the weir crest straight and level.

Avoid obstructions on the upstream side of the weir structure.

Make the crest and sides of the weir notch not more than one-eighth of an inch in thickness.

If possible, set the weir structure at the lower end of a long pool sufficiently wide and deep so that the water will approach the weir free from eddies, at a velocity not exceeding .5 ft. per second.

The height of the crest of the weir above the bottom of the channel, upstream from the weir, should be at least twice, and preferably three times, the depth (or head) of the water flowing over the crest. Remove debris accumulating behind the weir.

The distance from the side of the weir notch to the sides of the channel or weir box (except for a suppressed weir) should be at least twice the depth (or head) of water passing over the crest.

See to it that the length of the weir crest is such that the head to be measured exceeds two inches and the maximum head, preferably is not greater than one-third the length of the weir crest.

Construct the crest of the weir in a manner that air can circulate freely beneath the overflowing water.

Recording of water head, H, above the weir gives, the discharge. In Table 3, values of discharge for different heads of water are given. The main precaution is that the fall of water on the downstream side should be free. After the fall, the water level may at least be six inches below the crest level of the weir.

TABLE 3

Discharge in Cubic Feet per Second (Second-feet) per foot of length of Weir Crest by the Francis Formula

$$Q = 3.33\, H^{3/2}$$

Depth of Water or Head H.		Discharge in feet per second
Feet	Inches	
0.20	2-3/8	0.298
0.25	3	0.416
0.30	3-3/8	0.547
0.35	4-3/16	0.689
0.40	4-13/16	0.842
0.45	5-3/8	1.005
0.50	6	1.177
0.55	6-3/8	1.358
0.60	7-3/16	1.547
0.65	7-13/16	1.745
0.70	8-3/8	1.950
0.75	9	2.163
0.80	9-3/8	2.383
0.85	10-3/16	2.610
0.90	10-13/16	2.843
0.95	11-3/8	3.083
1.00	12	3.300
1.05	12-3/8	3.583
1.10	13-3/16	3.842
1.15	13-13/16	4.107
1.20	14-3/8	4.377

The discharge is worked out from the formula:

$$Q = 3.33\ LH^{\frac{3}{2}}$$

Where L = Length of the weir plate, and

H = the water head on the top of the plate.

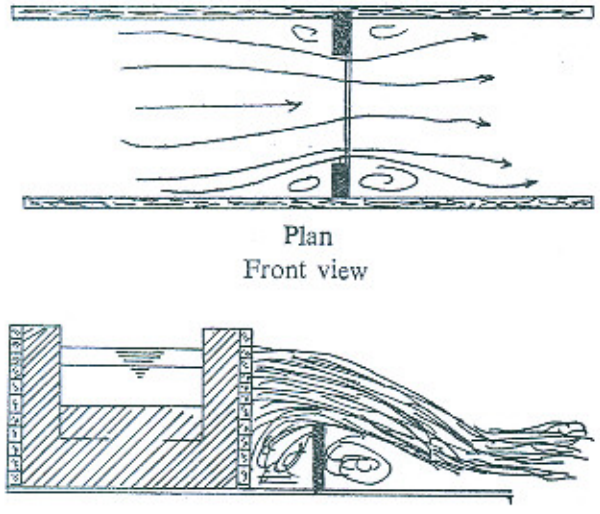
It is called the Francis formula.

Discharge measurement by a rectangular weir with end contraction

A rectangular weir cut in an iron plate can even be fixed in a channel. This causes contraction of flow at the sides in addition to the bottom. For such a condition Francis formula is changed to:—

$$Q = 3.33\ (L - 0.2H)^{3/2} \times L.$$

Sharp Crested Weir with 2 end Contractions fixed in a flume.



Plan

Front view

Fig. 6-*a*

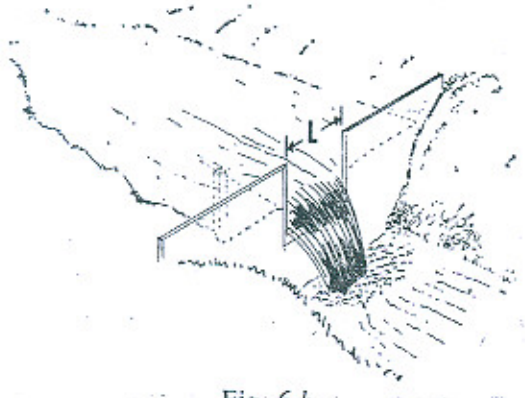


Fig. 6-*b*

It is called the Francis Formula with both ends contracted (Fig. 6 *a*, *b*). While measuring the discharge in gallons per minute the constants are changed to:—

$$Q = 1494.6\ (L - 0.2H)^{3/2} \times L.$$

The discharge is recorded from Table 4.

TABLE 4

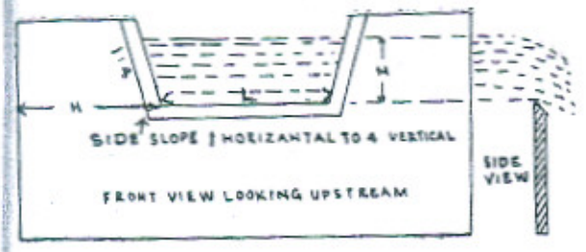
Flow over rectangular contracted weirs

Cubic feet per second.

Head 'H' in feet	Head in inches (approx.)	Crest length (L) equal to 1.0 foot.
		Flow in cubic feet per second
0.10	1-3/16	0.105
0.15	1-13/16	0.191
0.20	2-3/8	0.291
0.30	3-5/8	0.527
0.35	4-3/16	0.661
0.40	4-13/16	0.804
0.45	5-3/8	0.955
0.50	6	1.11
0.55	6-5/8	1.28
0.60	7-3/16	1.45
0.65	7-13/16	1.63
0.75	9	2.01
0.80	9-5/8	2.21
0.90	10-13/16	2.62
1.00	12	3.06
1.10	13-3/16	..

Capolleti weir

An Italian Engineer, Capolleti, however, designed a trapezoidal weir with complete end contractions. He kept the sides sloping at 1 horizontal to 4 vertical (see Fig. 7) The formula for such a condition is $Q = 3.37\ LH^{3/2}$. Here the coefficient of Francis formula is changed from 3.33 to 3.37. Table 5 is added to give the discharge for any head above the crest for such a weir.



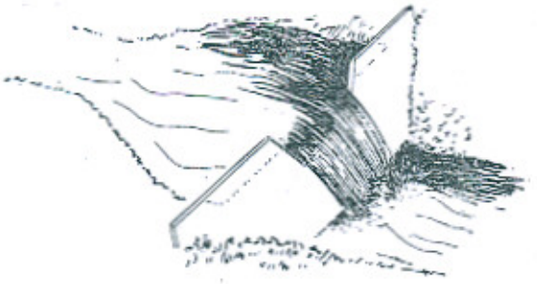


Fig. 7
A Trapezoidal or Cipoletti Weir Q—3.37 LH 3/2

TABLE 5

Discharge over Capolleti's Trapezoidal Weir for various Heads

Formula $Q=3.37\ LH^{3/2}$

Head, H on Crest in ft.	Length of Weir Crest	
	One ft.	Two ft.
	Discharge in Cubic ft./Second	
0.21	0.32	0.65
0.23	0.37	0.74
0.25	0.42	0.84
0.27	0.47	0.94
0.29	0.53	1.05
0.30	0.55	1.11
0.36	..	1.45
0.41	..	1.77
0.46	..	2.10
0.51	..	2.45
0.56	..	2.82
0.65	..	3.53
0.71	..	4.03
0.76	..	4.46
0.86	..	5.37

Orifice for discharge measurements

The methods for measurement of discharge will not be complete without reference to the orifice technique. If there exists a tank full of water and an outlet of any shape, rectangular, square or circular, the discharge can also be measured. Here the head of water above the centre of the orifice is noted and the discharge is worked out by the relation:

$$Q=CA\sqrt{2gh}$$

where h=the water head above the centre of the orifice.

C=a coefficient usually taken equal to 0.61. It, however, varies with the shape of the orifice and slightly with the head of water.

A=the area of the orifice.

In Table 6, the discharge for various water heads and size of orifices is given for free flow conditions, using the formula:

$$Q=0.6\sqrt{2gH}$$

Orifice fixed to a pipe

This is a very convenient method to estimate discharge of a tubewell. All tubewells discharge through a pipe and which generally runs in full. If the section of the pipe is reduced suddenly, it works as an orifice fixed to the pipe. Recording of water head in the pipe gives the discharge.

The size of the orifice depends upon the diameter of the discharging pipe. The orifice is usually welded to a socket. Its edges are sharp and smooth. The socket can be screwed to the discharging pipe and the water is allowed to fall freely (Fig. 8).

TABLE 6

Flow through Orifices in Cubic feet per second.

Head 'H' in feet	Head in inches approx.	Cross sectional area of orifice in sq. ft.						
		0.25	0.333	0.50	0.75	1.00	1.50	2.00
0.01	1/8	0.122	0.163	0.245	0.367	0.489	0.73	0.98
0.06	3/4	0.300	0.399	0.599	0.899	1.20	1.80	2.40
0.11	1-5/16	0.406	0.540	0.811	1.22	1.62	2.43	3.24
0.16	1-15/16	0.489	0.651	0.978	1.47	1.96	2.93	3.91
0.21	2-1/2	0.561	0.746	1.12	1.68	2.24	3.36	4.48
0.26	3-1/8	0.624	0.831	1.25	1.87	2.49	3.74	4.99
0.31	3-3/4	0.681	0.908	1.36	2.05	2.73	4.09	5.45
0.36	4-5/16	0.734	0.976	1.47	2.20	2.93	4.40	5.87
0.41	4-15/16	0.783	1.04	1.57	2.35	3.13	4.70	6.27
0.46	5-1/2	0.829	1.10	1.66	2.49	3.32	4.98	6.64
0.51	6-1/8	0.873	1.16	1.75	2.62	3.49	5.24	6.99
0.61	7-5/16	0.955	1.27	1.91	2.87	3.82	5.73	7.64
0.71	8-1/2	1.03	1.37	2.06	3.09	4.12	6.19	8.25

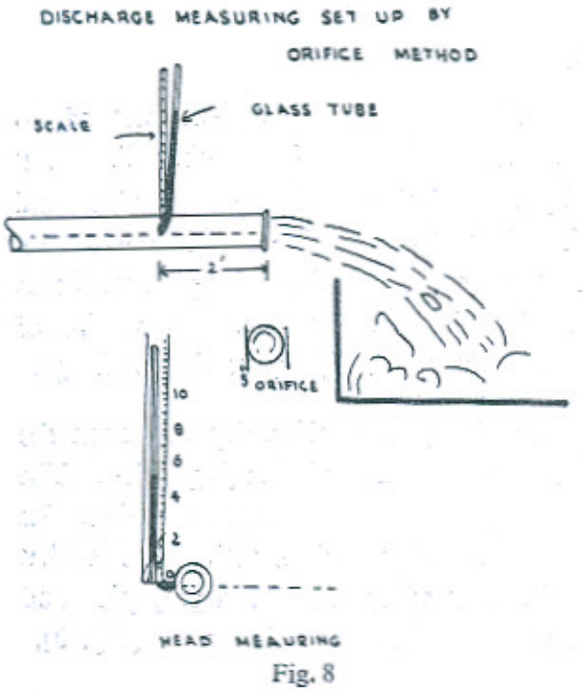


Fig. 8

In order to measure the head, a small hole, 1/8 to 2/8 inch is drilled, about 2.5 ft. upstream of the socket and a small metallic pipe is fixed to it, so that it is kept flush with the wall on the inside of the pipe. A small piece of rubber tubing is used for connecting a glass tube to the metallic tube which is fixed on a scale to measure the head of water on the orifice.

This arrangement is permanently installed on the discharge pipe. When the flow starts, the water rises in the glass tube to a certain height. Measurement of the height of water above the centre line of the orifice which is zero in this case, gives the discharge in gallons per minute or cusecs.

TABLE 7

Tabulation of yields from Circular Orifice Weirs, Range from 56 to 2000 G.P.M.

Head of water in tube above centre of Orifice (inches)	Yield in gallons per minute										
	4 inch pipe 2½ inch opening	4 inch pipe 3 inch opening	6 inch pipe 3 inch opening	6 inch pipe 4 inch opening	6 inch pipe 5 inch opening	8 inch pipe 4 inch opening	8 inch pipe 5 inch opening	8 inch pipe 6 inch opening	10 inch pipe 6 inch opening	10 inch pipe 7 inch opening	10 inch pipe 8 inch opening
1	2	3	4	5	6	7	8	9	10	11	12
5	56	93	..	..	..	..	..	..	..	..	..
6	62	102	82	155	300	148	240	380	..	..	..
7	66	110	88	168	325	160	260	410	370	550	850
8	70	118	94	180	350	170	280	440	395	590	900
9	75	126	100	190	370	370	180	295	420	630	950
10	80	132	106	200	390	190	310	490	440	660	1000
12	87	145	115	220	425	210	340	540	480	720	1100
14	94	156	125	238	460	225	370	580	520	780	1190
16	100	168	132	253	490	240	390	620	560	840	1275
18	106	178	140	268	520	255	415	660	595	890	1350
20	112	188	150	283	550	270	440	695	625	940	1420
22	118	198	158	298	575	280	460	725	660	980	1480
25	125	210	168	318	610	300	490	780	700	1050	1580
30	138	230	182	350	670	330	540	850	760	1150	1725
35	150	250	198	375	725	360	580	920	820	1249	1865
40	160	265	210	400	780	380	620	980	880	1330	2000
45	170	280	223	425	820	400	660	1040	940	1410	..
50	180	300	235	450	870	425	700	1100	990	1480	..
60	195	325	260	490	950	465	760	1200	1090	1610	..

In Table 7 is given the discharge for various water heads above the centre line of the orifice fixed to pipes of different diameters.

Discharge estimation on the basis of measurement of X & Y axis of the falling water

Sometimes a rough estimation of discharge is possible by measuring X and Y axis of a freely falling jet of water. If the flow is occurring through a pipe kept horizontal, then measure the horizontal distance, D, when the vertical fall of water is 12.0 inches as shown in Figure 9. The discharge Q in gallons per minute is given by the relation:—

$$Q = 1.015 \times A \times D$$

where A is the area of cross section of the pipe in square inches and D is the horizontal distance in inches when the upper surface of

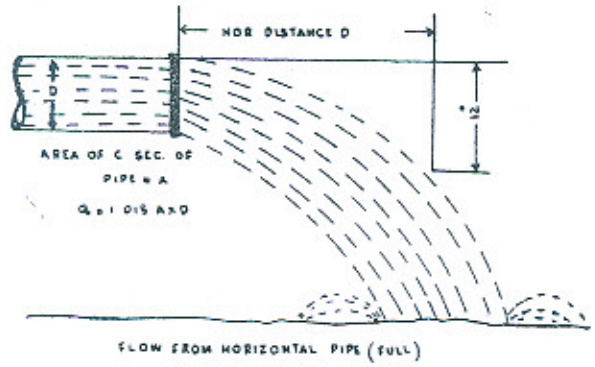


Fig. 9

the water has fallen by 12 inches below the horizontal line. Using the formula, discharge is worked out in gallons per minute for different diameters of the pipe. This is given in Table 8. It may be noted that this method can even be used if the discharge pipe is not horizontal.

TABLE 8

Approx. discharges for a pipe running full in Gallons per Minute.

Pipe Diameter (inches)	Discharge in Gallons per Minute — Horizontal Distance—D in inches						
	12	14	16	18	20	22	24
2	41	48	55	61	68	75	82
3	90	105	120	135	150	165	180
4	150	181	207	232	258	284	310
6	352	410	470	528	587	645	705
8	610	712	813	915	1017	1119	1221

If the discharging pipe is inclined at any angle to the horizontal (Figure 10) the distance

Discharge Measurement from Free flowing Pipe

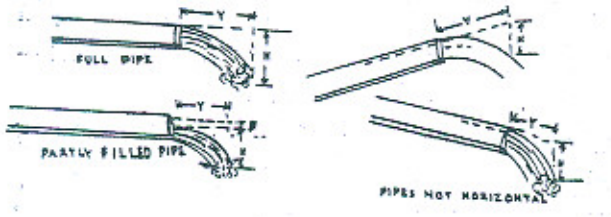


Fig. 10

D for 12.0 inches fall of water, is measured as before but measurement is taken in the direction of the inclination of the pipe as shown in Fig. 10. The discharge is determined with reference to Table 8 or Fig. 11 which

Discharge measurement by Flow through Pipe

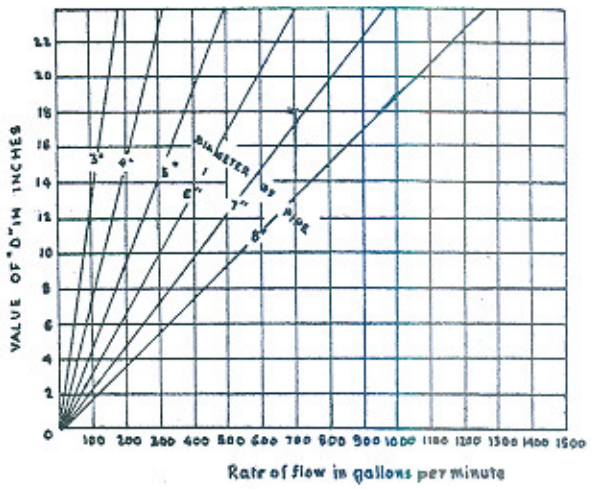


Fig. 11

is meant for various diameter of the discharging pipe.

Discharge measurement by a vertical flowing pipe

When the discharge is small and the pipe cannot flow full, it can be recorded by keeping the pipe vertical. The height to which the water rises through a vertical pipe is measured

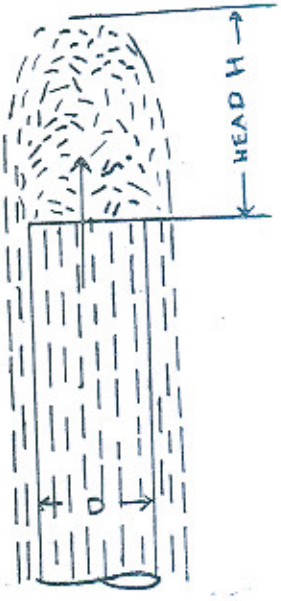


Fig. 12—Discharge measuring through a Vertical Pipe

as explained in (Fig. 12). The discharge in gallons per minute is determined by squaring the diameter of the discharging pipes, multiplied by a factor 5.5. The formula used is $Q=5.5D^2\sqrt{h}$. In Table 9 values of Q for three values of pipe diameter and six values of h are given. This is a quick but an approximate method for discharge measurement.

TABLE 9

Discharge from a vertical pipe.

$Q=5.5\ D^2\sqrt{h}$

Height of water flowing from pipe h. in inches,	Pipe Diameters		
	4″	6″	8″
	Discharge in cusecs		
3	..	0.69	1.22
6	0.43	0.95	1.73
9	0.53	1.18	2.1
12	0.61	1.37	2.44
18	0.75	1.69	2.98
24	0.86	1.94	3.44

Common units to record the flow

Measuring of discharge through an outlet channel:

Parshall flume:

The parshall flume is a special type of critical flow meter. It is being used widely in America. It is self cleaning, requires only a small amount of drop and allows reasonably accurate measurement even when partially submerged. A section of a typical partial flume is shown in Figure 13. The sides of the throat section are parallel and vertical. On the down-stream section the sides diverged towards the outlet. The floor is inclined upward.

Plan and section of Parshall Flume

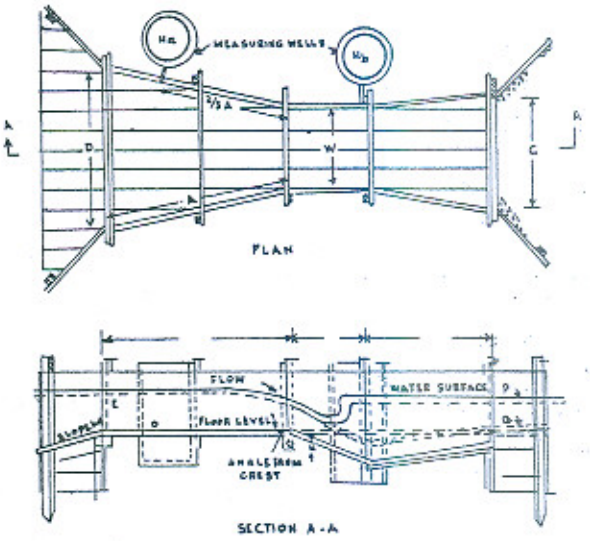


Fig. 13

The size of the flume is determined by the width of the throat of the flume. Flumes with throat width varying from 3 inch to many feet are in use. Formulae and tables for discharge estimation have been worked out. See Table 10.

TABLE 10

Water Head H_a	Throat Widths			
Feet	3″	6″	9″	1′
	Flow in Cubic Feet per Second			
0.10	0.03	0.05	0.09	..
0.20	0.08	0.16	0.26	0.35
0.30	0.15	0.31	0.49	0.64
0.40	0.24	0.48	0.76	0.99
0.50	0.34	0.69	1.06	1.39
0.60	0.45	0.92	1.40	1.84
0.70	0.57	1.17	1.78	2.33
0.80	0.70	1.45	2.18	2.85
0.90	..	1.74	2.61	3.41
1.00	..	2.06	3.07	4.00

The measurement of head above crest is carried out and discharge is noted from the tables. Where a canal has considerable slope and the banks are high, the flume can be installed with very little trouble. The size of the flume has to be selected keeping in view the discharge to be measured.

Tables for free fall Condition

When the down-stream water level in the flume is such as to cause no retardation to the flow due to back water, the condition of flow corresponds to free fall. Under such condition measurement of head above the crest determines the rate of flow as given in Table 10.

In case the flow is submerged ratio of submergence has to be worked out. There are separate tables for estimation of the discharge for submerged condition.

Syphon and pipe flow

It is a common practice to use a pipe to deliver water. It is possible to determine the discharge from a pipe which is flowing either as a free fall or under submerged condition.

Both these conditions are illustrated in Figure 14. The estimation of discharge is

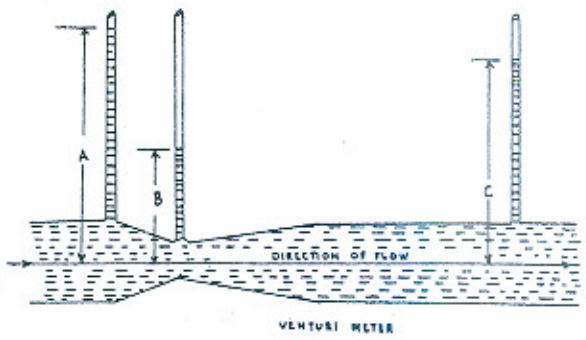


Fig. 14

based upon measurement of head of water (H). It is accurate for free flow condition. Table 11 gives the discharge in cu. ft. per second corresponding to head (H) in inches.

In this country syphon is seldom used to deliver the discharge as shown in Fig. 15. The measurement of discharge by this method is also similar.

In Table 12 we have put forth the discharge in cu. ft. per second corresponding to various H values of a syphon.

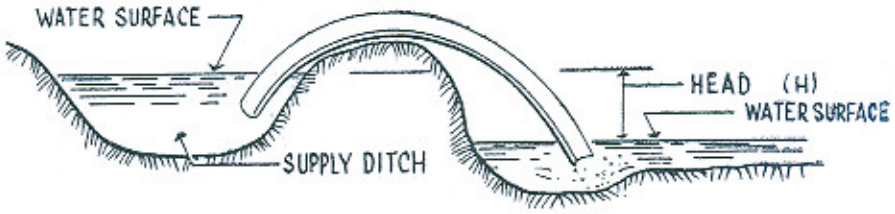


Fig. 15

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TABLE 11

Rate of flow through pipes.

Head (H) in inches (Pipe Dia in inches)	Flow in Cubic Feet per Second							
	1	2	3	4	6	8	10	12
2	0.01	0.05	0.11	0.2	0.5	0.8	1.25	2.0
3	0.015	0.05	0.13	0.25	0.6	0.96	1.5	2.3
4	0.02	0.07	0.17	0.3	0.7	1.2	1.8	2.7
6	0.022	0.09	0.21	0.4	0.78	1.5	2.3	3.3
8	0.03	0.11	0.244	0.49	1.0	1.72	2.68	3.8
9	0.031	0.12	0.26	0.50	1.1	1.84	4.8	4.1
10	0.032	0.122	0.27	0.51	1.15	1.98	3.0	4.3
12	..	..	..	0.58	1.22	2.15	3.25	4.65

TABLE 12

Discharge through Siphons.

Head (H) in inches (Siphon Dia. in inches)	Flow in Cubic Feet per Second.							
	2	3	4	5	6	8	10	12
2	0.04	0.1	0.16	0.25	0.38	0.68	1.05	1.51
3	..	0.12	0.22	0.29	0.48	0.81	1.3	1.94
4	0.067	0.13	0.25	0.4	0.54	1.0	1.52	2.2
6	0.07	0.17	0.31	0.49	0.61	1.2	1.9	2.65
8	0.087	0.19	0.36	0.51	0.76	1.4	2.2	3.05
9	0.089	0.21	0.4	0.52	0.81	1.5	2.3	3.3
10	0.09	0.22	0.42	0.6	0.9	1.57	2.4	3.46
12	0.11	..	0.45	0.68	0.98	1.7	2.6	3.8

Engineering Progress in West Pakistan

Agricultural Development Corporation

NEW CANAL FROM KALARI LAKE

Agricultural Development Corporation of West Pakistan has completed plans for the construction of a new canal off taking from Kalari Begar Feeder. This canal will be 18 miles flowing along the lake and will link with the canal. The canal will be not only presently off taking from the Lake. The present canal takes off from the lake after, all the silt brought down by the feeder is deposited in the lake. This step will increase the life of the lake and the silty water of the Indus will flow to the fields.

The estimated cost of this project is 25 million rupees.

* * *

WIND WILL INSTALLED AT KALARI LAKE

An experimental wind mill imported from Australia has been installed at Kalari Lake to lift water from Lake for the Irrigation of high land. The cost of the Wind Mill was Rs. 16,000.

* * *

MIANWALI LIFT IRRIGATION SCHEME

The Mianwali lift irrigation scheme, the second big scheme in the province was completed recently at a cost of Rs. 52 lakhs. Two hundred cusecs of water from Thal Main Line from R. D. 22,000 is lifted to a height of 35 ft. at the first stage and 100 cusecs are lifted by another 25 ft. in the 2nd stage. The water will irrigate 53,500 acres of lands.

* * *

SOAN VALLEY UNDER IRRIGATION

The Agricultural Development Corporation has launched a programme to reclaim the badly eroded land of the Soan Valley. So far 53 thousand acres of land has been levelled with 13 bull-dozers of 300 H.P., each and is made fit for cultivation.

* * *

TUBEWELL INSTALLATION IN LEIAH

The Agricultural Development Corporation is installing 100 tubewells each of 2 cusecs capacity in Leiah to deal with the Water-logging which is spreading in this

area. This project is to cost Rs. 39,00,000. Seven tubewells are already in operation whereas 15 more are in the installation stage. According to the estimates the completion of this project will lower down the water-table of the area to 10-15 ft. below the present levels.

* * *

SMALL DAM ORGANIZATION

By the completion of Kohal Dam, the organization has completed 9 dams in a short period of 3 years. The dams already completed are, Masseroot, Tanaza, Separa, Bangoo, Miana Ziarat, Bijwala Mansera and Garb. The dams under construction are Chichali, Mung, Tharnal and Dongi. Engineering data of some of these dams are in the Table given.

* * *

WAPDA

25-YEAR PLAN FOR LOWER INDUS

Final Report Submitted to Chairman WAPDA

A 25-year plan estimated to cost Rs. eight billion for the development and reclamation of about nine million acres of land in Lower Indus area of former Sind has been finalised by WAPDA.

The final report containing the plan was submitted to WAPDA Chairman, Mr. A. G. N. Qazi by Mr. V. C. Robertson of Messrs Hunting Technical Service Limited and Sir M. Mac-Donald and Partners, WAPDA consultants for Lower Indus Project.

The voluminous report is spread over 28,000 pages and is the fruit of six years of labour of about 1,000 Pakistani Engineers and Administrative personnel and 70 Foreign Experts.

The report contains detailed study of Indus River, soil, population, drainage, groundwater

Name of Dams	Location	Capacity	Length and height	Catchment area	Life	Cost	Date of execution	Commanded Area
Tanaza	45 miles from R/ Pindi (Distt. Campbellpur).	81 aft. or 220,000,00 galls.	395×32	0.95 sq. miles.	125 years	1,70,000	24-11-64	200 acres
Separa	27 miles from R/ Pindi (Distt. Campbellpur).	568 ac. ft. 16,00,000,00 galls.	568×35	4.02 sq. miles.	125 years	3,24,000	24-11-64	500 acres.
Garb	Tehsil Tilla Gang	—	1500×80	—	100 years	—	—	1,500 acres.
Bangoo	27 miles from R/ Pindi.	—	—	—	—	—	—	119 acres.
Dongi	3 miles from Gojar Khan.	—	—	—	—	—	—	—
Dhanal	Village Dhanal on Nikki Nullah.	—	—	—	—	—	—	—
Chichali	26 miles from Daud Khel.	—	142	—	—	45,00,000	—	12,000 acres.

and reclamation. On the basis of these studies, a plan has been prepared for whole of the southern region for increasing agricultural production by providing more water and reclaiming the land affected by water-logging and salinity.

The major capital requirement will be for engineering works, tubewells, drainage channel, remodelling of canals, storage reservoirs and construction of new barrage at Sehwan, midway between Sukkur Barrage and Ghulam Mohammad Barrage. The plan emphasises the Development of all aspects of agricultural production including the expansion of the agricultural research and extension services for the introduction of improved techniques in the region.

The report discusses the measures to increase yield per acre of most crops by introducing new varieties. The plan also proposes crash programmes for cotton and wheat. The extensive use of chemical fertilizers, the supply of short term agricultural credits, increase in livestock production, improve veternary services and extension of crop protection measures.

The production target proposes in the plan, will be achieved during the seventh plan year *i.e.* 1985 to 1990 when the region is expected to provide surplus food. Overall benefit cost ratio is 3 to 0 and the rate of return of capital is 10 per cent.

The development plan of the Lower Indus has been devided into five areas covering about 1.5 to 2 million acres each. There is further Sub-Division of these areas into various units for starting construction and development programme simultaneously.

Investigations into the land and water resources of the former Sind area were originally started in 1959 by the West Pakistan WAPDA. Later towards the end of 1962, an agreement was signed with the consultants association formed by Hunting Technical Services Limited and Messrs. Sir M. Mac-Donald and Partners for carrying out detailed investigations and studies. The consultants were assisted by the Water and Soil Investigation Division, WAPDA and other WAPDA Agencies for carrying out Studies in the quality and quantity of groundwater and the soil structure.

The report will be scrutinized by WAPDA experts before submitting it to the Government for approval.

* * *

WAPDA TO INSTALL 12,000 TUBEWELLS IN THIRD PLAN PERIOD

Chairman Explains WAPDA Plans to Russian Parliamentary Delegation

According to the Chairman, WAPDA, Mr. A. G. N. Kazi, WAPDA would install about 12,000 tubewells during the third five years plan period for the reclamation of land and to make the best use of the water resources of West Pakistan. In addition 40,000 tubewells put in by agriculturists would be energised.

Besides the programme against salinity and water-logging, the Chairman briefly recounted the activities of WAPDA in the Field of power development and the execution of the Indus Basin Projects.

* * *

Rs. 45 MILLION TANDA DAM COMPLETED

Tanda Lake Receives Water

The Tanda Dam reservoir has started receiving water from 30th June from Kohat Toi.

Assured water supply from the dam would be given for the Rabi cultivation and

for late Kharif Crop. The work on the Irrigation System was also in the advanced stage of completion. It is expected there would be sufficient rains in the Toi catchment to fill up the reservoir in July and August this year.

The Tanda Dam will have a reservoir capacity of 78,000 acre feet of water and will supply irrigation water to 32,500 acres of land in the Kohat District and the adjoining tribal territory. The dam has been built at a cost of Rs. 45 million.

* * *

HYDRAULIC DREDGE FOR TRIMMU-SIDHNAI LINK

The hydraulic dredge assembled at the site for removing silt in the Trimmu-Sidhnai Link Canal, will start functioning soon.

The dredge was supplied by Messrs. Watson of Australia. The dredge is being tested and Pakistani crew is being trained to operate it. This is a first floating dredge for removing silt from the canal as against the conventional method of silt clearance.

The water supply in the Trimmu-Sidhnai Link Canal has been raised to 10,000 cusecs and is giving satisfactory performance.

* * *

FIVE MORE HYDEL SCHEMES IN NORTH

Survey in Daral, Chitral and Kaghan Completed

WAPDA is planning for five small hydel schemes in the hilly areas of Swat, Chitral and Kaghan Valleys.

The survey work on Battgram, Daral, Chitral, Kaghan and Darosh hydel schemes have been completed. The data regarding the flow of rivers and meteorological conditions are being collected to submit feasibility reports for approval of the Government.

Recently five small hydel stations are being built at Gilgit. Baltit, Skardu, Chalt and Naltar. These schemes are scheduled to be in operation within this year. The station will generate from 100 kilowatts to 600 kilowatts with a provision to double their capacities as and when needed.

The small hydel station schemes are being built by WAPDA in those areas where it is difficult to extend the transmission lines from the main grid of West Pakistan and such an extension would have incurred heavy expenses.

* * *

Artesian Well at Islamabad

An artesian well gushing out sweet water at the rate of about 800 gllons a minute, has been struck at Islamabad.

WAPDA had bored 39 test holes in the Federal Area, of which nine were developed as test wells. The last of these wells revealed artesian conditions and was of flowing type.

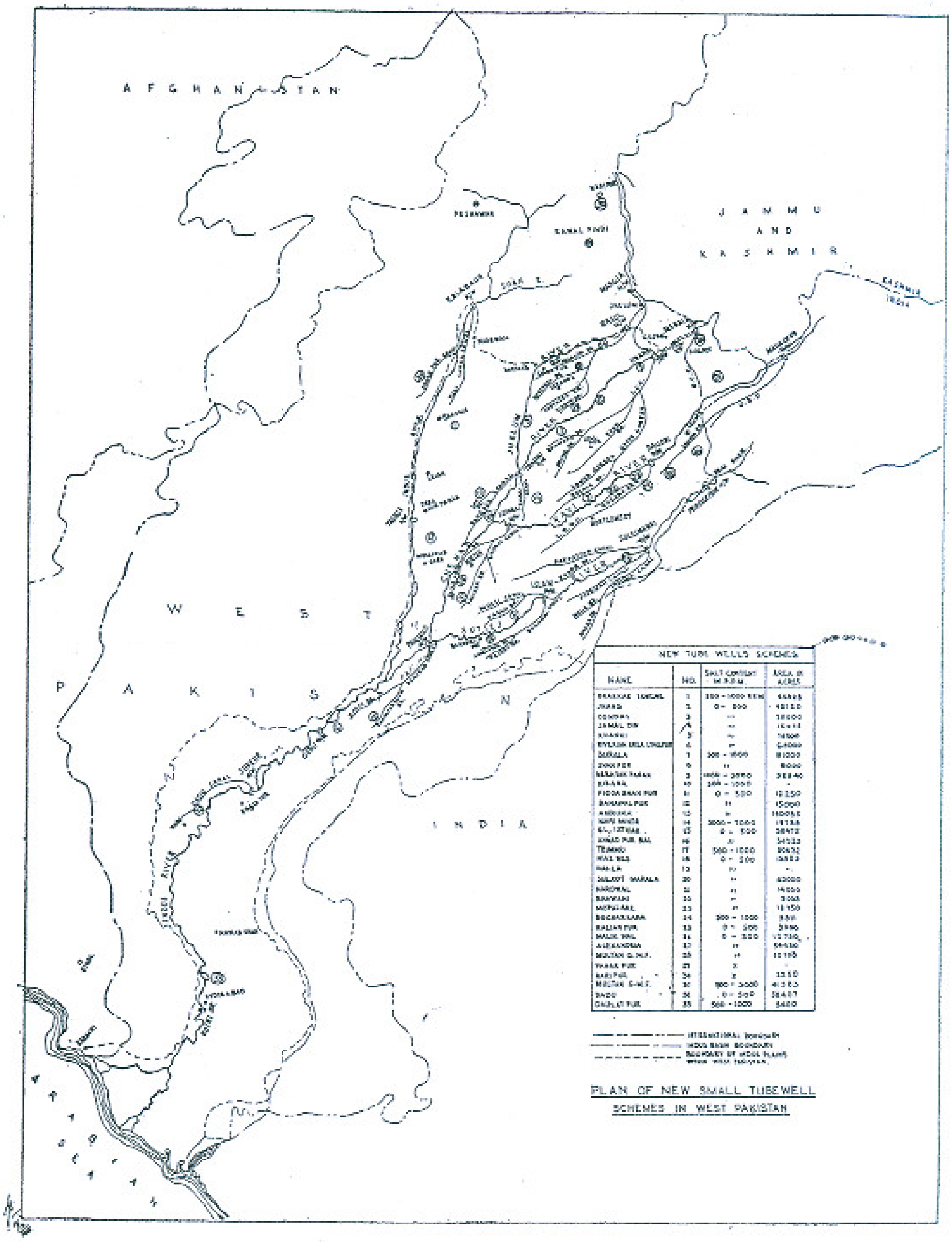
* * *

Irrigation Branch

Activities of the Irrigation Department

The Irrigation Department of West Pakistan whose main responsibility is for the maintenance of the vast Irrigation system is now undertaking installation of tubewells in the Riverine area. In the Annual Development Programme, Schemes of worth Rs. 20 million are proposed to be executed during the year. In fact there are 43 schemes areas in which it is proposed to utilize the groundwater to irrigate the land which practically has no Irrigation facilities so far.

In the adjoining figure the locations of some important schemes of tubewells are shown. Irrigation Engineers are busy planning in a way to keep the capital expenditure as well as the maintenance at the rock bottom level.



PLAN OF NEW SMALL TUBEWELL SCHEMES IN WEST PAKISTAN

News and Notes

INTERNATIONAL MEETINGS

Symposium on Groundwater in Mexico

Mexico is holding its first National Symposium on groundwater in Mexico City during October 1966. It is being organized by the Sectaria de Recursos Hidraulicos C/o Universidad Nacinal Autonoma de Mexico (UNAM), Ciudad Universitaria, Mexico 20, D. F. (MEXICO).

* * *

Seminar on Groundwater in Tehran

ECAFE and UNESCO will be holding a seminar on methods and techniques of groundwater investigation and development in Tehran from 17 October to 6 November 1966. This symposium is a follow up to the ECAFE/ UNESCO Seminar on the Development of Groundwater Resources with special reference to deltic areas held in Bangkok in 1962.

* * *

Establishment of Representative and Experimental Basin, Budapest Symposium

International Association of Scientific Hydrology in Collaboration with Hungarian Government and UNESCO jointly organized a symposium on representative and experimental basin in Hydrology in Bangkok from 29 September to 2 October 1965. 80 papers were presented during the 9 working sessions. The number of participants was 340 drawn from 36 countries of the world. The subject were grouped under the following headings.

1. Principle of the establishment of representative and experimental basis, their classification.
2. Research programme to be undertaken on representative and experimental basis.
3. Method of investigation and handling of data and instrumentation.
4. Utilization of representative and experimental basin and in instrument for research in hydrology.

The papers presented at the symposium are grouped in two volumes of 710 pages and are on sale priced 300 Belgium Frank pervolume from the Secretary General Mr. L. J. Tison. 61 rue des Ronces, Gentbrugge, Belgium.

* * *

Symposium on Sodic Soils

The Hungarian Academy of Sciences in Co-operation with UNESCO organized a symposium on sodic soils. It was held in Budapest from 9 to 16 August, 1964. The proceedings have been published. A booklet of 480 pages priced at $5, is available from the Research Institute of Soil Sciences and Agricultural Chemistry of the Hungarian Academy of Sciences, Budapest II, Herman Otto ut. 15, Hungary.

* * *

Symposium on water in the unsaturated Zone

UNESCO and the Govt. of the Netherlands in co-operation with F.A.O., IASH and ISSS held a Symposium in Wageningen from 19 to 25 June 1966. This symposium is within the framework of International Hydrological Decade. Correspondence can be addressed to Ir. P. E. Rijtema, Secy. of the UNESCO-Netherlands Government Symposium on Water in the Unsaturated Zone, Institute for Land and Water Management Research, P. O. Box 35, Wageningen (Netherlands).

* * *

Symposium on the hydrology of lakes and reservoirs

International Association of Scientific Hydrology, (I. A. SH) in co-operation with the UNESCO is holding a symposium in October 1966, in Italy, Lake Guardia. Inquiries concerning the symposium can be addressed to Professor L. J. Tison, 61 rue des Ronces, Gentbrugge (Belgium).

THE ABU SIMBEL TEMPLE

Over £ 8 million Sterling are being spent under the grant from UNESCO for rescuing the Abu Simbel Temple from being flooded the reservior of Aswan High Dam. These temples, about 170 miles U/s from Aswan, are of great archaeological interest and date from 1300 B. C. They are hewn out of soft sand stone, the Great Temple penetrating about 2 hundred feet into the rock and with four seventy feet high figures forming the facade.

The method of shifting the temple is to excavate round the temples, cut them into blocks of 12-30 tons and transport the blocks to a new site above and behind the present one where they will be re-erected. A 80 ft. high coffer dam consisting of a central membrance of steel sheet-piles back filled on either side by rock fill has been constructed to protect the temple during the operation.

The blocks are to be cut by hand saws, which have to be used dry, because water would crumble the sand stone. Fissures and weak places in the stone are being treated with epoxy-resin injection or by inforcement. Lifting bars are inserted in holes drilled in the blocks and are secured with resin mortar. After the blocks have been reassembled a reinforcement concrete shell will be cast round each temple and will carry the roof blocks by means of anchor bars. A concrete dome will also be built over the assembly to take the weight of an artificial hill which will surmount the site.

The deadline for clearing the site is 1st September, 1966 because after that date the coffer dam will be overtopped.

(*Extracted from Water Power, Vol.* 18 *No.* 2, *February* 1961).

Sixth Conference of International Society for Soil Mechanics and Foundation Engineering.

The Sixth Conference of the Society was held in Montreal, September 8—15, 1965. Canadian Soil Engineers were hosts to more than 1,200 delegates and 300 women guests from 45 countries of the world. At the opening session warm tribute were paid to the Late Dr. Karl Terzaghi, the First President of the Society. As a memory to the great Engineer, the Mission Dam was renamed as "Terzaghi Dam" and it was decided to install a plaque at the dam site which was unveiled by Mrs. Terzaghi.

There were nine technical sessions each was begun with a special lecture. Dr. Arthur Casagrande, dealt with problems associated with the increasing volume of literature in soil mechanics. The other lecturers were Dr. J. M. Harrison on "The Geology of Canada", J. Hode Keyser outlined the "Engineering Geology and Public Works in Montreal", Dr. Armand Mayer of Paris discussed the emerging field of "Rock Mechanics"; Prof. R. Haefeli, of Switzerland, compared "Creep and Progressive Rupture in Snow, Soil, Rock and Ice". There were similar other lecturers for each session.

A total of 218 papers from 40 countries had been submitted to the Conference. These were printed in two handsome volumes by the University of Toronto Press, Volume No. I, is of 422 pages and Volume No. II, is of 590 pages. The third volume of the proceedings contains the full detail of the conference. The three volumes are available from the University of the Toronto Press, University of Toronto, Toronto, 5 Canada at a price of Canadian $100.

The next President of the Society for four years was announced as Dr. Lauritz Bjerrum. The Seventh Conference will be held in Mexico in 1969.

Recent Books and Reviews

Evaporation Reduction

Volume No. XXVII in the Arid Zone Research series, prepared by Dr. J. Frenkiel.

This publication has been issued by UNESCO. It deals with the latest information on the subject. The background of this publication is the Symposium held in 1962 at Poona by South Asia Science Co-operation Office and Indian Council of Scientific and Industrial Research. The information collected as a result of the survey conducted by International Commission for Irrigation and Drainage on the subject has also been utilized. The publication is available through the UNESCO dealers.

* * *

Water Supply

By FRANK GIFFIN

143 *pp.*, 7½ *in. by* 5 *in., with* 11 *figures and* 22 *photographs, bound full cloth. Published* 1965 *by Frederick Muller Ltd., Ludgate House,* 110 *Fleet Street, London, E.C.* 4. *Price* 12*s.* 6*d. net.*

This book gives information about water sources and its supply to Towns. The story of Dams, Modern Pumping Machinery, Purification of water, Modern Use of water, Rainfall and well making are included in the Publication.

* * *

Dictionary of Civil Engineering

By ROLD HAMMOD, A.G.G.I., A.M.I.C.E.

253+*v pp.*, 7½ *in. by* 5 *in., with* 22 *figures bound full cloth. Published* 1965 *by George Newnes Ltd., Tower House, Southampton Street, London, W.C.* 2. *Price* 36*s. net.*

The book is intended to be a permanent work of reference. The definitions are expressed simply and clearly so that they will be of the greatest help to the student, and to the qualified engineers.

* * *

Design Textbooks in Civil Engineering

By SERGE SELIAVSKY, PH.D., M.I.C.E., F.ASCE.

Published by Champman & Hall Ltd., 11 *New Fetter Lane, London, E.C.* 4 *Price* £2 2*s. net each volume* (*in U.K. only*).

The book is in four volumes. The first one deals with Irrigation Engineering Canals and Barrages, Volume 2 deals with Syphons, Weirs and Locks. Volume 3 with the design of dams, Volume 4 deals with river and canals hydraulics. The cost of each volume is £2 2*s.*

* * *

Automatic Cathodic Protection for Water Tanks

By VAN DYKE J. POLLITT

Journal American Water Works Association, February, 1966, *pp.* 234-238.

Control of corrosion by Cathodic Protection is coming into use only recently. The protection provides a lining of the anodic particles which get deposit on the cathodic. It has been in practice to use aluminium anodes there require annual replacement.

This article includes explanation of corrosion, corrosion control, cathodic protection, development of automatic system, automatic potential control, function of the electrode, regulation circuit, field experience and subsidiary benefits or by-products of automatic control. There are no manual voltage adjustments required. There are no fuse problems.

Similarly many other advantages are described by the author about his Automatic Cathodic Protection Device.

* * *

Soils: Their Chemistry and Fertility in Tropical Asia

R. V. Tambane, D. P. Motiramani, and Y. P. Bali, in collaboration with Roy L. Donabue, Prentice-Hall of India (Private) Ltd., Connaught Circus, New Delhi, India. 1964, 475 *p.* $5.00.

* * *

Introductory Soils

Kermit C. Berger. The Macmillan Co., 60 Fifth Ave., New York, N.Y. 10011. 1965, 371 *p.* $5.95.

* * *

Fundamentals of Soil Science

By C. E. Miller, L. M. Turk and H. D. Foth. John Wiley & Sons, Inc., 605 Third-Avenue, New York, N.Y. 10016, 492 *p.* 1965 $9.95.

* * *

Water Resources, Use and Management

(*Published by Melbourne University Press, Victoria, Australia. Distributed in U.S. by Cambridge University Press, 32 East 57th Street, New York N.Y.* 10022, 1964. 529 *pp., bound* $35.00).

The 40 papers and discussions in this book comprise the proceedings of the National Symposium on Water Resources, Use, and Management held by Australian Academy of Science in September 1963. The participants from Australia, the United States and Russia covered a wide range of subjects from meterorology to the socio-economic side of water development. Other papers discuss work on geological surveys and statistical analysis of data, the movements of water in the soil and over the surface, the development of hydroelectric power and irrigation, and the organization of research facilities. Although the papers are specifically concerned with the problems of Australia, much of the information is applicable to other regions.

* * *

Measuring Road Surface Slipperiness (ASTM Special Technical Publication No. 366.

(*Published and distributed by the American Society for Testing and Materials,* 1916 *Race Street, Philadelphia, Pa.,* 1964, 108 *pp., bound* $6,00.)

The primary purpose of the experiments described in this report was to achieve an effective comparison of the several types of skid-testing machines used under varying conditions. The extensive data gained in the tests are tabulated and evaluated; to the equipment, its calibration, and the test procedures are carefully described; and conclusions drawn from the study are discussed at length.

* * *

Engineering and world water resources

(*Published by Princeton University Conference,* 128 *Pyne Administration Building, Princeton, N.J.,* 1963, 103 *pp., paper,* $34.00).

This publication contains the seven papers which were presented at a technical meeting held at Princeton University in 1963. The papers over such topics as the role of the consulting engineer in water resources, river basin developments in international rivers, the problem of national water resources planning, and the legal problems in development of water resources.

* * *

Ethical Problems in Engineering

(*Published by Philip L. Alger, N. A. Christensen, and Sterling P. Olmsted. John Wiley & Sons, Inc., 605 Third Avenue, New York, N.Y.* 10016, 1965. 299 bound $6.50).

Under the sponsorship of the Ethics Committee of the American Society for Engineering Education and the Cosponsorship of the ECPD and the NSPE, this book is the outcome of responses to a previous publication "Preliminary Book on Problems in Professional Ethics for Engineers".

Although agreement was the general result, opinions on difficult problems showed considerable divergence and as no attempt was made to provide a consensus in these areas, the reader must be guided by his own reaction. The problems have been divided into the field of consulting, the engineer in industry, government construction, and education. The format consists of unidentified individuals, and references to appropriate codes. The appendices contain the ECPD, NSPE, and ASCE conde.

* * *

Modern Hydrology

By Raphael G. Kazmann. Harper & Row, Publishers, Inc., 49 East 33rd Street, New York, N.Y. 10016, 1965. 301 pp.

This book has been written to simplify and to elucidate the technical problems associated with the occurrence of water and its development. Its objective is to bring into a single focus the methodology and science of hydrology and the practical applications and that have resulted. The book is written specifically for the specialists in one phase or another of hydrology who are interested in learning how their work relates to the general field, although scientists, engineers, and advanced students in fields other than hydrology who are interested in the subject will also find this volume useful as a guide.

* * *

Model Testing

(Published and distributed by Cement and Concrete Association, 52 Grosvenor Gardens, London, S.W. 1., 1964. 58 pp., paper £/1/5/0.

Six papers are presented of a one-day meeting of the Cement and Concrete Association in London in March 1964. Model analysis and testing as a design technique are discussed in relation to other established design procedures, and materials suitable for models are considered in some detail. Four of the papers describe specific examples in the field of reinforced and prestressed concrete structures, including a shell roof, two elevated highway structures and an unconventional cathedral to be built in Liverpool.

* * *

Behaviour of Large Swiss Dams

(Published and distributed by the Swiss National Committee on Large Dams Bahnhofquai 5, Zurich, Switzerland, 8023, 1964 pp., bound $12.00.

The purpose of this book is to provide dam engineers with fundamental data on the performance of dams under operating conditions. Included are the 930 ft. High Grande Dixence gravity dam and the 777 ft. high Mauvisin arch dam, the worlds highest of their types. The measurement data concern a total of five gravity dams eleven arch dams, and two earth dams. The text is in both French and English, and there are more than 190 illustrations.

* * *

Large Dams in Austria

(Published by the Osterreichische Wasserwirtschaftsverband, Vienna, and distributed by Springer-Verlag Molkerbastei, Wien 1, 1964. 171 *pp., paper,* $10,00.)

At the Eighth International Congress on Large Dams held in Edinburgh in 1964, a systematic description of large dams in Austria was presented as a survey of that country's achievements is this field. This book gives not only a verbal description of these dams, with pertinent statistical data, but also includes numerous photographs and illustrations.

Recent Researches

REPAIR OF CONCRETE STRUCTURE WITH EPOXY ADHESIVES

There is considerable information now available in the world on the use of Epoxy Resin to bind new concrete with old and for other repair works. Recently in an article in the California Highway and Public Works, Journal of September 1965, very promising results with this material have been described. In the New Zealand Engineering March 1966 results of experimental tests on the use of this material are also put forth. The tests were conducted by Mr. A. H. Johnston and G. I. H. Drewett.

The authors has described the successful test results on eight different formulations. These include:—

1. Bonding hardened concrete to hardened concrete.
2. Bonding poured concrete to hardened concrete.
3. Sealing cracks in concrete.
4. Filling voids and repairing spalls.
5. Bonding attached or embedded items such as dowels or bolts.
6. Surfacing framework for the fair faced concrete and refacing worn concrete surfaces.
7. Bonding steel to concrete, timber to concrete.
8. Water proofing.

There are many other uses which have not yet been tested by the authors.

The authors concluded that the work done both in the Laboratory and the Field show that claims made outside New Zealand for Epoxy are substantially correct. Formulation supplied by chemical firms with technical staff for particular uses are generally reliable but it is wise to check them with a trial application.

The work done in the field has been uniformity successful, There being no sign of failure or deterioration anywhere. The major disadvantages of Epoxy Resin are, however,

1. Their high initial cost.
2. Their rapid decrease in strength with rise of temperature the limit of which may be as low as 150°F.
3. Some formulation will not tolerate the presence of water prior to hardening.

4. The inability to cure at low temperature below 50°F.

* * *

USE OF RADIO ISOTOPES

(*a*) Sand Tracing Experiment in Botany Bay

Investigations carried out by the Maritime Services Officers of New South Wales and the Australian A. E. C. scientists on the movement of sand in Botany Bay last July (reviewed in BCGLO (64) (NL8-9) have proved successful. The tracing technique of mixing a radioactive isotope with samples of sand and tracing their movements with sensitive instruments from selected locations on the floor of the Bay is being repeated on a larger scale with the use of radioactive chromium in place of a radioactive isotope of gold. The results are expected to provide information essential for the successful planning of a proposed large-scale development for Botany Bay.

(*C.G.L.O. Newsletter, April* 1965).

* * *

(*b*) Use of isotopes in river Studs

Messrs. P. Wurzel and P. R. B. Ward, Hydrology Research Team of the Agricultural Research Council of Central Africa, Salisbury are studying the application of isotopic methods to river flow measurement. Laboratory tests have shown some promise and field tests are being planned by three different methods, (*i*) the total count method, (*ii*) the individual sample method, (*iii*) the integrated sample method.

With all three methods it was at first essential to establish whether the very high concentrations of suspended sediment in flood flow would interfere with the counting of injected radio isotope activity. The laboratory tests showed that sediment concentrations up to 40,000 ppm have a negligible effect on the count and may be neglected as a minor source of error. The major problems for the field tests are the level of activity of isotope required for any particular flow and the location of sampling points to ensure complete mixing throughout the full width of the stream. It appears from the literature that there is as yet no satisfactory method for calculating these two requirements and direct preliminary experiments are at present needed for each site.

(*C.G.L.O. Newsletter, April* 1965).

* * *

(*c*) Analogue Research at W.R.A.

Technical Papers D. 40 and D. 41 issued by the Water Research Association, Medmenham Marlow, Bucks, in April, 1965, describe the following applications of analogue techniques to ground-water problems:—Well Hydraulics: An electrical resistance analogue was set up to determine the equilibrium water table around a pumping well in an unconfined aquifer. The variables included: well water level during pumping, well radius, distance of recharging zone (radius of influence), and ratio of horizontal and vertical conductivities of the aquifer. Water table positions were determined for three values of well-water level and fixed radius of influence and also for fixed well-water level and three radii of influence. The results are presented in dimensionless form and are applicable to homogeneous aquifers of any depth or conductivity, cylindrical wells of any radius, and all steady pumping rates compatible with the supply at the zone of recharge.

The practical applications proposed include the determination of the (and hence degree of development) and the determination of the radius of influence (and hence interaction with other wells) for existing

wells, and the prediction of the yield draw-down curve for proposed future wells.

Ground-Water Lowering: A case history of pumping and progressive ground-water lowering by a ring of wells penetrating sands and gravels was simulated, and the analogue solution provided an excellent assessment of the eventual ground-water lowering achieved within the ring of wells. It was concluded that the step by step application of such analogues could be a valuable tool in the solution of complicated ground-water lowering problems to which mathematical treatment is not readily applicable.

(*C.G.L.O. Newsletter, April* 1965).

* * *

EVAPORATION CONTROL BY FLOATING CONCRETE

Ever since dams have been built in South West Africa, the problem of two-thirds of the water being lost by evaporation has troubled engineers and farmers. In 1957 experiments began to find a way to reduce this evaporation. At first use was made of thin film of waxy acetyl alcohol spread on water surfaces, but the wind broke up the film. Floating sheets of foam plastic were tried but these perished under the powerful rays of the sun. The sheets were painted, but the paint peeled off. Then floating concrete was developed. It consists of cement and sand but, instead of stone, small hollow plastic spheres were scale production took place last year, 2000 square metres of slabs being placed on an important storage dam. The Oshankati Dam, Ovamboland, is to receive this floating cover: it is expected to save so much evaporation that the price of water there can be dropped from 3s. a cubic metre to 1s. d.

(*Water & Water Eng., Vol.* 69, *No.* 832, *p.* 242).

DO YOU KNOW THAT

Black cars are most likely to be involved in accidents

An investigation of 293 automobile collisions conducted in Sweden and reported in "The Scandinavian Times" has shown that black cars are up to ten times as likely to be involved in accidents as automobiles in pastel tones. You are most likely to keep out of the hospital if you drive a pink car, though care in other Easter-egg shades light green, chartreuse, bady blue, for instance are also highly resistant to trouble. It is believed that dark cars are the hardest to see, especially on asphalt roads, against a background of trees or at dusk.

(*Civil Engineering ASCE, Ju'y*, 1965.)

* * *

There are over 10 million miles of roads in the world

The U. S. Bureau of Public Roads estimates that 3,620,457 miles of this vast mileage of roads are in the United States. Of these, 927,424 miles are unsurfaced; 1,325,880 miles have surfaces of slag, gravel or suitable soils: and 715,635 miles have bituminous surfaces designed for relatively light loads and low volumes of traffic. The remaining 651,518 miles have hightype bituminous and concrete surfaces.

(*Civil Engineering ASCE, August*, 1965)

* * *

There are over 600 pieces of junk in orbit

Since the launching of the first satellite in 1957, more than 1,100 man-made objects have been fired into space. Some of these have since dropped out of orbit, but as of early summer there were still 611 satellites, rocket bodies and metal objects speeding around the globe in varied orbits. These pieces of space junk range in size from 3 ft. across to the 37,800-lb upper stage of a saturn test rocket. The in space and, with today's precise launching techniques, it is possible to slip each new shot into an empty orbit. Howver, as the amount of space junk increases, it will be harder to find a collision-free orbit. Our thanks for this to the August 1965 Issue of the Kaiser Builder.

(*Civil Engineering October* 1965 *Issue*).

* * *

There are about 325 Million Cubic Miles of Water in Exispistence on this plant.

However, over 99 per cent of it is in the form of salt water and ice in oceans and inland seas. During the period of the New York World's Fair (April 1964 to October 1965) the population of the U. S. Used 180 trillion gallons of water. These factos were brought out by the U. S. Geological Survey in a recent compilation called "Earth Science Briefs".

(*Civil Engineering ASCE September* 1965).

* * *

Moons Surface

Maps of the Moon's surface are being prepared by the United States Geological Survey. They will cover 9 million sq. miles of area. The scale of the map is 1 inch=16 miles.

* * *

Earthquakes

Dr. William T. Pecora, Director of the Geological Survey for the United States Department of Interior has estimated that more than 900 earthquakes of sufficient magnitude to cause damage and loss of life, occur every year. A catastrophic earthquake will occur about once a year.

Rhyme and Reason

A Surgeon Dissects Engineers

By

T. GIBSON

Mr. Gibson is an eminent plastic surgeon, one of the honorary clinical directors of th Bio-Engineering Unit of the University of Strathclyde at Glasgow. He is a consultant plast surgeon at the Western infirmary, Glasgow, and senior lecturer in Tissu Trans-plantation in th Department of Surgery, University of Glasgow. ("Mister", incidentally, is the title of hon accorded to surgeons in Britain).

The poem, printed in abbreviated form here, was delivered at a dinner held in conjuncti with the symposium on Biomechani and Related Bio-Engineering Topics at Strathclyde. It serv as a toast to the host engineers.

They're handy chaps to have around
For making things with metals
Like atom bombs or ultrasound
Or soldering holes in kettles
But its a vast more complex trade
Than first sight it appears
There's specialists in every grade
Of practicing engineers

There's brainy chaps in electronics
Statics and Dynamics
Aeronautics, supersonics
——And some whore' just mechanics
There's engineers make ships and planes
There's some whose jobs are queer
Like digging up the sewage drains
The sanitary engineer

With tons of steel, cement and sand
They've bridged the river Forth
And opened up the hinterland
From Edinburg to the North
You mustn't stop to see the views
Altho' the bridge is clear
For miles of roads are jammed with queue
——Forgetful engineer'

At home, at work, at paly, in fact
They're there behind the scenes
Dominating every act
——Them and their machines
They make our clothes, process our foo
They even brew our beer
Our life itself depends on goods
Made by the engineer.

*Credit to "Engineer", Vol. VI, No. 3. Winter 1965-66 Published by Engineer's Joint Council, I New York, USA.

Their dams have flooded glens and hills
Their pylons skyward tower
The North Sea bristles with their drills.

For all they want is power
More power to rule, more power to base
Their urge to domineer
All set to be the master race
Ambitious engineer.

The atom bombs that stockpile fast
Are engineers' machines
Now Russia boasts that she can blast
Us all to smithereens
So get your spaceships ready
Lets get the Hell from here
This planet's doomed already
You clever engineer

They're infiltrating every sphere
Except perhaps theology
And now we find the engineer
Researching in biology.
There on the operation floor
If you should stop and peer
With surgeons ankle deep in gore
You will see an engineer.

The human body's structures are
Indinitely complicate
And yet, you know, they re' still by far.
The simplest to create.
Let love and birth, the soul, the mind
Stay free from racketeers
God grant that never human kind
Are built by engineers

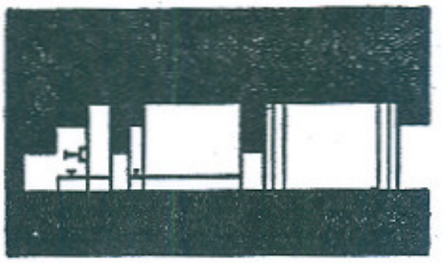
Just looking round this room perhaps
I've been a bit unkind
A nicer bunch of jovial chaps
You'd travel far to find.
I don't think they've yet realised
How they our lives could steer
If only they were organized
All powerful engineer.

Some cold and frosty morning
Not only friends, they've been our host
Forgive my unkind jeers
Fill up your glass and drink this toast
Our colleagues Engineers.

AEG

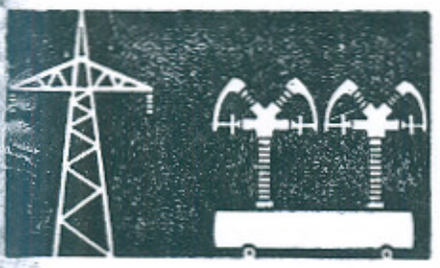
Electrical Plant and Equipment of all Kinds

Erection
Manufacture
Design



Power Generation

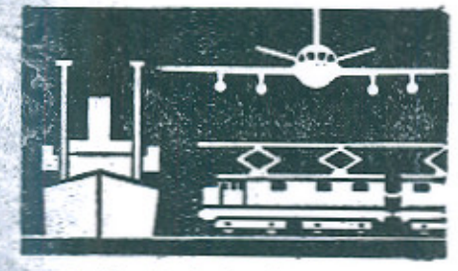
Nuclear Power Plant



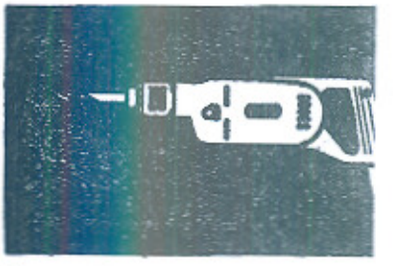
Power Transmission and Distribution

Energy Utilization Equipment

Industrial Plant



Electric Traction Engineering
Marine Engineering
Airfield Equipment



Electric tools

ALLGEMEINE ELEKTRICITATS-GESELLSCHAFT

Sole Agents for Pakistan:

AEG ENGINEERING PAKISTAN LIMITED

Head Office: Amcejee Chambers, Campbell Street, Karachi. G.P.O. Box 474.

Lahore Branch: Hayat Building, 36, The Mall, P.O. Box 451, Lahore.

Dacca Branch: 103, Motijheel, Ramna, G. P. O. Box 1094, Dacca-2.

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