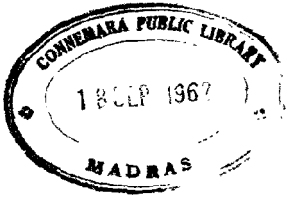
...round the River Valley Projects —



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Introduction

CAN A REVOLUTION be built? An answer in the affirmative is implicit in India's ambitious development plans generally and the river valley projects in particular. These multi-purpose projects, harnessing many rivers, big, medium and small, stand as the greatest monuments of new India. Inaugurating one of these projects, Prime Minister Nehru said: "For me the temple or the gurdwara or the church or the mosque today are the places where human beings labour for the good of humanity."

About a fifth of the hard-pressed nation's savings and still more of her limited specialized talents go into the construction of these projects. Their success or failure will be decisive for India's future for many years to come. Their achievements will be watched with interest by millions outside this country because for two-thirds of the human race which considers its economies under-developed the success of India's planned development will be the test of democracy.

What is the record of performance of India's first and second Plans in this sphere? In an attempt to assess this, Mr K. A. Sankarasubramanyan, a Special Correspondent of *The Hindustan Times*, visited a dozen river projects situated in various parts of the country. The impressions of his 6,500-mile tour were published in a series of articles entitled "Around the River Valley Projects" from July 18, 1960. They are reproduced in this booklet with minor modifications and additions.

A Silent Revolution

THE ECONOMIC PROGRESS of any country and the rise in its standard of living depend on the development and utilization of all available natural resources. Nature's gifts are the basis of all economic life and the most valuable of these gifts are land and water.

In obvious recognition of the agricultural bias of the country's economy, irrigation and hydro-power schemes were given a place of prominence in the first and second Plans. About Rs 1,200 crores to Rs 1,300 crores are expected to be spent on these projects during the ten-year period. But little is known of how well these valuable resources are being employed and what real benefits the country has derived and can hope for in the near future.

It is with a view to assessing this that I set out on a tour of a dozen representative river valley projects, which meant a journey through as many States, extending over 6,500 miles. It is not my purpose to review the working of all irrigation, power and flood control schemes but only to analyse the achievements of the more important among them, especially the multi-purpose projects, financed by the Centre by way of loans to the State Governments. The projects covered include Bhakra, Rajasthan Canal, Chambal, Rihand, Kosi, Damodar Valley Corporation, Hirakud, Koyna, Nagarjunasagar, Tungabhadra, Kundah and Mettur.

Judging by any standard, India has, in developing her rivers, attained a rate of progress that ranks her among the most dynamic nations in the world. Our record in this sphere is surprisingly good. The Mettur dam was the biggest of its kind in the world when completed in 1946; Bhakra is the tallest straight gravity dam; Hirakud is the longest of its type; Chambal has the largest reservoir; Nagarjunasagar has the world's largest masonry dam; lower Bhawani dam constitutes the biggest single earthwork; the Rajasthan Canal system has no comparable parallel elsewhere.

No wonder Mr Chester Bowles, a friendly observer, said that India had got "in full swing on her rivers the biggest construction programme any nation has launched since the War." This is no exaggeration or mere ex-

pression of the generosity characteristic of this former American Ambassador to India.

During the first decade of her economic planning, India has set about building more than twice as much irrigation and hydro-electric capacity as she acquired in the 50 years before independence. New canals brought irrigation to 8.7 million acres during the last half a century of British rule and an electrical capacity of 1.4 million kw was also installed. As against this, India's first two national Plans will bring under irrigation new areas extending to over 18.5 million acres and install a net additional 3.5 million kw of hydro-power. Thus, either in respect of the size of expenditure or of the target for additional benefits, the enormity of new India's development efforts has no precedent.

Equally impressive is the range of construction. The complete concrete structure of Bhakra, the mammoth masonry works at Chambal and Nagarjunasagar, the composite dam at Hirakud and the essentially earthen structure of Bhawani provide a complete range in dam building. It is, however, the multi-purpose storage reservoir which symbolizes the era of nation-building. India's achievement in this respect is indeed unique because the multi-purpose reservoir is not more than 25 years old anywhere in the world. The storage for comprehensive use is now being successfully employed in Bhakra, D.V.C., Hirakud, Tungabhadra, Chambal, and so on; Mettur and Krishnarajasagar alone did so before.

These huge multi-purpose projects are really giants in every way. Each one of them will irrigate a million acres and more and supply more power than any of India's pre-independence projects. They are noteworthy in that they assure more or less uniform benefits all over the year, irrespective of the vagaries of the weather.

A striking feature of some of the projects I visited was the happy blending of the efforts of men and machinery. The race between the two was keenest on canal earthwork where the enthusiastic local labour worked alongside some of the most modern machinery in the world, doing the same job. In sheer speed, manual labour cannot compete with machinery. But as regards cost, the human muscle is still surprisingly cheaper in some cases.

The economy of using machines, I was told, depended entirely on the width of the canal to be dug and the distance

to which the earth was to be transported. The more the width and the distance, the more competitive is the use of machinery. In the case of canals 40 feet wide, manual labour costs about Rs 15 per 1,000 c.ft. less than the machine job. On canals of 70 feet and wider, machines save money, it being as much as 50 per cent in the case of the large canals of U.P.

The competitive advantage of human labour is, however, gradually losing ground, with the incessant demand for higher and higher wages and the growing multiplicity of labour laws. The project authorities are naturally taking to mechanized methods in a gradually increasing measure. There is also a growing tendency to entrust as much of the work as possible to contractors because of the mounting labour problems, retrenchment difficulties, and so on. The Tungabhadra project is understandably happy at its having discharged about 40,000 of its construction-labour before the introduction of the irksome labour laws. The authorities of other projects are worried over the reported proposal to make the ultimate employer also responsible for contract labour.

A three-member official delegation, which visited China last year, had reportedly sung an endless song of glory about that country's incredible achievements in "construction by community effort." Had these experts only witnessed the enthusiastic people's co-operation in the construction of some of our projects like Kosi, Chambal, Nagarjunasagar and Manimuttar before visiting China, they would have been spared the time to see something more useful in that country.

I was particularly impressed by the wealth of talent shown by our engineers and technicians building the huge dams and power plants. Their capacity to learn new skills and techniques and adapt them to Indian conditions deserves appreciation. In fact, they have proved that our huge irrigation projects, with all their enormity and complexity, could be executed independently of imported technical assistance. This unfortunately is not properly appreciated by men in authority.

The result is that these technical personnel smart under a sense of inferiority vis-a-vis the administrator upon whose sanction much of the work of the former depends. This is further aggravated by the fact that the engineers and technicians are baffled by the bewildering number of rules of procedure.

The Chief Engineers of all the projects I visited are men of great calibre and character. But their activities are unfortunately hampered by irksome governmental rules and regulations regarding purchases, recruitment, disciplinary action and choice of methods of executing the various construction works in the best interest of economy and efficiency. Honest buying at the cheapest rate, the recruitment of the best personnel and the best way of constructing the project cannot be secured by subjecting the Chief Engineer and the Superintending Engineers to the rules of the Central Purchase Organization which they circumvent by splitting the value of the orders or by letting out work to contractors in order to get it done more quickly, or to the rules of the U.P.S.C. which are avoided by temporary appointments, or to the code of the P.W.D., the proverbial delays of which cannot just be put up with. That the Chief Engineer of the D.V.C. is relatively more effective because of the latitude he enjoys is worth noting.

At any rate, the vesting of sweeping powers in purely administrative people is not in the interest of efficient execution of our big Plan projects in general and specialized schemes of irrigation and power in particular.

India's challenge is not merely to complete the job she has set herself. It is to prepare the participants in the country's plan projects to do still more and still better. To achieve this, the morale of engineers and technicians necessarily needs to be boosted.

Learning by Mistakes

A NATION, LIKE an individual, learns by mistakes. If mistakes are to be avoided by the simple expedient of not taking any risks, the reverse of progress will be the result. But reckless risk without any relevance to experience is worse.

Are the lessons of the earlier projects beneficially employed in the construction, operation and control of the new ones? From what I saw, it cannot be said that the lessons of the initial mistakes of the D.V.C. and Hirakud, learned at great cost, are remembered in some of the projects as much as they ought to be. This is largely because of lack of unity of purpose among those engaged in the execution of these projects which in turn is born out of the confused system of control inherent in the present administrative pattern. Except the D.V.C., which is governed by a fairly well-planned autonomous statutory corporation, all other projects are, in varying degrees, afflicted by the imperfection of their administrative set-up.

The destiny of each project is formally regulated by a so-called control board, which is neither a board nor exercises much control. In effect, the directions come from the State secretariats, though indirectly, from persons in power but with little knowledge of the intricate problems of irrigation projects. The complications this could cause can be easily imagined. For instance, to the chief engineers of some projects like Koyna, Kosi, Rihand, Nagarjunasagar, and so on, proximity to the State secretariat is more important than the project site. It is not as though they are unaware of the disadvantage of the distance of hundreds of miles between their offices and the projects. They have learnt by bitter experience that constant consultations with the authorities in the headquarters can alone move matters.

Naturally, the administrative cohesion and efficiency varies from project to project. If the D.V.C. is perhaps best administered, the credit goes in no small measure to the effectiveness of the Act of Parliament governing its operations. The provisions of this Act could be implemented with better advantage if the top administrative heads of the corporation shake off their inextricable attachment to

Calcutta and expedite the shifting of their offices to the newly-constructed headquarters at Maithon. The experience of some projects like Chambal and Rajasthan Canal, which are inter-State schemes, is also not as bad as some others. The co-ordination efforts of the Centre are not altogether without effect in the case of these projects, thanks to the conflicting claims and the mutual distrust of the concerned States.

The problem of administration is more fundamental than it seems. There is an unfortunate basic assumption that the construction of irrigation and power projects, big or small, is the right of the States. The logic behind this practice is not easy to understand. There may be some justification for this if the States are not spending somebody else's money at a rate and on a scale verily impossible of repayment. Whether one likes it or not, the fact is that every State does not have the resources, financial and technical, for the proper planning and execution on the scale required by these huge projects.

Except to an extent in Mysore, Madras and Bombay, there is an acute shortage of experienced engineers and trained technicians. In a number of projects, retired engineers are re-employed as superintending engineers and the majority of executive engineers have had far less guidance and in-field training from their superiors than their predecessors did. Referring to his extremely young team of executive engineers, a superintending engineer of Kosi cryptically remarked that the engineers of his generation in the age group of thirties could at best be divisional engineers. He evidently was concerned over the progressive deterioration of standards for want of intensive training and supervision.

The lack of experience on the part of young engineers and administrators and consequent delays in decisions is costing us dearly. In big projects, more than elsewhere, time is money. One chief engineer estimated that a delay of a year in the schedule of his project would mean an additional capital cost of Rs 5 crores.

While not all States thus have the resources to undertake the construction of big multi-purpose projects, most of them have developed a fairly competent machinery to manage the distribution of the benefits of these projects. They are also adequately equipped to execute medium and small irrigation and power schemes.

The alternative to the States' inability to execute the big multi-purpose projects efficiently is not to entrust them exclusively to the Centre. The projects directly put up by the Centre have by no means set any perfect standards. On the other hand, the utter confusion and the wasting of several crores of rupees during the first five years of the construction of the Hirakud dam was the direct consequence of attempting to build a project in Orissa from distant Delhi. Judging by the experience so far, the institution of an autonomous corporation has been the most effective and productive instrument for the execution of big multi-purpose projects.

It is a matter for regret that none of the major irrigation schemes has been completed within time or within the original estimated cost. The main reason for this sorry state of affairs is that all the projects have been launched without adequate data regarding the rivers, the reservoir sites and the needs of the areas proposed to be covered by the projects. Consequently, the programmes have had to be revised many times and in some cases after commencement of work.

The progress has also been retarded because of scarcity of construction materials such as steel and cement, shortage of foreign exchange for importing machinery and spare parts, budgeting without strict regard to the phasing of physical targets, delay in acquisition of lands, shortage of experienced engineers and other trained technical personnel, non-availability of labour at or around project areas and delay in the selection of suitable contractors.

The cumulative effect of all this has been to push up the cost of these projects beyond recognition. To mention some conspicuous revisions, Bhakra is now expected to cost Rs 170 crores as against the original estimate of only Rs 75 crores, the Rajasthan Canal Rs 200 crores against Rs 67 crores. Chambal Rs 92 crores against Rs 77 crores. Rihand Rs 46 crores against Rs 35 crores. Kosi Rs 45 crores against Rs 37 crores, D.V.C. Rs 170 crores against Rs 92 crores, Koyna Rs 38 crores against Rs 35 crores and Nagarjunasagar Rs 137 crores against Rs 75 crores.

What is worse, even these revised estimates do not promise to be final. The authorities of not a few projects I visited are not confident of completing their schemes within the new limits. At this rate of blind execution, only the sky can be the ultimate limit.

The construction cost varies vastly from project to project, even in respect of identical work. Each 100 feet of masonry laid at Tungabhadra has actually cost Rs 128 to Rs 132, the lower rate accounted for by the use of lime-soorki mortar. In contrast to this, it has cost Rs 145 to Rs 150 per unit at D.V.C.'s Maithon, in spite of using modern machines. But the estimated cost of about Rs 110 to Rs 115 per 100 c ft. at Bhakra is about the cheapest. This rate is, however, not available on smaller dams. As regards wages, Rajasthan has to pay more than Bhakra, Bhakra more than D.V.C., D.V.C. more than Kosi, Kosi more than Hirakud, Hirakud more than Tungabhadra and Tungabhadra more than Mettur.

With all their other imperfections, some of the projects could have been completed at less cost and made to serve the nation better, had only their location not been swayed by considerations other than economic or engineering. In the case of the Hirakud dam, for instance, out of the three sites, Naraj, Tikarpara and Hirakud, considered for the location of the dam, the second was among the world's most attractive from the engineering point of view and promised the cheapest storage and the greatest head of water for hydro-electricity. The whole project could, in fact, have been completed at half the present cost. But the nation was not destined to reap the benefit of ideal site like Tikarpara because the proposal was sabotaged by the influential rulers of the tiny States along the Mahanadi, to whom a few hundred acres of their territory was more important than national interest.

Similarly, the sites of some projects like Bhakra and Tungabhadra are by no means most ideal. The Koyna project has gained in its site what the Tata Hydro had lost. It appears the latter had long ago planned to locate its power project at the present Koyna site but had to give up the proposal because of organized opposition from certain vested interests.

The high capital cost of most of the projects already completed or under completion is such that the return on them ranges from 3 to 4.5 per cent on the power side, while on the irrigation side, where the larger part of the capital is employed, there is either no return in the case of some projects or it is between 1|2 per cent and 1-1|2 per cent.

If the lessons of past mistakes are not remembered and the cost of construction kept as low as possible, these multi-purpose projects will be mere historical monuments and not milestones in the economic progress of the country.

Irrigation as Industry

PROJECTS ARE NOT completed when dams, canals, generators and even transmission lines and distributary channels have been constructed. It is here that the more important task of putting the water and power to the most productive use begins.

The huge multi-purpose projects are creatures of our national planning and make enormous demands on the very resources, such as steel, cement, machinery, spare parts, transport facilities, top technical talent, capital investment and foreign exchange, of which the country is running short. What a terrible tragedy it will be if these projects do not earn adequately to defray their cost of construction and maintenance is recognized in principle. But little is done to ensure the sound financial working of these multi-million ventures.

The irrigation potential created by the first two Plans will itself be about five million acres short of the targets. This is made worse by the fact that as much as 3.5 million acres of the potential created will remain unutilized by the end of the second Plan. The impact of such large-scale non-utilization on the economies of schemes on which more than Rs 760 crores of valuable money have been spent so far is obvious.

The second Finance Commission had in 1957 warned against the severe strain on State finances consequent on the delay in the utilization of the benefits created by major irrigation and power works. The Commission had noted: "The full extent of this burden on the revenue budgets of States is not yet apparent, because in respect of a number of projects like Bhakra-Nangal, Hirakud and Chambal, which are in process of construction, the interest on outlay is still being added to capital. We apprehend that sometimes towards the end of the second Five-Year Plan period, when some of these projects will be completed, the impact on the revenue budgets of the results of their working will cause anxiety."

These fears have proved correct. The practice in most States continues to be to treat all expenditure creating permanent assets—capital as well as interest thereon—as capi-

tal outlay. Consequently, deficits on current account, covered by big borrowing, have resulted in an unfair shifting of its burden by the present generation to future generations.

Why have the States ignored the considered advice of the Finance Commission that all development expenditure should be adjusted to available resources? Is it because these multi-purpose projects are essentially non-yielding? Or is it because these projects have become too big for our poor peasants? Or is it because our cultivators cannot move as fast as our planners and dam-builders? No. The reason for this revenue debacle is more political than economic.

The river projects of the British days were financially a success. As regards the canal systems built before 1940, the Census of India Report, 1951, had estimated a net surplus of more than Rs 50 crores. According to this Report, the revenue was larger from earlier projects built before 1891, 5 per cent for those built up to 1920 and slightly over 3 per cent for those built between 1920 and 1940. Evidently, all these projects had been planned with an eye on revenue.

If, in sharp contrast to this, free India's new projects are not self-supporting and self-generating, it is as much due to the low rate of utilization of the water as to the disinclination on the part of the State Governments to charge the cultivator for the water supplied. Proper utilization of irrigation involves co-ordinated efforts by a number of departments, such as irrigation, agriculture, revenue, community development and co-operation, working together with the people at the village level.

One of the main factors responsible for the lag in utilization of irrigation facilities is the delay in the construction of water courses and field channels. The Centre and the Planning Commission have, from time to time, impressed on the State Governments the importance of timely construction of water courses and field channels so as to synchronize with the construction of the main dam and the distribution system. The Planning Commission had also suggested to the States that village panchayats should be empowered by legislation to enforce the obligations of the community or of beneficiaries in respect of maintenance of field channels and other requirements to enable full utilization of irrigation facilities. Not many States seem to have taken these suggestions seriously.

The result is that hardly 75 per cent of the irrigation potential so far created is actually being utilized. Kerala utilizes 98 per cent of the potential created, Madras 87 per cent, Punjab and Bihar 82 each, Rajasthan 81, U.P. 74, Orissa 68, Madhya Pradesh 66, West Bengal 62, Bombay 59, Andhra Pradesh 55, Mysore 53 and Jammu and Kashmir 33. These figures do not, however, tell the whole story because the rate of development of the river resources in the various States is by no means uniform.

All the projects with a bad record of water utilization are unfortunately content with quoting the time-worn precedent that major irrigation works the world over take 10 to 15 years to achieve full utilization. With the enormous progress in agricultural research and the varying climate and soil conditions, it certainly should be possible to reduce this utilization period to five years, if not less.

There is no one best method of irrigating our country as a whole because each region requires adjustments to fit an irrigation system to the conditions of its soil, water supplies, habits of cultivation and marketing practice. Some States like Mysore, Madras and Bombay have worked out crop regulations in such detail that they are aware which areas would be suited for what type of crop rotation and take how much water. Other States would do well to evolve similar crop regulations.

While such is the unimpressive record on the physical side of utilization, the performance on the revenue side is even worse. All States, without exception, are shy of demanding more revenue from the farmer for the additional irrigation facilities, in spite of the fact that the value of the land and of the produce have more than trebled since the fixation of the existing water rates. Under pressure from the Centre and the Planning Commission, most States have enacted legislation for the collection of increased water charges and betterment levy. But nothing is being done nor are there any indications that these revenues will at all be realized. This is inevitable as long as the administration treats the farmer not as farmer but as voter. Economics ceases where politics begins.

Bombay was among the first to enact legislation for the collection of a betterment levy. It decided that 50 per cent of the appreciation in the value of land as a result of irrigation facilities should be paid as betterment levy. But ironically enough, by the time the proverbially slow administra-

tion began to move, land values in the State collapsed consequent on other restrictive land reforms. Orissa has passed a law that 50 per cent of the increase in produce over the base year should go to the State. This State has achieved a great adventure on paper by threatening to collect the levy retrospectively, while in effect the farmer is merrily using the water free The Bihar Government has cleverly done the trick. While passing an Act for the collection of betterment levy at fixed rates, the administration has managed to take shelter under a four-year moratorium exempting the collection. While the postponement of the evil day is indeed well-planned, it does not appear to have been realized that, four years after the completion of the project, the capital cost boosted by interest would increase to an extent that the betterment levy, if at all collected will be inadequate to cover even interest charges, let alone the repayment of capital.

These are some specimens of the sincere efforts of States to raise the resources required to build and maintain the big irrigation projects. The second Finance Commission had recorded a long list of Central loans which the State Governments would like to be written off. Assuming the present rate of collection of additional water charges to continue, it is but fair to presume that the fourth or fifth Finance Commission may go on record that most States are unable to repay their entire irrigation loans. As a portend of this prospect is the fact that the Centre is already giving additional loans for the payment of interest on original loans.

To an impartial student of economics, the only way out of this revenue muddle seems to be to declare irrigation an industry. Commercialization of irrigation is nothing new and is employed with advantage in the U.S.A. and other advanced countries. In India itself, the idea was commended as early as 60 years ago by the Indian Irrigation Commission, headed by Sir Scott Moncrieff. But today the proposal is more difficult of implementation than ever before. For an industry to be successful, it should be viable. But the multiplicity of land reforms, enacted in extreme hurry, has virtually killed the goose that lays the golden egg. Much needs to be done to restore peaceful progress in agriculture. Small mercies like the Madras Government's concessions to organized and mechanized farms cannot cut much ice. Given the suitable conditions, commercializa-

tion can lead to a revolution in irrigation. But a revolution cannot be brought about by pedestrian policies born out of conflicting political pulls and pressures.

Energy for the Wheels

IF THE COUNTRY'S irrigation schemes are blamed for non-realization of revenue, the power projects are accused of overcharging the consumer. In all the States I visited, there was a universal complaint that the cost of energy to run the wheels of industry was unfairly high. How has this come about in disappointing contrast to the promises of our planners and policy-makers when proposing the construction of these giant projects? Who is to blame for this?

Nature has indeed been bountiful to India in that every State is blessed with either falling water or extensive coal supplies, which could generate cheap power. That, with all this natural advantage, the consumer is called upon to pay a prohibitive price for power spotlights the sorry state of affairs of our power projects.

Hydro-power is generated in the country at an average cost of 1.25 np. per unit and thermal power at about 3 nP. per unit. But the cheapest rate at which hydro-power is available to industry is 6.48 nP. per unit in Madras State. The rates in other States are even higher. A comparative idea of the average rates (in naye paise per unit) charged in different States for industrial and agricultural loads up to 10 kw at 20 per cent load factor can be had from the following table:

Andhra E.B. ..	13.02	6.0
Bihar E.B. ..	12.0	12.0
Kerala E.B. ..	6.96	4.50
Madras: Thermal E.B. ..	9.0	7.20
Hydro E.B. ..	6.48	5.82
S. Madras (Company) ..	7.08	6.0
Mysore E.B. ..	7.44	4.74
U.P. Ganga Grid ..	10.74	7.68
Do. 30 p.c. L.F. ..	9.30	5.70
W. Bengal E.B. ..	19.12	12.48
Punjab: Bhakra ..	9.54	9.0
Do. 30 p.c. L.F. ..	9.12	8.52
Assam E.B. ..	13.0	13.0
Bombay E.B. ..	11.88	11.88
Gujerat ..	14.84	14.84

M-P E.B.	..	12.36	12.36
Orissa: Thermal	..	15.75	14.06
„ Hydro	..	10.92	8.35
Rajasthan	...	18.75	18.75

(E.B. means Electricity Board)

The big gap between the cost of generation and selling rates mostly represents the price of the bungling in the course of construction of the projects resulting in increased capital outlay, the high maintenance cost and the State Government's share of the bounty by way of electricity taxes. In many States, the selling price of power for agricultural purposes is much cheaper than for industry. Nobody will grudge cheap power being made available to agriculture. What is difficult to justify is that the industry is called upon not only to pay the inflated capital and maintenance costs but also to subsidize the energy needs of agriculture.

None of the authorities of the projects had any convincing explanation for this pattern of power rates. In fact, there seems to be no scientific basis for these rates, the only obvious thing being that the State Governments are taking the best advantage of the acute shortage of power in the country to make up, as far as possible, the loss on the irrigation side.

The progress of power programmes are far behind targets which are themselves very low, considering the country's power potential conservatively estimated at over 40 million kw. It was proposed to treble the installed capacity from 2.3 million kw at the commencement of the first Plan to 6.9 million kw by the end of the second Plan. But actually the installed capacity is not expected to exceed 5.8 million kw by 1960-61. This shortfall is largely attributable to the inordinate delay in the execution of some major projects like Bhakra-Nangal, Chambal, Koyna, Rihand and Hirakud (second stage). The foreign exchange difficulties that arose during the early years of the second Plan have provided a convenient excuse for mismanagement.

The authorities, as usual, are wiser after the event. It has now been decided to provide foreign exchange for implementing the remaining power schemes which had originally been regarded as 'non-core' projects. Work has also [illegible] from additional power schemes which

were not originally included in the second Plan with a view to meeting specific increases in regional demands that have arisen during the current Plan period. Arrangements are also being made to begin preliminary work on selected third Plan schemes.

These programmes and proposals, with all their promises, will take their own time to yield results. Meanwhile, the rationing of power, with its inevitable evil of increasing idle capacities in industries, is assured of another lease of life. The mounting cost of construction and maintenance of these projects is nobody's concern. The obstruse higher mathematics, which enables the State sector's schemes to squeeze the last naya paisa from the consumer can always take care of these increases in costs. This is perhaps no exploitation because the King can do no wrong.

The State electricity boards are not economically the better for all the money charged from the consumer. The State Governments are only too clever to mop up all available surpluses by way of taxes. A Study Group set up by the Union Irrigation and Power Ministry had suggested that the States should plough back into the industry the revenue derived from electricity taxes. But the State Governments are in no mood to change the present practice under which the income from electricity duty is credited to their general revenue and the funds required by the electricity boards are given back as loans.

Much is made of the great achievements of some States in the sphere of rural electrification. The Southern States generally and Madras and Mysore in particular have here done better than others. In Madras, where the number of villages electrified equals that in the rest of the country, the State Government has set a new target of providing electricity to all the villages by the end of the third Plan. This will be neither worth while nor justified if the industry in the State, which in several places is subjected to power cuts amounting to more than 50 per cent for the larger part of the year, is to put up with these cuts any longer.

In the context of this general approach in the matter of power supply to industry, it is idle to expect the State Governments to appreciate the special needs of industries which are energy-intensive. It is sheer accident that the Indian Aluminium Company at Hirakud enjoys the benefit of cheap power at the rate of about Rs 120 per kilowatt-

year on the basis of a constant maximum load of 25,000 kw. But the Hindustan Aluminium Corporation at Rihand has to pay almost 50 per cent more for its power. The former company, which proposes to double its capacity, is currently negotiating a new power agreement with the Orissa Government. Although it is evident that the additional load will relatively cost more, the Indian Aluminium Company's average rate will be substantially lower than that of Hindustan Aluminium. The impact of this differential rates for two units in the same industry lies in that energy constitutes more than 60 per cent of the cost of smelting aluminium. It is estimated that 10 to 12 kilowatt-hours of electricity will be required to smelt a pound of aluminium. Such artificial differences in the cost of production of a basic industry cannot find any justification in a planned economy.

This brings to the fore the problem of regional imbalances in the supply of energy to industry. Ten years of planning in power has only aggravated this problem. Optimum economy and efficiency in power generation and transmission can be achieved only by bringing about a proper balance in the different modes of generation and inter-connecting them, as far as possible, to meet the varying conditions of power demand, such as base, peak and seasonal loads in each grid.

From time to time, we hear proposals for the establishment of regional super-grids by the linking of the electricity systems of contiguous States and the ultimate formation of an all-India super-grid. There is no other way of bringing about equitable distribution of power all over the country at fairly uniform cost. Considering the varying cost of the different modes of power generation and distribution, the physical task of co-ordinating the activities of the 700 and odd independent private generating units existing in the country and, more than all else, the petty parochial attitude of most State Governments, the formation of regional super-grids and more so an all-India super-grid demands an absolutely dynamic policy. Signs of such a serious pursuit there are none.

The imbalance in the economics of irrigation and power is the cumulative effect of the errors of omission and commission of the various projects. It will, therefore, be worth while to analyse their records individually.

A Monument of Mishaps

BHAKRA-NANGAL, THE biggest showpiece among India's multi-purpose projects, can appropriately be called a monument of mishaps for more than one reason. Some of its major physical mishaps, like the flooding of the hoist chamber and the power house and the breakdown of the conveyor system are now well known. But little has been recorded of the mishap in planning and in terms of money.

Bhakra is a project with many records. Its design height of 740 feet is next only to Switzerland's Grand Dizence Dam, also under construction. Its two river diversion tunnels are the longest in the world and its two power houses are the biggest in Asia. It is the highest rolled fill dam in the country. But perhaps the biggest record of Bhakra is the several changes in concept and cost that the project has undergone.

The original planners could never have imagined today's Bhakra even in their wildest dream. Bhakra today is a mighty multi-purpose project as against the irrigation reservoir it was meant to be.

The story of Bhakra is as old as 1908, when Sir Louis Dane, the then Governor of Punjab, originally conceived the project as an irrigation storage over the Sutlej, with a reservoir level of 1,500 ft. R.L. The project, intended for the exclusive benefit of Punjab, was to cost a few crores of rupees. After preliminary investigations a site for a dam 395 ft. high, with a capacity of 2.58 million acre-feet, was proposed. But for reasons not known, the scheme lay in cold storage for three decades.

The Punjab Government prepared a new plan in 1939-42, which envisaged the construction of a dam 500 ft. high, with a reservoir level of 1,600 ft. R.L. and a capacity of 4.75 million acre-feet of water. The canal system was intended to cover a gross area of 46.79 lakh acres for perennial and non-perennial irrigation. No firm estimate of the cost was made.

What is called "the first realistic estimate" of the project was made in 1946. This scheme, which also had no provision for power generation, was estimated to cost

Rs. 75 crores. In 1949, the scope of the project was again enlarged and the estimated cost revised to Rs 133 crores. This contemplated the raising of the reservoir level to 1,680 ft. R.L., the height of the dam to 680 ft. and the storage capacity to 7.4 million acre-feet, with a live storage of 5.7 million acre-feet.

Since a number of points in respect of design and certain other issues, such as the sharing of the water among Punjab, PEPSU and Rajasthan and the apportionment of the cost of construction, had not been settled at the time of the preparation of the 1949 estimates, another plan was prepared in 1951-52. Taking into account the changes in scope, the increase in the cost of materials and labour and the devaluation of the rupee, the project was estimated to cost Rs. 156 crores.

The estimates came in for another round of revision in 1955-56 because of a decision to increase the power potential of the project. The height of the dam was raised to 740 ft. and the cost to Rs. 170 crores. Things have since remained there. But the Punjab Government, with its proverbial greed, is persisting to take up the construction of the right-bank power house also, which will mean another Rs. 15 crores. The project will take many more years to complete and, since it is anybody's guess what further revisions it may undergo in the meantime, it is obviously idle at this stage to speculate what the ultimate cost of Bhakra will be.

It can no longer be claimed that there has at all been any planning in the evolution and execution of this project. There is also no denying the fact that this project has been given a priority and prominence which its economic value alone cannot justify. It is extremely unlikely that Bhakra will be able to generate power to its full installed capacity, unless the Rajasthan Canal, now being constructed at a cost of tens of crores, is to be starved of its legitimate supplies of water. This is because the Bhakra reservoir will be filled only in eight out of every 20 years. It is estimated that, in an average year, the reservoir depth will fluctuate between a minimum of 280 ft. and a maximum of 520 ft., whereas a minimum head of 400 ft. will be required to generate the full installed capacity.

In an attempt to avoid this discomfiture, it is now being suggested that some of the water stored in the proposed

Beas dam should be fed into the Bhakra reservoir by means of a link tunnel. The construction of the two dams on the Beas at Pong and Suket and the link tunnel business, if sanctioned, will cost another Rs. 125 crores. Crores, indeed, have no value for this privileged project!

Why are we putting all the eggs in one basket? Is it because the basket is exceptionally strong? Far from it. Bhakra has to rest on rock seamed with clay and it must withstand the pressure of a lake 680 ft. deep by sheer weight alone. The poor quality of rock in the foundation and abutments was not fully reckoned when politicians and planners went on piling up the economic projections of the project. Today the engineers have to perform a feat attempted nowhere in the world before.

The result is that five million cubic yards of costly concrete, which amounts to three Hirakuds or four Tungabhadras, have had to be poured into a foundation no longer than D.V.C.'s Tilaiya or Maithon. The shoulder hills in which the dam is imbedded have also to be specially strengthened by intensive and extensive grouting operations. Nowhere in the world is this kind of cement grouting done at a distance of less than every ten feet. But the rock conditions of Bhakra are so poor that this treatment has to be given at distance of every five feet and also at a number of intermediate points.

Considering this basic deficiency, it is the country's extraordinary good luck that saved this project from the tragic consequences that could have ensued from the mishap of August 21 last. How are we to believe that the recurrence of such mishaps will be avoided when on the causes of the accident of August last there are still as many theories as the number of engineers and experts in Bhakra?

Reports have it that even the inquiry committee of engineers of unquestionable calibre and character has got lost in the mass of explanations of the accident. It is said that the report of the committee contains more conjectures than conclusions. While on the most vital and controversial question on the need for the construction of the hoist chamber the committee is believed to have been non-committal, it is presumed to have hinted that the quality of the concrete used in the hoist chamber was not up to standard. It is significant that, at the time of the mishap, the reservoir level was around 1,430 ft. R.L. whereas the hoist chamber was designed for a level of 1,450 ft. The

Khosla Committee is believed to have blamed "unforeseen circumstances" for the mishap.

But Mr Harvey Slocum, the veteran American Consultant at Bhakra, has no doubts in his mind. He is believed to be of the view that the accident could have resulted from the "excessive head," which caused the tunnel failure. It appears the reservoir level was raised above the maximum recommended by Mr Slocum, when he was away in the U.S.A. Another error of judgment believed to have been committed was the decision to close the gates the day before the failure when the hoist chamber reportedly showed signs of trouble. The "excessive head" would have caused the failure whether the gates were open or closed. But, in Mr Slocum's opinion, had the gates been left open, they would have permitted the draw-down of the reservoir, which, in turn, would vastly have simplified the task of plugging the right diversion tunnel permanently. The plugging operations could, in that case, have started in November last instead of in February as now and could have been completed in less than three months, *i.e.*, by January last, instead of in five months they have actually taken.

Bhakra is back to normal. The tension and scare, let loose by the mishap, is replaced by an atmosphere of confidence and ease. The smaller fry are happy that the repair operations are now successfully concluded. The big bosses are even happier presumably because nobody has been pulled up for the mishap. Although it is more than two months since the Khosla Committee submitted its report, the Punjab Government is still to make known to the country the contents of the report or the action taken against those responsible for the tragic mishap. In any case, neither Parliament nor the country will accept that the August accident was an act of God. The acceptance of such a theory will, indeed, be the biggest of mishaps in the history of engineering.

The economics of Bhakra is as complex as its construction. As a specimen of this is the misleading report that the repairing operations have cost "no more than Rs 1.15 crores." In terms of the actual money spent, the figure is indisputable. But, then, what about the diversion of most of the labour force which has visibly upset the schedule of the dam and the main power houses? But for the accident, the spillway would have gone up to 1,510 ft.

R.L. instead of 1,460 ft. R.L. and the effective height of the dam to about 570 ft. instead of 540 ft. The first of the five units of 90,000 kw each in the left-bank power house was originally expected to be commissioned in January last. This was changed to June and again to October. In Bhakra, there is no awareness of the impact of this delay on the numerous industries, which have planned their programmes on the basis of this power supply. Delay of a day in Bhakra means Rs 3 lakhs.

The cost of the power now supplied by Bhakra is considerably higher than that of more modest projects. Considering the colossal capital base of the project, posterity can alone say what Bhakra's benefits will be to the community immediately served by it and to the country, which has been asked to regard it as a place of pilgrimage for new India.

Cart Before the Horse

PUTTING THE CART before the horse. This precisely is what has happened in the Rajasthan Canal Project. Two years after commencement of work, this much-publicized project has reached a dead-end, where it has to be either entirely given up or altogether modified.

The Rajasthan Canal Board has prepared a grand new scheme, costing three times as much as the 1955-57 programme. Compelled by economic considerations, the Board has taken a firm take-it-or-leave-it stand. The new plan, now being finalized for submission to the Planning Commission, envisages an expenditure of over Rs 200 crores,

[illegible] earlier estimates.

seepage, will command an additional 1.6 million acres of fertile land in Bikaner and Jaisalmer region.

A lined canal will not only reduce seepage losses but also cut down evaporation losses because of its greater depth and smaller exposed surface. Besides enabling navigation by vessels of deeper draft, it will carry water at a greater velocity, improving the efficiency of the canal by flushing sand and other matter blown into it by desert winds.

The Rajasthan canal administration is bent on having the lining. Otherwise, the project will be utterly uneconomic. Moreover, since the main canal is to be a perennial source of irrigation and will be the sole source of supply for the entire canal system, there is the physical impossibility of closing it down later for purpose of lining. The problem of lining the branches later is perhaps not as difficult; but here again the balance of advantage is in favour of immediate action.

This long story of the revised project does not end here. "The Rajasthan Government and the Canal Board are presently finalizing an even more ambitious development programme. This Rs 212-crore 20-year "master plan" envisages expenditure of Rs 36 crores and Rs 113 crores and loans of Rs 26 crores and Rs 37 crores from the Centre and the State Governments, respectively. The basis for this big plan is that the great desert will devour all the investment on the canal project if matching development of the area is not made an integral part of the canal programme.

The Rajasthan desert is potentially fertile and has an exciting economic future. All it needs is water. A tract which otherwise is as wild as the wildest part of Arabia becomes a vast green land with succulent grasses in a year of good rainfall. With 18,500 cusecs the Rajasthan canal will deliver this life-giving water in abundance to about 10,000 sq. miles. This change from barrenness to prosperity is estimated to yield agricultural produce exceeding 2.7 million tons a year, valued at about Rs 66 crores at current prices.

The realization of this promise of prosperity will entail colonization on a stupendous scale. The immensity of this task lies in that, within a short period of 20 years, the population of less than a lakh in the area is proposed to be increased twenty-fold, a ninth that of the State's total

population. The master plan contemplates construction of 3,000 new villages, 30 model towns, mandies, roads, electrical installations, post and telegraph offices, schools, colleges, hospitals, and so on. Almost the entire population has to be brought from outside the region, which provides an excellent opportunity for the rehabilitation of landless displaced persons from East and West Pakistan and for migration from other over-populated parts of the country. All this is within the realm of physical possibility. Israel has demonstrated it by changing a similar desert into a prosperous country within ten years. It is claimed that costwise also Rajasthan's master plan compares favourably with that of the development of the Thal in Pakistan and the Liberation Province in Egypt.

The benefits of the Rajasthan project are no doubt worth the investment. But are investments of the dimension in a single project manageable? The sponsors say that the programme should be taken up as a whole or the Rajasthan canal should be deferred till the entire scheme is sanctioned. With all the protestations, the sponsors themselves evidently doubt their success. How else can the artificial prolongation of the duration of the master plan to 20 years be explained?

The whole dilemma is a deliberate one. The original Rajasthan canal plan, prepared by the Central Water and Power Commission in 1953, did provide for the lining of the entire main canal. The lining programme was given up in the 1955-57 project at the instance of the Rajasthan Government. Such deliberate under-estimates of projects with a view to obtaining the sanction more easily and reckless revisions of scope and cost later on have become a regular practice with State Governments. The developments in the negotiations for this Rs 412-crore programme will be watched with interest.

As and when the Rajasthan canal is given more positive planning, it will be worth while to give its control board an autonomous character under effective Central supervision if it is not to become another Dandakaranya. The present administrative pattern of the Rajasthan canal has no parallel. Although the canal board is not a statutory body, by convention it has been accepted by the Governments of Rajasthan and Punjab that all decisions of the board will be accepted by them without further scrutiny.

The 465-mile-long canal scheme will be the largest in the world. Its designed full discharge of 18,500 cusecs will also be the highest for any irrigation canal. The quantity of earthwork involved in the construction will be nearly five times that of Bhakra canals, more than five times that of Chambal canals, more than three times than that of Nagarjunasagar canals and more than eight times than that of D.V.C. canals.

The progress of the work so far is claimed to be in accordance with schedule. About 17,000 men and women and 11,000 donkeys have been mobilized for the job. The problem of finding labour is really difficult. For one thing the entire area is sparsely populated, for another the little available local labour is otherwise engaged. Inducements by way of free huts, water and transport are being given to attract labour from Ganganagar, Nagor, Biratnagar and Jodhpur. The construction has to be in stages because pilot channels have to be dug all along to provide water for drinking and for construction.

The Rajasthan canal authorities have put the cart before the horse not only in taking up the project before planning but also in constructing the canals without a firm source of water. It is the measure of India's sacrifice in accepting the World Bank's formula for the division of the Indus Basin waters that enough water will not be available to irrigate this rich virgin land. It was originally planned to divert some waters of the Upper Chanab into the Ravi through a tunnel at Mahru and utilize a combined storage of 10 million acre-feet on the Beas and the Ravi. Now the Chanab has gone to Pakistan. Of the three eastern rivers, the waters of the Sutlej being entirely used by Bhakra, the Rajasthan canal has to depend on the Beas and the Ravi. But here again, the winter supply will not be available to India till Pakistan has built alternative sources of supply in its territory. The Mangla Dam on the Jhelum is under construction for the purpose and will take about ten years to complete.

The only solution lies in the construction of the proposed dam on the Beas at Pong. Even with Pong dam, the Rajasthan canal will face water shortage once in every three years. Without Pong, the canals will be perennially dry. The construction of this dam could already have been taken up to synchronize with the progress on the canal side but for the Punjab Government's dog in the

manger attitude. It has been insisting on either priority for Suket or the construction of Pong and Suket simultaneously. It is no concern of Punjab that Suket is not only highly seismic but will also submerge 12,000 acres of the most fertile area in Himachal Pradesh.

The Rajasthan canal is now in a position to irrigate 1.5 lakh acres of fertile land in the districts of Norangesar and Rawatsar, provided Punjab gives a thousand cusecs from the Sirhind feeder, which will be ready next month. Will Punjab be generous enough to oblige, though with a supply of 4,000 cusecs in the Sirhind feeder she can do it without any sacrifice?

The financial forecast of the Rajasthan canal project assures a return of 7.1 per cent in the 10th year after completion, 13 per cent in the 20th year after completion and 36.6 per cent in the 30th year. This curious forecast is vitiated by several uncertainties of which no account seems to have been taken. Too much reliance is placed on the sale of the land in the entire area over 90 per cent of which belongs to the Government. The revenue from this source depends largely on the cost of development and the price at which the Government of that day may choose to sell the land. It is not known on what basis this sale price has been assumed by the Rajasthan canal authorities, who may not even be consulted at the time of the actual sale. Moreover, the canal project will take ten years to complete and the master plan 20 years. How are we to believe that the grand new scheme will be free from the pestilence of bad planning, of which it is born?

RAJASTHAN CANAL

Canal: Length	:	465 miles
Discharge at Head	:	18,500 cusecs
At tail	:	6,000 cusecs
Storage	:	Beas dam
Headworks	:	Harike
Benefits:		
Irrigation	:	3.5 m. acres
Power	:	23,000 kw
Colonization	:	2.5 m. people
Cost	:	Rs. 200 crores

Project with Promise

THE CHAMBAL VALLEY Development Project is slow but sure. It is one of the few exceptional schemes on the construction of which not many can have reasonable regret.

The Chambal reservoir, with a water spread of about 270 square miles, is one of the largest and cheapest man-made lakes in the world, the cost per unit of water stored being only Rs 25 per acre-foot. This could have been cheaper still had the project not been denied the benefit of thorough investigations in the pre-construction stage. In view of this, it was not possible to draw up definite schedules of materials, technical personnel, machinery and equipment at the commencement of work. This naturally has left its mark.

The project had to undergo several changes because of the extraordinary circumstances of the existence of a number of Princely States to begin with and their merger later with different States in different stages. The Kotah Barrage, for instance, has undergone a continuous evolution, involving in all six designs.

The former States of Indore, Udaipur and Kotah had independent schemes for generation of hydro-power on the Chambal. With the merger of Indore in Madhya Pradesh and Udaipur and Kotah in Rajasthan, the project is today a joint venture of the two States. The multi-purpose scheme is now financed by the two participating States from loans advanced by the Centre. The two States are separately executing the work lying in their respective territories, while the work on the Gandhisagar dam, which is on the border of the two States, is entrusted to Madhya Pradesh.

In refreshing contrast to other projects, the Chambal Control Board is really effective. Under the able chairmanship of Mr Jaisukhlal Hathi, Union Deputy Minister of Irrigation and Power, the Board consists of representatives of the two States and the Union Finance Ministry. In spite of its not being a statutory body, the Board's decisions are by convention implemented by the two State Govern-

ments. What is more, the chief engineers, though administratively under the control of the respective State Governments, execute the work under the general directive of the Board.

This effective co-ordination by the Board and the competence of Mr A. K. Char, the Chief Engineer of the Gandhisagar Dam, are the greatest asset of the project. It is to the credit of the authorities that the Chambal project is utilizing the valuable services of a retired chief engineer in a crucial position. This is in accordance with the considered suggestion of the Committee on Plan Projects that retired chief engineers in the country should suitably be associated with the execution of schemes costing over Rs 15 crores and that each such project should have a consultative committee with necessary specialized personnel.

According to the revised estimates, the first stage of the project will cost Rs 63.6 crores as against Rs 48 crores. Several factors have contributed to this revised estimate. It was originally intended to have three units of 23,000 kw each in the Gandhisagar power house. Now a fourth unit is provided for. In the sphere of transmission, two additional 132 kv lines—one from Sawai Madhopur to Gwalior, 125 miles away, and the other from the Gandhisagar dam to Neemuch, 57 miles away—and another 66 kv line from Neemuch to Mandsaur, 28 miles away, have been added.

The second stage of the project contemplates an expenditure of Rs 18 crores for the construction of the Rana Pratap dam, 25 miles down-stream, a power house with a generating capacity of 92,000 kw at 60 per cent LF and transmission lines and sub-stations. In the third stage, another dam is proposed to be put up near Kotah Barrage. Evidently, the ultimate cost of the project will be nearer Rs 100 crores than the original estimate of Rs 77 crores.

Considering the expanded scope of the project and the rise in the prices of materials, not much objection can be taken to the revised estimates. Moreover, the original estimate was based on certain data regarding the cost of submersible land in respect of which alone the revised plan provides an additional Rs 3 crores. Among other things, the additional cost on account of cement has been Rs 47 lakhs, that of steel Rs 17 lakhs, that of other materials Rs 30 lakhs and that of wages Rs 21 lakhs.

Nature has provided many advantages in Chambal. The deep and narrow gorge at Chowrasigarh offers many

excellent sites for cheap power generation. About 2,500 ft. wide at its mouth, the gorge narrows down to a width of 600 ft. within a distance of three miles. The cliffs rise between 300 and 400 ft. high. The river falls by about 1,650 ft. at Chowrasigarh and 400 ft. in its 70-mile course between Chowrasigarh and Kotah. The Gandhisagar dam is located five miles down-stream of Chowrasigarh, where the boundaries of Madhya Pradesh and Rajasthan meet. The basin above the mouth of the gorge at Chowrasigarh makes a magnificent reservoir. The result is that although the height of the dam is only 204 ft. its storage will be 6.85 million acre-feet. The dead storage will be only 130 ft. and the live storage 70 ft., with a head varying from 135 ft. to 185 ft.

The argument has been advanced that there is no need for all the three dams in different stages and a single dam with a height of 450 ft. near Kotah could have served the purpose better. This is evidently against sound scientific data. The length of such a high dam will have to be the same and the cost more or less identical, if not higher. Again, a high dam of the type will have a dead storage of more than 250 ft. and the power potential will be less, as also the storage for irrigation, because the reservoir at this point is by no means ideal.

The Gandhisagar dam is essentially a masonry structure with concrete-capping and blanketing. About a third of the total volume of work is accounted for by concreting. The cost per unit at Rs 160 per 100 cft. for masonry and Rs 240 per 100 cft. for concrete work compares unfavourably with that of some other projects.

The project is, on the whole, a year behind schedule, with the first stage now expected to be completed in 1963-64. The Kotah Barrage, earlier expected to be ready in December last, is just nearing completion. The power supply, which was to start in December last, will now begin in August on an experimental basis and from November on a commercial scale. The canals, which should have been laid in October last, will be ready with a delay of a year. The performance on the Rajasthan side in this sphere is relatively good.

The delay on the main dam is because though it was agreed in principle that M-P should build this border dam it was only in October last that Rajasthan actually handed over about five square miles of its territory required by

the project. The difficulties in the procurement of machinery and equipment were also considerable. The project authorities are grateful to the U.S. Technical Co-operation Mission for the timely assistance in supplying Rs 2 crores worth of machinery.

The benefits of the project will be shared equally by the two participating States. Out of the 1.4 million acres of land, which will eventually be irrigated and the 215,000 kw of power to be generated, the benefits of the first stage will be 1.1 million acres of irrigation and 92,000 kw of power. The irrigation of 1.4 million acres will, besides yielding an additional 4.75 lakh tons of food grains annually, change the complexion of agriculture in the area. Recent soil surveys have shown that the land in the commanded area is quite suitable for irrigation. The Madhya Pradesh area to benefit by this irrigation has been prone to frequent famine conditions.

In the eastern portion of Chambal, the pressure on land is excessive. The soil is of alluvial type; but agriculture depends almost entirely on the monsoon. The result is poverty, which in quite a few cases has led to anti-social and criminal activities. The benefits that Chambal irrigation will bring to these troubled areas can bring in its wake a desirable change in this aspect also.

It is estimated that the aggregate annual revenue from irrigation and power at the end of the first stage will amount to about Rs 3 crores and that the net annual receipts will be Rs 2 crores after making allowance for maintenance, operation, collection and depreciation charges. These financial returns cannot be realized unless the agricultural aspect of the project is given adequate attention. There is need for more earnest crop studies and regulated rotation schemes. No doubt, new research centres have been established in both States. But the specialists in various branches are scattered all over the State, presumably to satisfy the political claims of the capitals of erstwhile Princely States. This certainly is not in the interest of agricultural promotion.

CHAMBAL

Type	:	Concrete
Units	:	Gandhisagar main dam, and power house, Rana Pratapsagar dam, Kotah dam and Kotah barrage

Storage	:	6.85 acre ft.
Waterspread	:	270 sq. miles
Benefits:		
Irrigation	:	1.4 m. acres
Power	:	210,000 kw
Cost	:	Rs. 100 crores

A Costly Venture

RIHAND, WHICH IS an abridged version of Bhakra, has almost all the imperfections of its big brother in the matter of planning and execution.

The U.P. Government's Economy Committee had some time ago spotlighted the deficiencies of the Rihand project. Taking into account the defective planning, wastages and redundancy in execution, the committee had feared that at the revised cost of the project the entire anticipated revenue would hardly cover a 2 per cent interest on capital and a 3 per cent provision for depreciation and that such an inconvenient eventuality could only be overcome by putting up the power rate. The committee had come to the conclusion that power supply from Rihand would be "very expensive, rather uneconomical, thereby defeating the very object of construction of the dam, that is, supply of cheap power."

One has to visit Rihand to see how perfect these predictions have been. Considering its most ideal location and other natural advantages, Rihand's power should be among the cheapest in the country. But actually it will be one of the costliest. The original cost of the generation of 1.98 nP per kwh. which itself was fantastically high for a natural project like Rihand, has now been quietly raised to 2.33 nP per kwh. What an enormous burden the power tariff will be can be imagined from the fact that the project authorities have assumed an annual return of 5.85 per cent on the capital cost, which now stands revised to Rs 46 crores from the original estimate of Rs 35 crores.

The whole trouble has arisen from this revision of the estimate, which was mooted in 1956, hardly a year after the allotment of work on contract. It was approved by the Rihand Control Board in March, 1958. With all partiality for the project, this revision is rather hard to justify, because the additional benefits derived are more illusory than real. The Economy Committee's conclusion that even after allowing for the inevitable burden of past blunders the anticipated increase in the cost could be halved is an understatement.

The authorities are doing their best to create the semblance of additional benefits. It is claimed that they are now working on the basis of a generation of 125,000 kw firm power, which means an increase of 20,000 kw over original anticipations. It seems doubtful that the additional target will be realized. Even assuming it will be, its impact on the overall cost of generation will be negligible.

A Public Relations pamphlet of the project mentions a bald figure of 250,000 kw as the installed generating capacity in place of the original programme of 300,000 kw. This perhaps is deliberately designed to create the impression that the promised firm power of 125,000 kw is at least 50 per cent of the installed generating capacity. A discriminating observer can, however, see that the installed capacity remains unchanged at 300,000 kw and that the so-called sixth unit is as much a part of the original plan as any of the other five and is shown separately just as a visual explanation of the inflated cost.

The unpalatable truth is that the firm power generation of the project will range between 100,000 kw and 125,000 kw as against the colossal installed capacity of 300,000 kw. That this is so in spite of a splendid head ranging from 225 ft. to 250 ft. only establishes that the installed capacity is disproportionately high to the potential of the dam. Evidently, the machinery had been ordered without assessing the potential of the reservoir. The height of the dam has already been raised to 300 ft. from 270 ft. originally planned and there is no scope for any further revision. How, in the circumstances, can the high cost of generation be helped?

The usual excuse of the rise in prices, generally cited by project authorities, does not hold much water in the case of Rihand. For one thing most of the machinery had either been procured or firm orders placed before the revision of the cost; for another the bulk of the work had been let out to contractors at fixed rates.

The whole project could comfortably have been completed within the original cost, had the delays in the initial stages been avoided. Although the detailed project report was prepared in 1952, it was only in 1955 that tenders for the construction of the dam and power house were called and the contracts finalized. To add to it, the contractors took almost two years to erect their construction machinery and equipment. The result of it all is that concreting work actually started some time in April, 1957, by when the whole

project could have been completed. The question of any revision of cost would then not have arisen. The project is now expected to be completed by June next according to the revised schedule. The trial run of the first power unit is likely to be some time in November.

The capital cost of the project has been artificially inflated for want of effective control, which in turn is the result of the project being just a small part of a big department of a big State. It is significant that a Rs 46-crore project, like Rihand, has no Chief Engineer of its own. A Superintending Engineer is looking after the affairs of Rihand under the overall charge of the Chief Engineer of the State's Irrigation Department. It is too much to expect this busy Chief Engineer to spare adequate time for Rihand the Superintending Engineer of which is among the 22 such others under him.

A specimen of the redundancy in execution in Rihand is the existence of a superfluous supervisory staff. There is clearly no need for a big departmental staff at Rihand because the entire construction of the dam and power house has been let out on contract. The project authorities are merely responsible for the supply of cement, steel and certain other materials at fixed prices. The entrusting of the entire work to a single contractor has its disadvantages if it has some advantages.

At Rihand, they have also made a mess of the scheme of compensation for submersible land. It was originally decided to give every displaced family 6-1|4 acres of land and a small cash compensation for the house. With the subsequent introduction of rehabilitation grants, under which cash payment is available for submersible property on the basis of an *ad hoc* assessment, most people opt for this cash payment. To the easy-going irrigation administration of U.P. this indeed is a blessing in disguise. The right thing to do is to rehabilitate the displaced families in this sparsely populated hilly part of Eastern U.P.

Rihand is also saved the headache of the problem of water utilization. In fact, it is in the privileged position of saying what the neighbouring State of Bihar should do about the 5,000 cusecs of tail water flowing through the power house. The entire water of this pure power project flows through non-culturable mountainous region of Eastern U.P. into the river Sone.

Bihar, no doubt, benefits from this by way of flood protection and irrigation. As against a monsoon flow of 1.2 million cusecs and the peak summer discharge of a mere 500 cusecs, Rihand will now supply a regulated flow of 5,000 cusecs to Bihar for irrigation. The contention of the U.P. Government is that the cost of the dam and power house, estimated at about Rs 30 crores, should be shared equitably by Bihar in view of this irrigation benefit. Any payment by Bihar for this water will help reduce Rihand's power cost. The need for cheap power from Rihand cannot be overemphasized in view of its impact on industry as well as agriculture. About four to five thousand tubewells in Eastern U.P. and about 2,000 tubewells in Bihar will be energised by Rihand power.

There is a proposal to step up Rihand's power potential by linking it with a 450,000 kw thermal plant on the basis of the rich coal deposits of the Singaurali mines, about 30 miles away. The proposal is certainly sound. But the difficulty is that only a fourth of the mine is in U.P. and the rest in Madhya Pradesh. It is thus obvious that the economics of Rihand, distorted by its inflated cost, has to look for balancing factors from elsewhere.

The access road to the dam site crosses the river Sone at Chopan, 65 miles from Mirzapur, where a pre-stressed concrete bridge has been constructed. Though its cost of Rs 50 lakhs seems rather on the high side, the bridge is worth the construction. About 3,300 ft. long, it is the longest pre-stressed concrete structure in Asia and the third longest in the world. This, however, is poor consolation for not having at Rihand what should have been one of the cheapest power projects in the country.

RIHAND

Type	:	Concrete
Height	:	300 ft.
Length	:	3,254 ft.
Storage	:	8.6 m. acre ft.
Waterspread	:	180 sq. miles
Benefits:		
Installed	:	300,000 kw
Firm	:	100,000 kw
Irrigation	:	500,000 acres in Bihar.
Cost	:	Rs. 46 crores

Lesson in Co-operation

KOSI IS A LESSON in co-operation. The project is of the people, for the people, by the people.

There is no mystery behind this unusual identity between the people and the project. For the people of the Kosi region the project is the sole source of survival, while for the success of the project the people's participation is the prime prerequisite.

The people and the Government of Bihar have for centuries fought a war in vain against the Kosi, which has spelt large-scale disaster to over 8,000 square miles in Bihar and Eastern Nepal. Bihar's "river of sorrow" has perpetually been changing its course. All attempts to arrest the westward movement of this wayward river have been fruitless, and in the past hundred years the river has migrated about 70 miles.

The erratic Kosi, which drains the catchment area of the world's three greatest peaks — Everest, Makalu and Kinchinjanga—has a discharge varying from three lakh to nine lakh cusecs. The most devastating aspect of the river is its terrible silting, which in intensity is next only to that of the Yellow River of China. It is estimated that, in a 12-month period, the river carries 7,300 tons of sediment for every mile of the catchment area.

The 15-lakh people of the Kosi region have done their best to adjust their economy to meet this challenge of nature. Cheap bamboo and grass houses predominate the area. Cattle which thrive on the Kosi weed are reared in large numbers and constitute one of the main items of rural wealth. Some of the lands laid waste by the river have been reclaimed because in course of time they yield rich crops. Despite all measures of adjustment, the vagaries of the river have caused immense distress to the people and loss of property valued at about Rs 10 crores every year.

No more will one see this annual distress of people fleeing. The river has at last been harnessed. The two earthern embankments of about 75 miles long each on either

side of the river, tied to the four-mile-long barrage being constructed across the river at Hanumannagar in Nepal, have confined the unpredictable Kosi to a relatively straight course varying in width from three to ten miles.

Besides affording direct protection to more than six lakh acres of cultivable land in Bihar and Nepal from recurring submergence, the project will irrigate 1.4 million acres of land in Purnea and Saharsa districts in Bihar and 20,000 acres in Saptari district in Nepal. In addition, the project is likely to benefit another 1.2 million acres in Bihar and 1.83 lakh acres in Nepal. It will also help reclaim about 3.5 lakh acres of land rendered waste by the river. The irrigation system of the project, which will come into operation in 1963, will help produce an additional 10.5 million maunds of food grains valued at more than Rs 10 crores. There is also a proposal to generate 18,000 kw of hydropower at a site 2½ miles down the barrage where the canal is said to have a fall of 23 ft.

Among its other benefits, the project will enable easy all-weather communication in Purnea, Saharsa and Darbhanga districts in Bihar and in Saptari and Moran in Nepal. Family incomes in many parts of the Kosi region have risen, the bulk of the amounts paid for the construction of embankments and canals having gone to the people, who, with the little machinery available, have executed the larger part of the work themselves. This is reflected in the better living standards and the dwindling indebtedness of the peasantry in the region. Indicative of the people's confidence in the project is the fact that they are migrating back to the lands they were once compelled to leave by the meandering river. More solid and permanent dwellings are coming up in place of the temporary bamboo thatch huts, characteristic of the region.

The experience of Kosi is contrary to the general belief that execution of projects through public co-operation inevitably entails delay. Not only has the work been done ahead of schedule, the rates have also been 2 to 3 per cent lower than those of contractors besides the quality being better. Presumably prompted by the striking success of the scheme, the authorities are now assigning Rs 10 lakhs worth of building contracts as also some bridge construction work, apart from some more earthwork on the canals to the Bharat Sevak Samaj.

Considered from this intensely human angle, Kosi cannot be criticized much. Even as a purely flood protection scheme with a limited life the project is more than its money's worth. The revised cost of Rs 45 crores, which means an increase of Rs 8 crores from original estimates, cannot be taken much objection to, considering the annual loss of Rs 10 crores caused by the river, not to mention the human suffering and other complications.

The economics of the project, however, stops here, though the authorities are for obvious reasons shy of admitting it. The anticipated irrigation and power benefits are not without exaggeration, in view of the limited life of the Hanumannagar Barrage. As regards irrigation, the scope is rather limited because a large part of the region gets heavy rainfall, ranging from 50" to 80". The sub-soil water is as high as three feet. Moreover, the peasantry in the area is too poor to pay any worthwhile additional land revenue. The basis of the power programme is even more tender. The successful operation of this scheme will be an engineering feat in that an extremely low head of 23 feet will have to be maintained in a canal originating from the sandy Kosi.

The views of experts on the exact life of the Hanumannagar Barrage vary vastly, but there is no disagreement on the fact that the barrage is by no means the final solution to Kosi's problem of silting. It is felt that the construction of the four proposed check dams higher up should have been taken up simultaneously, which would have increased the life of the barrage. Survey operations on the first check dam at Kothar, near Chetra, have just been taken up.

Kosi has thus been tamed but not for good. The permanent solution lies in the construction of a high dam at Barachetra. This is no new scheme. It was proposed as early as 1946-47 to construct a dam 750 ft. high at Barachetra at a cost of Rs 145 crores. It had to be given up partly because of the hugh financial outlay and partly because of the controversy raised by some sections that the site was in the seismic zone. The entire question deserves to be thoroughly investigated. The Barachetra project also envisaged the generation of two million kw of hydro-power.

What has been gained by public co-operation has more than been lost for other reasons beyond the control of the project administration. The problem of sub-soil water in

medium industries. The capacity of the [illegible] plant needs to be expanded expeditiously. Kosi is generating its own diesel power.

Perhaps the biggest problem of Kosi is the transport bottleneck. It takes almost 15 hours for the metre-gauge train to cover 180 miles between Barauni and Forbesganj, the nearest railhead to Hanumannagar. The frequent material shortages experienced by the project are inevitable not only because of the slow speed of the trains but also because direct road haulage is made impossible by the absence of bridges on the several small rivers on route.

The existing narrow-gauge line constructed by the Kosi project, connecting Bathnaha on the North-East Frontier Railway with Bhimnagar on the barrage site, can be converted into the metre-gauge line and extended up to Nirmali by constructing a new line along the western Kosi embankment. The conversion can be done without much investment because the existing line of the project can take the heavier load of a metre-gauge commercial line. The extension of this line to Nirmali across the barrage will provide a direct link for the entire northern belt of the Darbhanga-Saharsa-Purnea districts through the Jogbani-Katihar branch line, with the market extending up to the port of Calcutta. Besides opening up a vast underdeveloped region of Nepal, rich in agricultural produce and timber, this line will provide a vital rail link of great strategic importance. The proposal deserves the prompt attention of the railway administration.

Best of the Bad Lot

IT IS PERHAPS not quite fair to the Damodar Valley Corporation to call it the best of the bad lot of our multi-purpose projects. While it will be idle to pretend that the D.V.C. has not made mistakes, it is only reasonable to recognize that the project has had more than its share of difficulties.

If due allowance is made for the initial inexperience and the difficulties in the recruitment of men and procurement of machinery, a pioneering project like the D.V.C. can, to an extent, be excused for its bad planning, high cost, inability to adhere to construction schedules and even wastages. In judging the achievements of a complicated venture such as the D.V.C. one is apt to miss the wood for trees.

The relevant fact to remember is that the project was started soon after World War II. Machinery and equipment were scarce to secure and suppliers refused to accept any firm delivery dates. The country had, no doubt, competent engineers, but not as many as needed and still less of those with experience of mechanized construction. The main handicap of the project was that it necessarily had to use complicated modern machinery. The task of welding an amorphous organization into a trained technical team was no easy one and the Corporation did take quite some time to get into its stride.

As regards the cost of the project, the latest estimate of Rs 170 crores is certainly a formidable figure, more so because Mr Voorduin, the original planner of the scheme, had put it at a mere Rs 55 crores. But the original figure was arrived at much before the designing of the project and the expert from the Tennesse Valley had himself made it clear that his estimates were merely "rough approximations," based on estimates that had been made for previous but not strictly comparable schemes and the 1945 rates for labour. The admittedly rough estimates of Mr Voorduin whose scheme was drawn up long before the D.V.C. came into existence, were intended to "serve no other purpose than that of an approximation of the magnitude of the capital expenditure involved."

The first realistic estimate was prepared in 1951, but this also came to be revised subsequently on several occasions. Although in no sense a justification, it may be pointed out that such revision of estimates was not peculiar to the D.V.C. but was general throughout the world during the particular period. If the DV Project has cost more than it should have, it is partly because of the emphasis rightly laid on schedule. On quite a few occasions, the authorities have had to prefer time to money. This has not been without its advantages. With all the delays that have still crept in, the completion of the four dams—Tilaiya, Konar, Maithon and Panchet Hill—the Bokaro thermal plant and the Durgapur Barrage with its network of canals commanding nearly a million acres, within a period of eight to nine years, is certainly an achievement. This is claimed to be a record not surpassed even by the Tennesse Valley Administration. The D.V.C. is a replica of the T.V.A.

The secret behind the superior execution of the D.V.C.'s definitely superior scheme lies in the dynamic policy of the Corporation and the legitimate latitude enjoyed by engineers. This, in turn, is entirely due to the autonomous character of the Corporation, which has come about more as an accident than by design. The planning of the project was as difficult politically as it was hydraulically. The differences of views between the two participating States of Bihar and West Bengal were so wide and so many that an autonomous Corporation under an Act of Parliament was born out of the compelling circumstances.

Despite this autonomy, the effectiveness of supervision by the Centre has been well preserved. The Corporation was promptly pulled up, when, under pressure to get water stored, it signed a contract for the construction of the Konar dam, which the contractors were too quick to exploit by demanding payments not strictly unavoidable. In another instance, the Corporation was taken to task for its costly experiment in the construction of model villages for the displaced families, which ultimately were not occupied by them. The Corporation had to give up its house-for-house scheme and change over to payment of cash compensation on an *ad hoc* assessment of the value of the submerged property. In striking contrast to this effective supervision is the fact that the serious cases of collusive buying, swindling of materials, bogus pay-rolls, and so on, that occurred during the initial years of Hirakud under direct control of the Centre, came to light only through audit reports.

That the D.V.C. is financially a sound proposition is evident in that the World Bank has singled out the project for particular loan assistance. The Corporation could be much better off financially if only the West Bengal Government were half as reasonable towards it as it ought to be. The Corporation's extensive canal system commanding nearly a million acres is today a dead weight on its finances, because of West Bengal's consistent policy of shirking responsibility to put the water to productive and remunerative use. In violation of its undertaking at an inter-State conference last year to take over the maintenance and operation of the D.V.C's canal system—this has a total milage of 1,555 including the navigational canal—West Bengal is now dictating all sorts of impossible conditions for the take-over. It seems to be insisting on retaining Rs 5 out of the rates collected for every irrigated acre of land, while the Corporation is unable to agree to more than Rs 3 per acre.

To make it worse, West Bengal wants to collect the water rates under its Act, although this is not in conformity with the D.V.C. Act, which is a Central legislation. There is also disagreement over payments for future alterations and additions to the irrigation system. The Corporation is willing to bear the cost of capital works already included in its plan and those that may have to be executed after the transfer of the maintenance of the canals to the State Government. It is naturally reluctant to enter into any fresh commitment on this. The result is that although the Corporation is able to irrigate about 700,000 acres this year as against 550,000 acres last year, it is in no position to realize its legitimate revenue.

Even more unfortunate is the West Bengal Government's unhelpful attitude towards the construction of more dams, which will increase the project's flood control as well as power generation capacity. The existing D.V.C. dams have demonstrated their ability to control a flood even higher than the maximum for which they have been designed. But their capacity is far less than the flood control requirements of the river. Only four dams have so far been constructed, whereas the Voorduin plan contemplated as many as eight.

The construction of an additional dam at Aiyar, which is an ideal site from many points of view, has been delayed unpardonably. It is a sad story that the Khungar Committee, which had also reportedly recommended this dam,

has met with the fate of not being able to submit its final report, because the representative of the West Bengal Government has boycotted the Committee. It has been canvassing the construction of a dam across the Rupnarain in preference to the Aiyar dam. It is a criminal national waste that the D.V.C. has been prevented from putting the Aiyar dam by utilizing thousands of its specialized staff at the Panchet Hill, work on which was completed in December last. The D.V.C. is no longer to blame and the West Bengal Government should squarely own the responsibility for any recurrence of flood losses by the Damodar river.

The Aiyar dam will augment the D.V.C.s flood control capacity up to 850,000 cusecs. The availability of adequate supply of industrial water to the proposed two-million ton steel plant at Bokaro, as also to other industries in the area, and the stabilization of the supply of industrial water at Durgapur depends on the construction of this dam. By reducing the "flood gap" at Panchet Hill, the Aiyar dam will also facilitate the installation of another unit of 40,000 kw at the Panchet Hill power house and enable additional storage to irrigate another 50,000 acres.

The potential demand for power from essential industries in the D.V.C. area cannot be met unless additional generating capacity is installed immediately. The shortage of power in 1960-61 is estimated at 179,000 kw, increasing to 216,000 kw in 1961-62 and to 265,000 kw in 1963-64. By 1965-66, the power shortage, on the basis of production figures, is expected to rise to 719,000 kw. Four more thermal units with an installed capacity of 125,000 kw each are proposed to be added in the D.V.C. area during the third Plan. But they will neither be adequate nor compare costwise with the additional hydro-power which the Aiyar dam offers.

D.V.C.

Dams	Konar	Maithon	Tilaiya	Panchet Hill
Type and Length	Concrete 900 ft. Earth 12,030 ft.	Concrete 1,188 ft. Earth 14,523 ft.	Concrete 1,200 ft.	Concrete 1,215 ft. Earth 20,940 ft.
Height	160 ft.	162 ft.	99 ft.	134 ft.
Storage	298,000 acre ft.	1.2 m. acre ft.	451,000 acre ft.	1.4 m. acre ft.
Power	40,000 kw	60,000 kw	4,000 kw	40,000 kw

Durgapur barrage Length	:	2,271 ft.
Benefits:		
Irrigation	:	1.4 m. acres
Hydel Power	:	146,000 kw
Thermal Power:		
Bokaro ,	:	225,000 kw
Durgapur	:	150,000 kw
Chandrapura	:	125,000 kw
Total cost	:	Rs 170 crores

Bungling and Perfection

HIRAKUD IS UNFORTUNATE. Paradoxical though it may sound, the project has combined bungling with perfection. Today it is perfection personified, but its past makes a sorry tale with a record of unprecedented mismanagement and corruption.

Misfortune befell the project even before it was born. The first fatal blow came when the project was denied the benefit of the most ideal location offered by Tikarpara. Given this site, the construction problems would have been far fewer and the cost far less.

The project suffered a series of serious setbacks in planning and execution during the first five years of its construction. It is a reflection on the Union Irrigation Ministry that the project was executed directly by it through the Central Water and Power Commission. To begin with it was not realized that the project was too big for the organization which handled it. The authorities declined foreign technical assistance. Naturally, what was gained by D.V.C. from the Tennesse Valley experts was lost by Hirakud.

There was too much concentration of power in the Central organization. These distinguished men in Delhi made impossible demands on the small staff stationed at Hirakud. Work was taken up without proper designs, which in certain cases were ready almost two years after the start of construction. The work had in several cases to be abandoned or redone.

The authorities showed little sense of realism in the matter of purchasing machinery and materials. Consequently, a number of valuable construction plants were not suitable to the peculiar requirements of the project. Some of them turned out to be a dead-weight. Most of the machinery could not be worked beyond half the installed capacity, the impact of which was further aggravated by the necessity to engage supplementary workers on a large scale. This double-handling led to an utter lack of coordination among the various construction plants and caused considerable delay and avoidable expenditure.

Curiously enough, cement was bought for the huge project in bags instead of in bulk. This entailed a loss of about Rs 15 lakhs. Kosi has repeated this mistake, but this perhaps could not be helped because the handling is done manually at Kosi. There were bulk cement handling machines at Hirakud but they were most of the time out of condition.

The project has lost heavily for lack of effective financial control. About Rs 5-crore worth of articles were bought by the authorities in 1949 from the Directorate of Disposals and dumped at Hirakud. This vast mess of Disposals stuff ranged from bull-dozers to binoculars, and in 1953, four years after the purchase, when the dam was half-built, almost 50 per cent of the 60,000 items had been neither listed nor priced. It is not known what ultimately happened to them. To the project, of course, it was a loss. Even more serious cases of swindling, collusive buying and corruption have been listed in audit reports.

The bosses in Delhi gave orders which betrayed a complete lack of a sense of proportion. One such was a command that the half-mile-long road-*cum*-rail bridge across the Mahanadi at Sambalpur should be completed in six months. This certainly was impossible for anybody to achieve, more so for the inexperienced youngsters at Hirakud. In this mad race, all sorts of designs were tried and all sorts of materials bought without any consideration of cost. With all this, it took two years to complete the construction and a scrutiny committee, set up for the purpose, came to the conclusion that at least Rs. 13 lakhs had been wasted in the construction of this Rs 68-lakh bridge.

Six years after commencement of work, the project underwent radical changes in planning and execution. Soon after Mr M. S. Thirumale Iyengar became the Chief Engineer of the project. He realized that nothing less than a complete overhauling could clear the accumulated confusion. Some corrupt officials were dismissed and many others transferred. The new Chief Engineer gave up the grandiose plant of navigation and took up a more economical power scheme providing 72,000 kw of firm energy instead of only 50,000 kw.

The Orissa Government also added to the overloading of the capital cost of the project. It was originally decided that the lands required by the project should be procured on the basis of 1947 prices. Interminable haggling however

the project was made to pay double compensation, one for land at current prices, which were much higher than 1947 values, and the other for trees, tanks, wells, and so on. This increased the cost of compensation by several crores

The Masonry Testing Laboratory of the project, of which any other country in the world should be proud, is gradually dying for want of patronage. The laboratory, with 4.5 million to 6.75 million lb. capacity, has been set up at a low cost of about Rs 4 lakhs, which is hardly a tenth of what a conventional steel column machine costs. It has proved its usefulness beyond doubt. On the basis of the tests conducted there it has now been established that masonry is in no way inferior to concrete in strength and can be used for high dams. The adoption of this suggestion has benefited the Nagarjunasagar project alone to the extent of Rs 40 lakhs. Other projects like Koyna and Sharavathy have also saved several lakhs. The efforts of the project to persuade the Council of Scientific and Industrial Research to incorporate the laboratory into their organization have not been successful. It will be a tragedy if a fundamental research station like the one at Hirakud is allowed to languish for want of support.

Hirakud's power house bears a permanent scar of past blunders. Of the four turbines, two units have a generating capacity of 37,500 kw each and the other two 24,000 kw each. Two of them run clockwise and the other two anticlockwise. The story behind this unsymmetrical power house is that the two smaller turbines, which were intended for an auxiliary power house, had to be shifted to the main dam because of a directive from the Planning Commission laying emphasis on irrigation, which, in turn, resulted in the giving up of the auxiliary power house programme. Since the two smaller turbines are designed for a constant head of about 75 ft. as against the main dam's head of 115 ft., precious falling water which could generate another 30,000 to 40,000 kw is being wasted. It is now proposed to install a fifth unit with 37,500 kw in the main dam. This, together with the three generating units of 24,000 kw each, being put up at Chiplima 13 miles downstream, is expected to increase the capacity of the project to 232,500 kw.

Not only has the project been unable to generate as much power as it could have, but its extensive canals system earns little or no revenue. The maintenance of

over 2,600 miles of canals, distributaries and water courses naturally costs a lot. The gross revenue of the project is presently within Rs 1 crore, which almost entirely comes from the sale of power. Against this, the maintenance of the dykes and the dam costs Rs 10 lakhs and that of the power system about the same. The balance is inadequate even for depreciation, let alone interest charges and amortization of capital.

The latest estimates put the cost of the project at about Rs 100 crores—Rs 71 crores for the first stage which has just been completed, Rs 15 crores for the second stage which includes the Chiplima power house and Rs 14 crores for the delta scheme, designed to provide perennial irrigation to 1.8 million acres in Cuttack and Puri districts. The project has been getting "reservation charges" from Rourkela steel plant for the emergency power arrangement to the extent of 25,000 kw. The income from this source will increase with the establishment of the fertilizer plant at Rourkela, when the emergency capacity is expected to be raised to 55,000 kw. But the project to pay its way depends entirely on the earnestness of the State Government in realizing additional revenues from the farmer for the benefit of irrigation. The Government has assumed powers under an Act to collect such revenues retrospectively. If it is half as effective as the Act, much of the project's problems would be solved. Today, Hirakud is unfortunate as much because the project which should have been the cheapest of its kind is one of the costliest, as because the project which should have been prosperous is poor.

Waste of Valuable Water

CAN YOU HAVE the cake and eat it too? Sometimes you can. But the sponsors of the Koyna project do not think so. For reasons best known to them, they have preferred 240,000 kw of power to 36,000 million c.ft. of water for irrigation.

It is difficult to believe that the choice between power and irrigation in the project was as inevitable as it is made out to be. The original scheme, suggested by the Gupchup Committee in 1949, envisaged irrigation and power generation. The committee had contemplated a 300-ft. high dam on the Koyna at Jalkawadi to store 156,000 million c.ft. of water for generating 660,000 kw of power and irrigating 7.4 lakh acres of land. It had proposed in the first stage generation of 420,000 kw of power and irrigation of 4.4 lakh acres, mostly in Bijapur district. This stage was estimated to cost Rs 52.5 crores.

Under this plan, it was certainly possible to have the cake and eat it. But it was not accepted and the project today is very different. The main dam is located at Deshmukhwadi, three miles north of Helwak, a village in North Satara district. From the point of view of power generation the site of the Koyna project with a head ranging fro[illegible] ft. to 1,680 ft. is not open to challenge, though the [illegible] less than in the orig[illegible]

What is[illegible] hardly a s[illegible] the Gupch[illegible] tail water i[illegible] tion becaus[illegible] mountainou[illegible] hungry Bij[illegible] under the [illegible] of this pre[illegible]

That fina[illegible] mentation [illegible] wholly tru[illegible]

with its limited benefits, is now expected to cost Rs 38.28 crores as against the earlier estimate of Rs. 33.22 crores. Taking into account the relative benefits of the two schemes, the Gupchup Committee plan was by no means formidable. Regional considerations have presumably influenced the decisions on the project.

The project will now be executed in three stages. The first stage, under construction, includes a storage of 36,000 million c.ft. of water and an underground power house near Pophali with six turbines of 60,000 kw each. In this stage, the main dam will be 207.5 ft. high above the river bed and at the deepest section 265 ft. over the foundation. In the second stage, the dam will store 73,000 million c.ft. of water, of which 53,000 million c.ft. will be used for generating 480,000 kw of power and 16,000 million c.ft. for irrigating about one lakh acres of land in North Satara district. The third stage will be concerned mainly with exploiting the further power potential of the tail water by installing a tail race power house expected to yield 60,000 kw. Another power house, to be installed at the foot of the dam to utilize irrigation water for seasonal power generation, will have a capacity of 30,000 kw.

According to the 1956 estimate, the spillway portion of the dam was to have been constructed to the full width required for the final storage of 98,000 c.ft. both in foundation and superstructure. This has now been revised in such a way that the foundations of the spillway portion will be constructed to the full width required for the final stage and the superstructure to the width needed for a storage of 73,000 million c.ft. of water. This change in the programme is likely to make construction work for the final stage difficult and costly. It is conceded that the thickening of the superstructure of the spillway portion later will present many problems. Besides constructional difficulties, there will be very limited time to do this work during the working season. The error of judgment having been committed is now being covered up by pleas that the additional work on the superstructure will create confusion in contract rates and dislocate the time schedule.

The Committee on Plan Projects has been rather critical of the project's revision of estimates. According to the committee, "the tenders for the works of dam and appurtenances, approach and ventilation tunnels and intake to the emergency valve tunnel have all exceeded the estimated

cost by 19 to 30 per cent. On some of the important items, like concreting of the head race tunnel and pressure shafts, the excess is of the order of 50 to 100 per cent. Under the terms of contracts, 90 per cent of funds are advanced and foreign exchange provided to the contractors for the purchase of machinery. In spite of these high rates and the facilities provided to the contractors, the works are not likely to be completed within the target date."

The committee had recommended that large works involving the use of machinery and extending over a number of years should preferably be carried out departmentally. Experience at Koyna has shown that departmental execution has been more economical and efficient than through contractors. The rate of underground excavation of the tunnel done departmentally is only 65 per cent of the contractors' rate for similar work. Equally conspicuous has been the advantage of departmental execution in the case of the concrete lining of the tunnel. The project is unfortunately denied the benefit of cheaper departmental execution because many of the important items of work have been entrusted to contractors.

The cost of the project is higher than it should be for the other reasons also. One of the factors to which the increase of Rs 5 crores in the estimated cost is attributed are the technical changes suggested by the Swiss consultants. An additional Rs. 2 crores had to be spent because of the defective foundation over 350 ft., where there was the need to go 60 ft. deeper. What is worse, the powerless project engineers had to wait for almost three months to secure the sanction for construction from the State Government.

Koyna's high cost is hard to justify. The dam is being built in rubble concrete, which weighs more but costs less than ordinary concrete. The underground power house is expected to save capital cost to the extent of Rs 1.5 crores, which is almost a third of the total cost. The length of the penstocks in the underground power house is no more than 2,000 ft. while in the case of the conventional overhead penstocks it is 6,900 ft. This has reduced total steel requirements to a sixth.

Although much is made of the efforts of the authorities to keep to the schedule, the fact is that Koyna's power supply has been delayed. The delivery period of power, which was originally expected in October, 1960, has been revised to July,

1961. Judging by the progress so far, it seems doubtful whether even this revised time-table will be adhered to.

The Koyna project is the World Bank's favourite, next only to D.V.C. This is not because the project has not cost more han it should have, but because of its assured earnings. Seldom has a hydro-electric enterprise had such a massive demand awaiting its product.

Koyna's power should normally be very cheap because of the exceptionally splendid fall of 1,525 ft. to 1,680 ft. and also the benefit of the underground power house. The reduced length of the pipe in the case of the underground power house will considerably lower frictional loss and consequently increase power generation. A superintending engineer at Koyna claimed a capital gain of Rs one crore for the underground power house as a result of better efficiency. With all this, Koyna's power does not promise to be as cheap as industry in the region anticipated.

In the project report of 1950, the cost of Koyna's power at Bombay was worked out to be 0.22 anna per unit and it was proposed to sell the power to Tatas at 0.33 anna per unit. These rates have been successfully raised with every revision of the project. The cost and selling prices were revised to 0.3 anna and 0.35 anna per unit respectively in January, 1952, to 0.37 and 0.40 respectively in December, 1952, and to 0.38 and 0.44 respectively in October, 1956. These rates do not seem to have taken into account either the capacity of the consuming industries to pay for the power without detriment to their production costs or the competitive costs of thermal power in some large load centres as Bombay. A Tariff Committee, comprising the Chief Engineer of Koyna, the Chairman of the Bombay State Electricity Board and the Director of Industries, Bombay, is now finalizing a detailed rate structure. The committee will have to strike a balance between the cheap energy needs of the country's developing economy and the project's immediate interest of earning adequately to pay its way.

KOYNA

Type	:	Concrete
Height	:	208 ft.
Length at road level	:	2,200 ft.
Storage	:	36 m. c.ft.
Benefits:		
Irrigation Stage I	:	Nil

Stage II	:	16,000 m c.ft. of water.
Stage III	:	Nil
Power:		
Stage I	:	240,000 kw
Stage II	:	480,000 kw
Stage III	:	90,000 kw
Cost Stage I	:	Rs. 39 crores

A Problem Project

IF NINE OUT of ten irrigation projects suffer from bad planning, some of them also have the misfortune of incompetent execution. Nagarjunasagar is a typical victim of both.

Nagarjunasagar is a problem project as much because of the never-ending nature of its planning as because of the extremely difficult terrain. Four years after the commencement of construction—it was February 1956, to be precise—neither the scope of the project nor its cost estimate has been finalized.

A rough estimate in 1954 put the cost at Rs 75.08 crores. This was changed soon after to Rs. 84.87 crores, due to some expansion in the scope of the project and certain modifications in the design of the dam. The estimates were again revised to Rs. 86.57 crores in 1956 and yet again in 1959 to Rs. 91.12 crores because of increases in the cost of materials, rise in wages, provision for field channels on the left canal to ensure uniformity with the right canal and a distribution system for an additional 1.5 lakh acres, not provided in the earlier estimates. It is significant that this net increase of Rs 4.55 crores over the 1956 estimates is in spite of economies to the extent of Rs. 2.2 crores secured on account of replacement of concrete by cement mortar, procurement of surplus machinery from other projects and savings by departmental working and public participation.

The project also has a second stage, when the height of the dam is proposed to be raised from 330 ft. to 380 ft. to augment the storage from 5.44 million acre-feet to 9.3 million acre-feet and to increase the irrigation potential from two million acres to 3.2 million acres. Generation of 75,000 kw of firm power is also contemplated. The total cost of the two stages is estimated at about Rs 137 crores.

These engineering projections have little meaning from the point of view of the economics of the project. In the first place, the cost is very high. Secondly, it is certain that the two stages will not be completed within the estimated cost. Thirdly, the Nagarjunasagar reservoir is unlikely to get all the water it proposes to store. In any case, the pre-

sent quantity of the waters of this inter-State river allotted to Andhra Pradesh is far too inadequate for the huge requirements of Nagarjunasagar, which has the world's largest masonry dam. Fourthly, the extent of lift irrigation required and the difficulties associated with it have not been fully reckoned. Last but not least, the benefit of irrigation goes mostly to the Rayalaseema districts, and the realization of reasonable revenues on the basis of the high cost of the project from the politically powerful people of this region will be the biggest surprise of our irrigation ventures. The optimistic assumptions of the authorities in this respect cannot be taken too seriously.

By its very nature, Nagarjunasagar is a costly project. Excavation work costs about Rs 170 to Rs 180 per 100 c.ft., which is much more than in most other places. This is partly because almost every inch of work has involved the cutting of hard rock. Canal work also costs considerably more than elsewhere, as the level of the canals is high and as they have to traverse difficult terrain. The right bank canal alone is estimated to cost about Rs 65 crores in the final stage. This canal will, in the first stage, be 133 miles long with a capacity of 11,000 cusecs. In the second stage, this is proposed to be extended to 271 miles and deepened to carry a discharge of 21,000 cusecs, the largest for any canal in the country. The Bhakra main canal, 40 miles long, carries 12,500 cusecs and the Rajasthan canal, 415 miles long, carries 18,500 cusecs. The two main canals taking off from the dam run through extensive and difficult hilly terrain before reaching the plains. At the head, they pass through tunnels more than a mile long.

The authorities have also added in no small measure to the high cost of the project. Though ideally suited for departmental execution, most of the construction work has been farmed out to contractors. The only good thing is that the canal contract has been split into small units and entrusted to more than a hundred contractors. The labour co-operatives organized by the Andhra State Co-operative Department have also been given some small canal contracts on commercial terms. But the Bharat Sevak Samaj, which has done a good job at Kosi, enjoys certain unfair privileges. It is difficult to justify why no security has been sought from the BSS against the contracts entrusted to it as in the case of other contractors including the labour co-operatives. What is worse, the BSS has been given advances for purchase of equipment.

The wage bill of the project has also been revised recklessly. This, perhaps, is attributable more to the bargaining power of organized labour than to the dearth of labour in the sparsely populated project area. It is disappointing that the Andhra Pradesh Government, which was a partner in the Tungabhadra project, has not taken timely measures to absorb the experienced labour discharged on the completion of Tungabhadra.

The Nagarjunasagar dam completely lacks compactness and gives the impression of a loosely executed project. The miles and miles of roads, the housing colonies scattered all over and the luxurious rest houses, which befit a modern tourist centre rather than a modest irrigation project, leave one in no doubt about wastages on a large scale.

There is criticism against the indifference of the project administration. Evidently, the project is too big for the people who are administering it. The authorities are not altogether unaware that only drastic measures can avoid the recurrence of another unfortunate Hirakud at Nagarjunasagar.

The Nagarjunasagar project is not the only instance of incompetent execution in Andhra Pradesh. There is the even more unfortunate episode of the Kadam dam, situated on the tributary of the Godavari at Kadam, 50 miles north of Manchirial. This dam, costing about Rs 1 crore, collapsed in the very first year of its commissioning. Although constructed in 1956, no storage was done even in 1957 on the plea that the water channels were not ready. Water was stored the following year and the dam collapsed. While the authorities attribute this to "unprecedented floods," others say that the earthwork and masonry were unequal to the contemplated capacity of the dam.

The Nagarjunasagar project will not end with the second stage. It is proposed to link it with a 330,000 kw power dam to be built on the Krishna at Srisailam in Kurnool district. This scheme, expected to cost about Rs 6 crores, envisages the construction of a reservoir and a power station at Srisailam in the lower Krishna basin, instead of the originally proposed two irrigation-*cum*-power reservoirs at Sidheswaram and Srisailam and separate power houses at each of the dams. The installed capacity at the Srisailam power house under the new plan will be three units of 110,000 kw each. Although the Andhra Government has taken the scheme for granted, it does not appear

to be free from all difficulties. As the project proposes to utilize the waters of the Krishna basin, and the re-allocation of the waters among the States of Maharashtra, Mysore, Andhra Pradesh and Madhya Pradesh has not been finalized, the Mysore Government is stated to have made it clear to the Centre and the Planning Commission that any new scheme on the Krishna basin should be deferred till the allocation of the waters of the river is settled. Meanwhile, the Planning Commission has sanctioned the investigation of the project.

The ambitions of the Andhra Pradesh Government are beyond its capacity to manage. The State Government is now considering a Rs 50-crore project at Pochambad on the Godavari, envisaging irrigation of another two million acres. The Bombay Government seems to be objecting to this scheme not only because the allocation of the waters of the Godavari among the concerned States has not been settled but also because a part of this water flows into the Krishna, which again is a disputed river. The former Bombay State, it appears, had accepted some sort of a scheme regarding the sharing of the Godavari at the instance of the Planning Commission. With the re-organization of the State, Bombay is now said to be insisting on a fresh and clear-cut allocation arrangement. It is difficult to understand the Andhra Government's hurry to take up the Pochambad project, particularly in view of the fact that Nagarjunasagar will itself take 20 years for full development. If the State Government is attempting to swallow much more than it can chew, it is presumably because too many resources have been thrust on too small a State too suddenly as a result of the reorganization of States.

NAGARJUNASAGAR

Type	:	Masonry and earth
Height	:	380 ft.
Length	:	3 miles
Storage	:	9.3 m. acre ft.
Waterspread	:	110 sq. miles
Benefits:		
Irrigation	:	3.2 m. acres
Power	:	75,000 kw
Cost	:	Rs. 137 crores

Between Two Borders

TUNGABHADRA IS INDIA'S most beautiful dam but its execution has been most difficult. That it has been so in spite of the project being so natural is because of the political controversy this border dam was caught in.

Tungabhadra is of course not India's only border dam, but it has no parallel anywhere in the world as a dam constructed from opposite banks of a river by two independent builders. The planning, execution and maintenance of the project have been and continue to be done by two separate State Governments, two independent chief engineers and two different corps of workmen.

No wonder the project has the unenviable record of a double century It will have taken more than a hundred years when it is finally completed by 1963-64 and its total cost will also exceed Rs 100 crores. The story of Tungabhadra is thus almost ancient history. The endemic famine regions of Rayalaseema attracted the attention of engineers as early as 1861, when preliminary proposals to harness the waters of the Tungabhadra were made. Several other schemes that subsequently came up also did not materialize.

The credit for the real inception of the project goes to Col. Smart, a Chief Engineer of Madras, who in 1902 proposed the construction of a large reservoir on the Tungabhadra with a high-level canal. Nothing, however, happened for another 40 years because the Governments of Madras and Hyderabad could not reach agreement on the allocation of the waters of the river. In 1942 an agreement in principle was reached between the two States to investigate the project on the basis of a common reservoir and a low-level canal in addition to a high-level one.

An agreement was signed between the two States in 1944, under which the main dam was to be constructed by the two States independently from their respective opposite banks of the river. It was also settled that the low-level canal should be taken up in the first phase in view of the feasibility of power generation and also on account of its lower cost. Following this agreement for a partial utilization of the waters, construction work began in 1945. But

the project suffered many vicissitudes as a result of this dual execution and also because of the difficult attitude of the Hyderabad Government, especially during the days of the Razakar trouble. With the formation of Andhra in 1954, the part of Bellary district in which the dam is located was transferred to Mysore and Madras ceased to be a partner in the project. The subsequent larger reorganization of States saw the disappearance of Hyderabad and today the project is the bone of contention between Mysore and Andhra, neither of which originally had anything to do with it.

The Union Government, in the meantime, constituted a common Control Board comprising representatives of the two States and of the Centre. The Board was reconstituted in 1955 and granted statutory powers. It was made responsible for the completion of the unfinished portion of the dam and the regulation of water from the headworks. But the area of control of the Board is limited and the project continues to suffer from artificial divisions of power, responsibility, interest and administration. The physical demarcation of the administrative control of the dam is absurdly artificial. The discharge of water over the spillway is regulated by 33 steel lift gates, each 20 ft. high and 22 ft. wide, with a span of 60 ft. Of these, 15 gates on the Hospet side are maintained and operated by the Control Board, and the remaining 18 gates on the Munrabad side by the Mysore Government.

A visitor to the project cannot help the feeling that the location of the southern half of the headworks in Mysore State has been prompted by purely political considerations. The canal head gates, the spillway gates and both sets of turbines are all there, although the use of water and power alike is mostly in Andhra. Under the existing dispensation, 80 per cent of the presently planned power and 55 per cent of water have been allocated to Andhra. The dependence of Andhra cultivators and customers of power on the headworks of Mysore is obviously unnatural.

The political metamorphosis and the administrative changes have resulted in bad planning. The canal and development schemes have not kept pace with work on the main dam. Even the left-bank canal, which will irrigate 580,000 acres, has not been completed yet. Work on the high-level canal, expected to irrigate 500,000 acres, has just been taken in hand. Consequently, although the main dam with a

storage capacity of 1.2 million acres was completed in 1953-54, much of the water is still not put to productive use.

This large-scale non-utilization is, however, not wholly attributable to the unrealistic canal programme. The problem of developing irrigation in areas like the districts of Raichur, Bellary and Kurnool where wet cultivation has been practically unknown is not an easy one. This is further aggravated by the fact that the average size of the land holdings on either bank of the river is about 10 to 15 acres, which clearly is beyond the capacity and resources of the local people to put to intensive cultivation. The inevitable impact of the carefully worked out crop rotation scheme is also there. Under this "localization" scheme, successfully operating in the districts of Raichur and Bellary, the crop pattern for every bit of land has been specified and the exact quantity of water fixed. Out of the 660,000 acres to be irrigated in Raichur and Bellary districts, 80,00 acres have been localized for paddy, 30,000 for sugarcane and the remaining 550,000 for light irrigation. The canals and field channels have been accordingly designed.

The development of the Tungabhadra irrigation system, though slow, is thus well planned. The localization scheme, with all its practical and administrative difficulties, has its own advantages. Several new centres of trade and industry based on the different commodities of different regions have come into being. For instance, the rich sugarcane area adjoining the project has attracted four sugar factories, where there was till recently only one sugar mill.

The high-level canal, as is now designed, is unrealistic. Prompted purely by the consideration of cutting the coat according to the cloth, the Planning Commission has decided against the lining of his canal. This decision is likely to create another Rajasthan canal in Tungabhadra. The lined canal will carry 4,000 cusecs of water against only 2,700 cusecs in the case of the unlined canal. There are also other advantages in lining the canal now. The stones cut during the construction of the canal can be used for the lining. The labour force can be mobilized more easily now. If the lining is to be done later, there is the danger of dislocation of irrigation, since the canal will be the sole source of supply for the area proposed to be irrigated by it.

The programme on the power side is also executed in two stages. The first phase including the installation of five

turbines—two of 9,000 kw each in Hampi power house—is nearing completion. When the second stage, now under way, is completed, the firm power capacity of the project will be 52,000 kw and the seasonable power will be increased to 58,300 kw. The two participation States of Andhra and Mysore had agreed to allot necessary funds in their yearly budget for the execution of the second stage of the power scheme. The response of the Mysore Government is not as good as may be expected. This, presumably, is because of the State Government's preference for power projects on the Western Ghats in view of their relative cheapness.

The Tungabhadra project will bring 12.1 lakh acres under irrigation and generate 172,500 kw of power, yielding a gross revenue of Rs. 8.4 crores. As the accounts relating to this project for the works lying on either side of the river were maintained separately by two different States from the very beginning, the financial returns are shown separately. On a rough and ready basis, the return at the end of ten years after the availability of irrigation potential is estimated at 1.75 per cent for both the canals and that for power at about 5.5 per cent.

The second power stage needs to be speeded up to improve the earnings of the projects. While its fresh capital cost is quite small, this stage will bring in additional revenue of about Rs. 20 lakhs annually after providing for working expenses. It is to be hoped that the unfortunate inter-State rivalry which affected the project in many ways during the days of planning and construction will not continue to infest its sound economic working.

TUNGABHADRA

Type	:	Earth, masonry and concrete spillways
Height	:	162 ft.
Length	:	7,942 ft.
Storage	:	2.6 m. acre ft.
Waterspread	:	146 sq. miles
Benefit:		
Irrigation	:	1.21 m. acres
Power	:	172,500 kw
Cost	:	Rs. 100 crores

Adventure in Hydrology

KUNDAH IS A great adventure is hydrology. Attempting to generate the largest possible power from one of the smallest rivers in the country, it is the biggest scheme so far undertaken by the Madras Government.

The project, situated in the Nilgiri Hills, envisages a series of inter-connected storages for the waters of the Kundah, the upper Bhawani rivers and their tributaries. These waters will be utilized for the generation of power in their descent from the Nilgiris and then trapped for irrigation behind the lower Bhawani dam, which was built five years ago. This plan to squeeze energy from every ounce of falling water in the Nilgiris, which catches both monsoons and has a rainfall ranging between 60 inches in the west and 140 inches in the east, will involve the construction of a dozen dams at an elevation of over 6,000 ft. inter-connected by a series of tunnels aggregating 25 miles in length.

The Kundah river itself is formed by two small streams, the Avalanche and the Emerald, rising amidst a group of high peaks of over 8,000 ft. high. The two streams have been separately dammed in such a way that the two reservoirs make a single lake. They have also been interconnected at the bed level by a half-mile-long tunnel. The stored water is let into a narrow canal and then into a three-mile long tunnel cut into the hills and dropped 1,177 ft. through penstocks to the first power house. The tail race water is again caught behind the Forebay dam with a catchment area of 44 square miles and let into another hydel canal and pressure tunnel to give a fall of 2,470 ft. at a place where the second power house is located.

The second stage includes a reservoir on the Upper Bhawani to be connected with the Avalanche-Emerald lake through a two-mile long tunnel. This additional storage will increase the generating capacity of the two power houses from 145,000 kw to 180,000 kw.

The total head of the Kundah scheme is much bigger than Asia's highest head of 3,080 ft. in Pykara, also in the Nilgiris. Of this, the present phase under construction will

utilize a drop of 3,647 ft. and the third stage the remaining drop of 1,712 ft. The fall in the third stage is proposed to be utilized in two stages in two power houses. The third power house will have an installed capacity of 120,000 kw in three units and the fourth power station 90,000 kw in two units. In addition, a third unit at the first plant and a fifth unit at the second plan, now under construction, and an auxiliary station to utilize the fall between the Upper Bhawani and Avalanche reservoirs with an installed capacity of 15,000 kw are also envisaged. The total installed capacity of the project after the completion of the third stage will be 420,000 kw. The first phase, which includes the first two stages, is estimated to cost Rs. 35.44 crores and the last phase Rs. 22.81 crores. The return on the capital cost of the first phase which includes that of transmission lines, sub-stations, and so on, is estimated at 4.5 per cent.

The penstocks at Kundah are made of special grade high tensile steel, which is readily weldable without pre-heating or stress-relieving. It has three times the yield strength of ordinary steel and four times the atmospheric corrosive resistance of carbon steel. This is the first time that such a type of steel is being used in India for penstock pipes.

The first two stages of the project are being executed simultaneously because they are inter-dependent. The work is in full swing at the three dam sites, the three tunnels, the two penstocks and the two power house sites. All the headworks connected with the first power house have been completed. The first plant and the transmission lines of both 110 kv and 230 kv have been commissioned for commercial use. The first unit of the second plant is also ready for commissioning. The progress at the Upper Bhawani dam site is impressive. The first phase is expected to be completed by 1960-61.

It is a matter of legitimate pride that the first phase of this mammoth scheme, with work sites extending over several miles in high altitudes, has been commissioned in the record time of about three and a half years. The credit for this goes to the perfect co-ordination among the engineers, contractors and manufacturers, both in India and Canada. The project, which is an Indo-Canadian venture under the Colombo Plan, has received Rs. 12.5 crores from Canada, covering the foreign exchange cost of the machinery and equipment required by the project. The Canadian

manufacturers have in a number of cases advanced their schedule of delivery equipment.

Even more worthy of appreciation is the fact that the project administration has effected a saving of about Rs. 2.5 crores in the work so far executed, thanks to judicious planning, economic execution, vigilant supervision and control of expenditure at every stage.

If Kundah will result in optimum utilization of all available waters in the Nilgiris for power generation, and then irrigation, the achievements of the more modest Mettur project are not as small as its cost. Although the Mettur project had the biggest masonry dam in the world when it was completed in 1934, it cost no more than Rs. 4.8 crores, much below its estimated cost. That a 177-ft. high masonry dam was constructed at so cheap a cost is not a little due to the efficient financial control in the days of its execution. The Mettur project was the first to introduce the scheme of combined audit and accounts, under which all payments used to be made after the bills were pre-audited by the audit officer. Care was also taken to ensure against any delay in payments; a sub-treasury was opened at the dam site to facilitate the cashing of cheques drawn by the audit officer. This practice is followed with advantage in all projects in the State. Even the Tungabhadra project benefited by the scheme to some extent.

Although there has been much delay, the project has now the record that the Cauvery, the waters of which have been impounded by it, is the only river in the country which has reached maximum utilization of the waters. Hardly 5 per cent of the waters of this river go into the Bay of Bengal, including the monsoon flow. The State has an even more attractive record in that two other relatively small rivers, namely, the Tambarabarani and the Vaigai, do not send any water at all to the sea. This is by no means an accident. The latest slogan of the Irrigation Department of Madras is "not a river drop to the sea."

The Mettur project is now working on an expansion programme. This tunnel scheme envisages the utilization of an irrigation discharge of 20,000 cusecs at the main dam to generate seasonal power for about seven months in a year from July to January. During this period, the storages in the Kundah and Pykara basins will be conserved to the extent necessary for utilization in the summer months for

firming up the Mettur power. Based on consultations with the Central Water and Power Commission, the programme is proposed to be executed in two stages. The first stage, which involves the construction of a power house with an installed capacity of 100,000 kw in two units and utilizing 10,000 cusecs, is expected to be completed during the third Plan period. The second stage, with an identical programme, will be taken up later.

With the commissioning of the Mettur tunnel scheme, the final phase of the Kundah and Periyar projects, Madras will lead all the other States in hydro-electric output. The State has built up an extremely well-organized electricity grid extending into all the districts and rural areas. The State is also taking the lead in the direction of establishing super-zonal grids, on which the Centre is keen but unable to show any results.

A striking feature of the Madras Government's transmission scheme for the third Plan is the formation of a 220 kv super-grid. This will facilitate effective utilization of power within the State and also efficient interchange of power between Madras and neighbouring States.

The super-grid contemplates the construction of a 220 K.V.D.C. line from Neiveli to Singarapet, Neiveli to Madurai and a 220 K.V.S.C. line from Tudiyalur to Kundah. It is proposed to inter-connect Madras and Mysore and Madras and Kerala by 220 K.V. lines. The interconnection with Andhra Pradesh is to be taken up later. Initially, it is proposed to consider the possibility of interchange of 50,000 kw between Madras and Mysore and an equal amount between Madras and Kerala, Singarapet and Madurai will form the linking points with Bangalore in Mysore State and Peermedu in Kerala State.

Madras and Mysore, as pioneering States in irrigation and power generation, offer many object lessons for projects in other parts of the country to follow with advantage.

KUNDAH

Type	:	Concrete:
Stage I:		
Avalanche and Emerald		
Height	:	200 ft. each
Length	:	1,200 ft. each
Combined storage	:	5,400 m. c.ft.

Stage II:		
Upper Bhawani dam		
Storage	:	3,047 m. c.ft.
Stage III:		
Six more dams	:	
Storage	:	2,700 m. c. ft.
Total head	:	5,359 ft.
Tunnels	:	25 miles
Power:		
Stages I and II	:	180,000 kw
Stage III	:	240,000 kw
Cost:		
Stages I and II	:	Rs. 35.44 crores
Stage III	:	Rs. 22.81 crores

METTUR

Type	:	Masonry
Height	:	176 ft.
Length	:	5,300 ft.
Storage	:	93,500 m c ft.
Waterspread	:	60 sq. miles
Benefits:		
Irrigation	:	1.35 m. acres
Power	:	40,000 kw
Cost	:	Rs. 4.8 crores
Expansion:		
Stage I Tunnel		
Power Seasonal	:	100,000 kw
Cost	:	Rs. 5 crores
Stage II:		
Power	:	100,000 kw
Cost	:	Not estimated