

# OUR RIVER VALLEY PROJECTS



THE PUBLICATIONS DIVISION  
Ministry of Information and Broadcasting  
Government of India

*July 1961 (Asadha 1883)*

**Rs. 1.25.**

**PUBLISHED BY THE DIRECTOR, PUBLICATIONS DIVISION, MINISTRY OF  
INFORMATION AND BROADCASTING, AND PRINTED BY THE MANAGER,  
GOVERNMENT OF INDIA PRESS, FARIDABAD**

## CONTENTS

Chapter	Page
I. INTRODUCTION ..	1
II. THE MAJOR PROJECTS ..	13
Damodar ..	13
Bhakra Nangal ..	24
Hirakud ..	35
Tungabhadra ..	43
Kosi ..	50
Rihand .. .. .	53
Kakrapar .. .. .	56
Mayurakshi .. .. .	59
Bhadra .. .. .	62
Matatila .. .. .	64
Ghataprabha .. .. .	67
Koyna .. .. .	69
Chambal .. .. .	71
Nagarjunasagar .. .. .	76
Lower Bhavani .. .. .	79
Mahi .. .. .	82
III. IRRIGATION AND POWER .. .. .	84
IV. FLOOD CONTROL .. .. .	99
V. INLAND NAVIGATION .. .. .	109
VI. RESEARCH AND TRAINING .. .. .	115
VII. PUBLIC CO-OPERATION .. .. .	122
VIII. AMENITIES FOR WORKERS .. .. .	126

APPENDIX I. UTILISATION OF WATER RESOURCES IN IMPORTANT RIVER BASINS ..	130
APPENDIX II. PRINCIPAL PROJECTS IN FIRST PLAN	131
APPENDIX III. PRINCIPAL PROJECTS IN SECOND PLAN	132
APPENDIX VI. PRINCIPAL POWER GENERATION SCHEMES IN SECOND PLAN ..	136

## CHAPTER I

### INTRODUCTION

Rivers have always played a vital role in India's history. Beginning with the Indus and its tributaries in the far North down to the Kaveri in the far South, all the great rivers of this sub-continent have cradled ancient civilisations. Along their banks some of the earliest settlements were made and most of the ancient cities grew up. For countless centuries the people of India have cultivated the fertile river valleys and derived sustenance from them. One has only to look at the physiography of India to realise how important are the country's river-systems to the economy and well-being of its 400 million people, most of whom are still dependent on agriculture. Small wonder that for centuries we have regarded these life-giving rivers with abiding sentiments of love and reverence.

If rivers have moulded India's past for untold centuries, they have also moulded our vision of the country's future. We are today raising on their beds the foundations of our prosperity on a scale hitherto unknown in our nation's history. Millions of dry acres are being transformed into smiling agricultural fields; new transmission lines are carrying cheap electricity to innumerable villages and towns, factories and mills; vast new reservoirs have been or are being built to absorb much of the flood waters and minimise the devastation of our countryside.

There is still another way of looking at the river projects. It is common knowledge that our country is rich in minerals and manpower. India's deposits of high-grade iron ore are hardly to be matched anywhere in the world and her resources are plentiful in alloy-minerals, fluxes and refractories like manganese, chromite, quartzite and fireclays which are all adjuncts to iron metallurgy. India's coal reserves, too, are not inconsiderable, the country being the seventh biggest producer of coal in the world. Besides, India holds a strong position in some rare or strategic minerals like

beryls, monazite and ilmenite, and innumerable other minerals of lesser importance are also available. These are our real sources of wealth. With these resources we can manufacture a wide variety of goods which are badly needed to make our life richer and happier.

In order to be able to do that we must have cheap electric power supply in plenty and a broad agricultural base for our economy. Even as we build new factories and mills, that base must keep on expanding for two strong reasons: ours is a growing population which makes increasing demand for food production; ours is also a growing industrial economy with more and more factories coming up and demanding more raw materials and power. Our problem is, therefore, one of being able to produce food and agricultural raw materials in quantities sufficient to build and maintain a prosperous economy. This would mean, first of all, that we make sure that timely and adequate supply of water is available to irrigate our lands and churn new power generators.

Talking of irrigation, we all know how greatly our country has been and is still dependent on rains. India's agriculture has often been described, and rightly, as a gamble in rains. Before we commenced our first Five Year Plan, four-fifths of our cultivated area was dependent on rainfall which, when it comes, is either too much or too little. This resulted—and still does, though to a lesser extent—in failure of crops in one region or the other of India, bringing great misery to our peasants who are already poor. When such a thing happens Government has to rush help to the affected areas at great expense. In this atmosphere of insecurity how can scientific cultivation be possible?

There is still another powerful cause for the insecurity of Indian agriculture—the flood havoc caused by some of India's rivers almost every year during the monsoons. This is how it happens. There are in all about 110 rivers in India, some of them big and perennial, others small and seasonal. On the average each of them has a catchment area of about 1,000 square miles. The total annual flow of water in these rivers, estimated at 1,356 million acre-feet\*, is enough to cover the

---

\*One acre-foot is equal to 43,560 cubic feet.

entire country to a depth of more than 1.5 feet! Of this, only 450 million acre-feet can be used for irrigation. But we had utilised only about 76 million acre-feet till 1951, representing barely 17 per cent of the usable resources. Even with the completion of the second Plan we will have utilised barely 26 per cent of this water!

The total volume of water carried by our rivers does not flow uniformly right round the year. Barring the snow-fed rivers rising in the Himalayas, which are perennial, all others are dependent on monsoon showers which are confined to five months in the year—between June and October. If it happens to be a weak monsoon, millions of fertile acres are converted into a simmering desert with their plants and trees desiccated. If it is a strong one, the rivers swell to many times their normal size and submerge vast regions. Villages are destroyed, crops are wiped out, cattle and men get marooned without fodder or food, and roads and railway tracks are washed away. As the floods recede, they carry away the precious top layers of soil from fields and leave them less fertile. The Damodar, the Kosi, the Gandak, the Teesta, the Brahmaputra, the Mayurakshi, the Mahanadi, the Jhelum, the Tapi and some other rivers have been known at one time or another to cause such havoc. Many other smaller rivers, too, whose beds will be entirely dry during summer are turned into rolling mass of water during the monsoon. Singly, these floods can be the greatest challenge to the economy of a country. But together with the prospect of uncertain rainfall in the next season it can break the spine of any economy as in fact it has done in India.

Under these conditions agriculture becomes abnormal. In sheer desperation a large number of cultivators are just content to have meagre 'catch' crops at little expense and effort. In the absence of assured water supply they grow only one crop where two or perhaps three can be raised. The fear of drought and floods robs the peasant of initiative and enthusiasm for better methods of cultivation. If these recurring dangers to agriculture are to be reduced, there is only one solution; we must have a nation-wide plan to control these rivers through multi-purpose projects designed to give to the peasant all that he needs—protection from floods, water

by flow irrigation and electricity with which to work pumps and factories.

#### ELECTRICITY FROM RIVER WATERS

In India today 'river' has become a magic word connoting power in its literal and figurative sense. In a way all our development plans depend for their success on our capacity to produce cheap electricity on a large scale. 'Hydel', meaning electricity generated from river waters, is the main key to industrial development, particularly the small-scale industries which are linked to agricultural occupations. Cane and oil-seed crushing, cotton weaving and food-processing are instances in point. In pure agriculture, too, cheap power can play a vital role. In high-lying areas which our networks of canals fail to reach, cultivators can use hydel power to pump underground water to irrigate their lands.

It is estimated that our rivers are capable of producing over 40 million kilowatts of electric power. This is indeed a great quantity. We shall have to utilise a considerable part of this potential power to work our mines and factories, to light our streets and houses and even to pull our trains. But we have so far exploited only a small fraction of this potential wealth. Figures show how little electricity India produced before the first Plan was started in 1951. On the average we had a meagre 14 kilowatt hours of electricity available per head of our population as compared with 1,100 kwh in the United Kingdom, 2,207 kwh in the U.S. and 3,905 kwh in Canada. In many parts of India the average was well below one unit per head per year. Even in regions where electricity was produced, the towns and cities got the lion's share and the villages were left neglected. All our talk of making the country strong and prosperous will have little meaning unless we take electricity to the villages. This is a great and mighty task.

#### INLAND NAVIGATION

River valley projects are important also for another reason. They can revolutionise our inland transport by creating facilities for canal navigation in many regions. At present river traffic exists only in certain parts of Assam,



Bihar, West Bengal, U.P., Orissa, Andhra Pradesh, Madras and Kerala. Besides being cheap, inland water transport can also help relieve pressure of traffic on the railways and the roads. River and canal navigation will be of great benefit particularly to the cultivators who produce primary articles like cotton, jute, sugarcane, foodgrains, etc., and need a cheap and dependable mode of transport to convey them to factories and other markets.

### NATIONAL POLICY AND PLANNING

These are, in brief, the main objectives for which river valley projects have been taken up as a major programme in India's Five Year Plans. The first Five Year Plan became formally operative from April 1951, nearly four years after Independence. But quite a few schemes which were included in the Plan had already been started earlier. Earlier still, a beginning had been made under British rule to use river waters for irrigation. The Indian Irrigation Commission which submitted its report in 1903 had recommended lines of policy for the selection, financing and maintenance of irrigation works. As a result of these recommendations a number of new works were taken up.

But there was one serious flaw in the projects that were taken up before Independence. They had not been conceived as part of a larger programme of national development. They were treated as individual schemes intended mainly for irrigation and secondarily for generation of power. So they had almost nothing to do with flood control for which embankments were generally considered adequate. Nor were they integrated with suitable schemes for starting new industries in regions known to be rich in minerals.

### PLANNED DEVELOPMENT

But the country continued to suffer from floods, drought and famine because these projects were sufficient neither to ensure irrigation over a wide area nor give protection against the ravages of floods. Today we view river-valley development in an entirely different perspective. We see them as the basis of India's prosperity, agricultural as well as industrial. They are to provide not only irrigation and prevent

floods but produce power and create new facilities for Indian industry and transport.

The river-valley schemes taken up during the first and second Plans are enormous undertakings. Some of them have been already completed and others are on the point of completion. In addition to the big multipurpose projects there are those which are purely meant for irrigation, like the Harike in the Punjab, Rajolibunda Anicut in Andhra Pradesh, Ghataprabha in Mysore, Mahi in Maharashtra, Kakrapar in Gujarat, Jawai in Rajasthan and the Malampuzha in Kerala. These are in addition to the purely power producing projects like the Machkund in Orissa and Andhra Pradesh, the Pykara, the Moyar and Papanasam in Madras, the Sengulam in Kerala, the Sharavati in Mysore and the Sarda in Uttar Pradesh. Situated in various parts of India these projects cover some of the potentially richest regions in the country.

#### NATIONAL POLICY

Besides the big multipurpose irrigation and power projects, there are many medium schemes costing between Rs. 10 lakhs and Rs. 5 crores each. The total cost of major and medium irrigation schemes included in the first two Plans is estimated at Rs. 1,400 crores. The investment made on these schemes amounted to Rs. 380 crores in the first Plan and about Rs. 390 crores in the second Plan. Some of these projects like the Bhakra Nangal and the D.V.C. are among the biggest of their kind in the world.

The task of building these innumerable projects involves a great deal of skill and organisation. Simultaneous work on dozens of projects, big and small, calls for co-ordinated effort on a country-wide scale. Thousands of skilled and unskilled labourers are needed. Enormous quantities of steel and cement have to be procured. Costly machines for digging, levelling and dumping have to be imported and a large number of technical personnel are required to man them. Detailed plans have to be prepared and the works have to be supervised at all stages of progress. As the dams are completed, whole groups of villages are submerged and lakhs of villagers have to be rehabilitated. Channels have

to be dug and transmission lines laid to take electricity from the generating stations to remote parts of the country. All these require organisation on a large scale.

Before 1920 irrigation projects were being sponsored by the Central Government. Then came the constitutional changes which transferred irrigation and power to the responsibility of the State Governments. But the great Bengal famine of 1943 and the flood havoc in the Damodar Valley again underlined the need for a national policy for developing river resources. While the States continued to retain their initiative in the field of irrigation and power, it was thought that the Central Government should formulate a national policy on river valley development. The works that were already in progress also presented difficult problems for the engineers and organisers. Some States did not possess the resources or organisation necessary to plan and execute large projects. Besides, since most of the major rivers flow through more than one State, any utilisation of their waters could be done only as a joint undertaking. If they happened to be big projects involving large financial outlays much beyond the resources of the State, the Central Government alone was in a position to supply the funds. All these factors necessitated central direction and control.

When the first Plan started, India's total irrigated area was 51.5 million acres, of which 22 million acres were irrigated from large and medium projects. We aim to create an additional potential of 28 million acres through large and medium schemes by the end of the third Plan. As for power, the aim is to produce about 13 million kw by 1965-66 compared to 2.31 million kw in 1951. All this is possible of achievement only if we have an adequate machinery capable of ensuring speedy and efficient work on the projects. Apart from the requirements of long range projects the growing tempo of work that had already been started by 1951 like the Damodar, Bhakra Nangal and Hirakud, together with other urgent schemes for power generation and flood control made heavy demands on the administration.

In view of these new needs, the Union Government created the Ministry of Irrigation and Power in 1952. The

Ministry thus constituted is in turn assisted by the Central Water and Power Commission which undertakes basic work pertaining to the river valleys, irrigation, hydro-electric power, navigation and technical examination of irrigation and power schemes proposed by the State Governments for inclusion in the Five Year Plans. When in 1954 India suffered from exceptionally severe floods, the work of formulating an integrated flood control programme was entrusted to the Commission. The Commission has thus come to consist of three wings, namely, the Water Wing, Power Wing and Flood Wing.

#### PROBLEMS OF ORGANISATION

Within a year of its establishment, the Ministry came up against a bewildering variety of problems, technical as well as administrative. Of these, the foremost was that of technical personnel. It had been difficult to meet the demands for technical staff of the requisite calibre from various parts of the country for the performance of many functions which the Centre had undertaken on behalf of the States. These circumstances emphasised the need for a proper co-ordination and phasing of projects and training programmes.

Such co-ordination became necessary also in the use of machines at project sites. Already many machines worth crores of rupees had been acquired. These machines frequently come up for repairs which, if not speedily attended to by expert hands, would impair total output of work. Apart from good maintenance, there was also great need for a well-defined policy to govern the purchase of plants and spare parts. Absence of such a policy would mean that standardisation of equipment and interchange of spare parts from one project to another would become difficult.

On top of these problems cropped up a new difficulty. The cost of some of the major river valley projects went up for reasons which could not be foreseen. This could prove a serious hurdle unless attempts were made to evolve a scientific basis for estimates and provide for suitable checks on expenditure. One way of effecting both economy and speed in the execution of work was to deploy the available machinery, equipment and skilled personnel in such a way as to

derive maximum benefit without additional cost. Speedy execution of work was necessary if the projects were to yield irrigation and other benefits even while the work on projects progressed. Economy in expenditure would ultimately mean that our farmers and manufacturers could obtain water and power at minimum expense.

### REMEDIAL MEASURES

What have we done to solve these innumerable problems of organisation? The Government started by appointing expert committees to go into the various problems such as utilisation and standardisation of plant and machinery, rates and costs, cost accounting and technical personnel. The recommendations made by these committees have brought about considerable saving in money and effort. As a result engineers and skilled workers are more uniformly distributed. Machines go out of order less often now and operation costs are considerably less. Common problems regarding technical and organisational matters in the major river valley projects are discussed in the Engineers' Seminars which are organised periodically. The discussions held at these seminars have greatly benefited our technical personnel. A co-ordination board consisting of Ministers of the State Government has been set up to consider the recommendations of these seminars and take quick decisions on questions of policy.

### RATES COMMITTEE

A Rates Committee was set up in 1954 to examine the question of rates and costs and recommend a basic schedule of rates for manual and machine work on the projects. The Committee made a number of valuable recommendations the more important of which are: (i) introduction of cost accounting cells on major projects; (ii) revision of the existing system of classification of accounts and stores and introduction of the decimal system; (iii) preparation of manuals on costing and stores; (iv) standardisation of machinery and of life tables therefor; (v) scaling down of provision for contingencies for works; (vi) formation of a Central Clearing House for prompt disposal of surplus

equipment and stores; and (vii) making the river valley projects a Central subject.

#### COST ACCOUNTING

A good deal of progress has also been made regarding the introduction of cost accounting of the projects. This system has been introduced in the Damodar Valley Corporation, Bhakra and Hirakud. A beginning has also been made in intensive costing on the Nagarjunasagar project, while an accounts organisation is being established at Chambal and Kosi. At Rihand, where major civil works are being executed through a contractor, a small nucleus organisation has been set up for the purpose of cost accounting. A similar organisation for the Koyna project is also being contemplated.

There is also a cost accounting unit in the Central Water and Power Commission. This unit will co-ordinate the work on the various river valley projects, advise the project cells, scrutinise returns to find out the trend of costs and recommend measures for keeping them down.

#### TRAINED PERSONNEL

The Committee which was set up in 1954 to assess the demand for trained personnel has computed the requirements of personnel of various categories, particularly in respect of the work to be undertaken in the next five years. It has also made recommendations regarding training programmes and the pooling of personnel on a zonal basis.

#### NATIONAL PROJECTS CONSTRUCTION CORPORATION

In order to effect economy in the construction of the projects and to carry out the programmes more expeditiously, the National Projects Construction Corporation was set up in 1957. To begin with, the Corporation has undertaken the construction of certain works on the Chambal Project Canal system, and this is being followed up with works on the Badua Dam and Kosi Barrage in Bihar and the Wazirabad Barrage in Delhi.

#### CONTROL BOARDS

Also, Control Boards have been set up not only for the river valley projects on the inter-State rivers but for major

multi-purpose projects falling entirely within one State. At present, the Control Boards are functioning at seven projects namely, Hirakud, Kosi, Bhakra Nangal, Koyna, Rihand, Nagarjunasagar and Chambal. The main objective of these Boards is to ensure efficient, economical and speedy execution of the projects. The Boards are in overall charge of the projects, including their financial and technical aspects.

#### TECHNICAL ADVISORY COMMITTEE

The Planning Commission also set up a Technical Advisory Committee to advise on the priority of the projects in the second Plan. Even though the schemes are prepared by the State Governments, they are technically examined by the C.W.P.C. in the first instance to see whether necessary investigations have been carried out, the estimates of expenditure are reasonably correct and the estimates of revenue are based on adequate data. The Commission's scrutiny has, in a number of cases, resulted in improving the designs and economising expenditure.

#### WATER DISPUTES AMONG STATES

It had often happened in the past that when a river valley project affecting two or more States was taken up, clash of opinions and interests hampered smooth execution of work and resulted in wasteful delay. This sort of thing could happen because there was no adjudication machinery for settlement of disputes relating to the use, distribution and control of the waters of the rivers for which projects were planned. So the Government of India enacted two legislative measures in 1956. The first of them—the River Boards Act—provides for the establishment of River Boards for the regulation and development of inter-State rivers and river valleys. The second Act, namely, the Inter-State Water Disputes Act, provides for adjudication of disputes relating to the waters of inter-State rivers and river valleys.

An equally important measure enacted in 1956 was the amendment of the Electricity (Supply) Act of 1948. Prior to 1948, the generation and supply of electricity was governed by the Indian Electricity Act of 1910. After the War was over and the country started on a nation-wide programme

of industrialisation it was found necessary to co-ordinate development of electricity on a regional basis. The smaller towns and villages were fast coming up for a greater share of electric power under the new programmes of economic development. If the benefits of electricity were to be extended to these areas it was obvious that State Governments had to be given powers to set up semi-autonomous organisations to function on commercial lines, and promote electrical development in contiguous areas by the establishment of "grid systems". The Electricity (Supply) Act of 1948 was accordingly amended in 1956.

Under the Act as amended, a Central organisation known as the Central Electricity Authority has been set up. Its function is to develop a sound, adequate and uniform national power policy and co-ordinate the activities of various planning agencies. It provides, also, for the establishment of independent or joint corporations called Electricity Boards in the States with the object of promoting a co-ordinated development of generation, supply and distribution of electricity.



## CHAPTER II

### THE MAJOR PROJECTS

#### DAMODAR

When we think of the Damodar today we are at once filled with a sense of fear and pride—fear for the heart-rending distress it is known to cause, when in spate, to hundreds of villages, and pride for the mighty efforts we are making to tame its ferocious waters and compel it to yield wealth through irrigation and power. The Damodar is in fact the first river project of its kind to be taken up for the combined purpose of irrigation, power-production and flood-control. That is why it is called a multi-purpose project.

An innocent-looking streak of water during the dry season, the Damodar assumes frightful proportions during monsoon months. The floods, when they come, are so sudden and overpowering that they leave in their wake nothing but destruction over vast areas. People still remember with horror the devastation and pestilence caused by the Damodar floods in 1943.

Why should these floods occur at all, and when they do, why should they cause havoc on such a large scale? The answer to this question makes a tragic story. It is in fact the story of our failure in the past to preserve and strengthen Nature's own defences against the worst effects of these floods. For centuries people living in the catchment area of the Damodar River have thoughtlessly cut down trees for fuel and other purposes and never bothered to plant new ones in their place. We all know now how important trees and plants are for preventing soil from being washed away by water or blown away by wind. Apparently the people who for generations indulged in tree-cutting never cared to learn this lesson from experience. As a result vast quantities of soil have been washed away by rains from the hill slopes which drain into the river. The top soil thus washed away year after year from the upper catchment has been accumu-

lating in the river bed down below, reducing its depth and thereby its capacity to hold large quantities of water. When the river is fed by continuous rains in its upper reaches an enormous volume of water collects and rolls forward with great speed, spreading out on either side and inundating vast stretches of agricultural land and innumerable villages.

The Damodar which becomes one vast, moving sheet of water during monsoons shrinks to the size of a small stream during other seasons. The middle and lower areas of the valley have become, due to accumulation of silt over a long period, highly fertile and capable of yielding rich crops. But just when water is most needed for the fields very little of it is available. So people living in these parts suffer from frequent failures of crops. Only with irrigation is it possible to prevent such failures and make the life of millions of people in the Damodar valley happy.

Besides providing irrigation during the dry months, the Damodar Project has also other important uses. The Damodar valley is the richest zone for minerals in our country. Besides its large reserves of iron ore and coal, it contains mica, chromite, bauxite and aluminium laterite. It contains other important minerals, too, like fire-clay, china-clay, limestone, copper, kyanite, lead, silver, antimony, steatite, molybdenite and quartz.

Already, many industries vital to the economy of the country have grown round the valley. Among these are iron and steel, cement, paper, pottery, fertilizers and glass. Given cheap electric power, the industrial importance of the Damodar valley can be increased manifold.

In spite of all this potential wealth the people of this region are desperately poor. As agriculturists they are constantly faced with starvation because the Damodar, instead of being a river of plenty, has long been a river of sorrow. This has had, however, one salutary effect. It created in us a compelling incentive to action. It was decided in 1945 to tame the river and harness its resources on the lines of the TVA in the USA. But it took us three years afterwards to act on this decision and set up the Damodar Valley Corporation under whose authority the project is now being

executed and administered. A significant factor which influenced so early a decision was India's independence in August 1947. The project became a joint venture of the West Bengal, Bihar and the Central Governments.

### PROJECT FEATURES

The various schemes which the project comprised were originally programmed to be completed in two phases, the first phase comprising (i) a dam each at Tilaiya, Konar, Maithon and Panchet Hill with a hydro-electric station attached to each of them excepting Konar, and together being able to produce 1,04,000 kilowatts; (ii) a thermal power station at Bokaro with an installed capacity of 1,50,000 kilowatts; (iii) 800 route miles of double circuit transmission lines, 30 sub-stations and receiving stations; (iv) an irrigation barrage at Durgapur with 1,550 miles of canal system, including two main canals, one of which would also be used for navigation; and (v) afforestation and soil conservation measures in the upper Damodar valley. The Konar hydro-electric station was subsequently deferred for consideration in the latter part of the second Five Year Plan. All these schemes were later integrated with the National Plan and those included in the first phase of the programme became a part of the first Five Year Plan. In addition to the unfinished schemes carried over from the first Plan, the following additional schemes were included in the second Plan: (i) addition of a fourth unit to the Bokaro thermal power station with an installed capacity of 75,000 kilowatts; (ii) a second thermal power station at Durgapur with an initial installed capacity of 1,50,000 kilowatts; and (iii) further extension of 96 route miles of double circuit transmission lines and one grid sub-station.

The estimated cost of the Damodar Valley Project is about Rs. 131.71 crore, including overhead and audit charges but excluding interest on capital.

### ACHIEVEMENTS

#### *Tilaiya*

The Tilaiya is an all-concrete dam on the river Barakar, with earthen extensions on either side. It is 1,200 feet long

and 99 feet high. Its construction was started in January 1950 and completed in December 1953. Its storage capacity is 3,20,000 acre-feet. Its stored up waters were used even in the dry season of 1952-53 as the dam was still being built. This is the first straight gravity all-concrete dam to be built in India, and it was done entirely by our engineers.

Today, a thin river courses down Tilaiya for 128 miles right up to the Damodar. Previous to 1952, the river bed used to be dry and sandy for about eight months except between July and October.

A high level irrigation scheme from the Tilaiya reservoir is now under consideration. When completed, it will irrigate 10,000 acres during *kharif* and 5,500 acres during *rabi*. The hydro-electric station has been supplying 4,000 kilowatts of power, which is the maximum of its installed capacity since the end of 1953.

### *Konar*

The dam across the Konar river is situated in the Hazari-bagh district in Bihar State. One hundred and sixty feet high, this dam is a composite structure with a concrete section 848 feet long and earthen embankments on the flanks running to a total length of 11,639 ft. It was completed in 1954. Work on this project was begun in April 1950, and water began to be stored from November 1952. The reservoir is supplying cooling water for the Bokaro Thermal Power Station. An underground power house at the dam is also envisaged which, when completed, will generate 40,000 kilowatts of electricity.

### *Maithon*

Situated at a distance of 16 miles from Asansol on the Eastern Railway, the Maithon is an earthen dam on the river Barakar. It is 2,062 feet long and 162 feet high. It has been designed mainly for flood control. The underground hydro-electric station near this dam has a capacity of 60,000 kilowatts. The concrete spillway of the dam is 612 feet long. On either side, a total length of 12,462 feet of earthen dyke stretches round the reservoir. The dam was inaugurated on September 27, 1957.

The builders of the Maithon dam had to face a particularly tricky problem between October 1952 to June 1953. A diversion channel had to be cut on the right bank and the material thus excavated placed right across the river. This channel, 350 feet wide and 4,400 feet long, was meant to divert the flow of the river during the monsoon months of 1953. The volume of earth and rock excavated approximated 2 million cubic yards. This operation required not only constructional equipment but trained staff to operate and supervise it. All this had to be ready by October 1 so that the diversion channel could be completed before the monsoon set in. To start with, the prospects appeared bleak because even when equipment was obtained, there were not enough trained men to handle it. These men were trained on the spot to handle tractors, shovels and other heavy earth-moving equipment and what seemed impossible was soon turned into achievement.

A feature of the Maithon project is its underground power station, the first of its kind in India. The station, which was completed by 1958, is reached by a tunnel through the rocky side of the abutting hill and has an installed capacity of 60,000 kilowatts.

### *Panchet Hill*

The Panchet Hill dam over the Damodar River is, like the Maithon, primarily designed for flood control. It is situated in the Dhanbad District of Bihar. It comprises an earthen dam 7,135 feet long and 134 feet high, a concrete spillway 1,215 feet long and 13,805 feet of dykes, and stores 12,14,000 acre-feet of water. The power house provides for a generating capacity of 40,000 kilowatts initially, with provision for one more unit of the same capacity at a later date.

The dam started storing water in the monsoon of 1958, and was completed in December 1959. The generating set was commissioned in 1959. The Panchet Hill and the Maithon dams will ensure for the lower valley not only protection from floods, but also perennial irrigation over a wide area.

### *Bokaro Thermal Power House*

Another achievement of which the DVC can well be proud is the construction of a huge power station at Bokaro

by the side of the Konar River in Hazaribagh District, Bihar. This station is one of the biggest in the East. It was commissioned in February 1953 and is now supplying power to various consumers to the full extent of its installed capacity of 1,50,000 kilowatts. This power is being consumed by the iron and steel works at Jamshedpur and Hirapur (Burnpur), copper mines and refinery at Ghatsila, coal mines of West Bengal and Bihar, the new cement works and engineering industries in and around Asansol and Sindri and Calcutta. The demand on the system still exceeds its installed generating capacity. An additional unit of 75,000 kilowatts at this station is expected to be commissioned very soon.

The significant fact about Bokaro is that in spite of many difficulties, this gigantic construction was completed in a comparatively short time of about 3 years. The entire plant and equipment for the station had been ordered for from abroad. But owing to the long postwar boom in the manufacturing countries the machinery could not be imported readily. Also, there was considerable difficulty in recruiting technical personnel.

While the construction and initial operation of Bokaro was a joint enterprise of foreign and Indian engineers, power transmission and distribution were entirely done by our own engineers. Today, there are about 1,000 miles of high voltage transmission lines in this system, while 31 sub-stations have, meanwhile, been completed.

#### *The Durgapur Barrage*

The Durgapur barrage in West Bengal is 2,271 feet long and 38 feet high. It will have an extensive canal system extending over 1,550 miles. It will utilise the water from the four dams up-stream for providing *kharif* irrigation to nearly 10,44,000 acres (including 1,85,000 acres of the existing system) and *rabi* irrigation to an area of 3,00,000 acres on full development. By the end of 1959 water had been made available for irrigating 6,21,071 acres.

Work on the barrage was started in 1952 and completed in April 1955. The work on the associated canals, too, is nearing completion. At the same time, work is progressing

on the 85-mile long navigation-cum-irrigation canal on the left, the 55-mile long irrigation canal on the right and 1,410 miles of branch canals, distributaries and drainage channels. The entire project is expected to be completed by 1960. An army of about 30,000 labourers assisted by giant earth-moving machines have been working incessantly. The method of work at the barrage is a judicious combination of manual labour and mechanical devices. The Durgapur barrage has been entirely designed and constructed by Indians.

#### POWER DEVELOPMENT AND SUPPLY

Ever since the Bokaro thermal station and the Tilaiya hydro-power station were commissioned in 1953, the load on the DVC power system has been steadily going up. To meet the rising load it was decided (i) to step up the generating capacity of the Bokaro station from 1,50,000 to 2,25,000 kilowatts, (ii) to construct a thermal station at Oyaria near Durgapur with an initial installation of 1,50,000 kilowatts, and (iii) to construct a thermal station at Chandrapura with an installed capacity of 2,50,000 kilowatts. This station will rank, when completed, among the largest power stations in Asia.

Correspondingly, the transmission system is being extended to meet additional demand. The power transmission lines will thus ultimately run to about 1,000 route miles. Work on the 48 substations and receiving stations planned has almost been completed and most of them have been put into commercial operation. With the rise in demand and supply of power, revenue has also been steadily increasing. In the coming years we can confidently look forward to a substantial rise in power consumption and income.

Schemes for the electrification of the Howrah-Mughal Sarai section of the Eastern Railway and the Howrah-Kharagpur section of the South Eastern Railway have already been finalised. The DVC has agreed to supply power for the electrification of the Howrah-Burdwan section initially. In fact, power is being already supplied since December 1957 for a portion of this section (Howrah-Bandel).

#### SOIL CONSERVATION

The construction of storage dams and power plants of the

DVC are in themselves great achievements contributing to the prosperity of the region. But a still greater contribution of the Corporation to national economy is in the field of soil conservation. Almost the entire land surface of the upper catchment of Damodar covering an area of about 7,000 sq. miles is badly eroded. Conservation of soil in this area will, apart from increasing the productivity of land, reduce the silting up of reservoirs. These dual benefits will take some time to have an appreciable effect on agriculture in the Damodar valley area. In the beginning, one of the main tasks of the Soil Conservation Department of DVC was confined to the reclaiming of waste-lands for paddy cultivation. The need to do so was rendered urgent because thousands of persons had been displaced by the major reservoirs. They had to be resettled on new lands. The land reclaimed under this programme came to 6,540 acres. Later, all the available resources of the department have been diverted to solving the problem of soil conservation. As a part of this programme the entire upper catchment area has been air-photographed, and a considerable area has been soil-surveyed and mapped.

There is an Experiment Station at Deochanda which is finding out new methods of soil conservation suitable for the farms in these catchments. The methods thus developed have to be carried to the doors of the farmers of this area to enable them to practise soil conservation on their own lands. The several demonstrations held on farmers' lands so far cover an area of about 2,500 acres scattered over different parts of the upper valley.

The four major reservoirs have sizeable areas in the peripheral zones which get exposed every year when there is a fall in the water level. Suitable agricultural practices are being developed and demonstrated for utilising such lands as are particularly capable of producing rich crops.

#### AFFORESTATION

The need for forests as sources of timber, fire-wood and fodder is well known. Besides, forests are necessary to prevent the top soil from being washed away by rain water which gushes down the hill slopes. If the top soil is thus



protected, streams and reservoirs also will not be silted and consequently flood water in the streams and reservoirs will be reduced. The Corporation has therefore taken up a programme of planting trees in steep and barren areas of the valley and also of protecting the existing forests against damage. So far, over 3,000 acres of barren slopes have been planted by the Corporation authorities. Arrangements have also been made with the Bihar Forest Department for afforesting 20,000 acres during the second Five Year Plan period.

With the completion of the canal system it is expected to irrigate more than one million acres in the lower valley. This envisages a big change in the agricultural pattern of this area. Two or more crops can grow in a year where only one grew before. The introduction of new crops, new rotations and above all the judicious utilisation of irrigation water are some of the main problems being studied in the Experiment Station at Panagarh.

#### FISHERY

The four major reservoirs of the DVC can be used for producing large quantities of fish. Work has already been started for developing fisheries in two of the major reservoirs to start with, viz., Tilaiya and Konar. This programme will in time be extended to other reservoirs as they are completed. Commercial exploitation will commence as soon as the reservoirs are full.

Another significant achievement is the construction of small dams at the headwaters of the river system. These dams stock the run-off water from the catchment and thus prevent soil erosion and the rapid silting of the larger reservoirs. This water is used not only for irrigation but also to meet the needs of nearby towns. The Corporation has constructed six small dams in the upper valley. Investigation and survey are in progress in respect of a few others.

#### REHABILITATION

The dams will no doubt promote agricultural and industrial development in the area. But they will also, on completion, displace nearly 78,000 people. About 71,000 acres of

land will be lost, nearly half of which is luckily waste land, sparsely populated. In addition, about 45,000 houses will be submerged. The people have been, however, given alternative land and houses at places of their own choice. Those who preferred compensation in cash were given money instead.

Rehabilitation work at Tilaiya, Konar and Bokaro has been completed, while at Maithon and Panchet Hill it is still in progress. The people have been given houses and land better than the ones they vacated and, more important still, with amenities which they never had enjoyed before. Adequate roads, wind-mills, wells, community centres, places of worship, schools, playgrounds and parks for children have been provided in the new colonies.

#### INDUSTRIAL DEVELOPMENT

The DVC has also launched a number of pilot schemes for developing small-scale industries in the valley. A small unit for the manufacture of locks was started at Tilaiya and its products have already found a wide market. A hand tool finishing workshop at Maithon has also started commercial production. Both these factories were transferred to the Government of Bihar in September 1957. Besides, machinery for a 660-ton cold storage plant has been installed at Burdwan. A spun pipe factory, too, has been set up at Durgapur.

The benefits from the Damodar Valley scheme will be many and varied. The capricious river will be turned into a series of lakes, and inundation by flood waters which has plagued the valley for centuries will be prevented. Our farms and factories, roads and railways will be hereafter safe from its devastating fury. The impounded water will be diverted into 1,550 miles of irrigation canals by a barrage at Durgapur. Damodar, which has so far been only a seasonal river, will have perennial flow, making water available for cultivating at least two crops where there was formerly an uncertain one. Instead of 1.85,000 acres as before, there will be 10,44,000 acres of *kharif* land under irrigation, and 3,00,000 acres for *rabi*. The project will also make possible terracing and rotation of crops. Soil stability and fertility will be

built up by growing leguminous crops. Rocky and barren regions will be clothed in green vegetation.

The waters which were so far running to waste will produce sufficient electricity to work numerous mills, factories and mines. Rich minerals which lie buried in this region will be dug up. The Damodar region is already the home of key industries like coal, iron, steel, aluminium, copper, chemicals, etc. On the supply of these minerals depend dozens of industries, old and new. More of them can be started now, and thousands of families will find employment. These industries will not only make our country prosperous, but strong.

Another attractive feature of the DVC scheme is that a 85-mile long navigation-cum-irrigation canal will be cut which will enable boats to carry goods and passengers between Calcutta and the coalfields, thereby reducing congestion on the roads and railways. As the economy of the valley develops, the volume of freight is also bound to increase. Cheap transport will be in itself a great incentive to industrial growth.

The availability of water for industrial and domestic use is another great benefit. Many of the towns and villages being situated far away from the river suffer from lack of fresh water. A regulated flow of water from the reservoirs will solve this problem for ever. This benefit alone may be worth several crores of rupees annually.

These reservoirs will be eminently suitable for fish cultivation, in addition to the irrigation canals in the lower valley. Fish culture will provide additional food and employment to the local people.

Another important benefit will be the eradication of malaria. This region was, at one time, flourishing and healthy but later became infested with malaria. A large-scale campaign launched recently to prevent the breeding of mosquitoes in this area has already borne fruit and the entire valley will soon be completely rid of the scourge.

In course of time, the valley will also become an important tourist attraction with its expansive lakes sprawling amidst beautiful, wooded hills, its bracing climate and forests teeming with wild life. The Damodar Valley Project is, in

reality, a combination of short and long-term schemes and people will not have to wait long for benefits to accrue from it.

When the work on the DVC started in 1948, experienced technical personnel were almost entirely unavailable. There were, besides, also other unhelpful factors characteristic of the post-war years. There was shortage of money, foreign exchange, plant, equipment and technical men. We had to obtain most of these things from half way across the world. There was not only great delay in getting the equipment we needed, but the prices also were high. If the project has progressed thus far, it is in spite of these difficulties.

Work on the Damodar Valley Project is still incomplete. Even so, the valley has undergone transformation beyond recognition. Instead of the brown, bare, rugged hills of the past we now have neatly terraced hill sides covered with green vegetation. The marshy and malarial tracts of the lower Damodar are giving place to green and productive fields. Lakes, dams and huge transmission towers have started relieving the monotony of the valley. The change that has already come over the valley is bound to excite anyone with admiration and fill our hearts with pride. The Prime Minister, Shri Jawaharlal Nehru gave expression to this sentiment when he remarked: "A new India is being born in the valley. It is the India of our dreams."

#### BHAKRA NANGAL

And now from the capricious Damodar in West Bengal to the mighty Sutlej in the Punjab. Against a backdrop of the lofty Himalayas rises India's biggest multi-purpose project—the Bhakra dam—which ranks among the greatest engineering feats of the world. It is the world's highest dam and has two of the largest diversion tunnels besides the largest unit of lined canal system. It has also the longest belt-conveyor system and the biggest power houses in Asia.

Like the Damodar, this project was also conceived before we became an independent nation. Like the Damodar again, it remained only a dream till India became free and

sovereign. We have already gone a long way since construction was started in 1946. Today, the waters from the Nangal canals flow into smiling fields and churn the turbines at Ganguwal and Kotla. The Bhakra dam has reached the final stages of construction. When it is completed, we expect that the country's food problem will have been largely solved. In particular, it will bring greater prosperity to millions of people who, uprooted from their home in Pakistan, have settled down in Punjab.

Before the partition of the sub-continent the Punjab used to be the wheat granary of India. A network of the finest canals in India irrigated its lands. But most of them lay in the west, in what is now a part of West Pakistan. The eastern part of Punjab was an arid tract and suffered from frequent drought and famine. With partition, therefore, the Indian part of Punjab became heavily deficit in food, and added to the country's food problems. East Punjab's age-long cry for water together with that of Pepsu and Rajasthan thus became a grave national problem. The only remedy lay in making effective use of the waters of the mighty Sutlej.

A dam across the Sutlej was no new idea. The scheme was conceived as early as 1908, but it was repeatedly shelved for one reason or another. After the second World War the project came up again for consideration. The upheavals that came in the wake of partition brought a new sense of urgency to the problem of irrigation and power supply in the Punjab.

Free India revived the idea of the project in a big, bold way. The project now comprises the Bhakra and Nangal dams, and a vast network of irrigation canals and power houses and transmission lines spread over the Punjab, Rajasthan, Himachal Pradesh and Delhi. Besides, it provides for augmentation of supplies to old canals.

The estimated cost of the project is about Rs. 170 crore, of which a major part has already been spent. The Bhakra dam is expected to be completed by 1961.

#### *Preliminary Operations*

The Bhakra Nangal project is in every sense a tremendous undertaking. Nothing so thrilling had been attempted

before in our country. Naturally, it brought with it problems of an unusual nature which demanded skill and resources far beyond the comprehension of those who originally conceived the idea. The design, planning, construction and organisation involved in converting a great dream into a mammoth achievement have given invaluable experience to our engineers and administrators.

A few examples will show the unprecedented nature of the work. Extensive investigations were carried out before a suitable site was chosen for the dam. The daily discharge observations of the Sutlej over a period of 30 years formed the basis for assessing the irrigation and power potential and for estimating the highest floods to be expected at the dam site. Topographical surveys of the gorge and the foundations were undertaken. The geological formations at Bhakra also called for a thorough sub-surface exploration. Moreover, extensive rock drilling, aggregating to nearly 40,000 feet, into the foundations of the dam and appurtenant works was necessary for studying the rock formations which are to support the dam. In addition, 50 exploratory tunnels of a length of 4,064 feet were driven into the walls of the canyon to enable visual inspection of the rock formations.

This was not all. Generally speaking, river valley projects are located in remote and inaccessible places, and the Bhakra Nangal project is no exception. In the initial stages investigation and construction work were severely handicapped because we did not have adequate means of communication.

One of the first tasks that faced the engineers was, therefore, the establishment of a railway link between Rupar and the Bhakra dam site. But the rugged country could not be adequately served without a good road. Heavy equipment had to be continually moved from place to place, and the railway line could not fulfil all such requirements. Work was, therefore, commenced simultaneously on the construction of a metalled road capable of withstanding the load of heavy draglines, shovels and tractors. The road now runs from Rupar to the Bhakra dam site. A road-cum-rail bridge also links the dam site with the right bank.

The problem of providing housing and other essential amenities to the workers made it necessary to build a camp where the working people could be accommodated for about 10 years until the job was completed. So a colony has arisen at Nangal, now developed into a modern township with houses for engineers, experts, foremen, technicians, operators and workers. The township has all the amenities of modern life, including schools and hospitals.

#### *Mechanised Construction*

The construction of a dam of the magnitude of Bhakra called for mechanised operations on a large scale. It was necessary, for instance, to adopt the 'assembly line technique' and keep it going for at least four years after the commencement of concreting operations. This meant that the entire system was to be kept running smooth with no bottlenecks anywhere. If a machinery broke down, it would have to be set right there and then, and the supply lines would have to be maintained at all times.

Thus, whether it is the excavation of rocks, erection of steel trestle bridges or transportation and installation of heavy gates, penstocks, machinery, turbines or generators, mechanised methods have to be adopted in each case. The workshop at the Nangal township looks after the fabrication and repair of heavy machinery.

#### THE BHAKRA DAM

At the Naina Devi Dhar, where the greyish waters of the Sutlej pierce the last spurs of the Sivalik range, is being built the 740 ft. high Bhakra dam to impound 74,00,000 acre-feet of water covering 64 square miles. Of this, 57,30,000 acre-feet will be utilised for irrigation and generation of power, enough to meet the domestic needs of our entire population for one year.

The dam, estimated to cost about Rs. 70 crore, is a gigantic undertaking, built entirely of cement concrete. It will be 740 feet high (nearly three times as high as Kutab Minar), with 625 ft. width at base, tapering off to 30 feet at the top. The length at top will be 1,700 feet between the canyon walls. The dam will create the highest man-made cascade in the world. In volume the structure will be so big as to enclose

within it the dimensions of a 60 storey skyscraper with 1,00,000 rooms.

A spillway, 260 feet wide, will permit flood waters to flow over. Sixteen river outlets and 10 steel penstocks will release additional supplies of water. Together, they can take care of a flood of 4,00,000 cubic feet per second. The dam will make possible a discharge intensity of 1,160 cubic feet per second. This figure represents the highest obtained on any dam.

The dam is scheduled to be read by 1961. Partial storage in the reservoir began even from 1958. When the excavation of the site was completed in November 1955 the laying of concrete was started.

### *Giant Tunnels*

For diverting the river from the dam site to keep it clear for work, two huge tunnels, each 50 feet in diameter, have been constructed. They are the biggest tunnels of their kind in the world. The magnitude of the work may be gauged from the fact that 1,56,00,000 cubic feet of rock had to be excavated and 57,78,000 cubic feet of concrete were required to line the tunnels. The total cost incurred was Rs. 4 crore.

In the variety and magnitude of problems it offered Bhakra has no parallel in India. One has only to go to the dam site to realise how hazardous and difficult has been this job of building the diversion tunnels. In the vicinity of Bhakra the mountains are made of the most shaly loose rock ever encountered in India. It crumbles under ordinary pressure. In fact, the real problem at Bhakra is not so much the building of the dam, as building the strength of mountains which are to enclose the enormous 55-mile-long reservoir. The tunnelling operations involve continual risks of rock slides which can bury dozens of workers and wipe out the good work done so far. Such a thing has happened occasionally. At one place the rock was so soft and loose that it caved in to a length of 30 feet without any blasting. At another place, a huge boulder weighing nearly 600 tons slid off the parent rock, smashing the steel ribs put up to keep the rock in place.



### *Coffer Dam*

In addition to these tunnels two rolled fill dams, technically known as "coffer dams", for diverting the river and the flood waters into the tunnels have been raised. They involved the handling of 2,51,00,000 cubic feet of clay, gravel and rock. The upstream dam, 215 feet high, is the highest earthen dam in India. The entire work was completed according to schedule at a cost of about Rs. 45 lakh. These temporary structures now enable uninterrupted work on the main dam, floods or no floods.

### *Foundation Excavation*

The excavation work at Bhakra has been one of the most extensive and exciting jobs undertaken in India. Be it the laying out of a road or railway, the boring of tunnels or the laying of the foundations of the dam—all have had to be preceded by extensive excavation, conducted with speed and efficiency. During peak periods, as much as 2,70,000 cubic feet of rock were excavated daily and transported to dump sites 1½ miles away. Eleven shovels were engaged in excavating rocks day and night and loading them into trucks.

The abutments on either side of the gorge are extremely steep, and consist of loose matter which has to be scraped away before the dam can be built. This was one of the hardest and most delicate jobs and it could be done only by manual labour. Hundreds of workmen were daily required to climb up the dizzy heights to chip away loose material by hand tools. This they often had to do perched on steep precipices, as high as 500 feet above the ground. About 4,05,00,000 cubic feet of material had to be literally scraped off the abutments by this process.

### *Concreting Plant*

The concrete mixer which delivers over 144 crore cubic feet of finished concrete for the dam and appurtenant works, has a 4-mile-long belt-conveyor system. The plant is capable of mixing 400 tons of concrete per hour with a maximum capacity of 2,50,000 cubic feet per day. The plant was designed at Bhakra.

## THE NANGAL DAM

Another component of the Bhakra Nangal project is the

Nangal dam. It constitutes the hub of the entire irrigation network, serving as a balancing reservoir for the Bhakra dam and diverting water into the Nangal hydel channel. Located at a point where the Sutlej debouches into the plains, the dam is 95 feet high and 955 feet long with an inspection gallery 67 feet below the surface of the river. One can walk through the gallery from one side of the river to the other while the river flows overhead. The gallery helps in discovering damages, if any, to the foundations of the dam. When a leakage of water is detected, cement is grouted under heavy pressure to make the foundations impervious to water. The dam which has a storage capacity of 24,000 acre-feet of water was completed in 1952.

Great precaution has to be taken against silt and sediment in the river water which can choke up the canals. Therefore, the Nangal waters, before flowing into the hydel channel, percolate through a double-decked shingle excluder serving as a sieve for holding shingle and gravel. Similar devices in the rest of the channel filter the water further before it pours into the Ganguwal power house to turn the turbines.

### THE CANAL SYSTEM

The canal system of this mighty project comprises the Nangal hydel channel, the Bhakra main canal and the Bhakra main branch. Together, they constitute the longest single unit of lined canals in the world. The total earthwork done comes to a stupendous 340 crore cubic feet, sufficient to build a road, 20 feet wide and 3 feet high, between Delhi and New York, a distance of nearly 9,200 miles. The total length of earthwork done runs to 2,850 miles. As many as 1,50,000 labourers were engaged during the peak period of excavation.

#### *Nangal Hydel Channel*

The Nangal hydel channel is an irrigation-cum-power canal. It is 40 miles long, 140 feet wide at the top and 20.6 feet deep—almost a man-made river carrying 12,500 cubic feet of water per second. It is lined with concrete to prevent loss of water by seepage. The canal was completed a year ahead of schedule.

The Nangal canal runs along the Sivalik foothills through one of the most difficult terrains in the country. It is intercepted by as many as 62 flashy hill torrents whose maximum flow ranges from 15,000 to 1,50,000 cubic feet per second during the monsoons. Naturally, the construction of the canal through such a country presented a major challenge, and many of the problems encountered were without precedent. The excavation involved 24 million cubic feet of earth, gravel and boulders. High ridges and deep ravines had to be excavated, and earth had to be piled 40 to 80 feet high to make high embankments and cross drainage works. The opening up of a thick thorny jungle infested with outlaws made an exciting story. No wonder that the channel has been hailed as a commendable feat of engineering.

#### *Bhakra Main Canal*

The Bhakra main canal, which is the main feeder of this system, is 108 miles long with a discharge capacity of 12,500 cubic feet per second. About 27 crore concrete slabs have been used in its construction which, if placed end to end, would go round the equator twice. As much as 90,000 tons of cement and 81,000 tons of slack coal for burning the tiles were consumed in the lining work.

The excavation of the Bhakra canals in the Punjab has been completed and the canal system was opened in July 1954, a year ahead of schedule. In Rajasthan the work is proceeding according to plan. During 1955-56, the canal system served more than 1 lakh acres in Rajasthan, 9.6 lakh acres in the Punjab and 1.4 lakh acres in the former State of Pepsu. When the scheme is in full operation with its new branches and distributaries, an additional 36 lakh acres will receive perennial supply of water bringing the total area served in these States to 10 million acres.

#### THE POWER PLANTS

The Bhakra Nangal project will produce 6,04,000 kilowatts of power. To start with, five units of 90,000 kilowatts each in Bhakra left power house, and two units each of 24,000 kilowatts and one each of 29,000 kilowatts at Kotla and Ganguwal power houses along the Nangal hydel channel are being built.

Against each shoulder of the Bhakra dam will be built two of the largest hydro-electric power plants to be found in Asia and among the largest in the world. Each generating station which will have a capacity of 90,000 kilowatts will be, when completed, as high as a 15 storey building, 400 feet long and 110 feet wide. The generators will be impelled by 1,25,000 horse power turbines.

#### *Nangal Power Houses*

The two power stations on the Nangal channel are Ganguwal and Kotla with an installed capacity of 96,000 kilowatts, of which 72,000 kilowatts will be firm power. The former was brought into commission in January 1955 and the latter in June 1956. Together, they supply power to the Bhakra works, Delhi and many towns in the Punjab. One more unit of 29,000 kilowatts is being added in each of these power houses. The firm capacity will then aggregate to 1,20,000 kilowatts.

An encouraging feature of the power houses is that they are the first of their kind in this part of the country to be built entirely by our engineers. The peculiar difficulties faced by them in the course of construction have given invaluable experience to our engineers.

Another interesting feature is that while the Ganguwal station is manned by the operating personnel, Kotla is controlled from Ganguwal itself. Also, telemetering equipment has been installed at Ganguwal which enables the load dispatcher to know the load conditions on several remote sections of the power system at all times. It thus provides a useful guide for him in controlling the generating capacity and load conditions on the system. Besides, tele-communication has been provided on the entire system. Thus communication can be established with any point on the huge network.

#### *Transmission System*

The total mileage of the transmission lines will be about 2,300. An outstanding feature of this system is the use of a voltage of 220 kilowatts between Nangal and Delhi. Such a high voltage is being used in India for the first time.

This is a gigantic transmission system entailing the labour of thousands of workers over hundreds of miles of difficult

terrain. More than 8,000 miles of conductors and ground-wires and 21,000 tons of steel structures were required to set up these lines. Their transportation over the length and breadth of Punjab, the former State of Pepsu and Rajasthan was in itself a huge problem, especially because the lines were located in the countryside across fields, streams, unbridged *nullas* and marshy lands.

The transmission lines are also exposed to the vagaries of weather and climate. The scorching heat in summer followed by freezing cold in winter cause wide variations in the tension of the electric cables. Dust storms cover the insulators with dust and tend to short-circuit the current. Lightening is the worst enemy as it hits the lines frequently whenever a thunder-storm is on. Our engineers have had to take into account these factors and ensure trouble-free operations under the worst climatic conditions.

The transmission system is indeed an imposing part of the Bhakra Nangal project. As we travel on the highways or hurriedly pass through in a train, we can see the tall, gleaming, steel bars rising sky-high. They stand there like sentinels keeping watch over the rising prosperity of the Punjab.

### POTENTIALITIES

#### *Irrigation*

In keeping with the outlay and the enormous effort and ingenuity that the project has called for, the Bhakra Nangal has immense potentialities for the future development of this region. The project will, on completion, provide perennial irrigation to 36 lakh acres. These are expected to yield an additional 0.85 million tons of foodgrains, 0.15 million tons of sugarcane and 0.03 million tons of pulses and oil-seeds. The present deficiency in foodgrains in this region will be more than made up by this increased production.

The addition to irrigation facilities will also step up production of cotton by 0.59 million bales and of fodder by 6 million tons. This in turn will improve prospects for setting up new textile mills and provide fillip to dairying in the States.

#### *Power*

The Bhakra Nangal power scheme will electrify more

than 70 towns and hundreds of villages around them. The total maximum demand which stood at 46,000 kilowatts in 1955-56 and increased to 82,000 kilowatts in 1958-59 is expected to rise to 1,15,300 kilowatts in 1963-64. The revenue from the sale of power to Delhi, Rajasthan and Punjab (including Pepsu and Himachal Pradesh) in the corresponding years will be Rs. 115 lakh, Rs. 182 lakh and Rs. 246 lakh respectively.

Plentiful supply of cheap electricity will induce the establishment of many new industries like cotton and woollen textiles, sugar, paper, cement, fertilizers and agricultural and electrical appliances. These, in their turn, will provide increased opportunities for employment and also improve the standard of living.

Similarly the farm lands, specially those not irrigated by the canals, will derive great benefit from the Bhakra Nangal power by using it for irrigation and other farm jobs. This power can, for instance, be advantageously used in working tubewells for *kharif* irrigation in Gurdaspur, Amritsar, Jullundur and Ludhiana districts, for lowering the water table in the waterlogged areas and for augmenting the supplies in the canals.

The installed power capacity of motors and engines used for irrigation in the Punjab which was over 60,000 kilowatts in 1958 will ultimately reach 95,000 kilowatts and make additional irrigation possible. This will not only help improve the financial position of the cultivators through increased agricultural yields but can also change the complexion of rural life in the State by providing enough leisure to the people for cultural pursuits.

When cheap hydel power is available the existing thermal generating plants and diesel factories can be closed and a large quantity of fuel and oil thus saved can be used for tractors and other farming equipment. Surplus power from the generating plants can be utilised for the electrification of railways. A very important benefit of the project is in the new opportunities for employment that it is expected to create. Ever since independence, the most pressing problem has been one of providing full employment to millions of

displaced persons from Pakistan most of whom are under-employed.

There is another delightful aspect to the Bhakra project. The Bhakra lake, for instance, will be about 55 miles long and nearly  $1\frac{1}{2}$  miles wide. Located among hills of great scenic beauty, it is capable of being developed into a very attractive recreational centre with facilities for boating, surf-riding and other water sports. In addition, this lake can provide excellent facilities for fish culture.

### HIRAKUD

The story of Hirakud is really the story of the Mahanadi—a river which, like the Damodar in Bihar, has harassed the people of Orissa with floods, famine and misery for ages.

With a catchment area of 51,000 square miles the Mahanadi happens to be one of the largest rivers of India. It carries 74 million acre-feet of water annually with a mean annual discharge of 1,00,000 cusecs. During the dry season the river is shallow enough to be waded across. But when monsoon is on, it swells into a mighty river inundating vast tracts of fertile land. Only an insignificant fraction of this enormous water was being used for irrigation. The remaining mass ran to waste, threatening the lives and homes of millions of people as it rushed madly to join the Bay of Bengal.

The history of Orissa has therefore been a history of floods and famines. When rainfall was too little it led to famines; when too much it caused floods. Terrible famines hit this region in the 14th, 15th and 16th centuries. In the famine of 1865-66, nearly a million people perished in the district of Cuttack alone. What the drought had spared was washed away by floods when they came. Since 1868, as many as 39 floods have visited the delta. People still remember with horror the Mahanadi floods of 1955.

### THE PROJECT

A proposal to harness the Mahanadi was mooted as early as 1858, and it remained a distant dream for ninety years.

The foundation for the Hirakud dam could be laid only in 1948 after India became independent.

The entire project of the Mahanadi comprises (i) a dam for storing 6.60 million acre-feet of water; (ii) power houses generating 2,32,500 kilowatts; and (iii) canals irrigating over two million acres in both the *kharif* and *rabi* seasons.

The scheme was divided into three stages. The first consisted of the main dam with four power units generating 1,23,000 kilowatts and canal systems on either flank. The second comprises a fifth unit of 37,500 kilowatts at the main power house, besides another unit to utilise the tail-race waters for the generation of additional 72,000 kilowatts at Chiplima, some 16 miles from the main dam. (This is taken up as a separate scheme called the Mahanadi Delta Irrigation Scheme). The third aims at the construction of a weir above Naraj with canal systems in the Puri and Cuttack districts.

When completed, the Hirakud project is estimated to cost Rs. 100.02 crore. The overall benefits from this project will include irrigation to 2,400,000 acres and 2,32,500 kilowatts of power. Addition of one more (sixth) unit of 37,500 kilowatts at the main power station has now been agreed to.

The Hirakud project is an enormous undertaking. The main dam alone will consume 44.16 crore c.ft. of earth, 381 lakh c.ft. of concrete and masonry and 473 lakh c.ft. of stone work. The earthwork on the dykes involves 19.77 crore c.ft. of earth, and 74.67 crore c.ft. of earth have to be dug out for the canals. The construction of the power house and the laying of the transmission lines are also tasks of great magnitude.

### *Men and Machines*

Such a colossal work naturally called for immense manpower. Hence, during the peak period of construction more than 30,000 workers were employed on the project. Yet the work was too big for mere men. Accordingly, high capacity machines have had to be used to ensure speed, efficiency and economy. Thus, concreting and earthwork were done almost wholly by mechanical equipment. In doing this, a variety of earth digging, loading and hauling equipment of large



capacities were used, and powerful batching and concrete mixing plants handled a million and a half cubic yards of concrete. The use of granite rubble stone masonry in cement mortar instead of concrete not only gave speed to the construction work but also reduced the expense. In order to improve the workability of cement, air entraining agents were employed. These were evolved at the Hirakud Research Station itself and have proved as efficient as the imported ones.

The machines were worked day and night. The entire workspot was floodlit from end to end, converting night into day, and all arrangements were made to transport workers to workspots from their colonies and back.

The Hirakud dam is now an accomplished fact, having been completed in 1957. It is 3 miles long (earth-masonry and concrete barrier), and is flanked by dykes which are in all 13 miles long. The total length of the concrete and masonry dam is 3,768 feet and of the earth dam 11,980 feet. The dam stands 200 feet high from the deepest river bed. Thus the Hirakud dam is 16 miles long, including the dykes on either side of the main dam.

The Hirakud reservoir can hold 6.60 million acre-feet of water. Its magnitude becomes clear when we compare it with some other reservoirs. The Krishnarajasagar reservoir in Mysore has a capacity of one million acre-feet, Mettur in Madras 2.2 million acre-feet, and the Tungabhadra 3.0 million acre-feet. This is twice the capacity of the four dams of the Damodar Valley combined and almost equals that of Bhakra.

To achieve this, colossal quantities of concrete and earthwork have had to be used—2,27,60,000 c. feet of concrete, 1,52,70,000 c. ft. of rubble stone in cement mortar, and 23.7 million c.yds. of earth. The earth used in this case exceeds in quantity the total earthwork of the four largest earthen dams in India, namely, the Lower Bhavani in Madras (6 million c.yds.), the Gangapur in Maharashtra (5.48 million c.yds.), and the Maithon and Panchet Hill in D.V.C. (10.3 million c.yds.). A 25 feet wide roadway on the main dam and the dykes provides a pleasant drive for 20 miles around the reservoir.

The construction of such a large earthen dam involved tremendous work and high technical skill. The soil to be used was to contain the right proportion of clay. Optimum moisture had to be maintained during compaction by spraying water over the earth in order to have the required density. It also involved highly mechanised operations for digging and transporting the particular kind of earth needed. It was thus a combined field and laboratory task, requiring the technical skill of both the engineers and soil scientists.

Apart from its exceptional dimensions and the enormous work involved, the Hirakud dam is distinctive for another reason. There are 64 sluices at the bed level and 34 radial gates at the spillway. One may wonder why so many sluices have been provided. For a reservoir like that of Hirakud, the sluices have been designed for a discharge capacity as large as 6,50,000 cusecs and, at the same time, they have been located at low levels. Both these factors will help to draw out more silt from the reservoir, thus ensuring a longer life of usefulness for it.

To operate the sluices, a gate gallery of 2,125 feet has been constructed in the body of the dam. This is the biggest gallery of its kind in the world. Complex calculations and model tests had to be done before its design was finalised.

The dam has come up to our fullest expectations. During the monsoon months of 1956, it acted as a flood absorber and moderator in the valley. The rainfall during that year happened to be much above normal. It was 85.47 inches between May and September against the normal 55 inches.

As many as 33.25 million acre-feet of water passed through the dam sluices which is six times the holding capacity of the new reservoir. But the maximum flood level at Cuttack remained lower than during the 1955 monsoon when there was extensive damage to the delta caused by breaches in the embankment. The Hirakud reservoir amply fulfilled its purpose in the very first year of its construction.

### *The Canals*

Three canals take off from the Hirakud reservoir at Baragarh, Sason and Sambalpur. Of these, the Baragarh, with

its discharge capacity of 4,802 cusecs, is the biggest. The main canal of the left bank is the Sason designed for a discharge of 630 cusecs. The Sambalpur canal is to the left of the main canal.

The three canals will carry water by means of a network of distributaries, minors and water courses for irrigating 4,48,000 acres of *kharif* and 2,24,300 acres of *rabi* crops in the districts of Sambalpur and Bolangir. The total area under irrigation will thus be 5,62,500 acres.

The length of the main canals will be 91.5 miles with 460 miles of distributaries and minors, and 2,000 miles of water courses. Already, major structures have been put up and most of the excavation has been completed on the main canals and branches. Water was let out for the first time in September 1956 for irrigating one lakh acres. By the end of 1959 irrigation facilities were made available for 3,35,760 acres. The remaining works were completed by the middle of 1960.

Power generation at the Hirakud dam will provide a minimum flow of 8,000 to 10,000 cusecs in the Mahanadi river below the dam. The second irrigation scheme on the Mahanadi delta will utilise this water. The existing canals will be improved so as to take the increased discharge, besides introducing new courses. Thus, an additional area of nearly 3,50,000 acres will be brought under irrigation. Also, a new weir will be constructed over the Mahanadi, from which a system of canals with a capacity of 6,000 cusecs will carry water to an area of 5,36,000 acres in the Puri district. Excavation work for the main canal and its branches in the new area has been started.

### *The Power Houses*

Besides controlling floods and providing irrigation the Hirakud dam will also generate power. Designs of the power system were prepared in the Central Water and Power Commission.

The power house at the main dam has also been built. All the four generating sets, with a total installed capacity of 1,23,000 kilowatts, have been commissioned. The transmission

grid is steadily expanding, serving power to the cement factory in Rajgangpur, the steel town of Rourkela, the ferromanganese plant at Joda, the paper mills at Brijrajnagar, the Orissa textile mills and the Kalinga tubes at Chowdwar, the collieries at Talcher, in addition to town supply for Sambalpur, Sundergarh, Baragarh, Angul, Cuttack, Bhuvaneswar, Khurda and Puri.

Progress on the Chiplima power house scheme (Hirakud second stage) is in full swing. Excavation work for the power channel and power house foundation and construction of bridges, regulator and escapes are all in an advanced stage of progress.

#### *Research Station*

An important feature of the project is the research station which is the first field laboratory of this magnitude to be engaged in material-testing right from the investigation stage. At this station scientists check up the type of soil and concrete used for the construction of the dam. They are also engaged in research on other important problems, some of which have yielded valuable results. For instance, a formula for bituminized sunbaked bricks has been evolved. These bricks can stand heavy rains better and are cheaper to maintain than ordinary sunbaked bricks. People in the villages will find this of great benefit. The research station has also evolved a method by which thatch can be rendered fire proof by soaking it in a solution of chemicals and drying it later in the sun. This has proved fairly inexpensive, the cost being within the reach of the common people who use thatch for roofing their houses.

#### BENEFITS

The benefits of the Hirakud project for the economy of Orissa are many and important. The State, covering an area of 60,000 square miles, is underdeveloped, though it is richly endowed with natural resources. There is abundant rainfall, warm sun-shine and rich cultivable land. Its rivers carry annually 107 million acre-feet of water. Moreover, there are extensive forests and rich mineral deposits like iron, coal, manganese, bauxite, lime-stone and chromite. The hydro-power potential of the Mahanadi is also tremendous. The

State is also rich in manpower, and the people are industrious and ready to take on new jobs. The Hirakud project is the first major attempt in recent years to harness these resources for the benefit of the State and open up great new possibilities for the economic betterment of the people to whom it was but a dream barely ten years ago.

### *Flood Control*

The Hirakud project offers for the first time an effective solution to the problem of floods in the delta. The reservoir extending over 286 square miles with a flood reserve of 4.72 million acre-feet will successfully hold the flood water until flood peak in the lower catchment is drained off to the sea. This will reduce the intensity of floods in the delta by about one half to two-thirds. The large number of deep sluices in the dam will be able to pass down as much as 6.5 lakh cusecs.

### *Irrigation*

Flood prevention has provided a firm, new basis for economic security in the area served by the Hirakud dam. The water stored at Hirakud can be perennially made available for agriculture in an area of 5.62 lakh acres in the Sambalpur district. On the completion of the Mahanadi delta irrigation schemes, water will be made available for irrigating 5.41 lakh acres of the existing canal area, and an additional 5.36 lakh acres of the new area. Additional irrigation available every year under the Delta Scheme will be 1.6 million acres which will add 4 lakh tons to Orissa's annual output of foodgrains.

With assured irrigation right round the year, new agricultural practices can be adopted to increase food production further. The most immediate effect would be the application of fertilizers at an increasing rate. With the availability of water for irrigation in early May and June, green manure can be grown in paddy fields. Sowing of crops will not have to depend on monsoons and agriculture in these areas will cease to be a gamble.

The new irrigation in the Sambalpur zone will result in greater supply of silt to the field. It will thus help improve the fertility of the soil, particularly the *at* and *mal* lands

which have been continually losing their valuable top soil.

A secure income for the farmers, made possible by irrigation, will lead to greater investment on land improvement and rotation of crops. Commercial crops like sugarcane, cotton, groundnut, etc., can be grown in much larger quantities. In consequence, the losses through soil erosion will be reduced to the minimum, especially on the *at* and *mal* lands in the Sambalpur area. The production of commercial crops will have a salutary effect on the growing transport system and there will be greater scope for industries to expand. Sugar factories, textile mills and hydrogenated oil mills can be started as agriculture becomes prosperous.

### *Hydro-electric Power*

The Hirakud project will be able to produce considerable hydro-electric power. The per capita consumption of electricity in the State was very poor, being 0.63 units before the first Plan was started as against the country's average of 14. In 1952, the total installed capacity of electricity in the State was only 8,180 kilowatts. The project provides for an installed capacity of 2,32,500 kilowatts.

Generation of hydro-power on this scale will naturally pave the way for large-scale industrialisation. Aluminium at Hirakud, steel at Rourkela, ferro-manganese at Joda and Rayagada, cement at Rajgangpur, paper mills at Brajrajnagar and Chowdwar, cotton and tube mills at Chowdwar, sugar mill at Baragarh and many other industrial schemes in this region will open up fresh and varied prospects for the creation of wealth and new avenues of employment. The turbines have already started generating electricity and it is being supplied to many industries. Rural areas, too, are being electrified.

### *Navigation*

The Hirakud project will also provide water transport along the Mahanadi. The need for a reliable and cheap mode of transport in Orissa needs hardly any emphasis. For an area of 59,000 square miles, there are only 878 miles of railways and 12,742 miles of roads. This comes to one railway mile for every 67 square miles, and one mile of road for

every 4.6 square miles. Orissa is thus poorly served in respect of communication and transport.

Orissa's numerous river channels and drains make the construction of railways and roads a costly affair. On the other hand, the State has a splendid network of natural and artificial waterways. Therefore, if navigation can be developed, it will create new transport facility for the increasing volume of goods that will be produced as a result of industrial and agricultural development. The Hirakud dam makes development of water transport possible by controlling the flow of water during the monsoons and increasing the discharge during the dry season in the Mahanadi channel. This new navigational facility for increased transport and trade makes essential the development of port facilities at Pradip, at the mouth of the Mahanadi. With the development of this port Orissa's future as an important industrial region will be assured.

Although the construction of the Hirakud dam was fraught with many difficulties, it was completed within eight years and eight months, thanks to thousands of people who worked like dedicated men and women. By any standard it is a record for a project of this magnitude.

### TUNGABHADRA

The stone masonry dam which has been built across the Tungabhadra is one of the longest dams of its kind in the world. The Tungabhadra dam, as dams go, is not very high, but this by no means is a limitation. It has demonstrated vast possibilities for bigger ventures in stone.

The story of the Tungabhadra dam falls into the familiar pattern of stories that concern most other dams in India. The valley through which the river flows is a vast area, with not much of population. It was subject to recurring drought and famines in the past. Though the rainfall is 170 inches in the hills where the river rises, it touches a precarious 20 inches in the plains. Thus the districts of Bellary and Raichur in Mysore and the districts of Anantpur, Cuddapah and Kurnool in Andhra Pradesh have long been the victims of

drought, even as the Damodar valley has been a victim of floods.

The area has, therefore, been classed as semi-arid. But once upon a time impenetrable forests covered this area. Even now the soil of this region is fertile, and with an assured supply of water it will yield rich crops of rice, sugarcane, millets and cotton.

From June to October, the Tungabhadra is full and overflowing, just the time when its waters can be stored and canalised. The volume of water flowing past the gorge near Malapuram is 9.3 million acre-feet. This would be enough to cover all the five dry districts mentioned above with two feet of water. Engineering schemes for utilising these surplus waters were also there a century ago, but they were mostly in the minds of some enthusiastic individuals. Whatever feeble effort was made was rendered infructuous by interminable disputes between the States of Hyderabad and Madras which were to share the river waters. Work on the Tungabhadra could not, therefore, start until 1945.

The Tungabhadra scheme is unique in its own way. Dry irrigation of the area is the principal motive behind the Tungabhadra scheme. 'Dry irrigation' simply means assured supply of water to crops like millets and pulses which grow on "dry" land and depend on rain water as against crops like paddy and sugarcane growing on "wet" or irrigated land.

The principle of dry irrigation has a two-fold advantage. The waters of the Tungabhadra will be available to the widest possible area for the benefit of the largest number of people. This is possible because dry crops require less water than the wet ones. By assuring water to the dry crops over a larger area instead of converting only a part of the dry into wet land, the dietetic pattern of the people which is based mostly on dry crops can be preserved and there can be greater output of foodgrains.

#### THE PROJECT

The Tungabhadra dam is a multipurpose project designed to provide irrigation, generate hydro-electricity and incidentally also to develop the site into an attractive tourist resort.



It comprises a storage dam on either side of which will be canals capable of irrigating 8.3 lakh acres.

There will be two power stations at the foot of the dam known as Right and Left Bank Power Stations and one on the canal falls near the Hampi ruins. The total installed capacity of all these power houses will be 99,000 kilowatts which will eventually feed a vast power network linking Andhra Pradesh with Mysore.

### *The Dam*

The Tungabhadra dam which has already been completed is 7,942 feet long and 162 feet high. It has a central spillway 2,300 feet long, built of granite in red cement mortar. A unique feature of the mortar used is that 20 per cent of its cement ingredient is replaced by *surkhi* (a mixture of burnt brick pieces and lime mortar). The addition of *surkhi* has a threefold advantage. It improves the workability of the mortar, reduces the amount of heat which cement concrete generates while setting, and being cheaper, brings down the total cost of construction. The rest of the dam flanking the spillway is made of granite joined mostly with *surkhi* mortar.

The reservoir has a spread of 146 square miles and stores 3.5 million acre-feet of water. This is the largest stone masonry dam so far built in our country. It collects the rainfall run-off from a catchment area of 10,880 square miles behind the dam in the Tungabhadra valley.

Also, a drainage gallery, 5 feet wide and 7½ feet high, has been provided in the dam. A depressed drain to carry the seepage water to sumps runs along the gallery.

### *The Canals*

In the past, the area now under the Tungabhadra project was constantly haunted by the spectre of famine owing to uncertain rainfall and the absence of alternative means of irrigation. The main purpose of the project is, therefore, to supply water to 8.3 lakh acres of land in Andhra Pradesh and Mysore and the former State of Hyderabad. An extensive network of canals has been built, one on the right (Mysore-Andhra side) and the other on the left (Mysore side).

The canal on the right side of the dam is 217 miles long and will irrigate 2,50,000 acres. There is a branch canal, 30

miles long, and a distributory system consisting of 2,000 miles of minor channels. The manual labour employed during the peak period of construction was 40,000, while excavation took 30 million workdays to complete.

The canal has been completed. Most of the work on major and minor distributaries has also been completed.

The canal on the left side is 127 miles long. It commands an area of 10,80,000 acres which lies in the Raichur district. But irrigation is proposed only for 5.8 lakh acres. This district, which was once a part of the legendary Dandakaranya forest, is now practically bare of any vegetation. The region is therefore in great need of irrigated afforestation, not only to provide much-needed fuel to people in this region, but also to conserve soil and moisture. The canal will irrigate 1,35,000 acres for fuel, pasture and forests.

Besides irrigation, the canal has also been designed for navigation from the 24th to 127th mile up to Raichur, thus providing a cheap means of transport. The work on the canal is in an advanced stage of progress.

### *Engineering Difficulties*

The construction of the canals particularly in the earlier reaches called for special engineering skill. For the first 20 miles the canals run either between high earthen embankments, or through huge rocks blasted to make way for it. It also passes through man-made gorges or on long open concrete boxes placed on stilts. All through the hundreds of miles, the canal beds have to maintain precise levels to allow the water to flow smoothly. The beds, for instance, have to slope hardly six inches over a length of one mile—calling for an accuracy of less than one in ten thousand. This was not easy to accomplish. But it has been achieved at the Tungabhadra.

The two canals also pass through concrete tunnels, the left canal through a tunnel 3,557 feet long and the right one through a 1,106 feet tunnel. The approaches to the tunnels are picturesque and delightful. Deep ravines, too, come in their way over which mostly concrete aqueducts have been built. The largest aqueduct is over the Hagari river. The biggest in India, it is about 2,827 feet in length with 58 drainage

vents capable of passing a maximum flood discharge of 1,85,900 cusecs. Small reservoirs have been created in the low valleys to avoid building embankments. The canals enter the reservoir at one end and take off again at the other.

Our engineers have put the available resources in money, time, water and land to good use. The entire length of the left canal, for instance, is lined with concrete. This is the first instance in South India where such lining has been attempted. It cost about Rs. 2 lakh for paving the bottom and sides of each canal mile. But this expenditure is more than compensated in the prevention of seepage.

This also prevents the weed problem. Incidentally, cleaning and repairs are easier in a lined canal.

On the other hand, the right canal is water-proofed, and concrete is used only in selected reaches where soil seepage is known to be high. The canal runs through towns and built-up areas which require to be protected from too much of soil moisture and the like.

### *Hydro-electric Power*

The Tungabhadra project, though primarily intended for irrigation, will also generate power. The power potential of the various power sites has been estimated at 99,000 kilowatts, as detailed below:

RIGHT BANK		KW
	Dam power house	36,000
	Hampi power house	36,000
		<hr/>
		72,000
LEFT BANK		
	Dam power house	27,000
		<hr/>
	Total .. ..	99,000

The bulk of power generated is expected to be consumed by industrial undertakings and cottage industries. Besides, it will be used to operate electric water pumps in areas which are not served by irrigation canals. Villages in the region will also receive electricity by stages.

The power house at the main dam on the right bank is built to accommodate four units of 9,000 kilowatts each. Out of the four units, two were commissioned in 1957. The Hampi power house is also meant for accommodating four units of the same capacity. Two units in this power house were commissioned in 1958. The work on the power house at the main dam on the left side is progressing.

### BENEFITS

#### *Irrigation*

The project commands a total area of 2 million acres on both sides of the river. The crops proposed to be grown are mostly rice, sugarcane, cotton and millets. On the Andhra-Mysore side, the irrigable area has been fixed at 15,000 acres of sugarcane and other perennial crops and 1,92,000 acres of single dry crop together with 43,000 acres of single wet crop. This comes to 2,50,000 acres to be distributed as follows :

Nature of irrigation

blocks	Mysore	Andhra
1. Wet (rice—two seasons)	17,714 acres	38,012 acres
2. Dry (cotton, ground-nut and millets)	59,301 „	1,18,901 „
3. Perennial (rice & sugarcane)	15,330 „	—
Total .. ..	92,345 acres	1,56,913 acres

It is estimated that assured supply of water from this project will yield 1,40,000 tons of foodgrains and 80,000 tons of commercial crops, mostly cotton. Similarly, the left bank canal provides for 5.8 lakh acres in an area of 10.8 lakh acres.

#### *Flood Moderation*

Fortunately the Tungabhadra valley is more or less free from the danger of floods or bank erosion because of the deep and worn out river channel. However, sudden and excess flow from the tributaries of the Krishna can cause devastation in the Krishna delta. The project is able to hold back surplus water and release it so as to avoid a simultaneous influx from the Krishna and its tributaries. In July 1953,

for instance, there was a maximum inflow of 1,48,000 cusecs above the Tungabhadra dam. But the outflow was reduced to 43,000 cusecs because of the dam. Again, in September, for an inflow of 1,70,000 cusecs, the peak outflow was only 71,000 cusecs with palpable effect on the flood volume downstream.

This moderating effect of the Tungabhadra dam will be more in evidence with the construction of the Lakkavalli reservoir in Mysore which will store 67,000 million c.ft. This is about half the size of the Tungabhadra reservoir. Finally, with the completion of Koyna and Nagarjunasagar projects flood menace in the Krishna delta will be largely eliminated.

The Tungabhadra dam site can make an ideal tourist and health resort. It has an equable climate, green hills, a huge lake and an imposing dam. Close by are the famous ruins of Hampi, the one-time capital of the Vijayanagar empire.

#### *The Shutter Manufacturing Factory*

An important gift of the Tungabhadra dam is the Shutter Manufacturing Factory at the dam site. This is the first of its kind in the country. Until recently, and to some extent even now, the large steel gates for spillways and canal sluices were being obtained from abroad. At best, smaller ones were manufactured in the country by foreign firms. The Tungabhadra workshop was set up largely with the surplus machinery left in India after the last war, or tools fabricated in the workshop itself. It has demonstrated that most of the gates required for our dams can be manufactured within the country and at moderate cost.

For the Tungabhadra itself, the 33 spillway gates, each 20 feet in height and 60 feet in width, and high-head gates for canal sluices and penstock openings, operation bridges and machinery have been fabricated in this workshop. Other projects like Hirakud in Orissa, the Jawai in Rajasthan and the Kotah barrage of the Chambal project have placed orders for their requirements with this factory.

The workshop was entrusted with the fabrication and erection of 18' diameter low pressure pipe-line and 12' diameter penstocks for the Hampi power house. This is the first time that a pipe-line of 18' diameter has been manufactured in India.

## KOSI

The most notorious of India's "Rivers of Sorrow" is the Kosi. For decades within living memory it has wrought incalculable damage to life, property and crops. It is the most treacherous of our rivers because it is the most unpredictable in the choice of its course.

Emerging from an altitude of 18,000 feet in Tibet with Mount Everest and Kanchanjunga as its catchment area, the Kosi, laden with sand and silt, debouches into the plains at Chatra in Nepal. Then, it suddenly breaks up into several streams and channels which meander along until they join the Ganga near Kursela in Bihar.

The Kosi shows its freakishness in a variety of ways. It has been consistently changing its course, swinging several miles from east to west and leaving in its wake large deposits of sand and silt. Even with an average flood flow of 2.85 lakh cusecs, it creates a vast sheet of water, 50 to 60 miles wide. Before the Kosi cut its path across Bihar this region was renowned for its rich paddy fields, mango orchards and other plantations. The density of population in this area was the highest in Bihar. But now the entire area has a derelict look with vast stretches of sand, marshes and weeds. Only a few hamlets remain here and there to remind us of what were once flourishing towns and villages. The people, poor and undernourished, have a haunted look on their face.

In 1954, discharge in the Kosi river reached 8.5 lakh cusecs causing tremendous damage. This catastrophe gave a new urgency to the problem of flood control in the area. Past attempts, dating back to the Calcutta conference of 1896-97 and long after, the meeting of officials and non-officials in 1937 to tackle the Kosi problem, did not yield any firm decision. The first determined attempt to find a way to taming the river was made in 1946 and it was only in 1953 that the Kosi Control Scheme as we now know it received its final touches.

## THE PROJECT

The scheme is divided into four main parts. First, there is to be a barrage, 3 miles upstream of Hanuman Nagar in

Nepal. Secondly, there are to be flood embankments on either side of the river, both upstream and downstream of the barrage, the total length being 15.5 miles. This is accompanied by a plan to provide spurs at places where the current is swift and constitutes a threat to the embankment. There is also provision for dredging the river, wherever required, to stabilise the course of the river. The third part consists of the eastern Kosi canal system which is designed to irrigate 14.05 lakh acres of land annually. The fourth concerns power generation to the extent of about 15,000 kilowatts.

This region sadly lacks a dependable means of communication. A highway bridge over the spillway will provide an excellent road link between the eastern and western areas of Nepal and North Bihar. It will make possible also the extension of the N.E. Railway line and connect Bathnaha in the east with Ghoghardiha in the west. It will be also possible to bring irrigation to 1.83 lakh acres on the eastern side and 33,600 acres on the western side of Nepal every year. An additional irrigation of 5.67 lakh acres on the eastern side and 7.60 lakh acres on the western side in Bihar is also possible.

#### *Progress of Work*

The amount of work involved can be gauged from the fact that 87.05 lakh c.ft. of concrete work, 206 c.ft. of rip rap and filter works, and 28 crore c.ft. of earthwork are to be done for the barrage, earthen dams and "afflux" bunds. The total earthwork involved in the embankments will be 78 crore c.ft. The length of the main and branch canals, including distributaries, will be about 1,305 miles involving 55.55 crore c.ft. of earthwork.

Work on the embankments was started in January 1955 and was completed in 1958 in spite of initial difficulties and the limited duration of working seasons. The barrage is expected to be completed by 1962.

#### *Public Participation*

Priority was given to the construction of embankments which are designed to protect the villages from floods. Unlike on the other projects, conditions were not favourable

here for the use of machines. Procuring them would have taken time, but the work could not brook any delay. Besides, there were no roads by which to transport the machines and other equipment.

How then could these embankments be built? The answer was found in public co-operation. The Bharat Sevak Samaj undertook to organise this through the *gram panchayats*. Thousands of people volunteered to do the job. Some of them had never handled a spade, but still they came forward and worked day and night. The *shramdanis* (as the volunteers are called), including thousands of young men, worked cheerfully despite difficult working conditions. Their dedicated labour—some of them took no wages at all and others accepted moderate wages—made significant contribution to the progress of the work. Thousands of people enthusiastically surrendered their lands without waiting for formal acquisition proceedings.

More important still, this experiment in public co-operation has been an inspiration to others elsewhere. In parts of Bihar, Uttar Pradesh and Andhra Pradesh, people have similarly come forward to work on projects. The volunteers were no doubt paid for their work, but to them the question of payment was apparently secondary.

Another significant lesson has emerged from this experience. It has revealed that given adequate supervision, co-operative labour can be more efficient and brings in better economic returns than contract labour. Indirectly, it might have also helped to keep down the cost of the project.

### *Rural Development*

At Kosi, still another interesting experiment is being tried. A five per cent deduction is being made from the earnings of co-operative labour to be used for community development. If, for instance, a village is thus able to save Rs. 5,000, they would be asked to make a further contribution of Rs. 5,000 towards community development in the form of voluntary effort. The village could then claim from the Government a matching grant of Rs. 10,000 which would make a handsome total of Rs. 20,000. This could be used for the well-being of the village community.



There have no doubt been many hurdles and handicaps in the smooth execution of work. But these have been surmounted one after another, adding thereby to our experience. The tricky river is now being trained to a defined course and we can be sure that millions who inhabit the Kosi valley will reap the benefit of our labours and ingenuity for generations to come.

### RIHAND

Across a narrow gorge in the Vindhyan ranges in the Mirzapur district of Uttar Pradesh flows the Rihand, a stream of very uncertain character. Lazy and submissive in one part of the year, the Rihand is vigorous and violent in another. For miles and miles on either side of the river are to be found dry, waste-lands, parts of which are irrigable. Even more significant than irrigation is the hydel potential of the Rihand which when utilised will work tube-wells in areas where flow irrigation is not possible and supply power to industries for which raw materials are available in plenty.

At a point twenty-eight miles south of its confluence with the Sone, the Rihand flows through a narrow gorge—a site ideally suited for generation of electricity. By 1947 preliminary investigations which include extensive drilling of the foundation rock were completed. Later, designs for a concrete dam and appurtenant works near Pipri village were finalised.

Even so, the work was held up because of our more urgent preoccupations at the time with the country's food problem. Only in 1951 was it possible to resume work on the project. The details of the project were drawn up in 1952, and work was started in 1954.

### THE PROJECT

#### *The Dam*

The project will have a concrete gravity dam 3,065 feet long and 24 feet wide at the top, and 1,200 feet long and 227 feet wide at the base. The maximum height of the dam above the lowest point in the river bed will be 271 feet, and six crore c.ft. of concrete will be used in its construction.

The dam will create a reservoir 180 square miles in area for holding 8.6 million acre-feet of water.

When completed, this will be the largest lake in India to be created by man, exceeding even the capacity of Gobind-sagar behind the Bhakra dam. The spread of the Rihand lake will be more than three times that of Bhakra. But curious as it may seem, the Rihand cannot irrigate as much as Bhakra. This is because of its location and the hilly terrain of the command, and various other factors which limit the irrigable capacity of its waters to a bare 5 lakh acres against the nearly 36 lakhs by Bhakra.

### *The Power Station*

Mainly designed for power generation, the installed capacity of Rihand project will be 3,00,000 kilowatts, produced by six generating units of 50,000 kilowatts each. There is also the possibility of generating more power lower down the river at a barrage power station. The power house which will be located at the toe of the dam on the right side comprises a 420 ft. long structure. Initially, only five of the six generating units planned for the project will be set up. There will also be an extensive system of transmission and distribution lines to carry the power to remote areas.

The project will produce electrical energy at a cost of 4.47 pies per unit, which compares favourably with the cost of power produced by any other plant in India. A large part of this power will be utilised for pumping water from about 2,500 tubewells and pump canals for irrigation purposes in Faizabad, Gonda, Basti, Gorakhpur, Deoria, Ballia, Ghazipur, Varanasi, Azamgarh, Jaunpur, Sultanpur, Allahabad and Partapgarh districts, covering an area of about 25,300 square miles, and irrigating approximately 14,00,000 acres in Uttar Pradesh. Another large block of power will be utilised for electro-chemical, metallurgical and other important industries, such as cement, chemical fertilizers, aluminium, porcelain, paper and other products for which raw materials exist in abundance close to the dam site.

The project will also supply power to the railways for electrification. Eventually, the Rihand power station can

be interlinked with the Kanpur thermal station, the Betwa river hydro-electric development, and the Sarda and Ganga grids in Uttar Pradesh. The total cost of the project is estimated to be Rs. 4.5 crore. It will be taken up in two stages for implementation.

### *Flood Control*

Although primarily a hydro-electric and irrigation scheme, the Rihand project will considerably help reduce the extent of floods in the Sone. Besides, it will assure a flow of 5,000 cusecs of water throughout the year for the Sone canal system to irrigate approximately 5,00,000 acres in Bihar. Thus, the total area irrigated through the Rihand system will be 19,00,000 acres in Uttar Pradesh and Bihar. This is expected to bring in an additional yield of 2,00,000 tons of foodgrains.

### PROGRESS

The construction of a cement factory at Churk, 40 miles from the dam site, has been completed. A two-lane highway from Robertsganj to Pipri, and a 3,300 feet long prestressed concrete bridge, the longest in Asia, across the river Sone, have also been constructed.

Work on the excavation of the foundation has been completed. Concreting for the dam was commenced in April 1957, and is being continued with the help of 10 and 20 ton cableways. Steel penstocks, draft tube lines, etc., have been assembled at the site.

The concrete mixing plant set up at the dam site is capable of producing 1.2 lakh c.ft. of concrete per day. A refrigeration plant with a capacity of 1,100 tons has also been set up near the dam site. A quarry at a distance of 2½ miles from the dam site supplies stone for the concrete.

It is interesting to watch the crushed pieces of stone being taken to the dam site over a 12,000 feet ropeway. Belt conveyors then carry them from the piles, through the reclaiming tunnels, to the refrigeration chambers for being cooled nearly to freezing point. Refrigeration will ensure the placement of the mixed concrete at low temperature to avoid cracks in the dam through shrinkage.

For the generating plant to be erected at the main power station, orders have been placed for 5 units of turbo-alternators of 50 MW each together with other electrical equipment.

Arrangements for early completion of the project have been made and it is hoped that the project will be ready by the end of 1962.

Even as the construction of the dam is progressing, it has brought considerable benefit to this area. There are at present 6,000 people employed on the construction. When it was decided to raise a dam at Pipri it was also decided to start a cement factory at Churk. The production and employment potential of this factory will continue to be an asset even after the completion of these dams. The region is rich in mineral resources, and the moment power from Rihand is made available, numerous basic and supplementary industries can be started. First in the priority list is an aluminium factory proposed to be put up near the dam site. It will have a production capacity of 20,000 tons and will use about 60,000 kilowatts of power.

#### KAKRAPAR

Rising in the dense forests of the Satpura hills the Tapi is known to drain into the Arabian Sea every year over 16 million acre-feet of water which it gathers from 25,000 square miles of watershed situated in Madhya Pradesh and Gujarat. In the course of one single year, this colossal waste adds up to about a fifth of the exploited water wealth of the Indian Union. The rich black soil in the lower reaches which could well have utilised this water has been yielding fitful harvests because of its total dependence on monsoons. With assured and timely irrigation, the average yield of cotton and other crops can be increased two to three-fold.

There is also the fact that the Tapi in floods can cause great disaster to its delta. The most recent of Tapi's flood havoc was in 1944. The damage it caused to the inhabitants of the delta was irretrievable. Then there is the other sad story of frequent droughts which threaten the people in the Tapi basin with famines. The worst famine in the last 35 years visited Gujarat in 1951 when there were practically no rains. Grains had to be rushed to save the people from utter starva-

tion, and fodder for three million cattle. A large number of animals had to be moved to other States.

Paucity of power, too, has kept this region quite backward. The villages have no electric lights or power facilities and the cotton mills and factories in the area are run on power developed from coal brought from long distances. There is plenty of demand for power in the Ahmedabad-Baroda-Surat industrial region but there is not enough to go. The thermal power station run at Utran (near Surat) by the Bombay Electricity Board was designed to meet the requirements of power in South Gujarat. Now this station needs to be expanded a good deal if the growing demand for it is to be met. When its power potential is fully utilised, the Tapi will go a long way in removing the power shortage which keeps many cities and rural areas of Gujarat undeveloped and backward.

### *Investigations*

And yet, except for a small storage dam across the Girna, a tributary of the Tapi, and some small weirs in Khandesh, no attempts had been made to use the waters of the Tapi. These structures were utilising less than even one per cent of the water for irrigation. It was only in 1948, after India became independent, that possibilities of developing the valley through irrigation, power generation, flood control and navigation were explored. These investigations revealed that there was plenty of scope for all these things to be done, and the Kakrapar project emerged as a concrete attempt to develop the resources of this river valley.

### THE SCHEME

The project consists of (i) a stone masonry weir across the Tapi at Kakrapar village, 50 miles upstream of Surat, and (ii) two canal systems on the right and left banks of the river, the former 226 miles in length, and the latter 554 miles. It is proposed to irrigate nearly 6,54,000 acres every year. This includes 1,02,300 acres of gram which is mainly a follow-on crop.

The weir, built of stone masonry, is 46 feet high above foundation, 2,038 feet long and possesses a discharge capacity

of 13.5 lakh cusecs. Started in 1949, the weir including the right and left bank sluices was completed in 1955. The volume of masonry embedded in the weir, including head regulators, is about 21.4 lakh c.ft.

### *The Canals*

Of the two main canals, the one on the right bank, is 40 miles long at head and has a capacity of 1,125 cusecs. It will irrigate annually 1,64,200 acres. The main canal on the left bank has a discharge capacity of 3,024 cusecs. The canal systems are expected to be completed in 1963.

### BENEFITS

The construction of the Kakrapar project was so planned that manual labour could be employed to the maximum extent. Machines were used only on such works that could not either be handled by men or handled only at prohibitive cost. During the peak period of work in 1951-52 the labour force employed on the project touched 15,000, the average during the year being 9,000. A large number of Adivasis shared the benefits of employment.

The project, it has been noticed earlier, will irrigate 5,41,400 acres of basic crops annually, in addition to 1,12,400 acres of green manure. This is expected to produce 1,60,000 tons of additional foodgrains and 16,000 additional tons of cotton. It has also been found that about 30,000 acres of *Khar* lands can be easily reclaimed. Irrigation in this area will make it possible to grow long staple cotton, which is being at present largely imported from foreign countries.

### *Irrigation*

Though the irrigation network is not yet completed, supply of water has been started through temporary arrangements made on the Surat branch system of the Left Bank Main Canal. The following table gives the extent of such irrigation :

Year	Kharif	Rabi	Total
1953-54	3,817 acres	—	3,817 acres
1954-55	—	691 acres	691 "
1955-56	2,482 "	3,242 "	5,725 "
1956-57	863 "	1,570 "	2,433 "
1957-58	28,400 "	3,258 "	31,658 "

With the completion of the Kakrapar weir and the canal

system, the first stage in the development of the Lower Tapi basin will have been accomplished. Even so, a good part of the river's potential for yielding benefits will be left unexploited and it will be the main objective of subsequent schemes to turn these resources into good account. The next stage envisages a dam across the Tapi at Ukai, 17 miles upstream of the Kakrapar weir. As we can visualise it now, the Ukai system will provide continuous irrigation to 84,000 acres, including the perennial area under the Kakrapar command, and annual irrigation for 3,91,650 acres. Besides, the 5,62,000 acres of the Kakrapar command will also get assured seasonal irrigation. In addition, it is expected to yield about 1,10,000 kilowatts of power at 60 per cent load factor.

#### MAYURAKSHI

West Bengal is in a region where rainfall is uneven. In the monsoon months the rivers flow full. Occasionally they also overflow their banks ravaging the countryside as a consequence. But during the dry season they shrink into thin streaks of water making cultivation of lands impossible. It is a problem both ways. Here, as elsewhere, the solution lies in storing up the river water when it flows plentifully. This will not only provide facilities for irrigation, but also for power generation and help to moderate the floods. Among the schemes undertaken by the West Bengal Government with these objectives the Mayurakshi project is the most important.

The Mayurakshi is a hill stream rising in the uplands of the Santal Parganas district in Bihar. Entering West Bengal in Borohum district it finally joins the Bhagirathi near Dattabati. The highest flood discharge recorded is 2,00,000 cusecs. The river bed is almost dry in the summer months.

#### THE PROJECT

The Mayurakshi project comprises (i) a dam at Messanjore in Bihar with a power house at its foot; (ii) a barrage at Tilpara in West Bengal; and (iii) a major canal system taking off from the Tilpara barrage.

#### *The Messanjore or Canada Dam*

The masonry dam at Messanjore is 2,170 feet long at top

and 155 feet high. Started in 1942, it was completed early in 1957.

Foreign experts who were consulted in the earlier stages recommended an earthen dam. An earthen dam of such great size would have necessitated the import of expensive earth-moving machinery. Not only precious foreign currency would have to be spent but obtaining this machinery would have entailed great delay. A concrete dam, on the other hand, would also require heavy machinery, besides large quantities of cement which was none too plentiful at the time. This left the builders with only one alternative. They found that just the type of rock suitable for constructing a masonry dam was available at the site, and that work could be commenced immediately. The quantity of cement needed for it would be about 40 per cent less than what a fully concrete dam of the same dimension would have required. To the mortar made of sand and cement could be added *surkhi* (finely ground brick powder) which helps strengthen the structure. Incidentally, this also reduces the proportion of cement and therefore the cost.

Both masonry and concrete expand and contract with variations in temperature. If the dam is left as a huge single rigid mass, seasonal variations in climate will lead to cracks in the body. To avoid this, gaps have been provided at 90 feet intervals between the sections along the length for expansion, much like the rails along a railway track. And these have been interlocked with each other so that the side-wise thrust can be communicated from one to the other making the dam leak proof. On the reservoir face, the gaps have been covered with copper plates from top to bottom and those between the sections caulked with pliable bitumen.

The reservoir which collects water from a catchment area of 718 square miles spreads over 16,650 acres. It has a storage capacity of 5,00,000 acre-feet of water, 90 per cent of which is usable. This is a distinctive feature of the Mayurakshi reservoir.

#### *The Barrage*

The irrigation barrage is situated across the Mayurakshi, 20 miles downstream of the dam. It is 1,013 feet long with a discharge capacity of 2,90,000 cusecs.



At the barrage site, firm rock was available only at considerable depth below the river bed, sometimes 110 feet deep. So the barrage is founded on reinforced concrete raft from end to end. Such a raft is constantly subject to pressure acting from underneath. To minimise this, sheet piles have been driven close to either face running parallel to the barrage.

### *The Canals*

Two main canals, known as the North and the South Bank Canals, take off from the Tilpara barrage on either side. Each is about 70 miles long and capable of discharging 3,500 cusecs. This comes to about 13,00,000 gallons per minute. The total length of the canal system along with the distributaries comes to about 900 miles. There will also be about 1,450 canal structures like regulators, aqueducts, canal falls, syphons, bridges, etc., scattered over an area of 1,340 square miles.

Of the canal structures, the Dwarka and Brahmini barrages on the north canal and the Bakreswar and Kopai barrages on the south canal are the most important. These are constructed across rivers of the same name. In these barrages, the canal is dropped into the intercepting rivers on one bank and the water picked up from the other. The barrage across the river will help the canal pick back the water dropped into the river. These barrages vary in length from 205 to 485 feet.

### *Bihar Canal*

In addition to this canal system another canal springs from the dam and irrigates areas in Bihar. The Bihar Canal, already completed, is 12½ miles long and irrigates 23,270 acres of land lying in the Santhal Parganas. Furthermore, 750 acres lying at a level higher than the canal are proposed to be irrigated by pumping water from the canal.

### *Power Generation*

The power house at the foot of the dam with two units of 2,000 kilowatts each has been completed. This will generate 2,000 kilowatts of firm and 4,000 kilowatts of seasonal power.

### BENEFITS

The Mayurakshi project has been designed to provide irrigation and generate power. The canals will irrigate 6,00,000

acres during *kharif* and 1,20,000 acres during *rabi* lying in the Birbhum, Burdwan and Murshidabad districts. A part of this area used to receive water from the tanks. In the other areas which depended on rainfall the yield was very low. Further, 20,000 acres of wasteland will be newly brought under irrigation. Some of the irrigated areas will come under double crops, raising wheat, potato, mustard, etc. It is estimated that 3.60 lakh tons of additional foodgrains will be produced.

The construction of the Tilpara barrage started early in 1948 was completed in June 1951 at a cost of Rs. 1.1 crore. The canal system was opened in July 1951, bringing under irrigation about a lakh acres. By the close of the first Plan (1956), 2.10 lakh acres actually derived the benefit of irrigation. It is anticipated that by the end of the second Plan 4.8 lakh acres will have derived similar benefits.

Of the canal structures, the Dwarka barrage was completed in June 1953 and the Brahmini barrage in June 1954. All the other barrages along with the canal head regulators have already been completed.

#### BHADRA

Like the Bhakra dam, which is the highest gravity dam in concrete, the Bhadra across the Bhadra river (near Lakkavalli village, Chikmagalur District of Mysore) will be the highest stone dam in the world. The benefits, too, from this project will be just as great. It is expected to cost Rs. 33.33 crore. With a relatively small investment of Rs. 2.42 crore the Bhadra canals can be dug and they will be able to supply water to 2,44,663 acres and generate 33,200 kilowatts of power.

Luckily, we have many things in our favour to build this project. The dam site, like that of Bhakra, has a fine gorge, ideally suited for impounding water to serve for irrigation, power generation as well as navigation. The bare bed of the river is diamond-hard, and can easily take the heavy weight of the dam. Also, large quantities of granite for building the dam can be had from the hills close by. On top of this,

cheap labour, stone, *surkhi* and mortar are all readily available in the proximity of the dam site. Although only a sixth of the length of Krishnarajasagar (another stone dam in Mysore), the Bhadra dam can be raised higher to impound water half as much more, and generate almost an equal volume of hydro-power.

### THE PROJECT

With all these advantages there were quite a few hurdles to be crossed before the work was started. An agreement between the States sharing the river was necessary and preliminary investigations, project planning, administrative sanction and the like gave no small headache. Although work on the project was started in 1947, its further progress was held up till 1953 until the Central Government came to its rescue with financial assistance.

The Bhadra project comprises (i) a rubble masonry dam going up to 194 feet above the average river bed forming a reservoir of 43.5 square miles and a capacity of 63,035 million cubic feet of water; (ii) two irrigation canals, totalling 212 miles in length capable of irrigating nearly 2,45,000 acres; and (iii) power sluices in the dam on either bank to generate 33,200 kilowatts.

#### *The Dam*

The dam which spans a narrow, picturesque gorge, will be built with stone and *surkhi* mortar. It will be 1,400 feet long at the top. The two gaps on the left bank, of 1,600 feet and 780 feet, will be walled up with earthen embankments. To allow a major portion of the flood discharge to flow over the dam, a central spillway will be installed besides two undersluices. Between them, they can discharge a maximum flood of 1,20,000 cusecs. This is 25 per cent more than the maximum flood recorded in 1924. The dam is expected to be completed in 1961.

#### *The Canals*

The smaller of the two canals, the 50-mile left bank channel which has a 335 cusecs capacity, has been completed. It supplies water to 17,894 acres.

Much larger than this is the right bank channel, with a carrying capacity of 2,500 cusecs. It will run for 51½ miles and serve 39,551 acres until it enters the tunnel, and irrigate 1,76,755 acres beyond this point through branch channels in Davangere and Malebannur. Already the canal has been excavated through many a rocky out-crop in the earlier reaches. For negotiating the Ubrani hill range, the canal has to pass through a 2½ mile long tunnel. Work has been commenced on the tunnel and its approaches. The canal is expected to be completed by 1961.

#### *Hydro-electric Power*

The water that will flow through the irrigation channels is first passed through the turbines to generate power. Three sets of these turbines will be located, one at the head of the irrigation sluice on each bank and a third set at a lower level in the river valley. The entire output of 41,040 kilowatts will be available from 1961.

When the project is completed in 1961, the Bhadra dam will be a great tourist attraction, situated as it is in the midst of a vast tropical forest with plenty of wild life.

### MATATILA

The districts of Jhansi, Jalaun, Hamirpur and Banda in the south of Uttar Pradesh are criss-crossed with numerous rivers. Nevertheless their history has been one of recurring famines and chronic food shortage. Instead of being helpful to agriculture, these waterways have often been a source of nuisance during monsoon floods. During winter and summer, however, their beds become dry and agriculture becomes impossible for want of irrigation.

### THE PROJECT

The Matatila project derives its name from the goddess whose temple stands over a nearby ridge. It comprises a high masonry dam, 2,340 feet long and 120 feet high across the Betwa river, about 30 miles south of Jhansi. Two main canal systems will utilise this water to feed about 4.13 lakh acres in Uttar Pradesh and Madhya Pradesh. The project has been divided into two stages. The first stage in which

the dam was raised to the spillway crest was taken up under the first Plan to store 16,000 million c.ft. of water and to irrigate 2.64 million acres. It was also decided to provide penstock pipes in the dam.

The next stage which was included in the second Plan provided for gates over the spillway crest in order to increase the storage. The total storage capacity of the project is 40,000 m.c.ft. and 4.13 lakh acres become irrigable through a 770-mile net-work of canals fanning out from the reservoir.

### *The Earth Dam*

The central masonry dam at Matatila is flanked on either side by earthen bunds with a total length of 18,580 feet, the height varying between 20 to 80 feet. At its busiest period of construction as many as 30,000 labourers were at work. Apart from manual labour, earth-moving machinery was also extensively used, and a workshop was set up at the site to keep the machines in good repair.

### *The Canals*

Two life-lines, the Gursarai and Bhandar canals, take off above Paricha dam on Betwa river, roughly 36 miles below the Matatila reservoir, and utilise the water stored by it. The lie of the land in Bundelkhand renders the construction of flow canals rather difficult. For hundreds of yards at a stretch, hard granite has to be blasted to secure a passage. As much as 2 million c.ft. of stone (about 40,00,000 maunds) had to be blasted and dug out through the very first 20 miles of the Gursarai canal.

While its rocky soil created one type of difficulties, the uneven terrain of the land created a different problem. No less than 40 syphons and aqueducts had to be built in the first 20 miles over the Bhandar canal. The undulations called for extra digging and earth work over the land. Huge cement concrete barrels have been laid in these syphons to tunnel the water across difficult terrain. The total length of these barrels is roughly 2 miles.

Before the foundations for some of the canal structures could be laid, dozens of pumps had to work day and night to

clear the sub-soil of spring water. At the Pahuj syphon and the aqueduct on the Gursarai canal, the water from the springs had to be pumped out continuously.

Occasionally problems arose which had never been foreseen before. The entire foundation of the masonry dam, for instance, found a regular granite base, but over a length of 150 feet it had to be dug 30 feet deeper because of an intervening layer of quartzite. This obstacle alone held up the progress of work on the foundation for over a year.

In spite of these deterrents the first stage of the project was completed during the first Plan, and the second phase is expected to be finished by March 1962. The work on the construction of Gursarai canal has been completed, while on the Bhandar canal work is progressing satisfactorily. Major portion of the work in connection with the remodelling of Betwa canal has also been completed. Out of the 750 miles of channels provided in the project, more than half have been already completed and they have commenced supplying water for irrigation.

### BENEFITS

The Matatila project will provide irrigation to 2.59 lakh acres in the Jhansi and Jalaun districts of Uttar Pradesh, and 1.54 lakh acres in Madhya Pradesh. This is expected to yield an additional 75,000 tons of foodgrains.

The benefits from the projects are not entirely confined to the villages and the farms. Jhansi city, which is now being fed by a small reservoir on the Betwa, will also be able to augment its supplies from the Matatila reservoir. It will then be possible to have a flow system which will bring in considerable economy in maintenance and reduction in consumer rates. The railway colony and the military station of Jhansi may also, in course of time, have their water supplies augmented from Matatila.

As per revised proposal the power house will be able to generate 30,000 kilowatts of electricity which is sufficient to meet the demands of Jhansi, Jalaun and Hamirpur districts.

### *Cultivation of Cash Crops*

The Government is now providing new facilities for the cultivation of cotton which is specially suited to the soil of the area. A scheme for the cultivation of long staple cotton in Bundelkhand has already made good progress. Irrigation water is also being supplied, free of cost, to cotton growers during the pre-sowing period.

Another cash crop which once flourished in Bundelkhand, but since recently had become unpopular with the farmers, is tobacco. The State Government is now giving special facilities to tobacco-growers and this industry will be on its feet again.

### GHATAPRABHA

The Ghataprabha, with its two main tributaries, the Hiranyakeshi and the Tamraparni, is one of the principal rivers of the Deccan. Rising in the Sahyadri hills in the Western Ghats it flows in an easterly direction and joins the river Krishna in the Bijapur district. The Ghataprabha has a good catchment with a rainfall varying from 50 to 200 inches in the monsoon months. Thus, it drains annually large quantities of water—estimated at 1.25 lakh million c.ft. But, once the rains are over, the river dwindles to a streamlet.

While the rainfall in the Ghats is plentiful, it is scanty and untimely in the eastern parts of the river valley. This explains why large parts in the Belgaum and Bijapur districts are frequently affected by drought and famine.

### THE PROJECT

Accordingly, various proposals for utilising the waters in the upper reaches of the river to irrigate the scarcity areas had been under consideration ever since the turn of the century. A project (called the Daddi dam project) for a storage reservoir in the Belgaum district, was prepared in 1908. But then it was found to be uneconomical, and the proposal was dropped. Another scheme prepared in 1924 envisaged a storage of 25,000 million c.ft. of water and a canal on the left bank of the Ghataprabha. This idea, too, was dropped on the same plea.

The project was, however, revised in 1947. The proposals, in their present form, consist of two storage dams. one at Hidakal on the Ghataprabha and the other at Ajra, with a canal on the left and another on the right bank. The project is to be carried out in the three following stages :

### Stage I

A canal with 1,500 cusecs capacity, 44 miles long, taking off from the weir at Dhupdal to command 2.5 lakh acres on the left bank of the Ghataprabha and the right bank of the Krishna. It will irrigate 1.2 lakh acres during the monsoon months.

### Stage II

(a) An extension of the left bank canal from mile 44 to 73, increasing its capacity from 1,500 to 2,000 cusecs. This will irrigate an additional area of 1.78 lakh acres.

(b) Construction of a reservoir to store 23,300 million c.ft. of water on the Ghataprabha at Hidakal, about 12 miles upstream of the weir. It will supply water for 8 months giving assured irrigation for *kharif* and *rabi* crops in the area.

### Stage III

(a) A canal taking off from the weir at Dhupdal on the right bank to irrigate about 4 lakh acres.

(b) The construction of another storage dam of 32,500 million c.ft. capacity at Ajra on Hiranyakeshi which is a tributary of Ghataprabha. The canal which will take off on the right bank will irrigate the *kharif* and *rabi* crops.

The entire scheme is estimated to cost about Rs. 59 crores.

## FIRST STAGE

The programme for the first stage has been so phased as to enable successive sections of the canals to be opened for irrigation even as the work progresses without having to wait for the completion of the entire scheme. The first section of 8 miles to irrigate about 1,500 acres was opened in June 1951, the second from mile 9 to 17 to irrigate about 30,000 acres in June 1953, and the third from mile 18 to 32 to irrigate about 80,000 acres in August 1954. The first 8 miles of the north branch of the canal were also opened for



irrigation in October 1954. Finally, the remaining portion of the canal, which will command 2,50,000 acres, was opened in October 1955. With the opening of this section water from Ghataprabha is now available for raising crops on the rich black soil on the bank of the Krishna.

The first part of the second stage of development falls within the scope of the second Plan. The project for the extension of the canal was taken up in October 1956. This and other works related to the project have been in progress since then. The construction of the dam was also extended to the second Plan period. After the reorganisation of States in 1956, the dam site has come under the Mysore State.

The work of investigation and survey for the right bank canal is in an advanced stage of progress and construction is proposed to be taken up during the third Five Year Plan.

#### KOYNA

The river Koyna rises in the western slopes of the Mahabaleshwar plateau and in the Western Ghats and joins the Krishna. At the point where it passes Deshmukwadi near Halwak in North Satara district of Maharashtra, it offers the most favourable site for generation of cheap hydro-power and storage of water. On the western face of the Ghats there is a steep drop of about 2,000 ft. between the ridge and the foot of the hills. Catchment area up to the dam site is about 344 sq. miles which receives an average rainfall of about 210 inches. The Koyna electric project is designed to take maximum advantage of these factors.

The dam at Hidakal will be raised to store a gross volume of 51,000 cubic ft. A canal to be constructed on the right side will irrigate an additional area of about 3 lakh acres at an estimated cost of Rs. 20.45 crore.

#### THE PROJECT

After detailed investigations it was decided to construct the project in stages to generate power and store water for irrigation. The project is so planned that each stage can be completed as a unit by itself. For the present, the first stage of the project has been taken up for construction.

The first stage provides for the building of a dam and a water conductor system to generate 2,40,000 kilowatts of electrical energy through four generating sets of 60,000 kilowatts each. All the generating sets are expected to be commissioned by the end of 1961.

The initial stage of the project is estimated to cost Rs. 38.28 crore.

### *The Dam*

The Koyna dam is being built of rubble concrete. In the first stage the dam will be 207.5 feet high above the river bed and 2,200 feet long at the crest. The spillway is to be located in the gorge portion.

The capacity of the reservoir so formed will be 36,045 million cubic feet, and the water spread about 21 sq. miles. Excavation and concreting works have already made substantial progress.

### *Power Generation*

A unique feature of the Koyna project is that the power house will be located underground, 800 feet vertically below the ground level.

The water conductor system consists of a head race tunnel 12,300 ft. long and 21 ft. in diameter. It will lead the water from the lake to the surge system on the western face of the Ghats. Beyond the surge, four pressure shafts aligned at 45 degrees to the horizontal will carry the water to the machines in the power house. Of these four pressure shafts, two will be put up in the initial stage. Each shaft is capable of feeding two turbines.

The power house consists of three caverns, each a furlong long, to accommodate the valves, turbines and generators and the transformers. From the turbines the water is collected and let through a tail race tunnel, 7,500 ft. long for giving it an outfall into the local hill stream.

In the second stage four more generating units will be installed after raising the dam to the final height.

Power development in the third stage consists of exploiting the potential of the tail race waters flowing down the

rapids of the hill stream. The total power which will be generated when all the three stages are completed will be about 5,00,000 kilowatts.

With the second stage of construction it is proposed to store in the same reservoir about 0.90 million acre-feet of water for purposes of irrigation in the Koyna-Krishna basin.

#### BENEFITS

The Bombay-Poona area is highly industrialised and additional cheap power is badly needed to meet the demands of expanding industries in this area. The rural areas adjoining the Koyna project have also a substantial potential for industrialisation. The Konya power will, to some extent, help to decentralise the industries which are concentrating in a limited area.

The cost of power generation in the first stage of the project would come to about 2.18 nP per unit at the Koyna bus-bar. When it is transmitted over 220 kV. transmission lines to Trombay, it is estimated to cost about 2.8 nP per unit.

As the work of the construction goes on, the project offers employment to a large number of skilled and unskilled workers. Subsequently, as fresh supply of electric power is made available in Southern Maharashtra or in the Bombay-Poona area, new opportunities for gainful employment will be available to thousands of skilled and unskilled workers.

#### CHAMBAL

The plight of the people of the Chambal Valley has always been sad. Every year enormous quantities of water from the Chambal flow to the sea. Yet the people are left literally high and dry, looking up to the skies prayerfully for some rains. The soil is rich and fertile, and people, too, are hardy and industrious. That is what makes their plight particularly tragic. If only there were enough assured water for their land and power to work mines, many industries would prosper in this region. The Chambal Project is designed to meet this age-long need of the people of the valley.

The Chambal rises in the northern slopes of the Vindhyas

at an elevation of 2,800 feet, and flows across the States of Madhya Pradesh, Rajasthan and Uttar Pradesh. After traversing a distance of about 6,000 miles it joins the Yamuna near Etawah in Uttar Pradesh. The total catchment area, which mostly consists of a plateau covered by fertile black soil or alluvium, measures 55,300 square miles.

From its source down to its junction with the Yamuna, the Chambal has a total descent of about 2,400 feet. Of this, about 800 feet are in the first few miles and 400 feet at a distance of about 60 miles from the Chowrasigarh fort up to Kotah city. In the rest of its reaches it passes through flat and fertile areas, first in the Malwa plateau and later in the Gangetic plains.

At the fort of Chowrasigarh the Chambal enters a deep and narrow gorge of sandstone cliffs. At its mouth the gorge measures about 2,500 feet but narrows down to about 700 feet at a distance of three miles. It then widens to various widths ranging from 1,200 to 1,500 feet.

Like the rivers of South India, the Chambal also carries considerable volume of water during the monsoons, but is reduced to a trickle in the dry months. No power development or assured irrigation is possible without storage of water. Indeed, the basin near the mouth of the gorge at Chowrasigarh makes a good natural water reservoir. It is claimed that the Gandhi Sagar (as the lake is proposed to be named) will be one of the cheapest man-made lakes in the world.

In spite of substantial water potential in the Chambal Valley, no investigations were carried out before 1945. During World War II, investigations were set afoot to explore the possibility of using the river water to generate electric power for working the tin and zinc mines of Udaipur. Meanwhile the princely States of Kotah, Mewar and Indore prepared schemes of their own designed mainly for power development within their areas. But they did not draw up their schemes by mutual agreement. The schemes they prepared conflicted so much with one another that ultimately nothing came out of them. In 1954, however, the Central Water and Power Commission prepared an integrated plan for irrigation

and power. This forms the basis of what we now know as the Chambal Valley Project.

#### PROJECT FEATURES

##### *The Dams*

The scheme envisages the construction of three dams and a barrage. The first of these dams, the Gandhi Sagar Dam, which will be located at a site 5 miles downstream of the Chowrasigarh fort, will be a straight gravity dam, built of stone masonry. It will generate 92,000 kilowatts of power at 60 per cent load. The dam will be 207 feet above foundation and 1,680 feet long at the top. It will have a capacity of 6.85 million acre-feet of water, the lake covering an area of 265.6 square miles.

The second dam, the Rana Pratap Sagar Dam, will be 123 feet high and 3,620 feet long. It will be built at a distance of about 20 miles further down north of Rawatbhatta in Rajasthan. The reservoir behind the dam which will have a spread of 76.5 square miles will store 2.35 million acre-feet of water. It will serve as a balancing reservoir in addition to storing the run-off. The power station will generate 128,000 kilowatts of power.

The third dam called the Kotah Dam will be located at a distance of about 10 miles upstream of the city of Kotah. It will function as a pick-up dam with a power station below it. Only the regulated releases of water from the Gandhi Sagar Dam and the Rana Pratap Sagar Dam will be utilised for the generation of 81,000 kilowatts of power.

##### *The Barrage*

The irrigation requirements will be served by a barrage known as the Kotah barrage which will divert water through the two canals taking off from the reservoir, one on the right and the other on the left side. The barrage will be about 120 ft. high and 1,810 ft. long. It will be a composite structure, the main river section being made of earth and protected by stone, and the spillway will be in masonry topped with gates.

##### *Left Main Canal*

After taking off from the Kotah barrage the Left Main

Canal runs for 1.61 miles from where it will bifurcate into the Bundi distributary and the Kaperen branch. The Bundi distributary will irrigate 96,000 acres and the Kaperen branch 1,64,000 acres annually.

Taking off from the Kotah barrage the Right Main Canal carrying a discharge of 6,650 cusecs will pass through Rajasthan for the first 79 miles of its length. At its 80th mile at the crossing of the Parvati river, the canal will enter Madhya Pradesh, carrying a discharge of 3,900 cusecs.

#### *Transmission Lines*

A network of transmission lines will be constructed for the distribution of power. Two main lines will start from the Gandhi Sagar power station, one going south towards Indore and the other north towards Kotah, Sawai Madhopur, Jaipur and Gwalior.

#### PROGRAMME OF CONSTRUCTION

The project, which is being built jointly by the Governments of Madhya Pradesh and Rajasthan, will be carried out in three stages.

The first stage envisages the construction of the Gandhi Sagar Dam, the Gandhi Sagar power station, the Kotah barrage, the canal system and the transmission lines. The total revised cost of these works will come to about Rs. 62.0 crore. After the completion of the first stage 11 lakh acres of land will be irrigated in Madhya Pradesh and Rajasthan and 92,000 kilowatts of power will be generated.

In the second stage, the Rana Pratap Sagar Dam and its power station with a generating capacity of 1,28,000 kilowatts of power will be constructed and transmission lines extended. This will bring an additional area of 3,00,000 acres under irrigation. The total cost for this stage was estimated at about Rs. 17.20 crore.

The third and final stage will consist of the Kotah Dam and a power station of 81,000 kilowatts capacity besides further extension of the transmission lines. This stage is estimated to cost about Rs. 10 crore.

#### PROGRESS

Work on the Gandhi Sagar Dam which began in 1953 is

now almost completed and power generation commenced in November 1960. The construction of the Kotah barrage is also progressing satisfactorily. The work in connection with some of the cross drainages and earthwork in several reaches on the canals has been entrusted to the National Project Construction Corporation. Local labour is also engaged where possible, and labour co-operatives are being encouraged with the assistance of public workers and the Bharat Sewak Samaj. The first stage is scheduled to be completed in 1962.

### BENEFITS

When the phased programme of development of the Chambal valley is completed, it will irrigate annually 11 lakh acres of land, adding 4.75 lakh tons of foodgrains every year. The new facilities for irrigation are bound to change considerably the complexion of agriculture in these regions. The area lying in the former State of Madhya Bharat, which is proposed to be benefited by this irrigation, has frequently suffered from famines. During the last 25 years, the Government has had to spend on an average about Rs. 2,00,000 annually by way of relief to the distressed people and remissions of land revenue. When the project is completed all this loss can be avoided, and agriculture will become a paying proposition.

The principal crops grown in these regions are jowar, bajra, paddy, wheat, gram, barley, oilseeds, pulses and sugarcane. Cotton used to be grown extensively at one time, but was given up owing to recurring droughts. With the creation of new irrigation facilities it is expected that nearly 70 per cent of the area would be under wheat, 20 per cent under paddy, 5 per cent under sugarcane and garden crops and 5 per cent under cotton.

Furthermore, the Chambal scheme will generate 3,01,000 kilowatts of power. At the proposed rate of 6 nP. per unit, power supply should both be cheap and sufficient to bring new industries into existence in this part of the country. Moreover the scheme will save rail transport of about 1,75,000 tons of coal from the coal-fields which are situated some 800 miles away. With increased food production and

ample supply of cheap power the economic betterment of the 23 million people inhabiting this region is assured. The march of the desert, too, will be halted in Rajasthan, and smiling fields will appear where land simmered in the desert heat.

The first stage of the Chambal Valley development scheme was included in the first Five Year Plan. It was continued in the second Plan. The installation of the fourth generating unit at the Gandhi Sagar power station and additions to transmission lines from 772 to 911 miles have been approved by the Planning Commission. Subsequently in the second Plan Rana Pratap Sagar dam and power station have also been approved by the Planning Commission.

The project is being financed by the participating States from loans advanced by the Government of India and is under the Chambal Control Board.

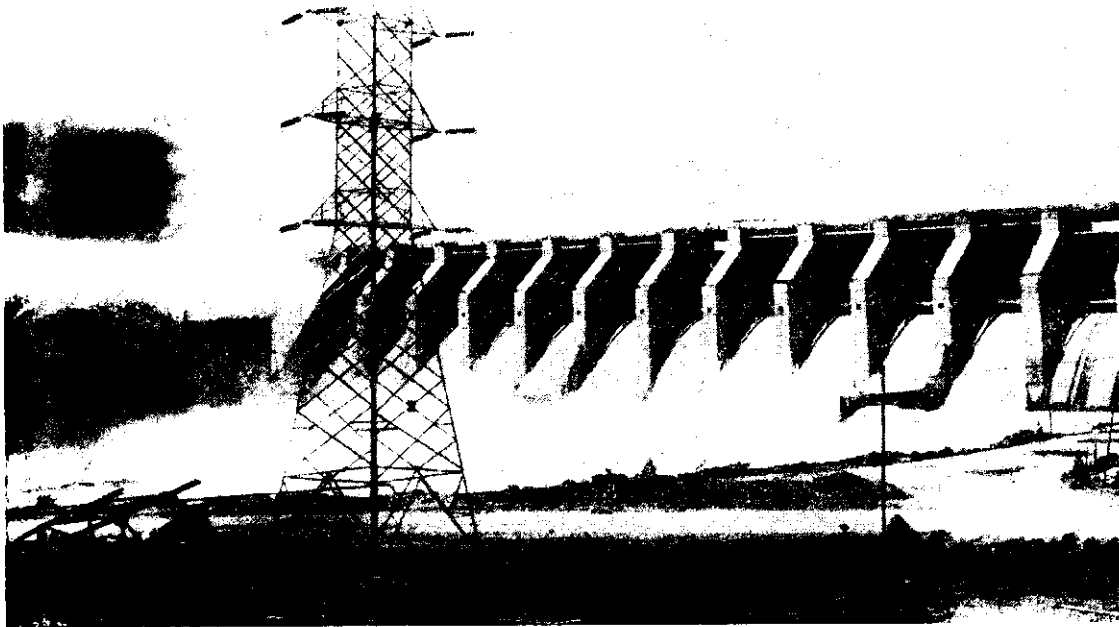
#### NAGARJUNASAGAR

The Krishna is the most claimed inter-State waterway in our country. At its source in the Western Ghats it is a sleek little fountain, hard to imagine that it could ever flow as a mighty river. The river has a catchment area of 97,050 square miles on either side of its seemingly endless course, almost touching the headwaters of the Godavari in the north and overlapping those of the Pennar and the Bay of Bengal. It has many tributaries, too—the Ghataprabha, the Malaprabha, the Tungabhadra, the Bheema and the Musi.

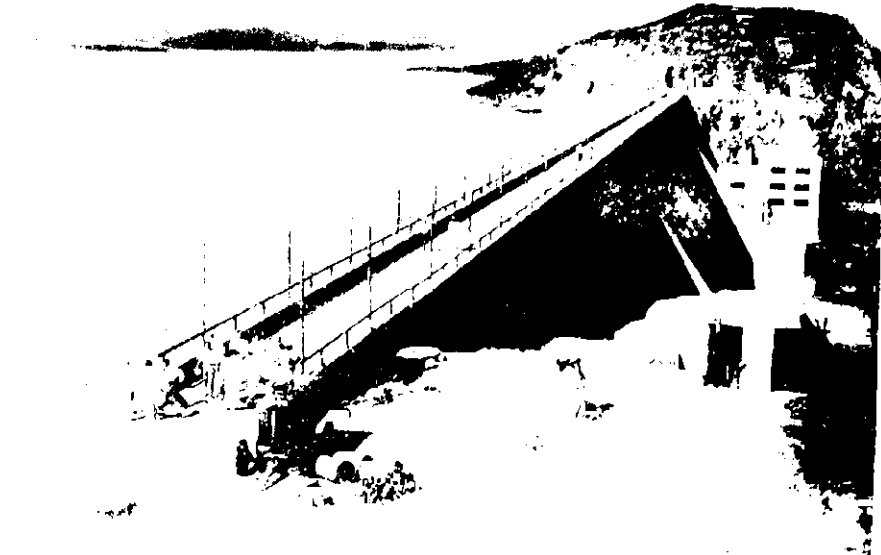
Krishna is a typical monsoon river. During the rainy season it swells into a mighty torrent, but is reduced to a streak during summer, meandering along insignificantly in wide sandy wastes. Thus, from June to October, it is full of water, and at the peak of flow a million cusecs sweep past the town of Vijayawada. After October the volume of water rapidly decreases till, by the end of January, it hardly overflows the anicut at Vijayawada if the head sluices of the canal are left open.

Along its course the Krishna flows through mostly fertile regions, but its waters are hardly sufficient for irrigation. These semi-arid parts lie in the districts of Belgaum, Chitaldrug, Raichur, Gulberga, Bellary, Kurnool, Guntur, Nal-

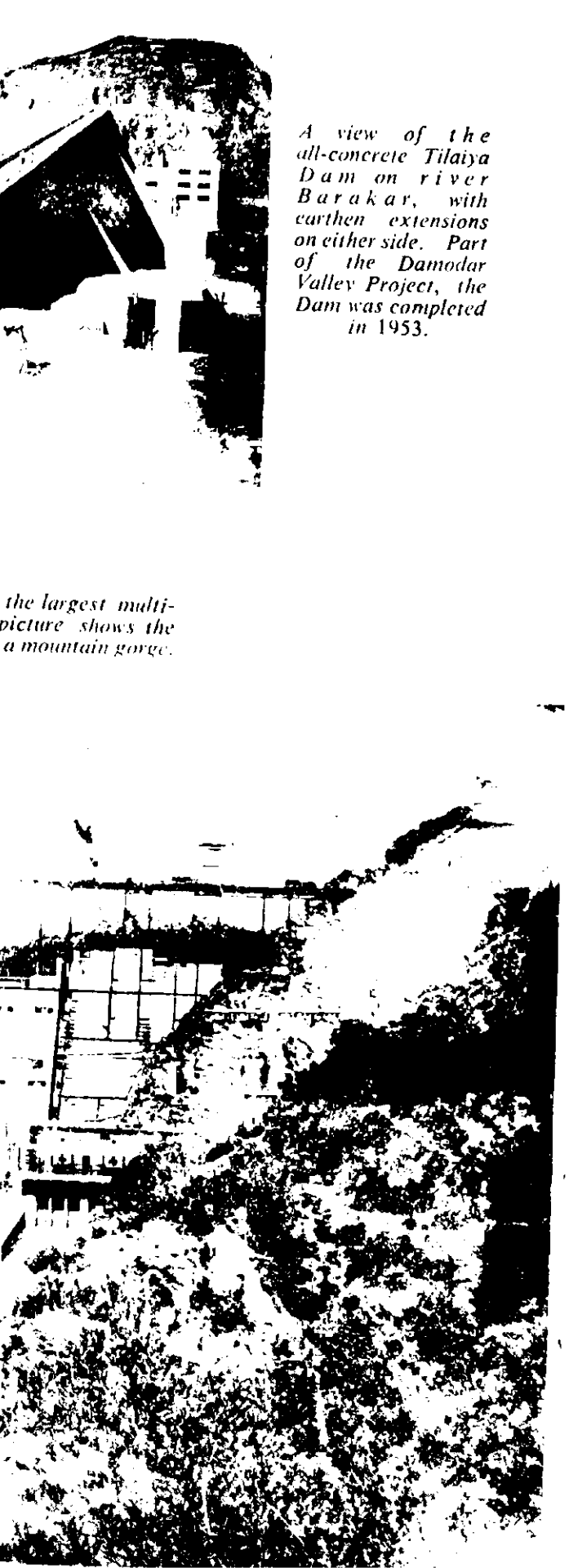




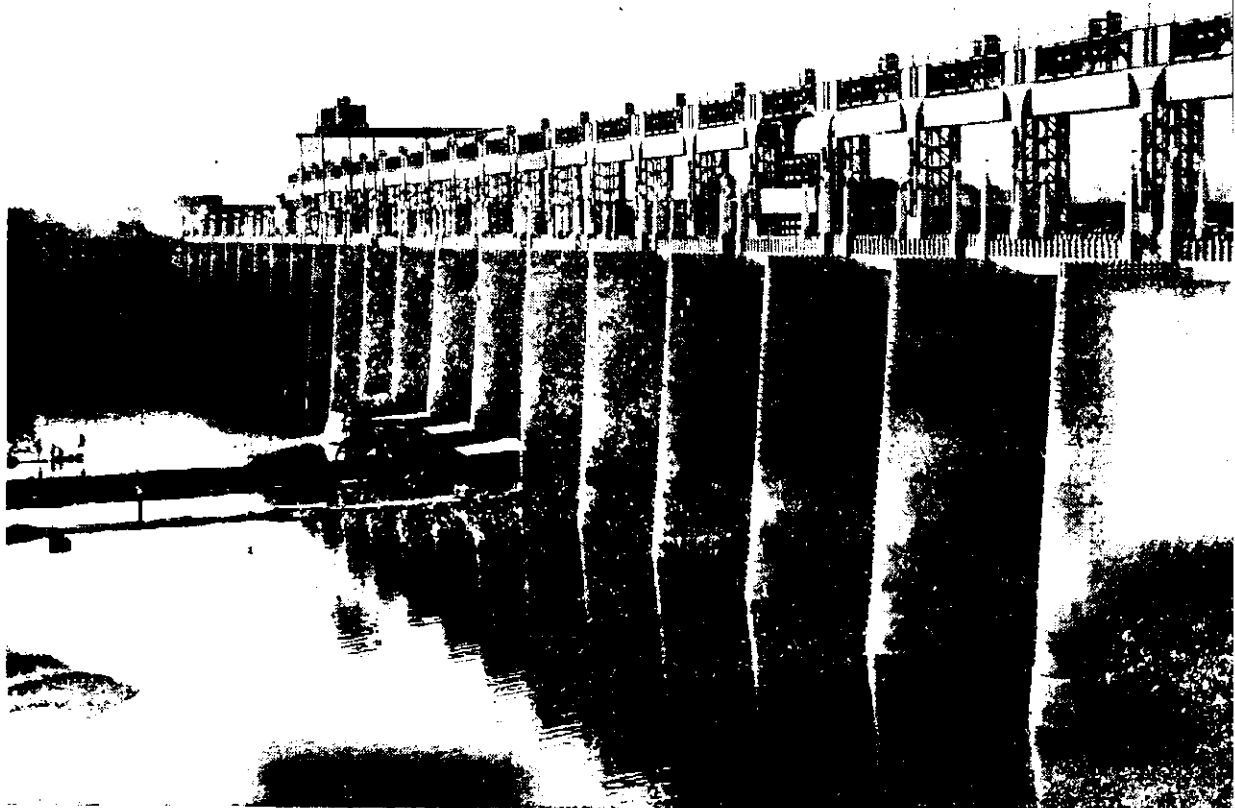
*The Panchet Hill Dam, designed primarily for flood control, is one of the four storage dams of the Damodar Valley Project.*



*A view of the all-concrete Tilaiya Dam on river Barakar, with earthen extensions on either side. Part of the Damodar Valley Project, the Dam was completed in 1953.*

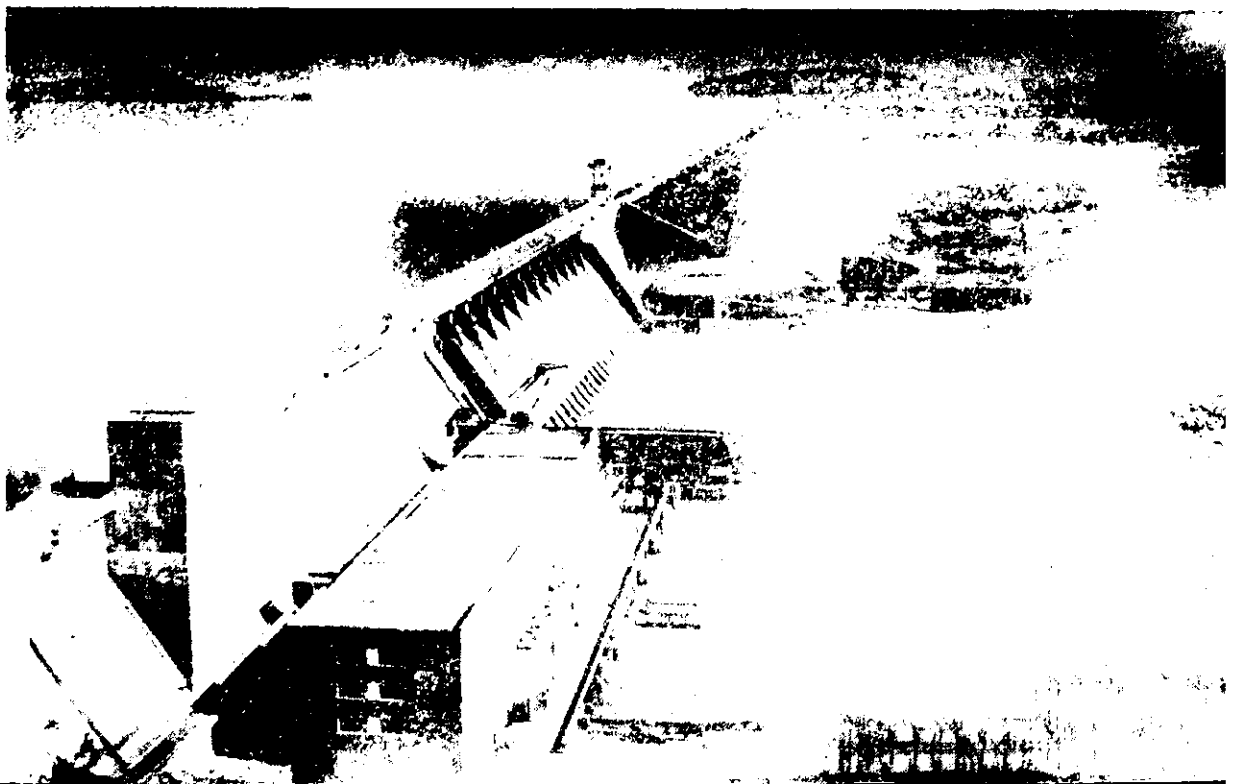


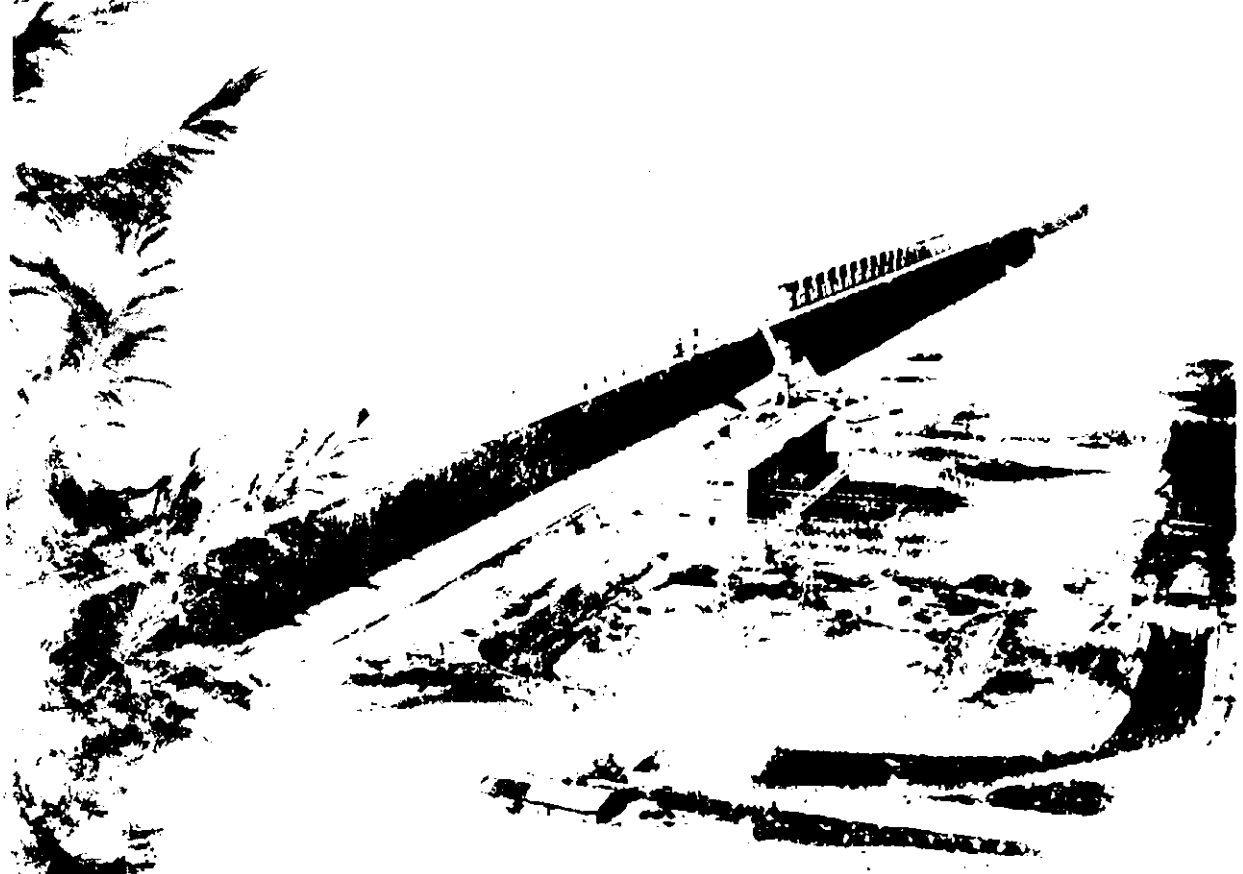
*The Bhakra Nangal Project is the largest multi-purpose project in India. The picture shows the Bhakra Dam across the Sutlej in a mountain gorge.*



*A view of the Nangal Dam, eight miles down-stream of Bhakra, built to serve as a balancing reservoir.*

*The 15,748-foot Hirakud Dam, flanked by 13 miles of dykes on both sides, is the world's longest main stream dam, and harnesses the river Mahanadi in Orissa.*



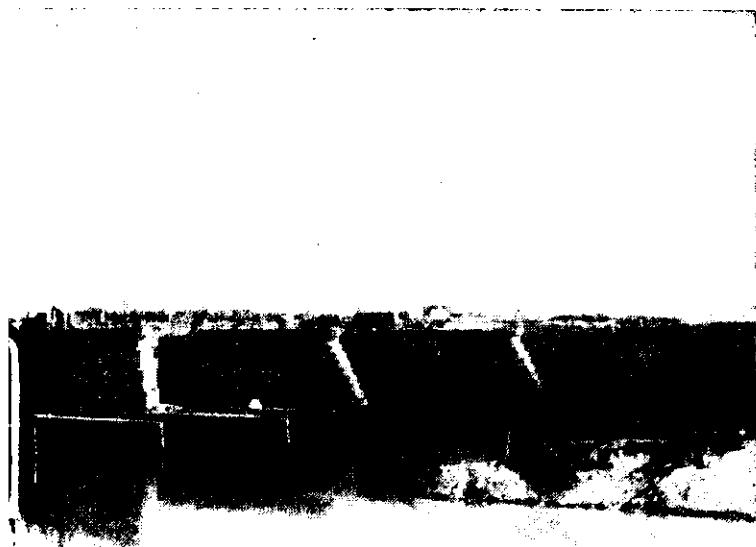


*A view of the Tungabhadra Project comprising a dam on Tungabhadra river and a system of canals and power stations on either side. The project is a joint undertaking of the Governments of Andhra Pradesh and Mysore.*





*A view of the Canada Dam, completed in 1920,  
under the Mayurakshi Project of the West Bengal  
Government.*

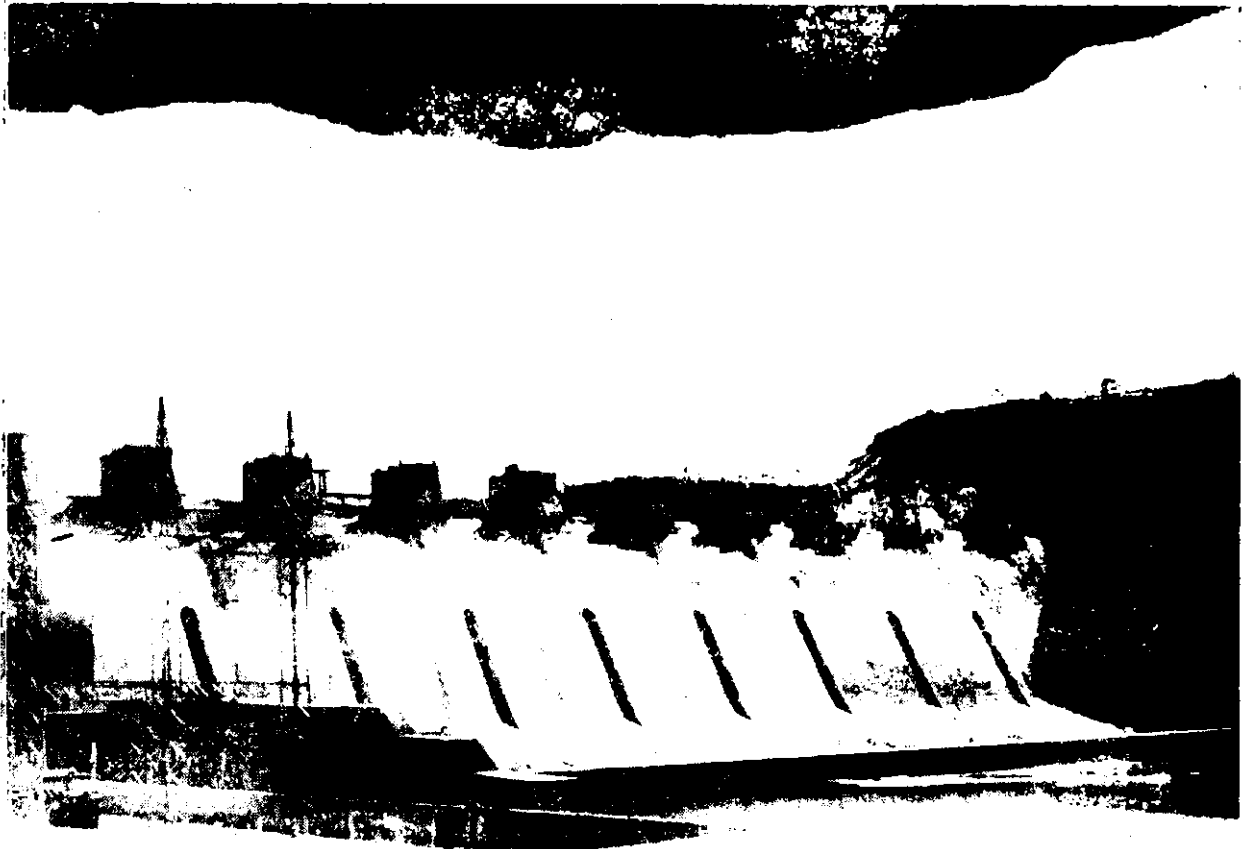


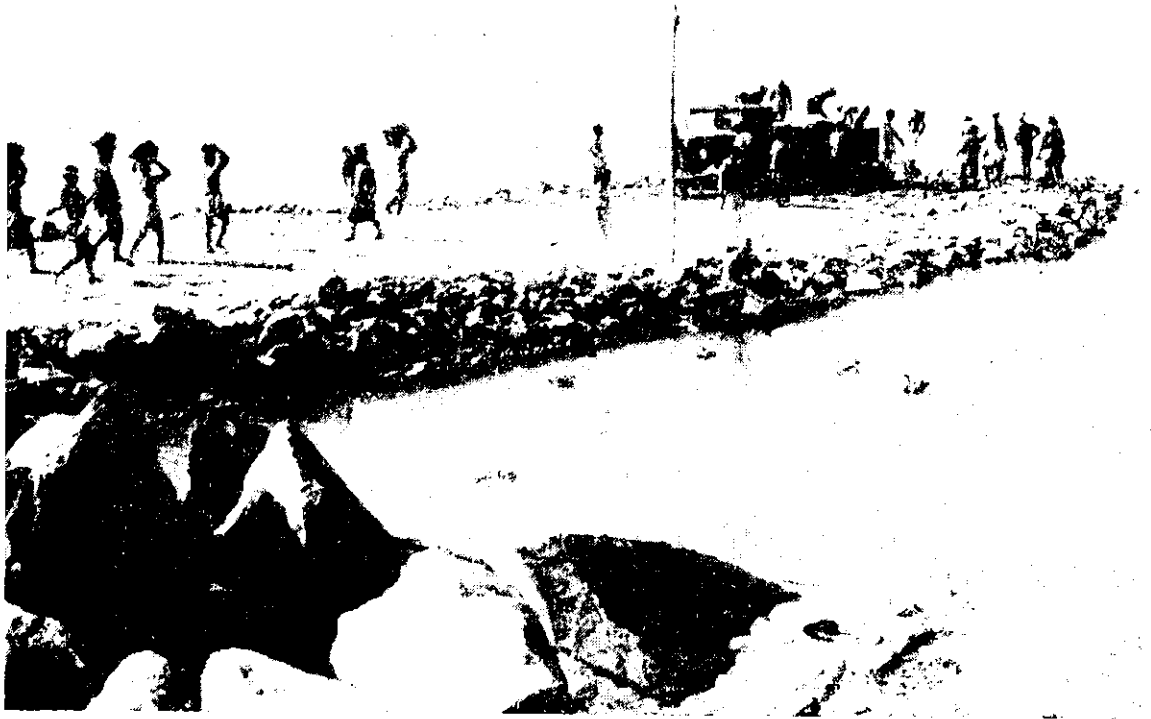
*The picture shows the  
main barrage under con-  
struction across the Kosi,  
as part of the Kosi  
Project.*



*The picture shows the Koyna Project under construction. A dam across Koyna river and an underground power station of a total capacity of 2,40,000 kw form part of the Project, which will benefit Bombay, Poona and the adjoining areas. 1*

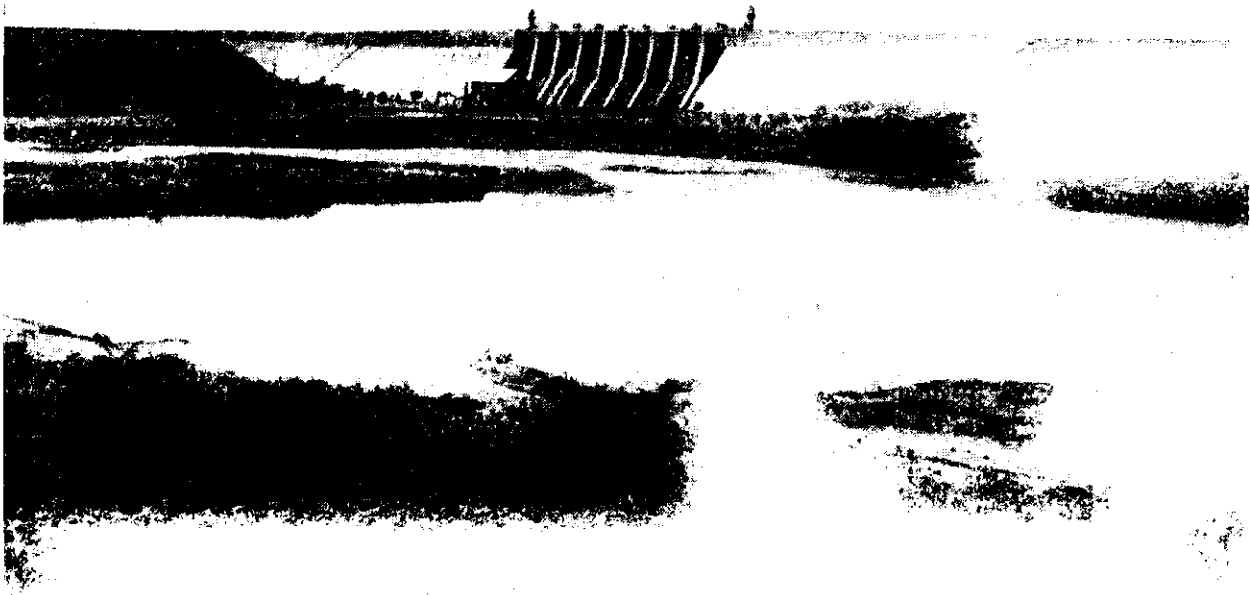
*The Gandhi Sagar Dam constructed under the Chambal Project which is executed by the Madhya Pradesh and Rajasthan Governments. A power station, transmission lines, the Kotah Barrage and canals on either side of the barrage are the other schemes of the Project.*





*Stones, sand bags and other material are used to save low-lying areas from the fury of floods.*

*A view of the Bhavani Sagar Dam, Madras*





*A little cargo boat sailing down the Godavari Canal*

*Workers engaged in taming the Kosi, on  
the western embankment, near Nirmali*





gonda and Khammam. The complete dependence of these areas on fitful rains has been responsible for the notorious famines to which this region is subjected. If the waters of the Krishna could be stored, the entire picture of the valley would change beyond recognition.

### *Early Attempt*

The first attempt to harness the Krishna was made in 1952-55 when an anicut was constructed across the river near Vijayawada. Although the area under cultivation expanded nearly 22 times, the demand for more water continued. The Irrigation Commission (1901-2) recommended the construction of a reservoir across the Tungabhadra, a tributary of the Krishna, and a reservoir on the lower reaches of the Krishna near Pulichintala. The Tungabhadra reservoir, as we have already noted, has been completed.

After examining the existing utilisation of the waters of the Krishna in the various States the Planning Commission agreed to the construction of the Nagarjunasagar project.

### THE PROJECT

The project was launched in 1955-56 as a joint venture of the old Andhra and Hyderabad States. It comprises a masonry dam near Nandikonda, about 90 miles below Siddeswaram, a right bank canal 135 miles long and a left bank canal of 108 miles. It will bring under irrigation 9.7 lakh acres under the right canal and 7.90 lakh acres under the left canal, besides an area of 1.50 lakh acres in the Krishna delta. The project will, on completion, irrigate 20.6 lakh acres in Andhra Pradesh, produce an additional 8 lakh tons of foodgrains and generate 75,000 kilowatts of power. The entire project is estimated to cost nearly Rs. 91.115 crore.

### *The Dam*

The Nagarjunasagar dam will be located  $1\frac{1}{2}$  miles downstream of Nandikonda village in the Nalgonda district. The site chosen for the dam offers many advantages. The foundation rock at this place is excellent, being hard granite. It is easily accessible both from the Hyderabad and Andhra sides. Large areas extending between the Krishna and the

Pennar in the south can be commanded by the reservoir. Since the reservoir submerges the site of an ancient centre of Buddhistic culture, the well-known Nagarjunakonda monuments, steps have been taken to remove the relics to a safe place for preservation.

The dam which will be 290 feet above foundation level in the spillway section and 330 feet in the non-spillway section will run to a length of 4,780 feet. It will be built almost entirely in stone masonry and provided with eight penstocks, each of 14 feet diameter, for generation of power in the final phase of the project. It will consist of a 1,430 feet long spillway capable of discharging 11.5 lakh cusecs.

#### *Excavation of Canals*

The right bank canal takes off from the right flank of the dam and is estimated to cost Rs. 30.78 crore. Detailed investigation of the main canal was completed by the end of 1958 and work on the main canal and its distributaries is progressing satisfactorily. The left canal takes off from a head sluice and will be built at a cost of nearly Rs. 24 crore. Preliminary investigations on this canal were also completed by the end of 1958. The railway line from Macherla over a length of 11¾ miles has been completed, and 1,355 residential buildings have been built for the workers. In addition, a central office, a hostel and a central hospital have also been built. Labour colonies have been provided with amenities like hospitals and fair price shops.

#### *Work on the Dam*

A 40 ft. high masonry coffer dam involving 1½ million c.ft. of masonry at a cost of Rs. 14 lakh was completed in May 1956. The excavation of the foundations for the main dam, started in June 1956, is almost complete.

To ensure communication between the two banks of the river, the construction of a road bridge, about 3,000 ft. below the dam, was started in April 1956 and completed in November 1957. The dam is expected to be completed by 1964.

The Nagarjunasagar Control Board is constituted by the Government of India with the Chief Minister of Andhra Pradesh being in overall charge of the project in his capacity as the Chairman.

## LOWER BHAVANI

What the Ganga is to North India the river Kaveri is to the South. These two river valleys have cradled ancient civilisations and given sustenance to millions of people all through history. It is little wonder that the Kaveri is among the most exploited waterways in the country. The utilisation of 60 per cent of its waters has not assuaged the thirst of the valley.

The process of development naturally started with the main river. First came inexpensive devices like anicuts across the flow and canals taking off from the river channel. Then followed the more elaborate schemes like the Krishna-rajasagar and Mettur dams, long canals feeding lakhs of acres at a stretch, power houses and transmission lines bringing electricity to hundreds of square miles. Eyes were then cast on projects capable of construction along the feeders to the Kaveri. The Lower Bhavani is one such project in recent years. As the name implies, it harnesses the waters of the Bhavani in the lower reaches of the river to provide irrigation and generate power.

Rising on the eastern slopes of the Western Ghats, the Bhavani drains an area of 2,376 square miles. The river comes under the influence of both the south-west and north-east monsoons and carries heavy freshet of the order of 50,000 cusecs and more. But these last only for a few days. At other times, the flow is barely sufficient for the irrigation of 39,000 acres under two anicuts on the river below the dam.

## THE PROJECT

The project comprises (1) a dam across the Bhavani about 10 miles upstream of Satyamangalam where the catchment is 1,621.5 square miles; and (2) a canal taking off from the dam on the right flank. The project has been completed and brought into use well within the period fixed for completion. The total cost of the project has come to Rs. 9.51 crore.

*Masonry Dam*

The dam is 204 feet high and 1,523 feet long. It is designed as a gravity dam, incorporating all the features of modern construction. Because of the presence of Tale Schists which

are soft, the foundations had to be taken down 64 feet below the river bed to reach the hard rock. The foundations have also been extensively grouted to reduce uplift. A drainage gallery has been provided for the entire length of the dam to intercept and lead away any seepage water that may cause the uplift.

The dam has nine sluices for passing the discharge along the existing river course. It will also dispose of a part of the floods, besides enabling heavy silt-laden flows to pass down and reduce silting up of the reservoir.

To the right of the river sluices four penstock pipes are located. These are to feed the machines intended for the generation of about 10,000 kilowatts of power. To the right of the penstock pipes are the five canal sluices to let in water into the new canal.

To the left of the river sluices is the spillway designed to discharge a flood of 1,11,000 cusecs. This, together with river sluices, will permit a discharge of 1,42,750 cusecs.

From the crest of the spillway, the over-flow drops through some 113 feet. The force of this fall would damage the toe of the spillway on the downstream side. In order to prevent this, measures were devised at the Poondi Research Station, Madras. A basin at the foot of the spillway creates a cushion of water which absorbs much of the destructive force of the falling sheet of water.

### *Earth Dam*

The earth dam on either side of the masonry portion is 110 feet high and 27,339 feet long. No earth dam in South India has been built to such a height over such length. The dam is of zoned type and consists of seven parts according to the latest practices in earth dam design. The rocky layer is drilled and cement slurry forced under pressure to fill all crevices within the rocks to prevent water getting underneath the dam.

Selected soils of requisite strength and porosity make up the different layers of the earth dam. The sloping surface of the dam on the reservoir is provided with dry stone revetment to prevent damage by water. The down-stream slope is turfed and regular drains are provided at intervals

to take away storm water without damage to the earth bund.

The entire dam from end to end is provided with a roadway 25 feet wide. The volume of earthwork involved in the formation of the earth dam is about 162 million cubic feet. A field laboratory established at the dam site carried out constant tests, from hour to hour, to ensure the required quality on the works in respect of watering, compaction, etc.

#### *The Canal*

A canal capable of discharging 2,300 cusecs takes off from the dam on the right flank. It is 124 miles long and has a network of branch canals and distributaries to a length of 500 miles. The canal will bring under irrigation 2,07,000 acres of land in the Coimbatore district and benefit dry crops, cotton and millets in rotation.

Being a contour canal, irrigation is only on one side and it intercepts a number of natural drainages. Hence 183 drainage culverts, 3 canal systems, 106 bridges, 6 regulators and a number of direct and head-sluices have been built.

#### REHABILITATION

A peculiar feature of the Bhavani project is the unusual length of the dam which became necessary to ensure its present storage capacity. The peculiar nature of the site selected for the dam made it necessary to have such a long dam. No better sites were available. About 1,000 families were displaced from this area. But they have been given, free of cost, alternative sites to build houses on, and land up to a limit of five acres for each family. They have also been given building materials at 25 per cent of the cost to compensate for the loss of their old buildings. Materials which could be salvaged from the old villages were transported to the new sites by the Government, free of cost.

The villages that were submerged by the reservoir had grown in a haphazard way. But the new villages where the displaced families are rehabilitated are well-planned and neat looking.

#### BENEFITS

The project began to yield its first benefits from September 1952. An area of 5,000 acres received irrigation in

1952-53, 30,000 acres in 1953-54, 1,14,000 acres in 1954-55, and 1,67,000 acres in 1955-56. Full area had been thrown open to irrigation during 1956-57. Ultimately, when the full target of irrigation is reached, the project will produce 30,000 tons of additional foodgrains and 40,000 tons of jute and cotton annually. Indirectly, the lands, which were all fallow and worth very little, have now appreciated very much in value. Because of the greater manpower needed to cultivate the irrigated lands employment, income and living standards are rising steadily in the region commanded by the lower Bhavani.

### MAHI

The Mahi river rises in the Vindhya range of Madhya Pradesh and drains into the Gulf of Cambay of the Arabian Sea. It has a potential capacity to irrigate 14 lakh acres and generate about one lakh kilowatts of hydro-electric power.

Gujarat is noted for the fertility of its soils and the prosperity of its agricultural population. The soils vary from light *goradu* to rich black (*kali*) soil, the latter being particularly suited for wheat and cotton cultivation. The richest land is found in central Gujarat, the Kaira district, which includes the well known *Charottar* tracts. But nine months in the year the land thirsts for water. The main problem of this area is its rainfall which is very uncertain and ill-distributed; 70 per cent of it falls in July and August. Scarce rains in June hinder sowing while the October showers hinder maturing. Assured and timely irrigation can yield twice or thrice the average yield of all types of crops grown in this region. If the Mahi is properly harnessed, it will go a long way in providing irrigation to the scarcity areas in this region. The Canal Project Scheme on the right bank of Mahi commands a gross area of 7,90,000 acres bounded by Mahi river on the east and south, Shedhi river on the north and Sabarmati river on the west. This constitutes the first stage of the project, and the second stage will consist of a dam at Kandana, 44 miles upstream of the weir site with a capacity of 80,000 million cubic feet capable of irrigating 9,20,000 acres.

The project was conceived soon after the famine of 1900-1901, but work actually started in 1948. The project has now been revised so as to extend the scope of irrigation. In its revised version it is estimated to cost Rs. 22.70 crore, and irrigate 4.6 lakh acres.

#### THE SCHEME

The scheme now being implemented consists of a masonry weir at Wanakbori (District Kaira) and a distribution system for 7.9 lakh acres with a main canal 44 miles long.

A masonry weir 2,610 feet long is designed to pass a maximum flood discharge of 11 lakh cusecs. The weir, 95.6 feet high above the deepest bed level, is of granite. The work has now been completed.

#### HEAD REGULATOR AND MAIN CANAL

The Head Regulator consists of 7 openings designed to pass a discharge of 8,400 cusecs against the maximum discharge of 7,000 cusecs of the main canal. The work on the Head Regulator as also on the flood embankments has been completed.

The 44-mile long main canal is designed for a capacity of 7,000 cusecs. The canal is being brick-lined to prevent seepage.

## CHAPTER III

### IRRIGATION AND POWER

#### IRRIGATION

We have seen in the foregoing pages how dams, barrages, weirs and power houses are coming up fast to provide irrigation and flood protection to our lands and villages, and to generate power to work our mines and factories and light our homes and streets. We are able to build these enormous projects today because we have the aid of modern science and the resources and interests of the whole nation.

But there was neither of these advantages in the ancient past. Still, large tracts of agricultural land were under artificial irrigation. Relying almost entirely on local resources and occasionally on royal munificence people were able to construct tanks, dams and canals from which water could be drawn to irrigate the fields. We have references in the four Vedas to wells, canals and dams. A passage in the Rig Veda makes a doleful reference to an empty bucket lying on the bed of a dried up reservoir. Words like 'Kulya' (an artificial river or canal), 'sarasi' (a big reservoir or lake), 'nika', 'nala' and 'nalika' (all meaning different kinds of canals) are to be found in the Yajur and Atharva Vedas, and classical Sanskrit literature. The Kausika Sutra describes the rituals connected with the formal opening of a canal.

There are innumerable inscriptions all over South India (7th to 17th century) which speak of tanks, dams and canals. Almost every village of some importance had its own tank which stored up precious rain water during monsoons. This was used for irrigating hundreds of acres in its neighbourhood. To this day many of these tanks are serving the purpose for which they were originally intended.

Where plenty of river water was available, as in the Kaveri basin, canals were dug to irrigate agricultural lands. There are some stone inscriptions of South India which speak of hydraulic engineers (*Jala Sutrada*) and the Depart-



ment of Water Works (*Vari-Griha-Karana*). There were special treatises on dam construction and canal irrigation. The Chola rulers proved to be among the greatest builders of dams and embankments for the river Kaveri. The village communities and kings made elaborate provision for the maintenance of these works.

In north India where rivers are both snow and rain fed and therefore perennial, the problem of flow irrigation has always been simpler than in the Deccan. Even so the practice of damming up hill streams was very common. Familiar to students of ancient history is the Lake Sudarsana (in Kathiawar) which was built by Chandragupta Maurya (about 300 B.C.) and repaired by the Western Kshatrapa ruler Rudradaman in 150 A.D., and again by Samudragupta in the 5th century. The famous Bhojpur Lake near Bhopal (about 1000 A.D.) is another such example. Two hundred and fifty square miles in area, it had the distinction of being the largest man-made reservoir in the country at the time.

Where the topography was plain and river water plentiful as in the Indo-Gangetic plain, canals were taken direct from the rivers. We still find remnants of these inundation canals in many places. The Hindu as well as Muslim rulers of north India caused many irrigation works to be built. The Anekar Bund (near Tughlaqabad, Delhi) built by Anangpal II in 1051 was an outstanding construction in stone masonry. The Satpula Bund built by Ghias-ud-Din Tughlaq in 1326 A.D. to take a stream from the Yamuna through Jahanpanah (his capital near modern Delhi) was a remarkable engineering feat. We have the instance of the Old Jumna Canal, also called the Firoz Shah Tughlaq Canal (14th century), which is still in use. Akbar renovated the Western Jumna Canal with the object of bringing irrigation to the Hissar District. Sixty years later this was further remodelled under Shah Jehan's orders.

Great care was taken to maintain these canals in good condition. Those who benefited from these dams and canals paid special taxes which met partly the cost of maintenance. Local administrative bodies like the Village Assembly or trustees of temple property often looked after the upkeep of these works of public utility. Some inscriptions in Tamil-

nad speak of separate committees appointed for the supervision of irrigation works.

While irrigation works under Hindu and Muslim rulers were innumerable, they were all small undertakings with limited utility. It was only under British rule that large schemes were conceived and executed. Initially, however, the British rulers were content to restore older irrigation works which had fallen to disuse. Such works as the Western Jumna Canal in the Punjab, the Eastern Jumna Canal in U.P. and the still older irrigation systems of the Kaveri Delta in Madras were improved early in the 19th century. The experience gained by British engineers on the two Jumna canals and on the Kaveri delta system inspired greater efforts for extending river irrigation in other parts of India.

Among the great irrigation works during early British rule was the Upper Ganga Canal, opened in 1854. This Canal which takes off from the Ganga at Hardwar irrigates 1.5 million acres. Later in 1890 was completed the Godavari delta system, which irrigates over a million acres. The Upper Bari Doab Canal in the Punjab (India) was completed in 1850. It irrigates annually 1.5 acres. The Kistna delta project at Bezwada was completed in 1855.

About the middle of the 19th century two private irrigation companies were floated. But they failed to function on commercial lines and the Government took over their works. This event led to the acceptance of a policy of financing irrigation works by public loans. The first major works taken up under this policy were the Sirhind, Lower Ganga, Agra and Mathura Canals. Towards the close of the century another big project, the Periyar system in Madras, was completed.

With the appointment of the Indian Irrigation Commission which presented its report in 1903 the story of irrigation in India took a new turn. Its recommendations pertained to the policy to be adopted regarding future irrigation developments and also about every individual scheme that was then under the consideration of the Government. As a result of this report the Triple Canal Project in the Punjab (now in Pakistan) and many other projects in other parts of the country were taken up. An important step was taken in

the fight against famine in areas where cultivation was insecure and precarious when the Trebeni Canal in Bihar, the Girna Left Bank Canal in Bombay, Ken, Tasam and Ghaghar canals in Uttar Pradesh and some schemes like the Mahanadi and the Wanganga in Madhya Pradesh were taken up by Government under this policy.

After the First World War the greatest irrigation project constructed by the Government was the Sutlej Valley Project in north-west India (now Pakistan). It consists of four barrages on the Sutlej and eleven large canals. Of these, only the Ferozepur Barrage now lies in India. About the same time, the Sarda Canal was completed in U.P. It has since been remodelled and extended to irrigate about 2 million acres. The Mettur (Madras) and the Krishnarajasagar (Mysore), both on the river Kaveri, were built in the thirties of the present century.

Though inadequate to meet the problems of a vast sub-continent like India, the efforts made by the British to extend irrigation had been considerable. In 1850 only two to three million acres were under assured irrigation. By 1945 the area had increased to 70 million acres. When India was partitioned in 1947 over 20 million acres of highly developed canal irrigated areas went to the share of Pakistan. Available statistics for the territory, which is now India, show that in 1895 there were 29 million acres under all types of irrigation. In 1945 this had risen to 49 million acres. Of this total acreage, 17 million acres were being irrigated by Government canals (diversion as well as storage) and Government managed tube-wells.

#### FIVE YEAR PLANS

The most exciting phase of irrigation development started since India became independent in 1947. The first Five Year Plan (1951-56) was formulated in the context of the overall needs of the country for irrigation, power, flood control and inland navigation.

Of the 293 million acres which were under cultivation in 1951, only about 51.5 million acres were receiving assured irrigation, utilising less than six per cent of our water resources. Of these 51.5 million acres 22 million were irrigated

from large and medium projects. The present estimates are that by the end of the fifth Five Year Plan we might be able to irrigate 85 to 90 million acres under such projects.

We produced only 2.3 million kilowatts of electricity in 1951 (including installations run by companies and privately owned industries) while the electricity potential of our rivers alone is over 40 million kilowatts. The first Five Year Plan could only be treated as the initial phase of a long-term programme for the development of irrigation and power. It is the aim of the Planning Commission to bring the total area under irrigation to about 100 million acres and step up power production to 13 million kilowatts within 15 years from 1951. Towards this end, 293 irrigation schemes to cost eventually Rs. 720 crore were included in the first Plan. The outlay on irrigation and power came to about 29 per cent of the total outlay for the Plan, which exceeds the amount spent on irrigation and power projects during the entire century before independence.

The large and medium-sized projects undertaken in the first Plan provide irrigation facilities to an additional 4.58 million acres of land. Regular irrigation rose from about 51 million acres in 1951 to about 63 million acres in 1956. Under the second Plan 8.2 million acres more are expected to receive similar facilities mostly from projects initiated under the first Plan. By the end of the second Plan a total of 78.5 million acres are expected to be under irrigation, including the benefits under minor irrigation projects. A sum of about Rs. 390 crore will have been spent on major and medium irrigation projects under the second Plan which includes nearly 217 new schemes. The percentage of medium-sized projects is higher than before as these could be completed earlier. The schemes started under the second Plan would themselves add 5 lakh acres by 1961.

An important point to remember about the major and medium irrigation schemes started under the first and second Plans is that they will not all have been completed within the five year periods of the two Plans. Some of the bigger projects will continue to be under construction during the third and even the fourth Plan. Their total estimated cost is about Rs. 1,400 crore, of which only about Rs. 770 crore was

spent by March 1961. When all these projects are completed they are expected to add 38 million acres of irrigated lands.

Additional irrigation facilities under the first Plan accompanied by favourable monsoons increased the yield of foodgrains from 50 million tons in 1950-51 to 65 million tons in 1955-56. As a consequence imports which amounted to 4.7 million tons in 1951 came down to 0.7 million tons in 1955.

These figures do not in themselves tell the whole story. Increased foodgrain production gave the nation a new-found confidence that with planning we could achieve great things. Declining imports saved precious foreign exchange with which we could buy much needed machinery. This in turn had a salutary effect on stabilising the price level. Controls and rationing, wherever they existed, were removed, much to the relief of the people and the Government.

#### POWER

Of the total installed capacity of hydro-power which stood at 2.3 million kilowatts on the eve of the first Plan, only 0.6 million kilowatts were being produced in the public sector. At the end of the Plan the installed capacity increased to 3.4 million kilowatts, of which the share of the public sector was 1.4 million kilowatts.

The following power schemes were completed and brought into service during the first Plan :

POWER SCHEMES	STATES	KILOWATTS
1. Nangal	Punjab	48,000
2. Bokaro	Bihar	1,50,000
3. Chola	Maharashtra	54,000
4. Khaperkheda	Madhya Pradesh	30,000
5. Moyar	Madras	36,000
6. Madras city Plant Extensions	Madras	30,000
7. Machkund	Andhra & Orissa	34,000
8. Pathri	Uttar Pradesh	20,400
9. Sarda	Uttar Pradesh	41,400
10. Sengulam	Kerala	48,000
11. Jog	Mysore	72,000

Moreover, considerable progress has been made on a number of major projects which were to be completed during the second Plan period. Brisk work is being done on the

construction of transmission lines which are designed to expand the grid system. About 19,000 miles of sub-transmission and transmission lines of 11 kV and above were added during the first Plan which is twice as much as it was in 1951.

India's planners have estimated that over a period of 10 years from 1956 the installed capacity would need to be expanded by 20 per cent annually, bringing the total to 13 million kilowatts by March 1966. The second Plan originally provided for raising the installed capacity to 6.9 million kilowatts, including the power supplied by private companies and industrial establishments. But actual production is not expected to exceed 5.8 million kilowatts. This shortfall in the original target is due to unexpected foreign exchange difficulties we ran into during the early years of the second Plan. In all, 55 major power-generating schemes (including extensions to existing ones) have been undertaken in the second Plan. During this period it is expected that the per capita consumption of electricity will rise from 25 to about 41 units. The first Plan had raised it from 14 kilowatt hours to 25 kilowatt hours.

The second Plan included about 266 irrigation and power schemes, of which 211 were for irrigation and 55 for hydro and steam power generation. The total outlay provided for the five-year period was Rs. 843 crore which comprised Rs. 416 crore for irrigation and Rs. 427 crore for power projects.

Power development in India before independence was meagre, haphazard and spasmodic. The bulk of electric installations had served only the large towns and cities, and rural electrification never received the attention it deserved because it did not bring in profits. Most of the production and supply of electricity was entirely in the hands of private enterprise except in a few cases like Mysore, Madras, U.P. and the Punjab. The total generating capacity stood at one million kilowatts in 1939. After independence, however, the picture began to change. Electric power came to be recognised as the life-blood of industrialisation.

### *Hydel-power Resources*

We all know that electric power can be obtained from oil,

coal, water and nuclear reactors. Our resources in oil are too limited to be of any use for the purpose. We of course have coal, but the deposits are not too abundant either. As for nuclear energy, our efforts are still in an experimental stage. So we are left with river water as the only major source. This fortunately is available in plenty in almost every region of India.

The power potential of India's rivers is estimated to exceed 40 million kilowatts. This includes 4 million kilowatts from the west-flowing rivers, 7 million kilowatts from the east-flowing rivers of the southern region, 4 million kilowatts from the Narmada, Tapi, Mahanadi, Brahmini and Baitarni basins in the central region and 25 million kilowatts from the Ganga, Brahmaputra, Indus and other Himalayan rivers in the northern and north-eastern regions. Of these, only about 0.6 million kilowatts had been tapped in 1951.

#### *Power Organisation*

Deplorable as the situation was, the task of harnessing the rivers for generating power was not an easy one. To begin with, we had to have an organisation which could tackle the problem of power development for the entire country at all the important stages. A Central Electricity Commission was therefore established in January 1948 to co-ordinate and promote the various schemes for generation of electric power and its transmission and utilisation in consultation with the State Governments. In 1951 this Commission was amalgamated with the Central Water, Power, Irrigation and Navigation Commission to form the Central Water and Power Commission, with a Power Wing as an integral part of the new structure. The Power Wing of the Commission organises investigations and surveys, carries out research and assists the Central and State Governments on all matters concerning power projects.

#### *Load Survey and Development*

In order to co-ordinate the development of power resources a Load Survey and Load Development Directorate was also constituted in the CWPC (Power Wing) in April 1955. Four load survey groups were formed at Calcutta,

Bombay, Meerut and Bangalore to meet the requirements of each region. The work of preliminary load survey for all the States has since been completed.

### *Hydro-electric Survey*

With a view to assessing the hydro-electric resources of the country India was divided into six contiguous regions namely, (i) west-flowing rivers of the Western Ghats, (ii) east-flowing rivers of southern India; (iii) central India rivers; (iv) the Ganga basin; (v) the Indus basin; and (vi) the Brahmaputra and other rivers in Assam, Manipur and Tripura. So far studies have been made of the hydro-electric resources of the first four basins. The reports cover 156 schemes with a potential output of 27.38 million kilowatts of power. The data collected are of great help in selecting sites for various hydro-electric projects. The work of assessing the potential of the remaining two river basins, namely, the Brahmaputra and the Indus, is in progress.

The CWPC has also been studying the hydro-potentialities of the hill streams in various mountain regions like Himachal Pradesh, Manipur, etc., and in the neighbouring countries like Sikkim and Nepal. It is felt that if we could develop and manufacture in our own country a standardised, self-contained generating unit assembly, it would bring cheap power within the reach of these areas. For this purpose a prime-mover based on what is known as the Mitchell-Bank principle has been designed by the Power Wing of the CWPC for drops ranging from 30 to 100 feet, and its model has been tested. At present an experimental test installation is being carried out in Himachal Pradesh.

Also, reconnaissance survey of 700 route miles of 132 kV and 170 miles of 66 kV transmission lines covered by the first stage of the Chambal project in the former Madhya Bharat and Rajasthan States was recently carried out by the CWPC.

### *Scrutiny and Design*

Out of the 182 power development projects included in the second Five Year Plan, 87 have been technically examined by the CWPC (Power Wing), in addition to the



schemes investigated by the State electricity authorities for the establishment of hydro or thermal power stations.

We have now an adequate administrative machinery to plan and carry out an integrated programme of power development in the country.

### *Legislative Measures*

New legislative measures were enacted to promote such a co-ordinated development. Thus the Electricity Supply Act passed in 1948 was meant to promote the development of power in the country, particularly in the rural areas. The Act provided for the establishment of a Central Electricity Authority and also regional organisations known as the State Electricity Boards.

### *Central Electricity Authority*

The main functions of the Central Electricity Authority Board which was constituted in January 1960, are: (1) to evolve a uniform policy for power development; (2) to co-ordinate the activities of the various agencies for the control and utilisation of power resources; (3) to arbitrate in disputes between a State Government or a State Electricity Board and the licensees; and (4) to carry out investigations, etc., regarding the generation, distribution and consumption of power.

Since its inception, 11 arbitration awards have been given—one in 1952, four in 1955 and six in 1956. In addition, six schemes of the State Electricity Boards amounting to nearly Rs. 15 crore have been approved.

### *State Electricity Boards*

State Electricity Boards, on the other hand, are semi-autonomous bodies whose function is to control and regulate power development in their respective regions. Joint boards may also be constituted for contiguous States. So far Andhra Pradesh, Assam, Bihar, Madhya Pradesh, Maharashtra, Gujarat, West Bengal, Kerala, Mysore, Madras, Punjab, Rajasthan and Uttar Pradesh have set up their Electricity Boards. The Boards combine the advantages of nationalised undertakings and private enterprise because (i) they are free from the influence of Government; (ii) profit motive is

absent, and (iii) there are facilities for organising the administrative machinery on commercial lines.

### *Power and Telecommunication Lines*

In May 1949 the Government of India constituted a Central Standing Committee of Co-ordination of Power and Telecommunication Lines. The chief functions of the Committee are: (i) to study the existing rules and regulations on the subject and suggest modifications in the light of present day research and development and international practices; and (ii) to undertake laboratory and field studies.

The Committee has so far examined several cases of parallelism between power and telecommunication lines and evolved a solution for placing the two lines in a manner which would satisfy the requirements of both the power and telecommunication authorities. The standardisation of methods for evaluating induction, methods of measurement of soil resistivity, protective measures to reduce the effects of induction, etc., are other important works carried out by the Committee. In order to reduce the noise on telephone lines, a device known as amplifier-cum-attenuator unit was developed. A 'code of practice' for the protection of telecommunication lines at crossings with overhead power lines was also drawn up by the Committee for adoption. Thus, the Committee has been rendering valuable liaison service between the power supply undertakings on the one hand and the posts and telegraphs department on the other.

### **FIRST FIVE YEAR PLAN**

The main achievements of the first Plan in the field of electricity were the setting up of an adequate administrative machinery for the development of power and the raising of the total installed capacity of generating plants. At the beginning of the first Plan this capacity was 2.3 million kilowatts. Of this, 1.7 million kilowatts came from undertakings in the public and private sectors and 0.6 million kilowatts from industrial establishments generating their own power. The target for the first Plan was 1.3 million kilowatts, of which 1.1 million kilowatts fell to the share of the public sector and 2,00,000 kilowatts to private electricity supply companies.

Of the above target, the public sector achieved about 8,00,000 kilowatts and the private sector 2,00,000 kilowatts. Also, there was an increase of about 1,00,000 kilowatts in the power plant capacity of industrial establishments. During the first Plan, the total installed capacity thus increased to 3.4 million kilowatts. In addition, work on power plants with an aggregate capacity of about 2,00,000 kilowatts was almost completed in the public sector. Thus an addition of one million kilowatts was achieved up to the end of 1956 in public utility undertakings. The energy generated also increased from 6,575 million units in 1950-51 to 11,000 million units in 1955-56, an increase of 67 per cent over the first Plan period.

In addition, the power schemes of the river valley projects will, on completion, generate large blocks of hydro-electric power.

### SECOND FIVE YEAR PLAN

The aim of power development under the second Plan was threefold: (i) to meet the normal load in the existing power systems; (ii) to provide the necessary capacity for the expansion of areas of supply; and (iii) to meet the needs of industries which are to be established. It was originally estimated that an addition of 3.5 million kilowatts would be required during the five years. Of this, 2.9 million kilowatts would come from State-owned undertakings, 3,00,000 kilowatts from private companies in the electric supply industry and the remaining 3,00,000 kilowatts from the lignite project and from steel, cement, paper and others, with their own generating plants. It was also expected that 35,000 miles of additional transmission and distribution lines would be laid in this period and electrification extended to 10,600 towns and villages.

But according to revised assessment the total additional installed capacity during the second Plan period is expected to be nearly 2.4 million kilowatts as against the original target of 3.5 million kilowatts. The construction of transmission and distribution lines is, however, going on as planned. Consistent with the emphasis on basic and heavy industries in

the second Plan, specified power projects were included in the "core" of the Plan.

The result of these programmes will be that total installed capacity of the power plants will increase from 3.4 million kilowatts in March 1956 to 5.8 million kilowatts by March 1961. Also, the per capita consumption of electricity will rise from 25 units at the end of the first Plan to about 41 units at the end of the second Plan.

### *Grid System*

The expansion of the grid system under the second Plan comprising 35,000 miles of transmission and subtransmission lines, carrying voltages varying from 220 kV. to 11 kV., is double the transmission mileage constructed during the first Plan.

A sum of Rs. 427 crores was originally provided for power development in the second Plan. Of this amount, Rs. 160 crore are for the schemes continued from the first Plan and Rs. 245 crore and Rs. 22 crore for the new schemes which will yield benefits during the second and the third Plans respectively. The following is the breakdown of Rs. 427 crore :

Generation	Rs. 235 crore
Transmission	Rs. 92 crore
Distribution in urban areas	Rs. 25 crore
Small town and rural electrification	Rs. 75 crore
Total :	Rs. 427 crore

The private electricity supply companies are expected to invest Rs. 42 crore for the installation of generating capacity and for extension to the existing transmission and distribution systems. The actual total outlay under the second Plan is estimated to reach Rs. 447 crore according to the draft third Five Year Plan.

### *Rural Electrification*

Before the first Plan, all towns with a population of 50,000 and over, (besides most of those with a population above 20,000) were supplied with electricity. Rural electrification, on the other hand, had made very little progress. Out of approximately 5,60,000 villages only 3,075 had electricity.

Today rural electrification finds a prominent place in our development plans. To meet this special need, a separate Rural Electrification Directorate was created in the CWPC.

It had taken 25 years since supply of electricity commenced in India to bring this benefit to 3,075 towns and villages. This was the situation in 1951 when the first Plan commenced. Within a period of five years, this number had risen to 7,400. Within three years of that the figure was doubled. The total number of towns and villages electrified by March 1959 was 14,978. At the end of the second Plan the number was expected to have gone up to 19,000.

In towns and villages with a population of less than 10,000 rural electrification raises difficult economic problems. Most villages are situated at great distances from the power sources. The average cost of distribution lines and substations is estimated at Rs. 60,000 to Rs. 70,000 per village. We should be requiring more than Rs. 3,000 crore to take electricity to all the villages in the country. This is indeed an enormous amount considering other needs for investment which are even more urgent. Therefore we can accomplish total electrification only by stages. Apart from the heavy capital cost, the operation and maintenance of electric installations in rural areas is more expensive than in urban areas. The reason is lack of load density. It was therefore decided to provide, in the first instance, power to those villages which were nearer to the towns where power supply already existed. For similar reasons of proximity it was also decided to take supply lines to such villages as lay close to grid transmission lines. There was another important reason for selecting villages nearer to urban areas. If the supply lines to urban and rural areas are integrated the surplus from revenue realised from urban and industrial consumers can be utilised for reducing the cost of supply to consumers in the villages.

### *Employment Opportunities*

Extension of electricity to rural and semi-urban areas acts as a powerful incentive to industrialisation and thereby enhance opportunities for employment. It was with this end in view that a scheme was launched in 1954-55 for expanding

power facilities for such areas. A sum of Rs. 20 crore was provided to the State Governments as loan for this purpose. The assistance so given covered 19 States and 214 schemes whose aggregate cost came to Rs. 20.70 crore. Most of these schemes are expected to be completed before long.

In order to evolve the most economical designs of rural line constructions, a Standardisation Section was opened under the Rural Electrification Directorate. The designs followed in the various States have been studied and compared with those adopted in foreign countries. As a result of these studies designs based on most economical considerations are being worked out.

## CHAPTER IV

### FLOOD CONTROL

To understand the flood problem, it is very essential to understand the concept of flood plain. The flood plain is the place where almost all the damage occurs as a result of floods. Flood plain may also be defined as that portion of the river valley which borders the main channel of the river and which gets covered with flood waters when the river overflows its banks during floods. For most part of the year, the river generally flows low and remains confined within its banks. It is only for a short period that the river overflows its banks and occupies the flood plain. The mere fact that a flood plain exists is a *prima facie* evidence of floods. The demand that a river makes on adjoining land during floods naturally clashes with man's hunger for more cultivable land. When this clash does occur, it is the man who has to pay the price in the form of flood damage over the land he has occupied.

Floods are primarily caused by rainfall and cyclones. Scientific knowledge has not yet advanced far enough to enable us to control factors which cause rainfall and cyclones. So, our efforts have to be concentrated on reducing flood damage as much as possible.

The flood problem is often aggravated by natural calamities like earthquakes and land-slides. Earthquakes alter the courses of rivers, raise their beds and cause considerable damage in areas which are almost immune to floods. Land-slides, on the other hand, obstruct flow of river water along the natural stream channels. These obstructions create artificial dams in the upper areas and, when the obstructions give way, the waters gush downwards with great velocity, causing severe floods and leaving a trail of destruction.

#### *River Systems in India*

India is quite fortunate in her river water resources. As we have observed already, there are 110 rivers with a catchment of more than 1,000 sq. miles each.

Broadly speaking, these rivers can be divided into two parts :

- (1) The rivers originating from the Himalayan catchments. These rivers traverse almost the whole of India to the north of the Vindhya. They are fed by snow as well as rainfall and hence are perennial. They come down from the hills which are comparatively of recent geological origin and as such liable to erosion. Therefore, these rivers bring down a considerable amount of sediment when they debouch on the plains and deposit the same in their channels.
- (2) The rivers in the peninsular regions, i.e., south of the Vindhya, are of great antiquity and their courses are well-defined and stable. These rivers are only rain-fed and generally non-perennial. The problem of sediment is almost non-existent in these rivers.

### *Flood Problems*

For understanding the nature of the flood problem, India can be divided conveniently into the following four regions :

- (i) The Ganga river system,
- (ii) The Brahmaputra river system,
- (iii) The North-western river system, and
- (iv) The Peninsular river system.

This classification is based on broad regional similarity of the areas in respect of meteorological, geographical, geological, topographical and the resulting hydro-logical characteristics of the rivers and their tributaries.

#### (i) THE GANGA RIVER SYSTEM

In this system, the major rivers having flood problems are the Yamuna, the Ghagra, the Rapti, the Gandak, the Kamla, the Bagmati and the Kosi. This river system covers the States of Delhi, Uttar Pradesh, Bihar and parts of the Punjab, Himachal Pradesh, Rajasthan and West Bengal. The problem in this river system is mainly that of inundation, though at places erosion and inadequate country drainage



also cause flood damage. The rivers like the Kosi, the Kamla, etc., change their courses frequently and cause great damage. In the prematurely reclaimed areas of the Sunderbans in West Bengal, tides synchronise with high floods and breach embankments causing great havoc. In the State of Punjab and parts of U.P., the inadequacy of surface drainage has aggravated the flood problem.

#### (ii) THE BRAHMAPUTRA RIVER SYSTEM

The major rivers causing flood problem in this river system are the Brahmaputra, the Barak, the Teesta, the Torsa and the Raidok with their tributaries. This system covers the States of Assam and northern portion of West Bengal. The major problem here is one of erosion although serious inundation also occurs. As the State of Assam lies in a seismic zone, earthquakes have aggravated the flood problem in the Brahmaputra. The earthquake of 1950 caused considerable change in the region of the Brahmaputra and brought about serious inundation and erosion. The rivers Teesta and Torsa in Northern Bengal, like the Kosi in Bihar, also change their courses frequently causing considerable erosion.

#### (iii) THE NORTH-WESTERN RIVER SYSTEM

The major rivers in this system are the Jhelum, the Chenab, the Ravi, the Beas and the Sutlej. This river system covers the States of Jammu & Kashmir and part of the Punjab and Himachal Pradesh. In the Kashmir Valley, the problem arises from inadequate channel capacity of the Jhelum to carry away the flood discharge while in the Punjab, it is mainly due to lack of adequate drainage.

#### (iv) THE PENINSULAR RIVERS

The major rivers causing flood problem in the Peninsula are the Mahanadi, the Brahmini, the Baitarni, the Godavari, the Krishna, the Tapi, etc. The States traversed by this river system are Orissa, Andhra Pradesh, Madhya Pradesh, Maharashtra, Mysore and Madras. In this river system, the problem is mainly that of inundation in the deltaic reaches

of the major rivers. Some coastal rivers like the Budameru in Andhra Pradesh and the Subarnarekha in Orissa also cause flood problem by inundation.

#### *Past Efforts at Flood Control*

Earlier efforts at flood control in India were neither properly planned nor scientifically conceived. They were mainly intended to protect some limited areas. Such flood protection works consisted of embankments built in short lengths by interested parties to prevent inundation of specific cultivated areas or villages. These feeble individual efforts led to Governmental interest in the problem, chiefly during the past century. As a result of this, a number of well-planned embankments were constructed on some of the rivers which were causing flood damage every year. The more important of such embankments are those on the Gandak in Bihar for about 100 miles, 75 miles along the Damodar in Bengal, 751 miles along the Mahanadi, 178 miles along the Brahmini, 100 miles along the Baitarni in Orissa and about 2,200 miles in the Sunderbans area in West Bengal.

No reservoirs were constructed in the past as a measure intended to control floods. A large number of tanks, more particularly in South India, however, served to moderate flood havoc. These tanks, many of them very ancient, were constructed for irrigation and drinking purposes. There are about 8,000 tanks in Andhra Pradesh, 35,000 in Mysore and a large number in Madras. These tanks, though individually small, have collectively functioned as absorbers of flood waters during the earlier parts of the monsoon season. During the last thirty or forty years our thinking on the flood control problem has been more scientific. We now think of vast reservoirs as a positive flood protection measure, although these reservoirs also serve other equally important objects like irrigation, power generation, navigation, etc. The major river projects taken up under the first and second Plans have been drawn up with these aims in mind. The Hirakud reservoir on the Mahanadi in Orissa and the reservoir system planned on the tributaries of Damodar in Bengal are some of the well known examples of our present day efforts at controlling floods.

### *National Programme for Flood Control*

Some of the most disastrous floods in recent memory occurred in 1954, and many parts of the country were affected. These events gave an added sense of urgency to the problem of flood control and as a result a comprehensive national programme for flood control was drawn up. Constitutionally, the authority for exploiting and developing river resources vests in the States and therefore the responsibility for flood control measures also rests primarily with the State Governments. But as most of the big rivers pass through more than one State, any unilateral action by one State may jeopardise the interests of another State. A co-ordinated action under the guidance of Central Government, therefore, became necessary.

A comprehensive programme was considered under three categories: (i) immediate, (ii) short-term, and (iii) long-term. The first or the immediate phase of the programme extended over the first two years and was to be devoted to collecting essential hydrological and other data and implementation of emergency measures such as protection of important towns, construction of a few embankments, raising the elevation of villages, etc. The second or the short-term phase, which roughly coincided with the second Five Year Plan, provided for flood control measures such as channel diversion, construction of more embankments, protection of more towns and raising of more villages, the works being planned and designed on the basis of data as it was collected. The third or the long-term phase was designed to create more permanent flood control measures such as storage reservoirs and detention basins. These were to be in addition to embankments, channel diversions and raising the elevation of villages on the basis of past experience.

### *Flood Control Organisations*

In order to plan and implement this elaborate programme suitable organisational arrangements were made at the Centre, in the States and at inter-State levels. At the State level, State Flood Control Boards, assisted by their technical

advisory committees, were set up. At the inter-State level, four river commissions, namely the Ganga, the Brahmaputra, the north-western rivers and Central India rivers, were set up, and to give the entire effort a national purpose and direction, a Central Flood Control Board was constituted to co-ordinate the work of various State Control Boards and River Commissions. A Flood Wing was also added in the C.W. & P.C. Important functions and achievements of these various organisations are described below.

#### (i) CENTRAL FLOOD CONTROL BOARD

The major functions of the Central Flood Control Board are to lay down general principles and policies for undertaking flood control measures, to consider and approve a Master Plan for flood control, as submitted by the States or River Commissions, and to arrange for necessary assistance in investigations, planning and execution of flood control works. In addition to making efforts to obtain more funds for flood control, the Board has also secured judicious allotment of funds to various States, in the light of the overall requirements of the country and the special needs of different States. It has evolved a detailed procedure for sanctioning flood control schemes and has given decisions on various matters referred to it by the River Commissions from time to time. It has also initiated action in the matters of levy of flood cess, flood plain zoning, surface drainage and anti-water-logging measures.

#### (ii) RIVER COMMISSIONS

The River Commissions have three functions. They examine and recommend for approval to the Central Flood Control Board outline Master Plans for flood control works of river basins as prepared by the States; they advise, when advice is sought, the State Governments on technical problems pertaining to flood control; and, they also advise the Central Flood Control Board in respect of problems on which there is a difference of technical opinion between the States or between the C.W. & P.C. and the State authorities.

The River Commissions have done useful work, especially in solving some inter-State problems. A notable example

was the problem of Ballia-Baria Bund, where the dispute between Uttar Pradesh and Bihar was amicably resolved. In order to plan a co-ordinated development of the Yamuna Valley, which involves the interests of U.P., Punjab, Delhi and some Central organisations, a Standing Committee called the Yamuna Committee has been set up. The Commissions have also appointed committees to examine other complex problems of a wider nature and make recommendations. The roads and railway bridges committees set up by the various States, the committee to examine the advisability of constructing high earthen dams in seismic zones, etc., are some of the well-known examples.

### (iii) STATE FLOOD CONTROL BOARDS AND TECHNICAL ADVISORY COMMITTEES

Flood Control Boards and Technical Advisory Committees at the State Government level have so far been set up in 12 States, namely, Andhra Pradesh, Assam, Bihar, Maharashtra, Jammu & Kashmir, Kerala, Madhya Pradesh, Mysore, Orissa, Punjab, U.P. and West Bengal. The major functions of these State Flood Control Boards are to approve long-range plans and specific schemes for flood control measures and fix their priorities; to deal with the question of policies in connection with floods, flood relief and flood control; to watch the progress of implementation of approved schemes; to approve all measures proposed for coping with emergencies, etc. The technical advisory committees assist the State Flood Control Boards in all these matters.

Since the inception of flood control programmes in 1954-55, various State Flood Control Boards have prepared 110 major schemes (schemes estimated to cost Rs. 10 lakh and above) at a total estimated cost of Rs. 46.50 crore, and 687 minor schemes (i.e., schemes costing less than Rs. 10 lakh each) at an estimated cost of about Rs. 13 crore.

### (iv) FLOOD WING IN C.W. & P.C.

Besides these organisations, a Flood Wing was established in the Central Water and Power Commission to assist in the secretarial work of the Central Flood Control Board and the

River Commissions as also to supply designs and render technical advice needed by the States on matters pertaining to flood control. This Wing carries out technical examination of all major schemes estimated to cost Rs. 10 lakh or more before they are approved by the Central Government for loan assistance. It also acts as a co-ordinating body between the various departments of the Government of India such as the Survey of India, the India Meteorological Department, etc.

So far, the Flood Wing has carried out scrutiny of 62 major schemes costing Rs. 27.80 crore which were approved for Central loan assistance. Besides, it has also approved, for Central loan assistance, 533 minor schemes at a total estimated cost of Rs. 11.6 crore. Among the notable examples of technical aid given to the States are: a complete design of Dibrugarh Town Protection Works, entire surveys, investigations and designs for the Kosi Project, design for Dalaighai protection works in Orissa, etc.

In addition, the Flood Wing provides necessary assistance for surveys, investigations, etc., particularly in those States where facilities for such work are lacking. Besides carrying out investigations for a number of dam sites, topographical surveys and hydrological observations, it has prepared about 80 reports on river basins and 21 more such reports are under preparation.

#### *Progress of Work*

So far, about 2,800 miles of embankments have been completed in various States, which now afford protection to about six million acres. Three river diversion works have been undertaken. Forty-six towns have been protected from river erosion or inundation or both, and 4,200 villages have been raised to higher elevations. A total area of 49,000 sq. miles has been aerielly photographed and 40,000 sq. miles of spot levelling and 25,000 miles of levelling for longitudinal and cross-sections have been done.

It was also necessary to tackle the problem of soil conservation because the problem of flood control had been aggravated by deforestation in the upper catchment areas, causing silting of river beds, and change in their courses.

Soil conservation works of an urgent nature have been taken up in the worst affected areas. These efforts, however, will take a long time and a good deal of expenditure before their effects can be appreciated.

Some States have also taken the precaution of warning people living in areas likely to be affected by floods not to put up permanent structures or cultivate lands in the flood zones during the monsoon season. Flood warning systems have been set up in most of the States to warn important places lower down the rivers about possibility of floods. This is done by ordinary telegraph, radio and police wireless stations. A flood forecasting unit to predict high flood levels in the River Yamuna at Delhi has been established in the Central Water and Power Commission.

The total expenditure on flood control works since the beginning of the first Plan up to March 1959 is Rs. 44.51 crore. Of this, Rs. 11.47 crore was spent during the first Five Year Plan. Total expenditure during the second Plan period is expected to be of the order of Rs. 56 crore. During the third Plan the expenditure on flood control measures is likely to be Rs. 80 crore.

In order adequately to assess the flood problem of the country and also to have authoritative advice on the measures that should be taken to tackle it, a High Level Committee on Floods was appointed in 1957. The Committee examined the flood problems and the hydrological and other data available in the various States and recommended lines on which the flood problems of the several States could be tackled. It also stressed the need to collect further data on floods. The Committee has recommended that a long-range plan should be prepared at least in outlines to tackle the flood problem in every State and review the existing organisational structures. After discussing the suitability of embankments as a method of flood protection the Committee has listed up the circumstances under which this method could be usefully adopted.

### *One River, One Plan*

Although considerable work has been done to mitigate flood damage a good deal still remains to be done. It has

been estimated that flood control measures carried out since 1954 have reduced the likely damage from floods by about one-fourth the average of annual damage during the last decade, and by about one-tenth the maximum recorded in any one year during that period.

The experience so far gained in India has revealed the importance of an integrated basinwise approach to the problem of flood control. Unco-ordinated efforts to solve specific flood problems of small areas might have unwelcome repercussions upstream or downstream. Therefore, flood control on a river has to be planned by treating it as a single unit, even though it may be passing through more than one State. Accordingly, the various States are preparing outline plans for flood control for the portion of rivers falling in their jurisdiction. These outline plans will be co-ordinated and an integrated Master Plan will be drawn up for the entire river by the Centre. One river-One Plan is the basic idea.

It has to be appreciated that while flood control measures generally assure a measure of protection to our lands and villages, they do not by themselves make for irrigation or power generation. Therefore, flood control schemes have to be made a part of other water development schemes and not be dealt with in isolation.

There is another important point to bear in mind when we talk of flood control. Many people tend to believe that flood control works can be a complete guarantee against floods. There is no such thing as complete control of floods. Even if such a thing were technically possible in the river basins, the cost would be prohibitive. Nature will remain unpredictable whatever we might do. It can better its own record for damage and destruction any time. Therefore, we can at best aim at reducing flood damage as much as possible. Our engineers engaged in the tests of flood control would be very happy if they could reduce the extent of flood damage by half after implementing all the existing schemes for river control.



## CHAPTER V

### INLAND NAVIGATION

#### *Historical Background*

Inland navigation was an important mode of transport in India about a hundred years ago. The introduction of steam vessels at the beginning of 19th century gave a great fillip to water transport and assisted in the growth of the indigo industry in Bihar, the jute industry in Bengal and the tea industry in Assam. Steamers at that time used to ply as far as Garhmukteswar on the Ganga, Fyzabad on the Ghagra, and Agra on the Yamuna. Kanpur had so many vessels on the river that it looked like a miniature port. So heavy was the traffic that passenger berths had to be booked three weeks in advance.

In 1874, Sir Arthur Cotton, the reputed architect of the Godavari and Krishna Canal systems, suggested the creation of a network of waterways by developing the various rivers for navigation. But the Government of the day was solely interested in the development of the railways, having guaranteed rich dividends to private companies. There was no programme of industrialisation to compel them to develop or even preserve cheap inland water transport and the result was rapid decline in inland navigation. There was also another factor which contributed to its decline. Large quantities of water were taken for irrigation which resulted in the decrease of navigable depths in the upper reaches of the Ganga and the consequent suspension of steamer services beyond Allahabad. Still another blow was dealt in 1947 when the country was partitioned. This completely altered the trade pattern between North-East India and East Pakistan, thereby affecting water transport. On top of this came the great earthquake of 1950 which played havoc with the rivers of Assam. For about a hundred years there had been regular steamer services on the Brahmaputra up to Dibrugarh. After the earthquake the main line services had to terminate at Deshangmukh, 46 miles downstream of Dibrugarh.

### *The Present Position*

In spite of all these adverse factors inland water transport has by no means faced extinction. Even today it is playing an important role in several parts of the country. About 93% of the jute and 90% of the tea trade of Assam as well as about 10% of the 10 million tons of cargo handled by the Calcutta Port is carried by inland water transport.

The total length of important navigable waterways in the country is estimated to be a little over 6,600 miles comprising (i) rivers navigable by steamers, about 1,550 miles; (ii) rivers navigable by country boats only, about 2,460 miles and (iii) canals and backwaters navigable by country boats, about 2,605 miles. This excludes small tidal creeks on the coast which are not connected to any waterway system. The most important navigable rivers are the Ganga with its tributaries, the Ghagra and the Gandak, the Brahmaputra and the Mahanadi. Navigation is also carried on on other rivers such as the Godavari, Krishna, Narmada and Tapti for short distances from the mouth as also extensively on the backwaters of Kerala, Orissa and Bengal. The Orissa Coast Canal connecting Cuttack with Calcutta (a portion of which was abandoned in 1928), the Buckingham Canal and the West Coast Canal are important canals constructed solely for navigation. In addition there are also irrigation-cum-navigation canals, such as the Krishna and Godavari Delta canals in Andhra Pradesh, Mahanadi canals in Orissa, Ganga canals in Uttar Pradesh, and the Son canals in Bihar. An 85-mile-long irrigation-cum-navigation canal taking off from the Durgapur Barrage of the Damodar Valley upstream of Calcutta has just been completed. The Tungabhadra left bank canal in Mysore under construction is also being designed for navigation. The Rajasthan canal, which is in the initial stage of construction, is also being proposed to be made navigable. If the proposal is accepted, it will be one of the biggest canals in the world.

### *Progress Since Independence*

With the advent of independence, the country embarked on a huge programme of all-round economic development. Such development calls for an adequate system of transport.

Although every mode of transport has its special advantages, inland navigation happens to be the cheapest and best suited for the movement of bulk commodities such as foodgrains, ores, industrial raw materials, etc. The Government of India therefore began to bestow serious thought on rejuvenating water transport in the country so that it could effectively play its part in the economic development of the nation. The Central Water and Power Commission have been collecting data regarding the different waterways. They have already surveyed the various rivers like the Ganga, Yamuna, Ghagra, Gandak, Son, Rapti, Kosi, Mahanadi, etc. These surveys cover a total length of more than 5,000 miles. They have also a programme for undertaking further surveys of some of these rivers and others like the Godavari, Krishna, Narmada, Tapti, etc., for a total distance of over 3,000 miles to ascertain how far they could be made navigable from the mouth upwards for depths of (i) 8 to 6 ft., (ii) 6 to 4 ft. and (iii) 4 to 3 ft. The Commission are also trying to find out navigational possibilities of certain important east and west flowing rivers and interlinking them so as to create continuous waterways from coast to coast.

In all these matters the Government of India have obtained expert technical opinion from foreign countries. Mr. Otto Popper of the E.C.A.F.E. visited India at our invitation in 1950 to advise on inland navigation in the country. He opined that the waterways of the country, if systematically organised and exploited, could become as important as railways in addition to being useful for irrigation. He appreciated the important role of country boats and suggested that their services be properly organised. To make them independent of winds and reduce their crew strength he recommended the introduction of specially designed tugs. At present steamer services are confined to the Ganga and the Brahmaputra river systems. Still, here, as elsewhere, country boats continue to be the most important craft.

In 1951, a group of French engineers visited Orissa to advise on the navigational development of the Mahanadi river. They suggested the improvement of navigation by introduction of power craft on the Mahanadi by stages. This

proposal concedes the need for eventually training the river reach from Sambalpur to Cuttack.

Mr. Surie, another expert who came in 1952, suggested the starting of a pilot project with tugs and dumb barges from Patna to Allahabad on the Ganga and Patna to Burhaj on the Ghagra. In 1959 the Government of India sought the services of Mr. Van-der-Ord, an inland navigation expert of E.C.A.F.E., to advise them on the proposal to introduce navigation facilities on the Rajasthan canal. Mr. Van-der-Ord visited the country and submitted a report in which he advocated the introduction of navigation facilities on the canal.

In 1952, the Union Government and the States of Uttar Pradesh, Bihar, West Bengal and Assam together constituted a Board known as the Ganga Brahmaputra Water Transport Board for tackling some urgent problems relating to navigation on the Ganga, Brahmaputra and their tributaries. The Board has been implementing the pilot projects recommended by Mr. Otto Popper and Mr. Surie.

#### *Inland Water Transport Committee*

In 1957 the Government of India appointed a Committee called the Inland Water Transport Committee under the Chairmanship of Shri B. K. Gokhale to review the part played by inland water transport and suggest further measures for its improvement. The Committee which submitted its report in June 1959 was of the opinion that inland water transport has a great part to play in the transport system of the country provided it is properly organised. They observed that the waterways of the country had considerably suffered from neglect and the need of the hour was that further deterioration should be arrested. The Committee's report is a comprehensive document containing a number of recommendations for the improvement of water transport in the various parts of the country. Some of the major recommendations made by the Committee are: that the Ganga, the Brahmaputra, and the Mahanadi should be developed as major waterways and industries should be located on the banks of these rivers; the deterioration of the Hooghly river which is affecting the Calcutta Port should be arrested by providing adequate head water supply; the High Level Canal and the

Kendrapara Canal in Orissa, the Ellora and Masulipatam Canals in Andhra Pradesh and the waterway between Cochin and Quilon in Kerala should be improved; while planning the development of river basins the navigation aspect of the project should be borne in mind; hydrographic surveys of specified stretches of important rivers of the country should be undertaken to explore the scope for immediate development of navigation on them; the waterways of the country should be classified; the country boats should be organised on co-operative lines, and finally, suitable technical organisations should be created both in the States and at the Centre to deal with inland navigation.

#### *Outlook for the Future*

Waterways of the country are bound to play an increasingly important role in the future. This will involve improvements in operational techniques (such as introduction of powered craft where necessary, use of radio-telephone and radar, and lighting of waterways by automatic flashing beacons and the application of pushing technique, using integrated trains of barges, etc., as well as development of existing waterways and the creation of new ones.

It is well known that water transport is by no means confined to the natural channels of rivers. In several parts of the world extensive stretches of rivers which were not navigable have been improved by suitable river training works. One way of doing it is to canalise them by converting stretches of rivers into a series of slack and deep water pools by constructing a number of weirs at suitable intervals and providing these weirs with locks to facilitate transit of boats from one level to another. We must remember that canals have been constructed in several countries to bypass difficult stretches of rivers or to interconnect seas, rivers, lakes, etc.

The modern trend is to treat the entire river as a unit and develop it on a multipurpose basis. The construction of a number of multipurpose dams on rivers like the Narmada and the Godavari will create a number of reservoirs covering vast stretches of these rivers. Virtually this will have the same effect as canalisation referred to earlier. The surplus

water impounded in some of the multipurpose reservoirs during monsoon can be released on a regulated basis for generating power. This will also help control floods and facilitate navigation in certain reaches not covered by reservoirs. Already the Hirakud dam is releasing a minimum discharge of about 8,000 cubic feet of water per second, which is of help in improving the navigability of the river. The premier navigable rivers of India, the Ganga and the Brahmaputra, will have to be further developed by undertaking river improvement works, dredging, etc., where necessary. By constructing storage dams on the tributaries of these rivers for power and flood control we will also be improving the navigability of the main rivers during the dry season by letting out water from the reservoirs. Wherever it is possible and necessary irrigation canals could be designed also to serve the purpose of navigation. These are all possibilities which we can look forward to in time to come when rivers and canals will have taken their place among the other arteries of the nation's economy.

## CHAPTER VI

### RESEARCH AND TRAINING

Research has now come to play a vital role in engineering construction. It has in fact become so important that it is now considered a branch of engineering itself.

Engineering research stations in India have been functioning in Madras, Mysore, the Punjab, Bengal, Uttar Pradesh and Andhra Pradesh. They tackle the many problems that arise from day to day. Some of the larger river valley projects, too, have set up their own laboratories for finding out new methods and techniques to ensure speed, scientific precision and economy.

River valley projects are now situated in almost every part of the country and the demand for trained personnel is continually growing. We need qualified men for designing and constructing projects in all the States. The Union Ministry of Irrigation and Power, with the help of the States, has been making earnest efforts to set up training centres to make such personnel available in adequate number. Research centres constitute an important ground for such training.

#### *Basic and Fundamental Research*

Basic research is very essential for the designing of river valley projects. For want of adequate facilities we were forced to depend on foreign countries for technical advice on basic problems of engineering. Creation of these facilities in our own country involves great cost and time. Many of the major projects included in the first Plan called for a great deal of research before their designs could be finalised. New schemes included in the second Plan have been making still greater demands on our research facilities.

Accordingly, the Central Board of Irrigation and Power drew up a scheme for research on basic problems concerning the river valley projects and flood control. It was

decided to undertake research on the following problems during the second Plan period: (i) air entrainment; (ii) turbulence; (iii) cavitation; (iv) sedimentation studies in streams and reservoirs; (v) design of channels; (vi) engineering properties of soils; (vii) subsoil flow; (viii) standardisation of the use of *sarkhi* and other pozzolanic materials in mortars and concrete; (ix) principles of mortar and concrete mix design; (x) studies on vibrations in soil under machine foundations; (xi) development of economic alternatives to stone for flood protection works; and (xii) instrumentation.

The following research stations have been set up to carry out research: (i) Central Water and Power Research Station, Poona; (ii) Irrigation and Power Research Institute, Amritsar; (iii) Civil and Hydraulic Engineering, Indian Institute of Science, Bangalore; (iv) Irrigation Research Institute, Roorkee; (v) River Research Institute, Calcutta; (vi) Hyderabad Engineering Research Laboratories, Hyderabad; (vii) Silt and Construction Materials Directorate, C.W.P. Commission, New Delhi; (viii) Concrete and Soil Laboratory, Chepauk, Madras; (ix) Bihar Institute of Allied and Hydraulic Research, Patna; (x) Mysore Engineering Research Station, Krishnarajasagar; and (xi) Irrigation Development Division, Poona.

The Central Board of Irrigation will co-ordinate research on the various projects, and the expenditure will be met by the Government of India. The scheme, estimated to cost Rs. 105 lakh, provided for 1,735 man-year employment for scientific skilled and semi-skilled personnel in the second Plan period.

A sum of Rs. 9 crore was provided in the second Plan for investigation and research. The scheme for research on basic and fundamental problems, as detailed above, is covered by this provision.

#### CENTRAL WATER AND POWER RESEARCH STATION

Among the well-equipped and up-to-date research organisations, special mention may be made of the Central Water and Power Research Station, Poona, which is the pioneer organisation in the field of hydraulic research in the country. Established as far back as 1916, it worked under the Govern-



ment of Bombay until 1937 when it was taken over by the Government of India in view of its importance to the nation. The CWPRS now forms one of the wings of the Central Water and Power Commission, New Delhi.

The CWPRS was reorganised in 1947 to meet the needs of various projects which were taken up after independence. Eight divisions were constituted, namely, Hydraulics, Navigation, Mathematics, Physics, Chemistry, Statistics, Soils and Materials of Construction and Hydraulic Machinery. The first three are located at Khadakvasla, eleven miles from Poona.

From time to time the CWPRS has undertaken the study of the various features of the river valley and flood control projects and the development of ports and harbours. During the last ten years alone it has solved over 500 problems. These include measures for protecting road and railway bridges, training and control of rivers, exclusion of sand from irrigation canals, improving the navigability of estuaries and harbours and testing of hydraulic structures like spillways, deep-seated sluices, weirs, canal falls, etc. It is estimated that application of the results obtained from various model studies has resulted in a saving of about Rs. 80 crore. Today, the CWPRS is one of the outstanding institutions of its type in the world.

Among the several successful examples, special mention may be made of the protection of Dibrugarh town from erosion by training the Brahmaputra in Assam. These measures to train the river have been found to be effective so far in preventing erosion and thus saving the town. Another problem was of the Calcutta Port Authorities who were finding dredging operations to be very costly. Annually more than Rs. 40 lakh were being spent to preserve the navigability of the Hooghly river. Their proposal for a ship canal estimated to cost nearly Rs. 35 crore was not found feasible by the Research Station. On the other hand, river training measures, costing well below Rs. 8 crore, were recommended after conducting hydraulic model tests. The construction of a 1,300 feet long spur at Akra for improving the Sankrail reach of the Hooghly river has afforded greater navigable depths without any dredging. This is an outstanding

example of the efficacy of model tests conducted by the CWPRS.

At present nearly 40 problems of river training, hydraulic structures of the river valley projects and the developments and improvements of ports and harbours are under investigation by means of hydraulic models. These include the study of the flood control project on the Kosi river. Already, flood embankments are being constructed on alignments finalised from the model tests. Analytical studies in connection with stresses in the foundations of the Bhakra dam are in progress. Geophysical investigations for many dam sites and soil surveys to study the suitability of soils for irrigation are being conducted.

Of late, the CWPRS has also extended its services to some Asian countries. The problem of sand exclusion from Ye-Yu canal, taking off from a weir on the Mu river in Burma, was solved by the CWPRS on the basis of model experiments.

A new line of research now being initiated at the Poona Station aims at testing ship models to determine the most efficient and economical design of the hull. A ship testing tank, 500 feet long, 12 feet wide and 7 feet deep, which is the first of its type in South-East Asia, has been constructed. An electrically driven and electronically controlled carriage has been given by UNESCO as a gift to the Research Station. The tank enables ship models to be tested to determine their hull form.

### POWER ENGINEERING

Under the second Plan a considerable sum of money was spent on the expansion of the engineering capacity and manufacture of heavy electrical equipment, and more will be spent later. But before undertaking such a programme we had to have a power engineering research institute in the country. Accordingly, a committee was set up by the Government of India in 1955 to formulate a programme of research on problems concerning power engineering.

In its report, the Committee recommended the setting up of a Power Engineering Research Organisation at Bangalore.

The Power Engineering Department of the Indian Institute of Science has a fairly good complement of equipment as well as an excellent research library which the Power Research Organisation can utilise with advantage. One of the divisions of the Power Research Organisation, the Switchgear Testing Station, will, on the same principle, be located in close proximity to the Government of India's Heavy Electrical Plant at Bhopal. The testing station will perform the functions of a national testing authority for all switchgear manufactured both in the public and private sectors.

The Power Engineering Research Organisation will, among other problems, conduct research on the following: (i) switchgear testing; (ii) standardisation of fuses; (iii) development of small-scale unattended hydro-electric power units; (iv) use of indigenous resins, fabrics and other materials for insulation purposes; (v) cavitation in hydraulic turbines and structures; (vi) testing and development of special designs of transmission tower, including wood pole supports and lines suitable for Indian conditions; (vii) vibration of conductors; (viii) improvements in electrical and mechanical properties of indigenous aluminium; (ix) bi-metallic corrosion in conductors; (x) lightning strokes and surges on transmission lines; (xi) D.C. transmission; and (xii) power utilisation research.

The total amount required for power engineering research in the first stage of development is estimated at Rs. 4.2 crore. Of this, nearly Rs. 3.5 crore is expected to have been spent during the second and the balance will be spent during the third Plan. The recommendations of the committee are being examined by the Government of India.

#### TRAINING

The Union Ministry of Irrigation and Power has made arrangements for imparting training in the techniques of designing dams and large power plants in the Central Water and Power Commission. Every year a number of serving engineers from the States and fresh graduates from technical institutions are being given training in the Central Water

and Power Commission. Sometimes engineers from other Asian countries are deputed for training here.

The Roorkee University has started Water Resources Development Training Centre for South-East Asian countries under the auspices of the UNESCO. A number of engineers from Egypt, Vietnam, Philippines, Japan, China, Burma and Ceylon have been given training in this Centre.

Centres for training operators of construction equipment are being set up. It has been estimated that in 1954 earth-moving machinery worth Rs. 40 crore was in use in the country. Since then the use of mechanical equipment has greatly increased. Such extensive use of machinery is somewhat new in our country. The problem of keeping this machinery in running condition all the time is mainly a problem of personnel. They have not only to be properly trained, but increasing number of men must be given training. The Government of India has, therefore, set up two technical training centres, one at Kotah and the other at Nagarjunasagar, for the training of operators and mechanics. Under the Technical Cooperation Aid basic machinery for the centres has been acquired. The services of four expert operators and mechanics have also been obtained.

For the present, arrangements for the training of 40 operators and mechanics at each centre have been made. The course is of one year's duration and a stipend of Rs. 100 is paid to each trainee. Training is imparted in the following subjects: (i) purposes and capacity of machines; (ii) co-ordination of controls; (iii) maximisation of output; (iv) ability to discover faults and carry out repairs; and (v) service and maintenance operations.

Noted Indian firms associated with the manufacture of earth-moving equipment, oil firms and tyre manufacturers are being associated with the training.

#### *"Hot Line" Training*

In addition, two more training centres have been opened at Ganguwal (Punjab) and Bangalore (Mysore) for training people to carry out repairs and maintenance operations on overhead transmission and distribution lines and equipment without switching off the power supply. This would make

it possible to carry out repairs on "Live Lines" and thus eliminate the need for multiple circuits. Under the Indo-US Technical Cooperation programme for 1954-55, an agreement was signed by the Governments of the USA and India in April 1955 for the supply of equipment and the services of experts for the training centres.

The training centre at Ganguwal serves West Bengal, Bihar, Uttar Pradesh, Punjab, Rajasthan and Orissa, and the one at Bangalore, serves Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Madras and Kerala. This scheme when fully implemented is expected to bring substantial economies in the operation and maintenance of transmission and distribution systems in the country.

## CHAPTER VII

### PUBLIC CO-OPERATION

Planned economic development in a democracy presupposes people's participation at all important stages. Particularly in an under-developed country where economic progress is both urgent and difficult public co-operation in the execution of Plan projects is of vital importance. Accordingly, the first Plan laid great emphasis on the role of public co-operation in the execution of river valley projects. The scope for such co-operation was even greater in the second Plan, and will increase as the process of economic development gains momentum. The second Plan provided a sum of Rs. 1 crore to render assistance to voluntary organisations engaged in organising the co-operation of the common people. An honorary Adviser on Public Co-operation has been appointed to advise the Government on mobilising such co-operation.

There are different ways in which people can offer co-operation. We are spending hundreds of crores of rupees on river valley projects which bring irrigation and protection from floods to millions of acres. Therefore, it stands to reason that those who benefit from these schemes should not grudge to pay the betterment fees and taxes imposed by the State on their lands.

Co-operation can be offered by the people in another way also. The excavation of canals involves a good deal of unskilled labour. When the Government gets this work done through contractors it spends much more money than it would have to if the workers organised themselves in co-operatives. By entrusting such works to the co-operatives of village workers not only could expenditure be considerably reduced, but there would be no middlemen to profit from their labour. This way employment can be created for thousands of men during the season when agriculture does not claim much of their attention.

A large number of irrigation projects and other public works such as embankments, canals, small bridges, culverts, roads, railway tracks, etc., are being constructed for which manual labour can be used on an extensive scale; and we have an abundant supply of such labour in our country. Apart from yielding tangible material gains, public co-operation will encourage self-help and strengthen our enthusiasm to work together for the good of the nation.

Our experience in the field of public co-operation has been quite encouraging. The first experiment of its kind was started at Kosi during the 1954-55 working season and proved a striking success. The organisation of public co-operation at this site was undertaken by the Bharat Sevak Samaj. Many people in the villages came forward, offering *shramdan* or voluntary labour. They formed labour co-operative societies and undertook the construction of embankments. It was significant that thousands of cultivators surrendered their lands for embankments without waiting for the land acquisition process to be gone through by the Administration. Had they not done so, it would have caused inordinate delay and resulted in greater overhead expenses on the project. This was a striking evidence of the enthusiasm of the common people for our Plan projects. Another direct result of such participation was the organisation of labour co-operatives through which available local labour could be mobilised. Thanks to these co-operatives a portion of the earnings of labour could also be set apart for projects of community development under a new scheme sponsored by the Government.

Public co-operation was also in evidence at other places during the 1954-55 working season. For instance, at Burhi Gandak in north Bihar, 75 per cent of earthwork on a 100-mile reach of embankment was started through *mukhias* and *gram panchayats* of the villages nearby. In Assam, public co-operation was available for the construction of embankment in Goalpara and the protection works at Dibrugarh. In Uttar Pradesh large numbers of villagers in the affected areas participated in the work of raising the level of the village sites. At Dhumrighat, about 6,000 persons offered

voluntary labour and constructed a river embankment and an approach road.

Public co-operation was remarkable during 1955-56 at the Kosi. Nearly 10.5 crore cubic feet of earthwork was done through the Samaj. This was double the previous year's record and represented about 90 per cent of the target. But for incessant rains and resultant floods occurring five weeks ahead of the usual time, the full target would have been achieved.

A considerable number of people, moved by a fervour for service, volunteered to work on embankments. Among them were those who were not accustomed to do manual work. In February 1955, the number of people working on the embankments was, on an average, about 3,500 per day. In February 1956 the number increased to about 21,000 per day although the work on the entire reach allotted for public co-operation had not yet been taken up.

The Bharat Sevak Samaj, which organised the movement, fixed the rates at which the work was let out to private contractors. This brought to the Government a direct saving of about Rs. 2.50 per 1,000 cubic feet, resulting in a total saving of about Rs. 5 lakh on the eastern embankment. There was similarly a saving of about Rs. 2.7 lakh on the western embankment.

The primary responsibility for organising the work at Kosi rests with the unit leaders who are generally *mukhias* of *gram panchayats* and the labour co-operatives. They are authorised by the Bharat Sevak Samaj to sign contracts with the project authorities. This arrangement has helped to promote the growth of village leadership. There is here no scope whatever for middleman's profits. Everything goes to the general benefit of workers and the community.

Similarly, the co-operative labour and construction societies which were formed in the Punjab in 1952 were utilised in the construction of canals and other public works. During 1955-56, the societies obtained contracts for works worth Rs. 268.4 lakh. Of these, works to the value of Rs. 121.67 lakh had been executed by the end of the year.

The major part of the work on the Delhi-Shahdara bund costing about Rs. 7 lakh was carried out by the Bharat Sevak



Samaj. The Samaj, in addition, completed earthwork on the left marginal bund costing about Rs. 20,000. At Nagarjunasagar, the Samaj has started work with public co-operation which is estimated to cost Rs. 20 lakh. At Kosi, too, the Samaj has done valuable earthwork.

### *Trained Personnel*

The organisers of the Samaj were handicapped for want of personnel trained to handle different kinds of jobs. The Samaj has, therefore, started schemes for training the workers. At Kosi two training centres were opened to train 250 supervisory and accounts staff, besides two camps where 100 candidates were trained for the work of organising and mobilising people for construction work. Similar training centres have been opened at Kotah, Nagarjunasagar and Delhi for imparting training to 50 supervisory and accounts staff (one year's course) and 50 organiser staff (1½ month's course), apart from obtaining people's co-operation in construction work at each centre.

While approving the above schemes, the Government has given grants to the Samaj to meet about 80 per cent of its expenditure, the balance being met by the Samaj out of its own funds. Also, grants have been given to meet the expenditure on account of the staff maintained at the headquarters of the Samaj. The first instalments of the grants were given in 1956-57.

## CHAPTER VIII

### AMENITIES FOR WORKERS

Of the many benefits resulting from river valley projects, the most immediate is the opportunity for employment they offer. Large numbers are today employed on building dams, canals, supplying various kinds of materials and services including maintenance of machines. On some of the bigger projects like the Damodar Valley and Hirakud there are several thousand workers engaged at the same time. The very fact that so large a number of workers are working together on such gigantic projects has brought among them an awareness of their rights and responsibilities.

As the project sites are generally located in isolated places, far away from cities and towns, new colonies and construction camps have sprung up close to the dam sites along the canals and transmission lines at the power substations. These colonies have been provided with modern amenities like electricity, protected water, post offices, first-aid posts, dispensaries, hospitals and schools. There are labour officers, labour welfare officers and labour inspectors to look after the interests of the workers, get their grievances redressed and deal with matters relating to wages and employment. Many of these colonies are capable of being developed into industrial townships.

#### *Housing*

Houses have been built for the workers at all work sites, free of rent. Most of these quarters have cement floors, shelves, and strong ceilings instead of corrugated iron roofs. Where rent-free accommodation is not possible, they are given house-rent allowance.

These newly built colonies for workers have been provided with filtered and piped water supply, electric lighting and sanitary and drainage facilities. Some of the work sites have community baths, storage tanks and public conveniences. Every colony has its own market. Privately owned

restaurants and hotels have sprung up in every colony to cater to workers.

Among the amenities provided in these colonies sufficient attention has been given to the education of children. High, middle and primary schools have been opened for boys and girls. The schools have spacious playgrounds and all the essential teaching equipment. At some project sites fee concessions are allowed to the sons and wards of low-paid workers. In addition to these, education centres for adults are also run.

### **Medical Aid**

Qualified doctors and midwives have been provided exclusively for the labour colonies. There are fully equipped and staffed hospitals with facilities for x-ray, infra-red ray equipment and air-conditioned operation theatres. In addition to these, compounders equipped with dispensaries have been posted at various work sites in the labour colonies. Injured workers at the project sites are given immediate relief by first-aid units stationed close by. Motor ambulances are available for services at all hours. An injured workman undergoing treatment at the hospital as indoor patient is given free diet.

In addition, maternity and child welfare centres under lady health visitors look after the pre and post-natal care in the colonies. Family planning clinics are also attached to the centres.

At the project site prophylaxis against malaria and seasonal epidemics like cholera, small-pox, dysentery, etc., is compulsory for the workers. For instance, the lower part of the Damodar Valley was highly malarial. No proper facilities existed for the control of this scourge in this area before the Corporation took over the development of the valley. Today, the control of malaria is an integral part of the DVC development programme. The Corporation took anti-malarial measures in 1950 at Tilaiya, Konar and Bokaro and later at Maithon and Panchet Hill. A striking result of these efforts in the Konar area is that the incidence of spleen trouble which was about 80 per cent has been brought down to 2 per cent within a period of two years.

### *Recreation*

Labour welfare centres with provision for indoor games, radios, libraries and reading rooms are being run in the different colonies for workers' recreation and social activities. There are children's parks with facilities for outdoor games. Free film shows, including feature, documentary and educational films are arranged quite often. Dramatic performances, variety entertainments and games are held from time to time.

### *Social Welfare*

A heartening feature of labour welfare at some projects is that educated ladies of the place have come forward to do voluntary social work among the workers. Ladies from officers' families are also running classes for women workers in knitting and sewing. Materials like wool, needles, etc., are supplied free to these women.

There are grain shops and co-operatives in the colonies for the benefit of the workers. Arrangements have also been made for supplying necessities of life. The canteens have been given subsidies to meet initial expenses. The Central Tea Board has opened cheap tea stalls at some work centres.

In order to ensure prompt payment of wages to the workers a central payments system has been introduced at the Bhakra Nangal project. Mobile pay offices make payments to the workers at the work sites or at their colonies.

In order to reduce the incidence of accidents, safety organisations have been set up to educate workers in safety methods while doing various kinds of works. All cases of accidents are promptly attended to at the hospitals and compensation is given, where it is due. Men working at hazardous jobs are given extra wages. Flood lights provided at workspots contribute to safety of workers during nights.

The Damodar Valley project issues a monthly "Labour Bulletin", which contains information regarding employment, welfare, progress of work, etc. The bulletin is brought out in Oriya, Hindi and English.

These amenities are but a sample of what the Government desire to do for the workers. The working people who in their thousands are toiling to build our dams, barrages,

canals and power houses are laying the real foundations of a prosperous India. While the engineers and other technical men prepare the blue-prints and supervise construction it is the so-called unskilled labour of thousands of men and women that transforms designs into achievements. They are the men of today who are building the prosperity of tomorrow. The amenities which have been created for their welfare therefore belong to them by right.

**APPENDIX I**  
**UTILISATION OF WATER RESOURCES IN IMPORTANT RIVER BASINS**

River system	Estimated average annual flow	Utilisation up to 1951	Important projects under first Plan	Proposed utilisation by first and second Plan schemes on full development
1	2	3	4	5
1. Indus .. .. .	168 million acre-feet for the entire river system lying both in India and Pakistan	About 8 million acre-feet	Bhakra Nangal	12·2 million acre-feet
2. Ganga .. .. .	400 million acre-feet	20·0 million acre-feet	DamodarValley, Kosi, Chambal	36 million acre-feet
3. Brahmaputra .. .. .	300 million acre-feet	Negligible; in general, irrigation unnecessary because of heavy rainfall in Assam	—	—
4. Godavari .. .. .	84 million acre-feet	12·0 million acre-feet	—	2·5 million acre-feet
5. Mahanadi .. .. .	84 million acre-feet	0·6 million acre-feet	Hiraku	10·7 million acre-feet
6. Krishna .. .. .	50 million acre-feet	9·0 million acre-feet	Tungabhadra, Nagarjunasagar	18·2 million acre-feet
7. Kavery .. .. .	12 million acre-feet	8·0 million acre-feet	Lower Bhavani	1·9 million acre-feet
8. Narmada .. .. .	32 million acre-feet	0·2 million acre-feet	—	10·1 million acre-feet
9. Tapti .. .. .	17 million acre-feet	0·2 million acre-feet	Kakrapar	4·2 million acre-feet

## APPENDIX II

### PRINCIPAL PROJECTS IN FIRST PLAN

1. Nagarjunasagar	.. .. .	Andhra.
2. Tungabhadra	.. .. .	Andhra and Mysore.
3. Godavari 1st Phase	.. .. .	Andhra.
4. Kakrapar	.. .. .	Maharashtra.
5. Mahi Right Bank Canal	.. .. .	.. .. .
6. Gangapur	.. .. .	.. .. .
7. Kosi	.. .. .	Bihar.
8. Pratap Canal Remodelling	.. .. .	Jammu & Kashmir.
9. Kishtwar Canal Project	.. .. .	.. .. .
10. Peechi	.. .. .	Kerala.
11. Malampuzha	.. .. .	.. .. .
12. Neyyar 1st Stage	.. .. .	.. .. .
13. Chambal	.. .. .	Madhya Pradesh & Rajasthan.
14. Manimuthur	.. .. .	Madras.
15. Araniyar	.. .. .	.. .. .
16. Bhadra	.. .. .	Mysore.
17. Ghataprabha Left Bank Canal	.. .. .	.. .. .
18. Raholibunda	.. .. .	Mysore and Andhra.
19. Nugu	.. .. .	Mysore.
20. Hirakud Dam Project	.. .. .	Orissa.
21. Bhakra Nangal Project	.. .. .	Punjab and Rajasthan.
22. Remodelling Western Jumna Canal	.. .. .	Punjab.
23. Jawai	.. .. .	Rajasthan.
24. Sarda Sagar Stage I	.. .. .	Uttar Pradesh.
25. D.V.C. Projects	.. .. .	West Bengal & Bihar.
26. Mayurakshi	.. .. .	West Bengal.
27. Tungabhadra Nellore Hydro-Thermal	.. .. .	Andhra and Mysore
28. Michkund	.. .. .	Andhra and Orissa.
29. Umtru	.. .. .	Assam.
30. Koyna	.. .. .	Assam.
31. Periyar	.. .. .	Madras.
32. Madras Thermal Station Extension	.. .. .	Madras.
33. Rihand	.. .. .	Uttar Pradesh
34. Nesiaramangalam	.. .. .	Madras.
35. Poringalkuthu	.. .. .	.. .. .

APPENDIX III  
PRINCIPAL PROJECTS IN SECOND PLAN

Project	State	Total Cost (Rs. lakhs)	2nd Plan Provision		Benefits			
			Irrigation (Rs. Lakhs)	Power	Irrigation ('000 acres)		Power ('000 Kw.)	
(1)	(2)	(3)	(4)	(5)	On completion	During second Plan	On completion	During second Plan
1. Tungabhadra HL Canal	Andhra and Mysore	1,300	395		187		120 (Avg)	
1. AUKai .. ..	Gujarat	6,164	300		392			
2. Tawa .. ..	Madhya Pradesh	1,834	304		590		22.5 (at 60% load factor)	
3. Purna .. ..	Maharashtra	769	500	210	160	15	4.5	
4. Vamsadhara .. ..	Andhra	1,256*	85		310*			
5. Narmada .. ..	Gujarat	4,310	100		1,017			
6. Banas .. ..	Do.	919	355		110	15		
7. Mula .. ..	Maharashtra	940	100		143	52		
8. Girna .. ..	Do.	938	400		89	52		
9. Khadakvasla .. ..	Do.	1,162	400		**77			
10. New Kattalai .. ..	Madras	157	130		21	12		
11. Salandi .. ..	Orissa	466	250		328			



(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
12. Kangsabati ..	West Bengal	2,526	475		950			
13. Chandrakeshar ..	Madhya Pradesh	89	85		12	10		
14. Kabini .. ..	Mysore	250	250		30			
15. Banas .. ..	Rajasthan	480	200		250	30		
16. Bhadar .. ..	Gujarat	295	103		45			
17. Boothathanketu ..	Kerala	348	201		63			
18. Lidder Canal ..	Jammu & Kashmir	81.5	40		7	2		
19. Barna .. ..	Madhya Pradesh	477	218.5		164			
20. Laxmanatirtha ..	Mysore	31	23		3			
21. Vidur .. ..	Pondicherry & Madras	89	89		3	3		
22. Sileru .. ..	Andhra	2,453		50			120	
23. Machkund Extn. ..	Andhra & Orissa	226		180			21	21
24. Tungabhadra Nellore Scheme	Andhra & Mysore	770		625			57	57
25. Chambal (Stage II) ..	Madhya Pradesh and Rajasthan	1,766	95	500	300		90	
26. Cherapunjee Steam Station	Assam	193		149			6	6
27. Barauni Steam Stn.	Bihar	294		294			30	30
28. South Gujarat Electric Grid Stage II	Gujarat	400		400			45	45
29. Korpai Thermal Stn.	Madhya Pradesh	1,234		1,148			90	90
30. Southern Grid Extn.	Do.	777		738			60	60
31. Katni Power Station	Do.	270		256			20	20
32. Kundah .. ..	Madras	3,544		2,200			180	180
33. Pykara Dam .. ..	Madras	30		30			3	3
34. Papanasam Dam ..	Do.	41		41			4	4
35. Hirakud Stage II	Orissa	1,432		1,187			109	109
36. Yamuna Hydel Scheme	Uttar Pradesh	1,959		570			201	
37. A Scheme in Western U.P.	Uttar Pradesh	1,088		20			75	

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
38. Harduaganj Steam Stn. Extension	Uttar Pradesh	284.71		250			30	30
39. Matatila Hydel Scheme	Do.	374.25		326			15	15
40. Kanpur Power Stn. Extension	Do.	170		170			15	15
41. Jaldhaka Hydel Scheme	West Bengal	350		194			17	—
42. Konar Hydel Station or alternative	West Bengal & Bihar	449					40	—
43. Durgapur Thermal Station	Do.	1,270		1,270			150	150
44. Bokaro Extension ..	Do.	456		456			75	75
45. Tungabhadra Extension	Mysore	50		47.5			9	9
46. Gandarbal Power House	Jammu & Kashmir	73		42			9	9
47. Mohora Power House	Do.	109		71			9	9
48. Bhadra .. ..	Mysore	3,353		960.48	244	145	33	33
		(Including Rs. 160 lakhs for power plant).		total to end of 11/59 during the II Plan				
49. Sharavathy .. ..	.. ..	2,297		1,300			178	—
50. Jodhpur .. ..	Rajasthan	30		30			3	3
51. Rajkot .. ..	Gujarat	11.35		20			2	2
52. Porbander .. ..	Do.	200		150			15	15
53. Jamnagar .. ..	Do.	95		95			8	8
54. Morvi-Wankaner .. ..	Do.	64		64			4	4
55. Bhavnagar .. ..	Do.	50		50			8	8
56. Surendranagar .. ..	Do.	80		72			4	4
57. Veraval .. ..	Do.	100		100			10	10

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
58. Panniar .....	Kerala	324		280			30	30
59. Sholayar .....	Do.	425		262			54	54
60. Pamba or Poringalkuthu	Do.	965		220			100	—
61. Burhar & Satna Extns.	Madhya Pradesh	260		237			20	30

\* Figures as per original proposal. A revised scheme based on investigation at Gudari site is to be prepared.

\*\*Figures as per original proposal. Revised scheme based on investigation at alternative sites is awaited

APPENDIX IV

**PRINCIPAL POWER GENERATION SCHEMES IN SECOND PLAN**

Scheme and Name of the State	Total cost Rs. lakhs	Expenditure in second Plan for power Rs. lakhs	Benefits '000 kW	
			On completion	In second Plan
(1)	(2)	(3)	(4)	(5)
<b>CONTINUING SCHEMES</b>				
1. Tungabhadra (Andhra & Mysore)	* 6,000	795	54	54
2. Bhakra Nangal (Punjab and Rajasthan).	16,000	2,183	598	598
3. Hirakud (Stage I). (Orissa) ..		763	123	123
4. D.V.C. (Bengal and Bihar) ..		1,062	254	100
5. Chambal (Stage I) (Madhya Pradesh & Rajasthan).	*4,803	1,330	69	69
6. Machkund (Andhra and Orissa)	2,732	611	93	51
7. Umtru (Assam) .. ..	158	82	8.4	8.4
8. Koyna (Maharashtra) .. ..	3,322	2,900	240	240
9. Periyar (Madras) .. ..	1,048	723	105	105
10. Madras (Thermal Station Extension, Madras)	956	271	60	30
11. Rihand (U.P.) .. ..	4,526	2,600	300	150
12. Ramagundam (Andhra) ..	406	137	38	38
13. Thermal Power Station (Rajasthan)	310	216	24	24
14. Neriamaingalam (Tamil Nadu)	290	274	45	45
15. Poringalkuthu (Kerala) ..	346	35	32	32
<b>NEW SCHEMES</b>				
1. Ukai (Gujarat)** .. ..	*6,000	--	160	—
2. Tawa (Madhya Pradesh) ..	*1,839	—	39	—
3. Purna (Maharashtra) .. ..	*773	210	10	10
4. Chambal Stage II (Madhya Pradesh and Rajasthan).	*1,356	500	92	23
5. Sileru (Andhra) .. ..	2,453	50	60	—
6. Machkund Extension (Andhra and Orissa)	226	186	21	21

(1)	(2)	(3)	(4)	(5)
7. Tungabhadra Nellore Scheme (Andhra and Mysore)	770	675	57	57
8. Cherapunjee Steam Station (Assam)	193	149	6	6
9. Barauni Steam Station (Bihar)	294	294	30	30
10. South Gujarati Electric Grid Stage II (Gujarat)	400	400	45	45
11. Korba Thermal Station (Madhya Pradesh)	1,234	1,148	90	90
12. Southern Grid Extension (Madhya Pradesh)	777	738	60	60
13. Katni Power Station (Madhya Pradesh)	270	256	20	20
14. Kundah (Madras)	3,544	2,200	180	180
15. Pykara Dam (Madras) ..	30	30	3	3
16. Papanasam Dam (Madras) ..	41	41	4	4
17. Hirakud Stage II (Orissa) ..	1,432	1,187	109	109
18. Yamuna Hydel Scheme (U.P.)	1,959.3	570	201	—
19. A Scheme in Western U.P. ..	1,088	20	75	—
20. Harduaganj Steam Station Extensions (U.P.)	284.71	250	30	30
21. Matatila Hydel Scheme (U.P.)	374.25	326	15	15
22. Kanpur Power Station Extension (U.P.)	170	170	15	15
23. Jaldhaka Hydel Scheme (West Bengal)	350	194	17	—
24. Konar Hydel Station or alternative (D.V.C.) (Bengal & Bihar)	449	..	40	—
25. Durgapur Thermal Station (D.V.C.) (Bengal & Bihar)	1,270	1,270	150	150
26. Bokaro Extension (D.V.C.) (Bengal and Bihar)	456	456	75	25
27. Tungabhadra Left Bank Stage II (Mysore)	50	47.5	9	9
28. Ganderbal Power House (Jammu & Kashmir)	73	42	9	9
29. Mohora Power House (Jammu & Kashmir)	109	42	9	9
30. Bhadra (Mysore) .. ..	82	82	33	33
31. Sharavathy (Mysore) .. ..	2,297	1,300	178	—

(1)	(2)	(3)	(4)	(5)
32. Jodhpur (Rajasthan) .. ..	30	30	3	3
33. Rajkot (Gujarat) .. ..	11·35	20	2	2
34. Porbunder (Gujarat) .. ..	200	150	15	15
35. Jamnagar (Gujarat) .. ..	95	95	8	8
36. Morvi-Wankaner (Gujarat) .. ..	64	64	4	4
37. Bhavnagar (Gujarat) .. ..	50	50	8	8
38. Surendranagar (Gujarat) .. ..	80	72	4	4
39. Veraval (Gujarat) .. ..	100	100	10	10
40. Pannihar (Kerala) .. ..	324	280	30	30
41. Sholayar (Kerala) .. ..	425	262	54	54
42. Pamba or Poringalkathu (Kerala)	965	220	100	—

\* The total cost shown includes outlay on irrigation portion.

\*\* Figures are yet to be finally accepted.