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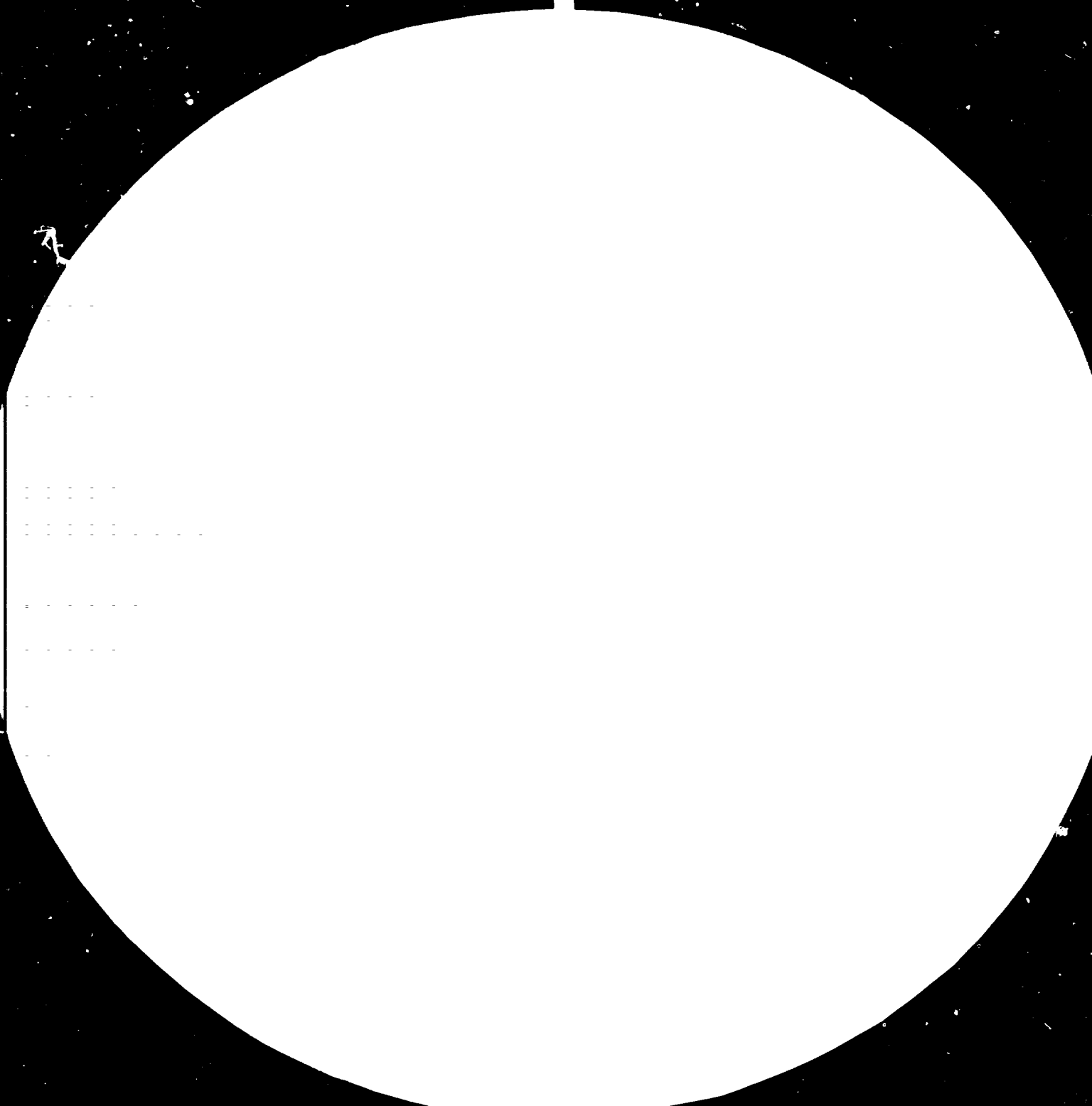

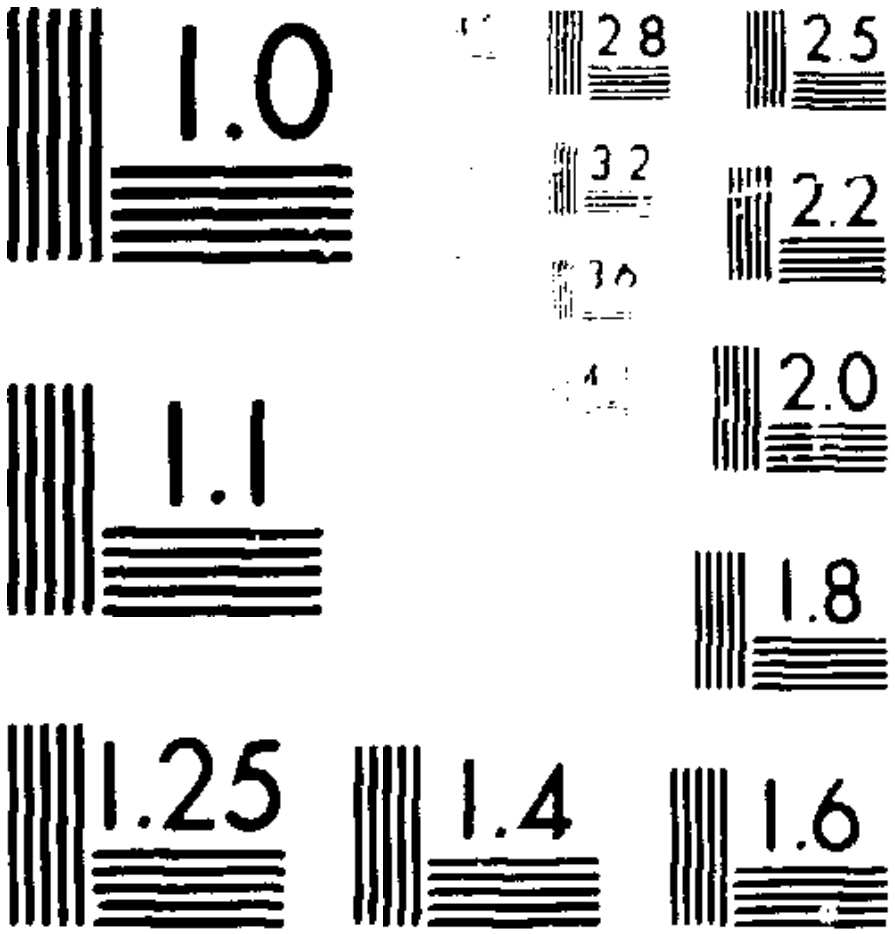

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MULTI-PURPOSE DEVELOPMENT OF THE JINGJIANG BASIN*

by

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I. General Introduction

Situated in the south-west part of the Pearl River Delta, the Jingjiang Basin has an area of 1,450 square kilometers which occupies the whole En-ping county by its upper basin. The En-ping county consists of 15 people's communes and a town, with a total population of 350 thousand and a total amount of arable land of about 490 thousand mu. A half-hilly half-mountainous area, the county extends itself descending from west to east. The main river of the county, Jingjiang (128 km. long) flows through nine of the communes, the gradient of the river bed being 1/2250. In the basin there are 360 thousand mu of arable land. Since the upper reach of the river finds itself among mountains after mountains, it enjoys an abundant rainfall and is, therefore, rich in water resource. The average annual rainfall amounts to 2,514 mm, the maximum rainfall being up to 3,835 mm. The average total flow of the river is 2,129 million m^3 each year, with the maximum total flow reaching 3,387 million m^3. The average annual discharge is 65 m^3/sec while the peak discharge of the flood of 20 years recurrence is 3,870 m^3/sec and the average annual minimum discharge is found to be 4.5 m^3/sec.

The jingjiang Basin used to suffer a great deal both from floods and droughts. Since 1969 the people of En-ping, mobilized and led by the People's Government of the county have been engaged in harnessing the river and the multi-purpose development of the basin. Now in the Jingjiang Basin there are 134 reservoirs of various sizes with a total capacity of more than 700 million cubic meters have been built, which have the capacity to control the rain-water over 678 square kilometers, or 47% of the whole basin. With the large and middle-sized reservoirs as their backbones and small reservoirs as their base, two large scale irrigation systems, one on the north bank and another on the south bank of the river, have been set up in order to meet the needs of irrigation of more than 400 thousand mu of farm land in this county. Mean while, for the purposes of drainage and flood storage, the Xe-shan Gorge in the lower reach of the river has been dredged to enlarge the outlet and a flood protection levee of 153 kilometers has been built up. In addition, 73 pumping stations for drainage with a total power of 7,705 kw have been built, which is capable of making 100 thousand mu of lowlying farm land free from flood and waterlogging.

For the purpose of making full use of the water resource, hydropower generation has been taken into consideration in the course of river harnessing. Now 137 small size hydro-electric stations have been built with Jingjiang Reservoir Hydroelectric power station in the lead. The total installing capacity of these power stations sums to more than 37 thousand kw,including the 29 700 kw of the seven cas-

cade power stations. The total annual power output reaches 120 million kwh. Six transformer substations of 35-110 kv have also been built up and more than 3,000 km high and low tension transmission lines have been erected in order to connect them to the state grid. The wide rural areas which are inhabited by over 95% of the population of the county are supplied with electric power, a low-cost and convenient power source.

The movable water-locks for fifty-ton motor ships were provided along with the four cascade electric power stations, the water depth between these four cascade were improved and thus the navigability of the river were greatly increased, the annual tonnage now is about 200 thousand tons.

In the course of harnessing the Jingjiang River the earth work amounts to 67,270,000 cubic meters, the stone work to 1,350,000 cubic meters, the concrete work to 160,000 cubic meters, and the total investment sums to 61,000,000 yuan. The gains of the multi-purpose development of the Jingjiang Basin are shown in the following table (Tab. 1) and the plan of development of the Jingjiang basin are shown in Fig. 1.

II. Measures taken for the multi-purpose development of the basin

Thanks to the ten-year's harnessing of the river, the Jingjiang Basin has become basically free from floods and droughts. Along with the harnessing of the river, a number of power stations have been built up, which, to a certain extent, provide industrial and agricultural production with power supply. The achievements in harnessing the Jingjiang river, as mentioned above, have been made as a result of the exercising of the concentrated leadership of the People's Government of the county, the all-round planning and arrangement as well as the division of the construction into proper stages.

In the harnessing of the Jingjiang River, the main points we held to are as follows: storing in the upper reach, releasing in the lower reach and building the flood protection levee along the river, cascade development, comprehensive harnessing in order to get multi-purpose economical results.

Building reservoirs in the upper reach is the key-link in harnessing the Jingjiang River. Not only do such reservoirs serve as flood storage and flood detention projects, but also essential for regulation, irrigation and power generation, and benefiting the harnessing of the lower reach of the river. As the upper reach flows through mountainous areas, it accepts rainfall over 672 square kilometers (the annual rainfall being 2,500 mm, the maximum rainfall 3,800 mm; with over 80% of the rainfall concentrating from April to September) and the gradient of river bed is as grea as 3/1000. heavy storms are apt to result in disastrous floods. Flood discharge of 20 years recurrence is found to be about 2,100 cubic meters per second, whereas the main course of the upper and lower Jingjiang is only 150 meters and 180 meters wide, respectively. Therefore, before the reservoirs on the main course of Jingjiang were built, the Jingjiang River had been suffered in flood not once a year and the one hundred thousand mu of farm land on both sides of the river had always been subjected to flood. For the purpose of flood prevention, on the upper reach of the Jingjiang River (on the main course as well as on the tributaries) a number of reservoirs such as the Jingjiang Reservoir, the Hongqi Reservoir, the Fengzhishan Reservoir and others have been built which are able to have a control of the rainwater over 411 square km. or 65% of the total rainwater over the upper reach basin. The

reservoirs mentioned above, working along with such medium-sized reservoirs, namely, the Xi-Keng Reservoir, the Liang-xi Reservoir, the Qing-Nan-Jiao Reservoir and the Sa-hu Reservoir, which have been built on some main branches, and a series of small size reservoirs when functioning as flood storage and flood detention projects, can reduce the flood discharge of the upper reach occuring every twenty years from 2,100 m^3/sec to 1,250 m^3/sec, that of the middle reach from 2,200 m^3/sec to 1,400 m^3/sec, and that of the lower reach from 3,400 m^3/sec to 3,100 m^3/sec, thus lowering the water level of the upper middle and lower reaches by 2.1 m, 1.1 m and 0.2 m, respectively. This helps a lot to prevent flood all the way along the Jingjiang River and provides the possibility for hydro-electric generation by means of the cascades.

As above-mentioned, the reservoirs in the upper reach have a catchment area over 678 square km, so the annual inflow of these reservoirs reaches up to 700 million cubic meters. In accordance with its peculiar geographical features the Jingjiang Basin has been planned to possess two irrigation systems with the Jingjiang Reservoir and Xi-Keng Reservoir as the backbone of each, which will be served to irrigate four hundred thousand mu of farm land. According to calculation, it requires only 500 million cubic meters of water. Thus, 200 million cubic metres of water can be provided as supplementary watersource for the cascade stations for power generation. As is shown, the reservoirs in the upper reach of the river are not only essential for flood protection, but also serve for power generation. Meanwhile, with the multi-purpose utilization of the water resource, the construction cost of power stations has been greatly reduced.

On the dams of the reservoirs of Jingjiang, Xi-Keng, Hong-qi, Fengzheshan, Qin-Nan-Jiao and Liang-xi, power stations have been built with a total installing capacity of 26,000 kw. Regulated by the reservoirs, these power stations operate for more than 3,500 hours each year, and the cascade power stations on the main course of the river for more than 3,000 hours; only in this way has the aim of the multi-purpose utilization of the water resource been achieved, with the reservoirs being made versatile uses. The technical and economical features are shown in table 2.

For the purpose of flood releasing, the He-Shan Gorge has been dredged, in addition, a new outlet channel, 120 m. wide and 800 m. long has been dug where the He-shan power station is located. The new channel was expected to increase the discharge by 1,400 m^3/sec. Besides, the length of river channel dredging and short cutting of river bends are 22 km so that flood releasing could be made much easier. This releasing project was carried out along with the construction of the nineth cascade He-shan power station. This station is a low head hydro power station with installed capacity of 1,250 kw. In this junction project there is a flood releasing sluice with seven openings, each being 16.2 m wide and 5.3 m in height These radial-gates were made of reinforced concrete frame with wire mesh mortar leaf (Fig. 2). This type of gate saved a lot of steel. Besides, a movable dam for the navigation of 50-ton ships has been constructed.

The cascade development makes it possible to make the best use of the natural gradient of the river bed. It serves for the multi-purpose of flood releasing, irrigation, power generation and navigation. The section of the main course of Jingjiang between the Jingjiang power station (the first cascade) and the He-shan power station (the ninth cascade) is 78.25 km. long, while its head drop is 37.8 m and the average gradient comes to 1/2250. In correspondence with the peculiar geographical

features on both sides, the river has been harnessed in nine cascades. Among them the Jingjiang Reservoir Power Station is the first and the leading station in the main course. It has a catchment area of 362 square kilometer, and its annual flow is more than 570 million cubic meters. In order to make full use of the reservoir for the purpose of flood retarding, irrigation and power generation, after comparison between several alternatives, it is determined that the flood storage capacity of the reservoir is 88.6 million cubic meters while the capacity for irrigation and power generation are 360 million cubic meters, the height of dam is 64.2 m., the water head is 45 meters and the discharge is 45 m^3/sec. Besides, the irrigation water supplied for the 20 thousand mu of farm land, there are still 200 million cubic meters of water which can be used as supplementary water source for other cascade power station in the main course (the cross section of the main dam of the first cascade is shown in Fig. 3). At the upstream of second power station, the tailwater of stage I power station is diverted partially to the south trunk canal. A third power station with the installing capacity of 2500 kw has been built along with Frengzhishan Reservoir. The tailwater of the third power station flow into Jingjiang to be utilized from the fourth down to the seventh power statione by cascades which have been developed for multi-purpose of flood prevention, drainage, irrigation and navigation. The total installing capacity of all the nine power stations sums to 29,520 kw (Fig. 1).

The power output of these nine cascade power stations is delivered to the provincial transmission network to meet the peak load used in draining the farm land of En-ping county. This is considered as the key-link to guarantee the agricultural production.

To make full use of the water resource, the cascade hydro-electric development would be carried out not only on the main course, but also on the branches and even small streams in the mountainous areas. For example, six cascade power stations with an installing capacity of 3,360 kw and an annual output of 12 million kwh have been constructed on the branch Lang-Di which has a catchment area of 25 km^2 but possess a considerable head drop of 170 m. This has also been done on such branches as Liang-Xi, Fengzhishan, Huang-Jian and others. Even on the still smaller mountain streams such as he Lazhifuzhejing with a catchment area only over 3 km^2 four cascade power stations have been built with an installing capacity of 500 kw and more and an annual power output of 1.6 million kwh. In rural areas such small-size hydro-power stations are very useful for agricultural products processing (husking, threshing, milling) and lighting.

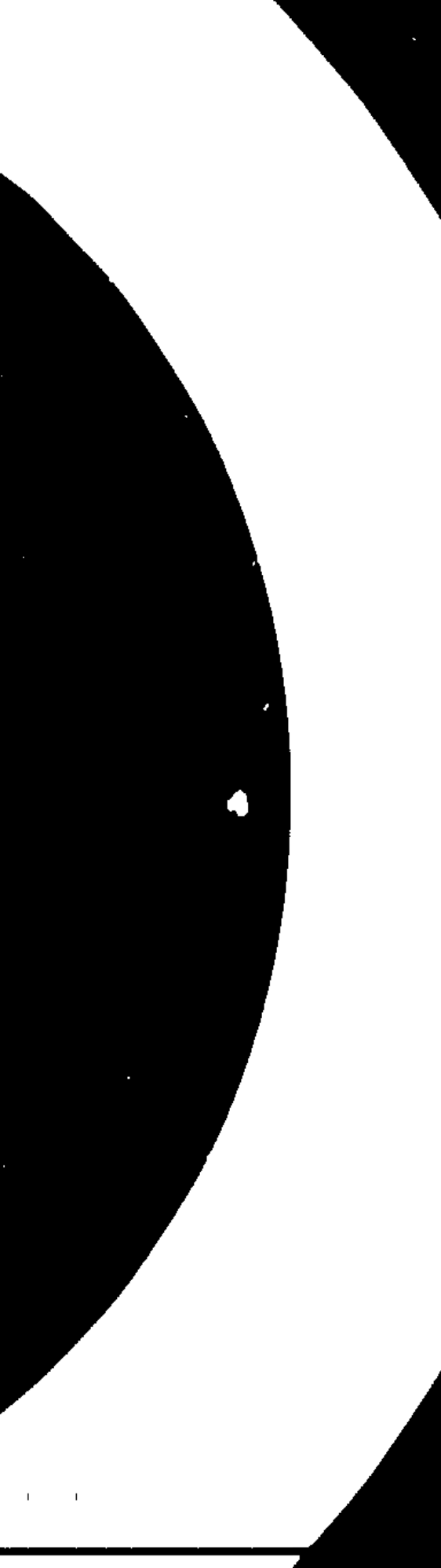
The Jingjiang River have been harnessed, the Jingjiang Basin has been rid of floods and droughts. The power stations built up in the course of river harnessing provide the rural areas with low-cost power. Further improvement and consolidation of the existing water conservancy facilities are required in order to guarantee steady and bumper harvests. Besides, active measures should be taken to construct more and better small-size hydro-power stations. According to the investigation of the water resource of En-ping county, the prospect installing capacity of small power stations will reach 68,600 kw, of which stations of 37,000 kw are now in operation and more than 30,000 kw are still o be developed. By 1985 power stations of 20,000 kw are planned to be built, then the total annual power output will sum up to 200 million kwh, which will provide more power source for the realization of the electrification of the rural districts.

Projects	Main Course or Branch	Catchment Areas (in km²)	Main Dam		Capacity (in 1000 m³)		Power Generation		
			Type of Dam	Maximum Height (in m.)	Total Capacity	Irrigation Capacity	Designed Water Head (in m.)	Designed Discharge (m³/sec.)	Total Installin. Capacity (generators/kw
J Jingjiang Reservoir Power Station	M.C.	362	Stone block Masonry gravity dam	64	47500	32600	42	45	3/19500
Xi-keng Reservoir Power Station	B.	76	Earth dam	42.9	5966	4191	24	7.2	3/1200
Sa-Hu Reservoir Power Station	B.	25	Earth dam	21.3	2936	2176			
Liang-Xi Reservoir Power Station	B.	34.6	Earth dam	29.8	2880	1915	9	1.8	1/125
Hong-Qi Reservoir Power Station	B.	72	Earth dam	33.8	908	777	153 12	2.45 2.6	2/235 12/3125
Qingnangjiao Reservoir Power Station	B.	19.4	Earth dam	19.5	1575	1240	9	4	2/260
Fengzhishan Reservoir Power Station	B.	25	Stone block Masonry gravity dam	54.2	2735	2007	52 15	3 35	3/1200 8/2980

SECTION 1

(m^3)	Power Generation			Annual Power Output (in Kwh)	Other Purposes		Amount of Works (in 10000 m^3)			Cost	Remarks
ation city	Designed Water Head (in m.)	Designed Discharge (m^3/sec.)	Total Installing Capacity (generators/kw)	(10000 kwh)	Irrigation (in 10000 mu)	Flood Protection (in 10000 mu)	Earth Work	Stone Work	Concrete Work	(in 10000 Yuan)	
2600	42	45	3/19500	6000	20	10	80	23	3.3	2200	
91	24	7.2	3/1200	550	8	2	90	2.5	0.2	565	
76					1.5		30	0.65	4.12	144	
15	9	1.8	1/125	35	3.3		79	2	0.11	185	
77	153 12	2.45 2.6	2/235 12/3125	70 1100	0.10		51	2.7	0.8	371	in 6 cascades
40	9	4	2/260	78	3.4		64	1.4	0.05	88	
07	52 15	3 35	3/1200 8/2980	360 900	3		2.7	8.1	2.3	588	in 3 cascades

SECTION 2



Projects Completed

Reservoirs		Levee	Pumping Stations for Drainage		Power Stations		Waterlocks
Number	Capacity (in 100 Million M^3)	Length (KM)	number	Installing capacity (in KW)	number	Installing capacity (in 10^4 KW)	number
134	7.5	153	77	7700	134	3.7	4

Benifits from Multi-purpose Development			
Irrigated Farm Land	Flood Control and Drainage	Annual power output	Annual water transport tonnage
(in 10^4 mu)	(in 10^4 mu)	(in 100 million kwh)	(in 10 thousand tons)
40	10	1.2	20

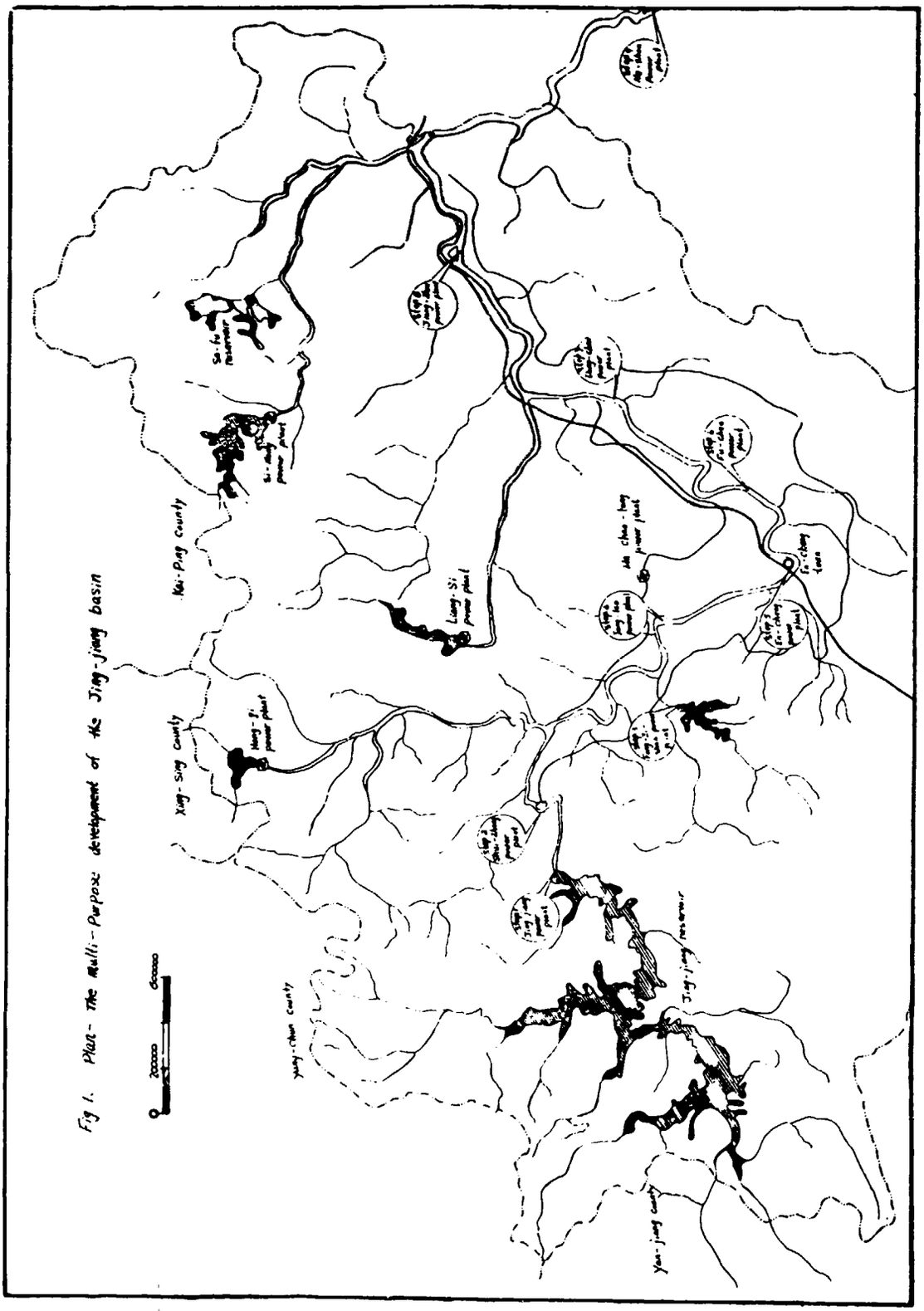
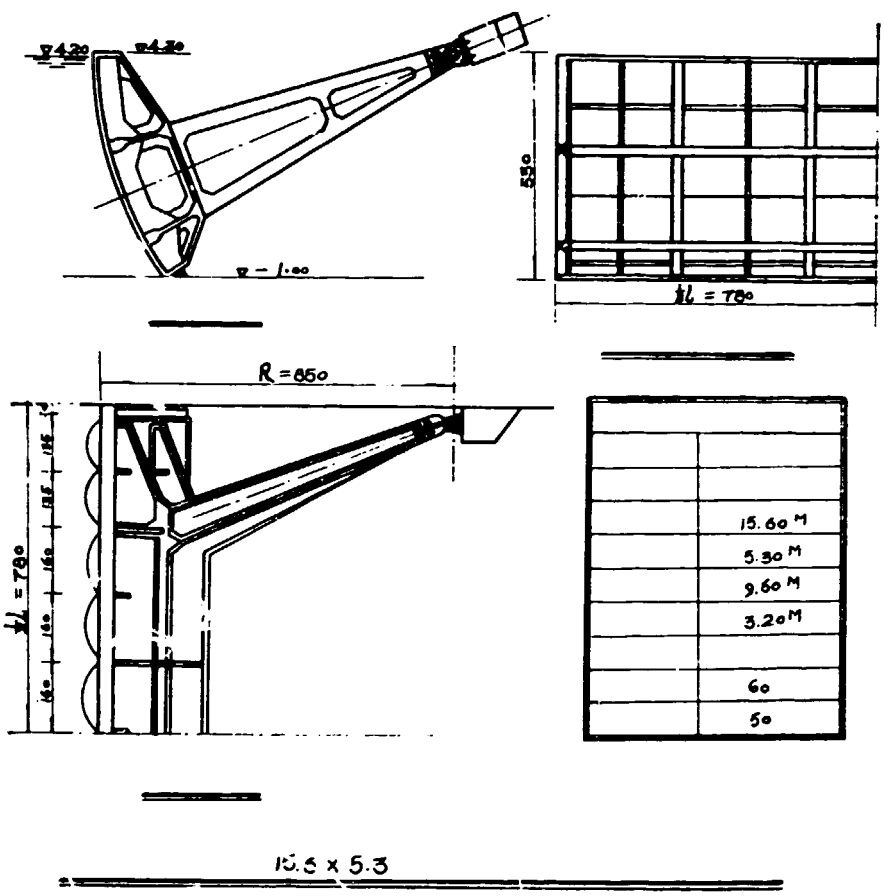


Fig 1. Plan - The Multi-Purpose development of the Jing-jiang basin
Xai-Ping county
Xing-Sing county
Yang-chun county
Yan-jiang county
Long-Si power plant
Hong-Fi power plant
Fu-chong town
Jing-jiang main canal

Fig. 1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+4.20
+1.00
550
11 = 780
R = 650
11 = 780
15.60 M
5.30 M
9.60 M
3.20 M
60
50
15.6 x 5.3

Fig. 2

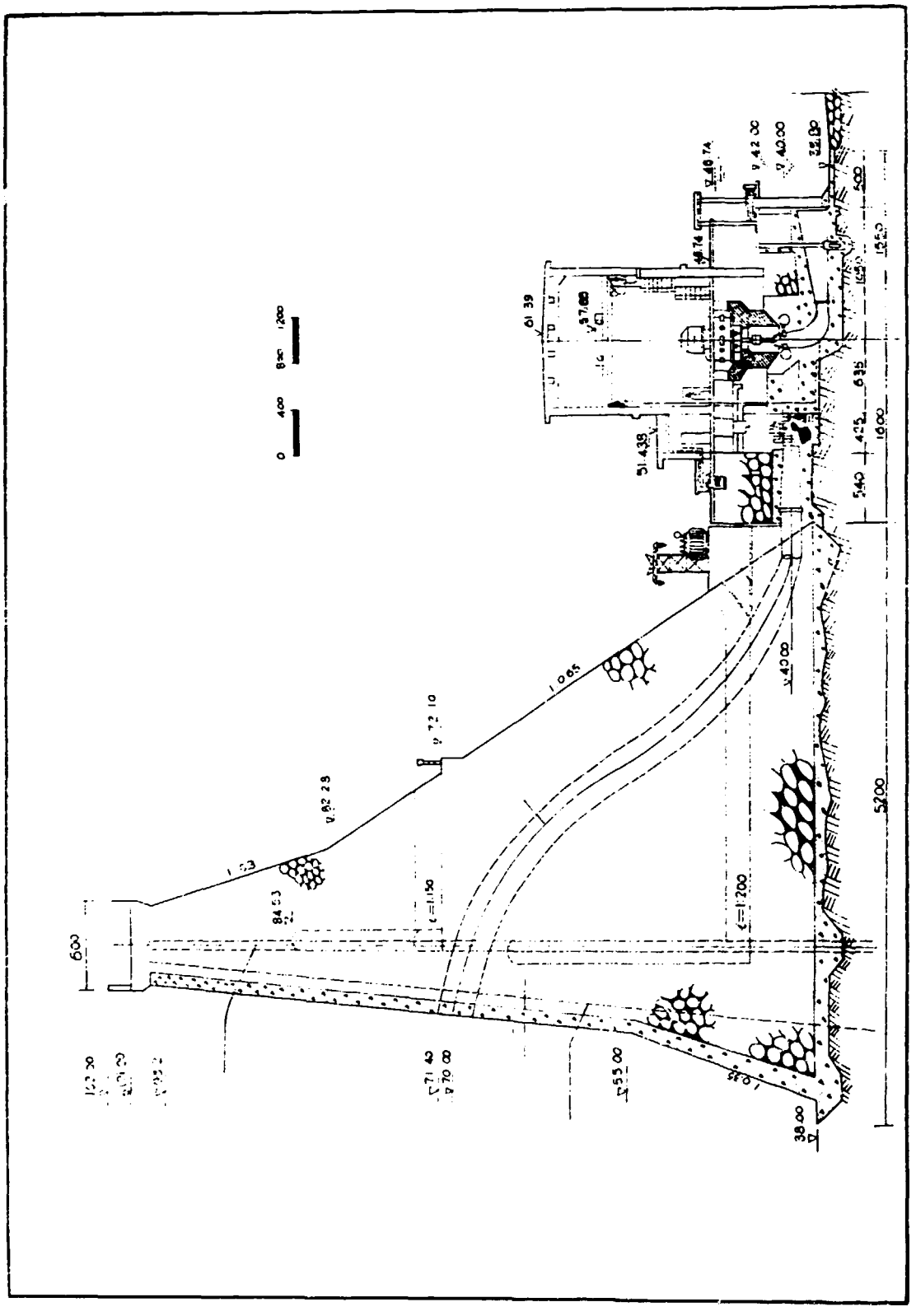
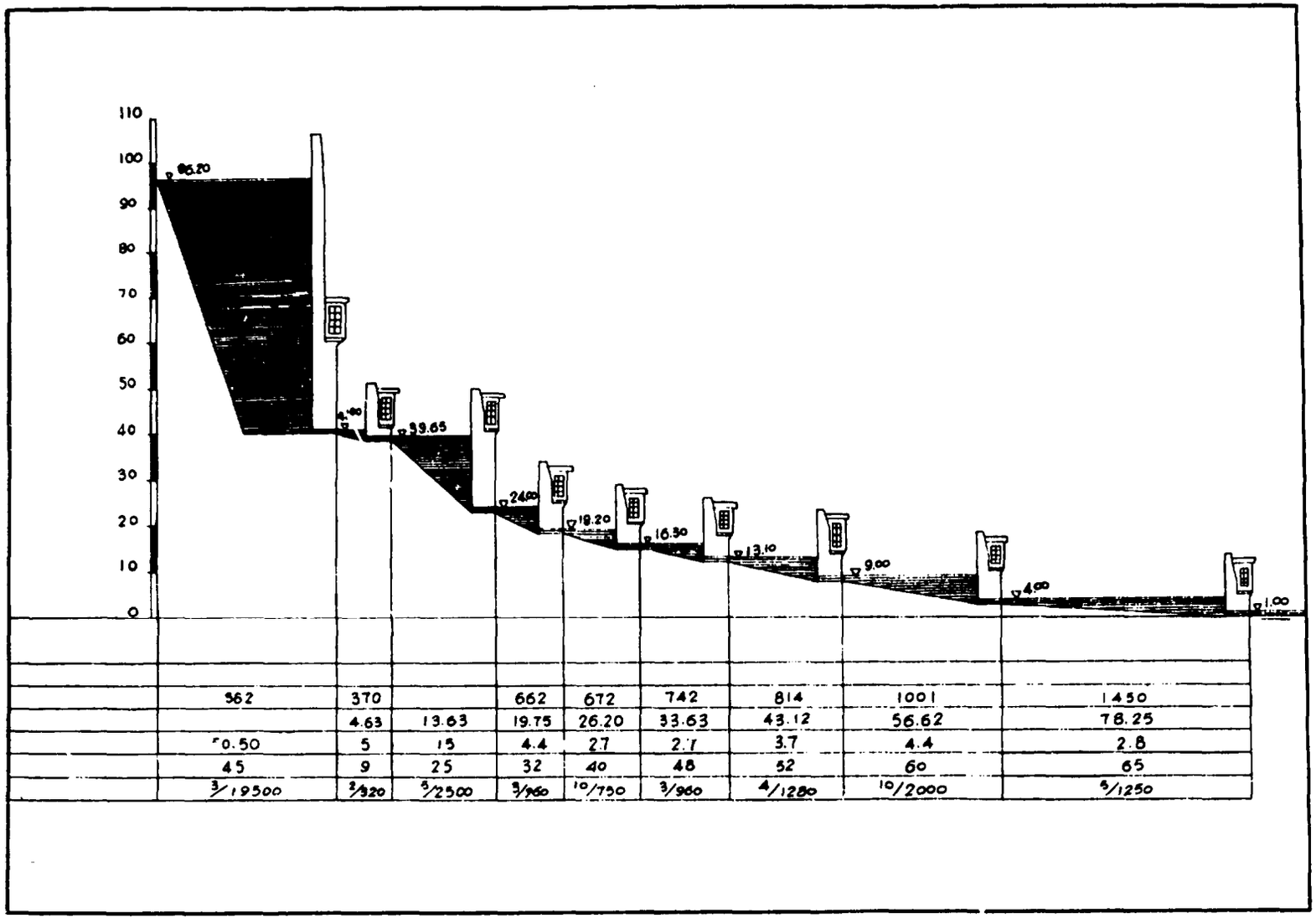


Fig. 3



362	370		662	672	742	814	1001	1450
	4.63	13.63	19.75	26.20	33.63	43.12	56.62	78.25
0.50	5	15	4.4	2.7	2.1	3.7	4.4	2.8
45	9	25	32	40	48	52	60	65
3/19500	3/320	5/2500	5/960	10/750	3/960	4/1280	10/2000	5/1250

Fig. 4