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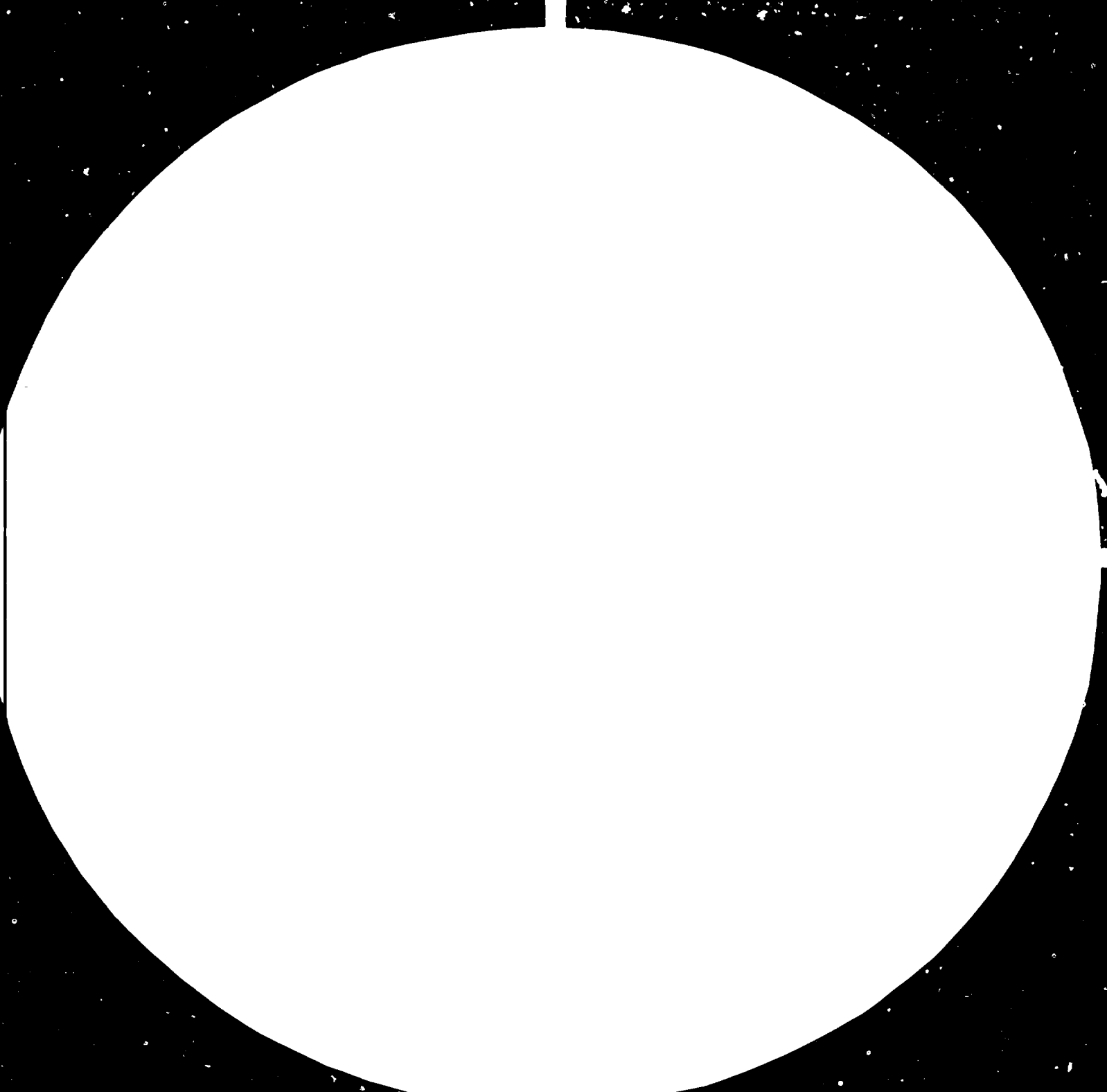
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This is a resolution test chart. It consists of a grid of patterns. Each pattern is a small square containing a 3x3 grid of horizontal lines. The patterns are arranged in a grid that is 5 rows high and 4 columns wide. The patterns in each row have a different size and orientation. The patterns in the first row are the largest and are oriented vertically. The patterns in the second row are smaller and oriented horizontally. The patterns in the third row are the same size as the second row but oriented vertically. The patterns in the fourth row are smaller and oriented horizontally. The patterns in the fifth row are the same size as the fourth row but oriented vertically. The patterns in the first column are the largest. The patterns in the second column are smaller. The patterns in the third column are the same size as the second column but oriented vertically. The patterns in the fourth column are smaller and oriented horizontally.

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**INTEGRATION OF SMALL HYDRO PLANTS OF YONGCHUN  
COUNTY INTO THE SMALL LOCAL GRID\***

by

**Department of Water  
Conservancy and Electricity\*\***

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\*\* Yongchun County, Fujian Province.

Yongchun County is situated in the southeast of Fujian and at the upstream of the Jingjiang River. It has a total drainage area of 1,447 km with 250,000 mu of farm land and a population of 410,000. The county is mountainous and there are streams everywhere. The average annual rainfall is 1,700 mm. The potential water power resources are very rich, estimated at about 80,000 kw. Since 1956, under the leadership of government, many small hydro plants have been built. By the end of 1979 the number reached 257, the installed capacity of which added up to 20356 kw. The already erected high-tension and low-tension transmission lines extended to a distance of 2,300 km. Electricity is used by all the communes, brigades and about 80% of the production teams. At present, three small electric networks have been formed. The first is network of the county proper where there are 24 hydro plants with a total installed capacity of 9,880 kw, among which 5 plants with a capacity of 2,214 kw were put into operation at the later half year of 1979. Within this network the high-tension transmission line is 264 km long, and the transformer capacity is 25,000-kva. Electricity is supplied to 11 communes, an overseas Chinese tea-and-fruit farm and 86 brigades. It is mainly to the fertilizer, ironcasting, machine manufacturing, food and other light industries for production uses. The second is network of the Tianhu Mountain Mine district where the installed capacity of the plants is 2,910 kw. It is mainly supplied to the provincial run coal mines, the county-run blast furnace, cement and other plants. The third is network of Yidu district where the installed capacity is 546 kw. It is supplied to the county-run paper mills and gum rosin plants, as well as to the communes and brigades for agricultural uses.

The system of the small hydro plants of Yongchun County is characterized by its being scattered, numerous in number and of small capacity. The reliability of power supply by individual hydro plants to meet the demand of agriculture and industry is far from being sufficient. With the vigorous development of the small hydro plants, and the incessant increase in load demand, the electric networks have also been developed correspondingly. In 1974, the network of the county proper got in parallel operation with the provincial grid. This further promoted the growth of the production of agriculture and industry very effectively. The beneficial results were obviously remarkable. They are as follows:

1. To increase the electric power output for power supply and also to raise the utilization ratio of the equipment. In Yongchun, factories and enterprises are mainly centered around the county proper. The power consumption was rather large, but the demand could not be fulfilled. Before parallel connection the surplus power of most of the hydro plants of the communes and brigades could not be fully utilized, but after parallel connection, thanks to the good coordination, the

supply and demand would be adjusted and the contradictions between surplus and deficiency would be solved. For example, the two small hydro plants in Bungwu commune with an installed capacity of 325 kw, the annual power output was increased from 627,000 kwh before parallel connection to 1,760 000 kwh by 1979. The annual utilization hour increased from 1929 to 5438.

2. Rational utilization of power resources and the raise of the standard of management of small hydro plants. Most of the hydro plants in Yongchun County are of the runoff type. After parallel connection more hydro power can be generated and supplied to the network in highwater seasons, while the small self-owned 2,250 kw thermal power station of the Chemical Fertilizer Plant stops its generating. On the contrary, in dry seasons while the output of the small hydro plants is insufficient, the thermal plant comes into operation. Only in this way could the water power resources and the fuel be rationally utilized, and at the same time the cost of electricity generated could be considerably reduced. The quality of the power supply is improved and its reliability is assured.

3. Promotion of the growth of the production in agriculture and industry. After integration of small hydro plants due to the raise of the reliability of the power supply for production and daily life, a growth of production followed. The crop output of 158 million catties in 1976, increased to 206 million catties in 1979. The main products in industry were increased to 44,550 tons of ammonium bicarbonate, 3,664 tons of phosphate fertilizer 13,600 tons of cement, 35,000 kw of hydraulic turbo generator sets and 8,000 kw of electric motors.

4. Increase of the income of the hydro plants. After integration, every hydro plant might be operated to its full capacity and give power supply to a greater extent. The income of the plant increased. The collective economy would be developed and strengthened. The commune members got more income too, thus heightened the enthusiasm for the building of hydro power plants. The Zhaolin brigade of Wufeng Commune built a small hydro plant with an installed capacity of 275 kw in 1978 and connected it to the network. The electricity output in 1979 was 880,000 kwh, among which 800,000 kwh was sold to the network with an income of 36,700 yuan. The distribution to the commune members grew up. There was a bumper harvest of crops, too. The masses were so glad, and said that "the buzzing of the electric machine is worth ten thousand ounces of gold."

In making good use of the integration of the small hydro plants, an overall plan of electric networks is at once required. The geographical shape of Yongchun county is narrow and long. The length between the east and the west is 105 kilometers and the width between the north and the south is 55 kilometers. The water power resources are chiefly scattered in the Taochi brook in the midpart of the county and in the Kungzhikou brook and Yidu brook in the west. At present, most of the water power resources of the Taochi brook have been developed while those of the Kungzhikou brook and the Yidu brook are mostly unexploited. Now the center of the power consumer is at the county proper where it is also the center of development in the future. Therefore, the overall planning of the small electric networks within the county is to develop the water power resources in the west and then transmit the energy to the county proper.

In consideration of Yongchun's 5-year development hereafter, for the main network of the small hydro plants, the 35 kv transmission voltage and 10 kv distribution voltage are chosen. On the basis of the county's planning of the electric net-

works, three individual networks have now been formed, namely, in the county proper, in Kungzhikou and in Yidu. Hereafter, the 35 kv power transmission lines are to be erected at different stage to perfect the paralled connection of the networks of Kungzhikou and Yidu with that of the county proper, forming a county-wide network system.

An overall arrangement of small electric network in Yongchun county is shown in Fig. 1.

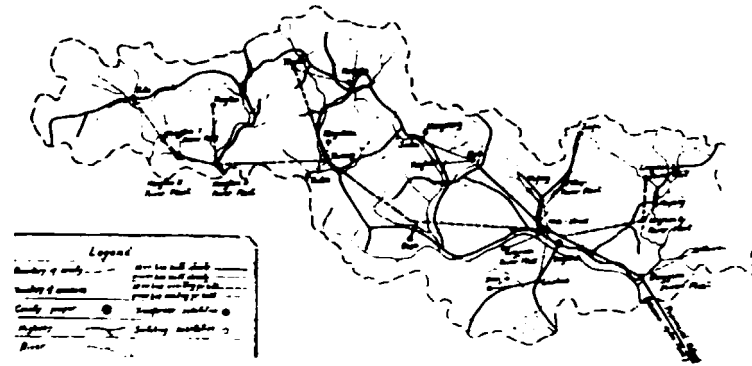


Fig. 1

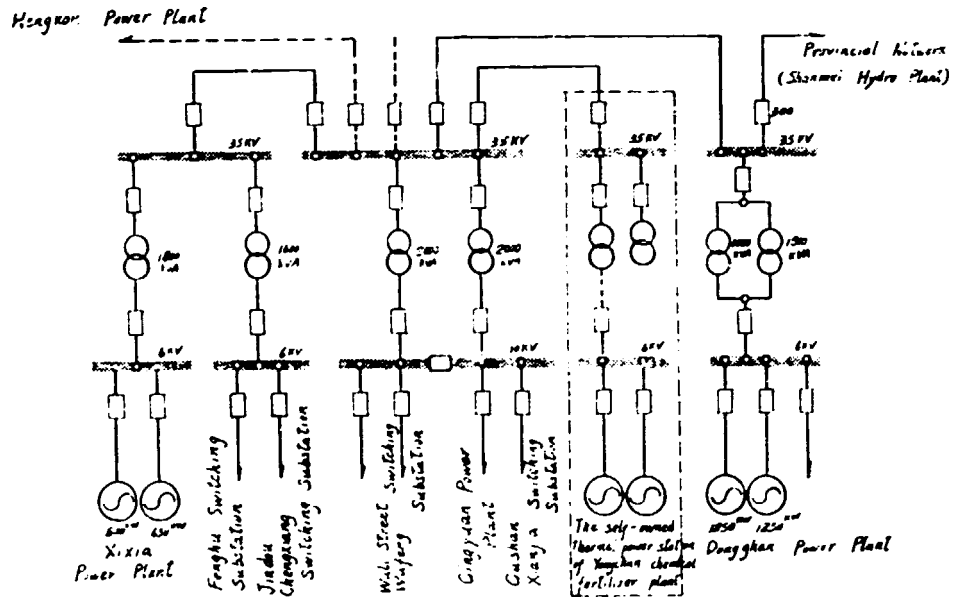


Fig. 2

Fig. 2 shows the electrical network in Yongchun county proper. Within the dash line block is the thermal power plant of the Chemical Fertilizer Plant of Yongchun, with two condensing type steam turbine-generator sets of the capacity 1,500 kw and 750 kw respectively. The main purpose is to make use of the



steam from the boilers to produce fertilizer. Ordinarily these two generators are not in operation. Electricity is supplied by the small networks in Yongchun. Only when electric energy was not sufficient or when dry season comes, the plant generates its own electricity for plant's use. Therefore, that thermal plant is not considered as a regular constituent part of the county network.

The county network is composed mainly of 3 parts, namely, the secondary substations (including 10 kv lines to connect the small hydro plants), the 35 kv substations and the 35 kv lines.

In a commune or among several communes where small hydro plants are numerous, a secondary substation is located to collect the electricity from these small hydro plants and transfer the energy to the county network. The outgoing lines of several secondary substations at some distances are to be collected at a 35 kv substation for stepping up to 35 kv and then transmit to the county's network. Fig. 3 shows the electrical single-line connection in Xianjia secondary substation. Only drop-off fuses and knife switches are installed for the 10 kv incoming lines, while the pole-mount oil circuit breaker installed for the outgoing line of the substation. Should there be a trouble, the feeder oil circuit breaker at the 35 kv substation will make the disconnection. This kind of simple arrangement has been operated very well in the past two years and is applicable when the line is short in distance and the environment condition is comparatively good. Of course, it will be better if the drop off fuses and the pole-mount breaker can be replaced by regular oil circuit breakers.

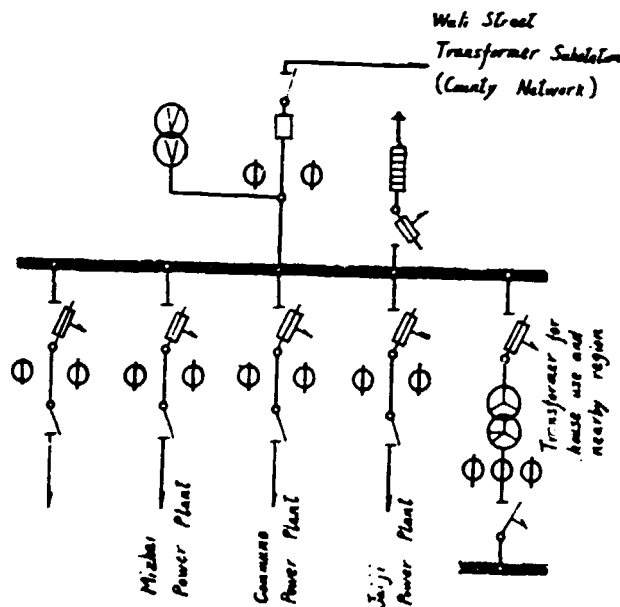


Fig. 3

There are three types of 35 kv substations in Yongchun. The first type is for the stepping up substations of the key hydro plants. The second type is for the centralized stepping up substations at which the power from the secondary substations are gathered for stepping up. These secondary substations should, as far

as possible, be affiliated to the key power plants to facilitate management and dispatching. The third type is the step-down substations at the load center. For example, the 35 kv substation of Wuli Street in the country proper concurrently plays the role as a connecting link of the small networks.

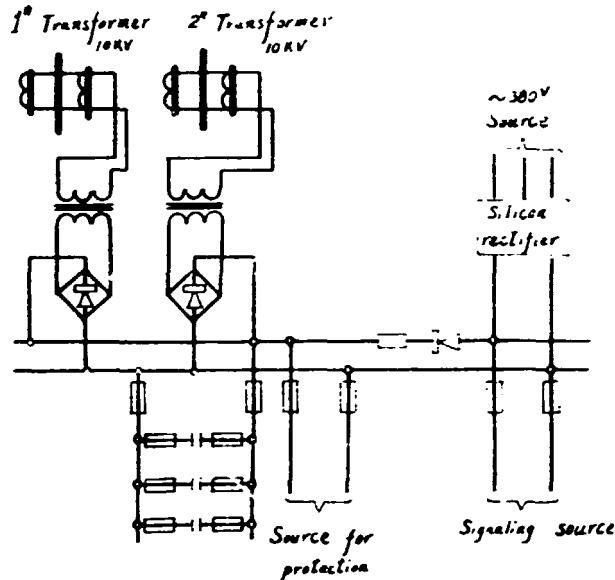


Fig. 4

The whole network of Yongchun County goes out from Dongguan water power station through a 35 kv line to integrate into Shanmei hydro power station in the provincial grid. The No. 300 circuit breaker of Dongguan acts as the synchronizing and disintegration point of the parallel connection from Yongchun to the provincial grid; in case an accident happens outside the county's system, the breaker automatically interrupts. Thereby, Yongchun is disintegrated from the provincial network and the county's important loads can be maintained. It is planned to install along this line with (automatic) recloser with no-voltage discrimination (on the side of Sanmei) — and catching for synchronism (on the side of Dongguan).

**Protective relaying:** Generally, protective relaying is made according to the state-set regulations. Both sensitivity and selectivity should fulfill the safe operation of the network.

**In the case of small hydro plants:**

For the main generator sets over 1,000 kw, the longitudinal differential protection and over-current protection initiated by low-voltage or combined voltage are installed as the main protections. Only over-current protection is installed for low tension sets below 500 kw.

**Main transformer:** buchloch relays, quick-tripping current relays and over-current protections are equipped. When the sensitivity of quick-tripping current relay is inadequate, differential protection will take its place.

**35 kv line:** Generally, quick-tripping current and voltage protections and over-current protection are installed. According to actual requirement directional elements are added to the line with power sources from both sides.

6-10 kv line. For the outgoing line of a main substation with single side th or without quick-tripping is generally power source over-current protection wi equipped. For the line with power sources from both sides, the directional or non-directional qick-tripping current protection and over-current protection are installed according to the existing circumstances. Generally, only high tension drop-off fuses are installed for lines from the substations in the villages.

Most of the small hydro plants in Yongchun County are in the run-off. As a consequence due to the varied volumes of water in different water seasons, there is a great variety in the way of operation. Experiences have been proved that under these circumstances the employment of currentcontrolled voltage-quick-tripping protection gives higher sensitivity and broader range of operation. It is decidedly superior to the voltage-controlled current-quick-tripping protection.

In our county the outgoing lines from the switchboard of the low-tension turbine generators below 500 kw are installed with air circuit breakers. Both the shunt tripping type and non-voltage tripping type are used. For shunt tripping, the trip coil only works when the voltage is above 65% of the nominal voltage. Should there be a short circuit nearby, the bus voltage will drop below this value and fail to trip. Therefore, for generators integrated in the grid, air circuit breaker with no-voltage tripping coil should as far as possible be used.

In Yongchun, alternating current operation is not used at present. In choice for the direct current source the 110v or 220v storage battery is expensive and troublesome in maintainance and is by no means suitable for the small networks. For the key hydro power stations the 48v storage batteries are used as the source for protection, signalling and for emergency lighting. Silicon rectifiers are used as operating source of circuit closing. In substations and small hydro plant, silicon rectifiers and circuit breaker tripped by energy stored in capacitors are used. Fig. 4 shows a sketch of the direct current system of Wuli-Street substation in this county. In order to improve the reliability of the source of protection a set of energystorage capacitors has been removed from the customary design, while a combined tripping device utilizing the rectified short-circuit current has been added. It proves to be satisfactory in operation.

On the problem of communication in the networks the carrier telephone on power lines are used. As for the micro power station, only ordinary telephony is available now, and will be changed into carrier telephone on 10 kv power lines later.

For energy metering in the county's power network two sets of active and reactive kilowatt-hour meters with check-up elements are installed on the separating point of the lines belong to differententerprises to record the quantity of input and output of electricity respectively.

In order to bring the role of the small electric network into full play, the proper management of its operation is of paramount importance. The hydro power has its seasonal significance, and the electric energy varies greatly, especially in the case of run-off type plants. During high-water season there is a surplus of electricity, while there is a deficiency of electricity during the dry season. With a view to generating more electricity, giving more supply, balancing surplus and deficiency and meeting the load demands, it is necessary to map out an overall arrangement to unify the distribution of the items, namely, generating, supply and use. A dispatcher office was set up under the county's department of water

conservancy and electricity with the responsibility of balancing the work of generating, supply and use. In respect of generating, the run-off power stations are to be considered first and then the reservoir regulating power stations; the hydro power first and then the self-owned small thermal power station. In respect of the use of electricity, the surplus power during the high water season is dispatched to the provincial network, and the deficiency of electricity during the dry season is made up by the provincial network so that the load demands of agriculture and the key industries may always be satisfied.

Following the rapid development of agricultural and industrial production the consumers called for the supply of a better and still better quality of electricity and also the higher rate of its reliability, it has been a tendency that the standard of the management and the operation of the county's small networks must be improved. Several measures have been adopted, such as putting up a short term technical training course, making visits, exchanging experiences and taking part in the field work as well. A number of personnel who did the work to handle electricity have been trained. They were taught not only to operate and put to use, but also to grasp the technique of installing and overhauling. Now the small-scale overhaul can be solved in the plant itself while the big scale overhaul can be solved in the county itself. This is adoptable to the operation and management of the small grid. The principle that "who invest and build, who own and manage as well as be benefited" must be held. The administrative offices of three levels have been established, i.e. in county, commune and brigade level. A set of rules and regulations has been brought out based on the system of personal responsibility. The rate of good condition of the equipments increased to over 90%. Line loss dropped from 25 to 11 per cent. The safety, reliability and economical operations are fulfilled.

The small networks have provided the agricultural and industrial productions with cheap power. They have promoted the development of the small hydro power, and will speed up the construction of our county along the line of four modernization. It is found that building of the small networks is the proper way for utilizing electricity in the mountainous regions.



