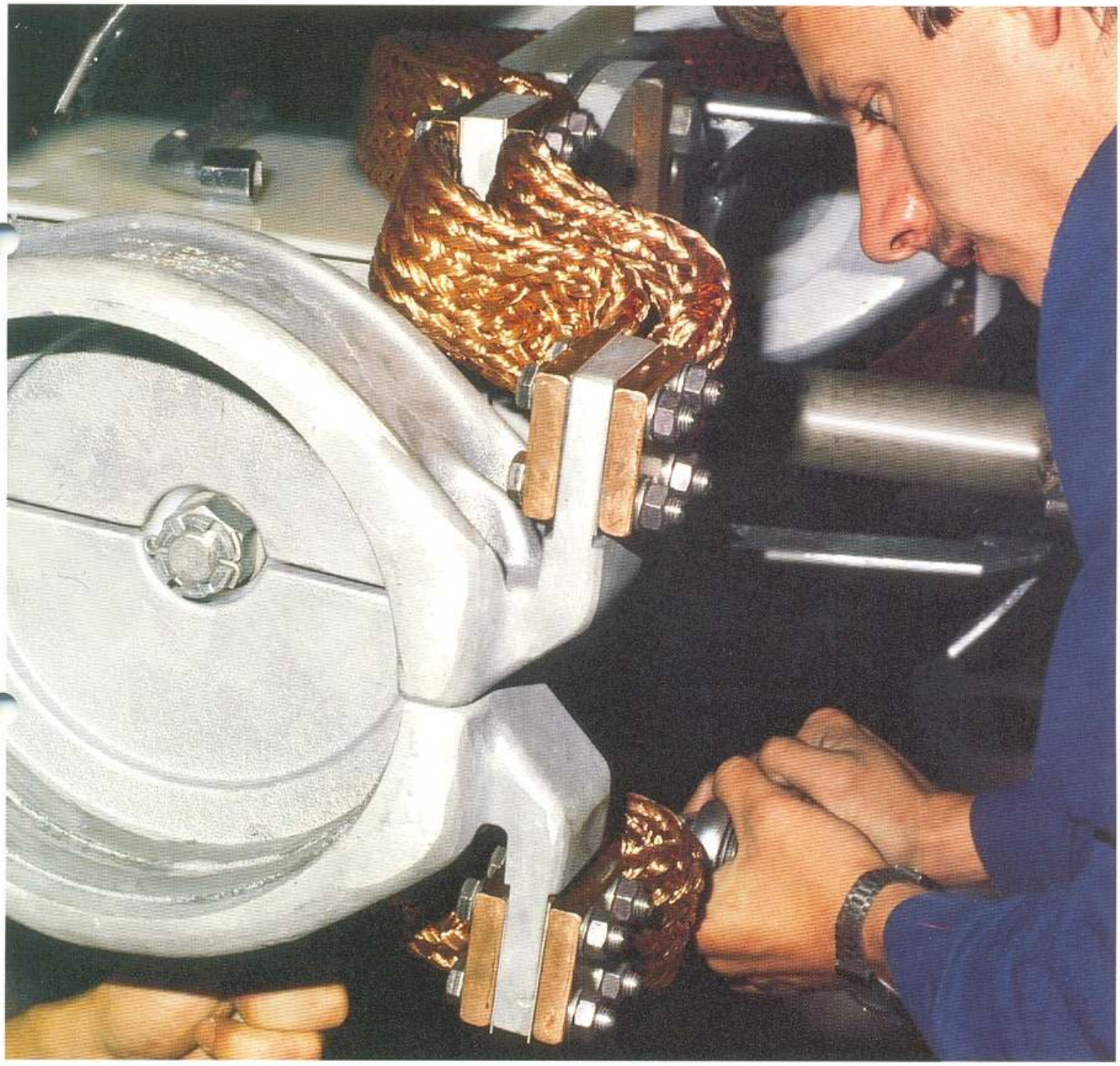
Substation connectors

500 kV-HVDC Project Gezhouba - Shanghai: „GESHA-Project"



Overhead Line Project GEZHOUBA - SHANGHAI:
Development and production of LORÜNSER special connectors for the substations of the Chinese 500 kV HVDC transmission projekt "GESHA"

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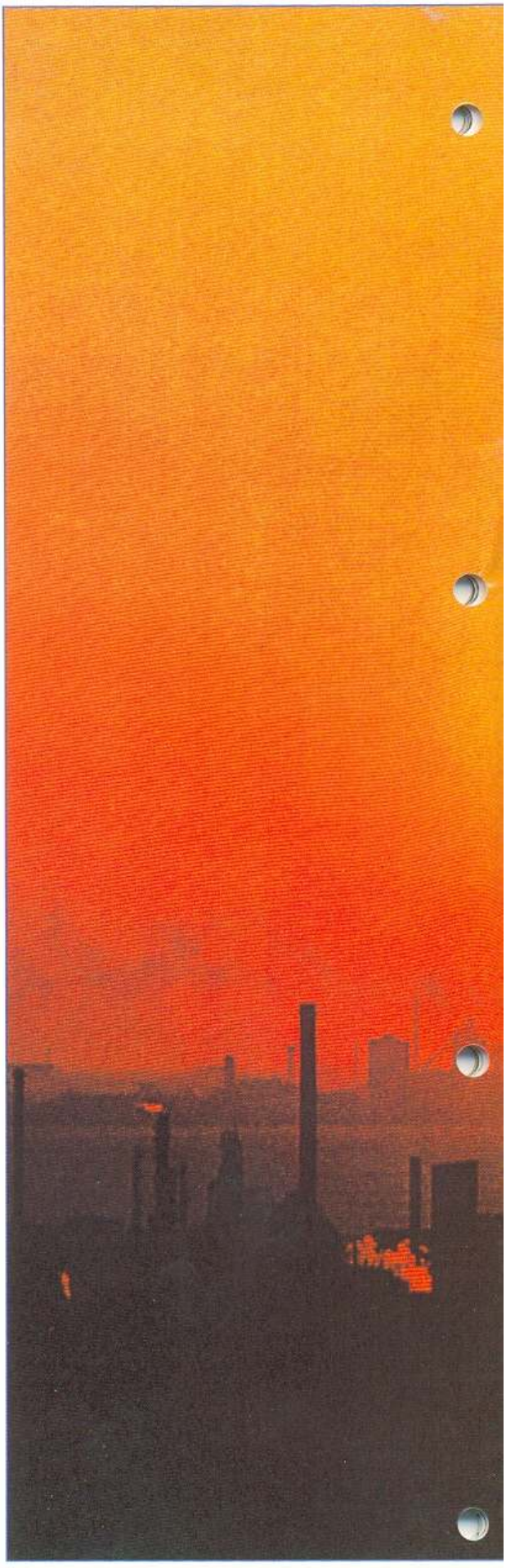

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Leichtmetallwerk GmbH
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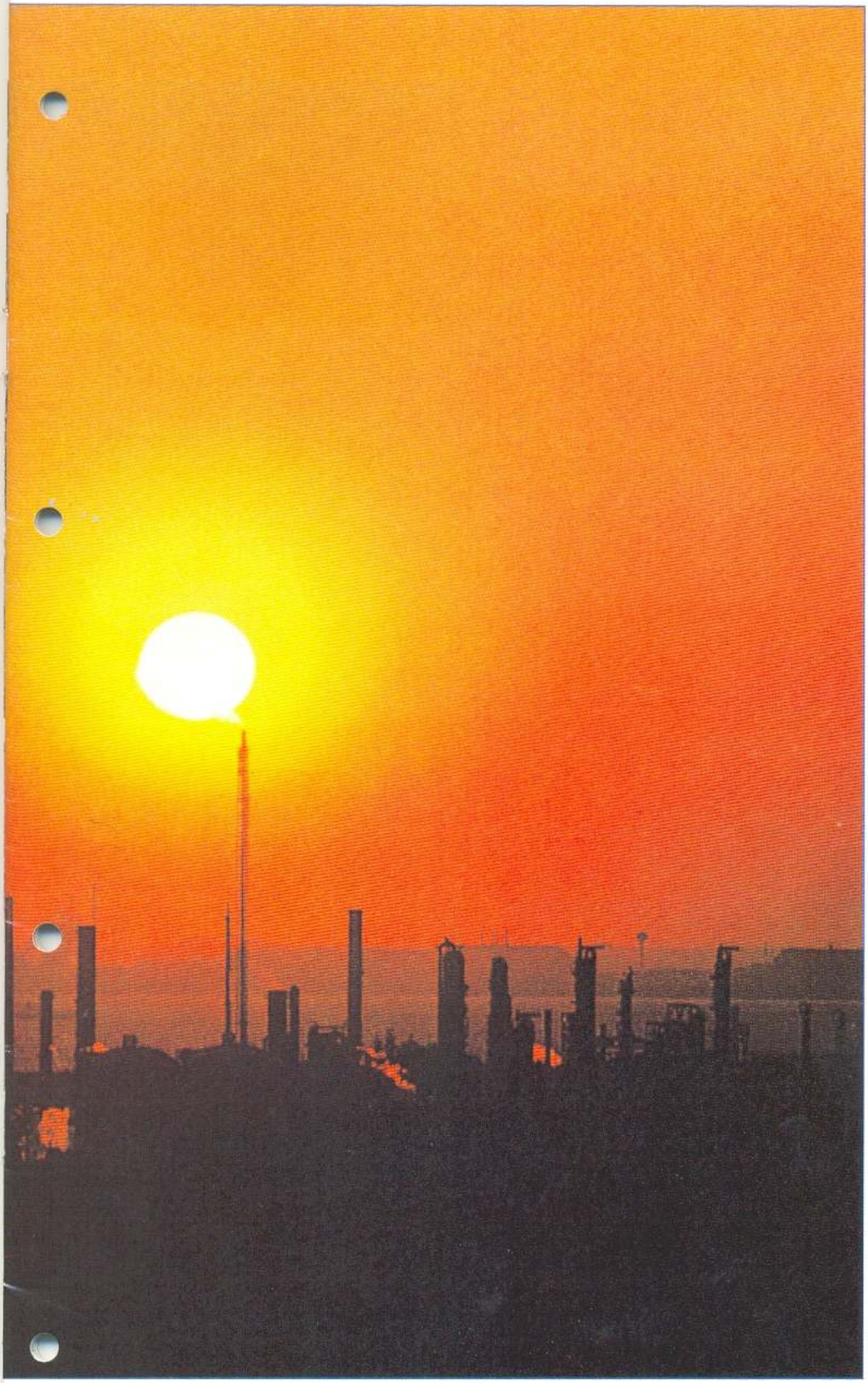
500 kV HVDC Transmission Project "GESHA" from Gezhouba to Shanghai



Those who have had the chance to get to know the vastness of China will understand the dimensions of a project which aims at supplying the whole country with energy in an era of steady economic growth.

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The country

The People's Republic of China has a total area of approx. 9.5 million km² but, due to its extremely varying geographical and climatic conditions, its energy supply is mainly covered by small, regional distribution networks differing considerably in density and capacity.

The construction of small-size power stations meant progress in energy production and distribution for a country where three fourth of the population do still work in agriculture. Nevertheless, a permanent, sufficient energy supply system, an indispensable prerequisite for economic and industrial growth, is not available in many regions of this vast, from the European point of view rather strange "country of the East".

Therefore, the improvement and expansion of the energy distribution system is one of China's major tasks. The difficulty of this task can only be understood by someone who knows this vast land and its enormous, almost inaccessible mountain ranges, a land which covers the major part of East Asia and large parts of the elevated planes of Central Asia.

The purpose

Chinese economic policy focuses on the target-oriented promotion of light industry, the centres of which are concentrated alongside the coastline, comprising cotton and silk factories, grain and oil mills, sugar refineries and tobacco factories. The second pillar of Chinese economy is heavy industry, which is, at the present moment, exclusively situated in the province of Liaoning and around the port of Shanghai, where, apart from iron and steel works and a large number of tool and machine production sites, also chemical enterprises have been established.

Shanghai, the "capital" of Eastern China with its millions of inhabitants and its consequently very high energy demand, has utmost priority in the expansion of the Chinese energy supply system. In order to safeguard the future energy supply of this city with an area of 5,800 m², an extraordinary power plant project, brandnew for Chinese standards, was drafted, a project which was to differ considerably from traditional power plant systems with regard to future-oriented planning of energy generation. For the first time, it was not the enormous hard coal reserves of the country but the equally enormous water power that were to be exploited for a power plant of that size.

Every morning, the eleven million inhabitants of China's largest city switch on the light and the heating, turn on machines and conveyor belts and open the large factory gates. The port Shanghai is the centre of trade, industry, culture and higher education as well as China's largest labour market. Shanghai never stands still. And it is electricity which makes this possible.

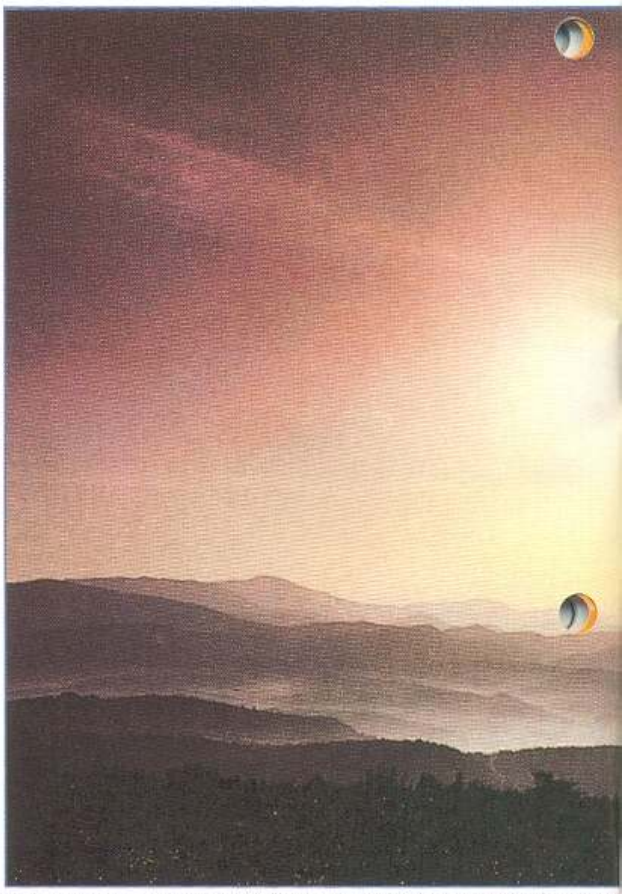


Fig. 2: Vast, untouched and almost inaccessible mountain ranges m
frontier for everyone involved.

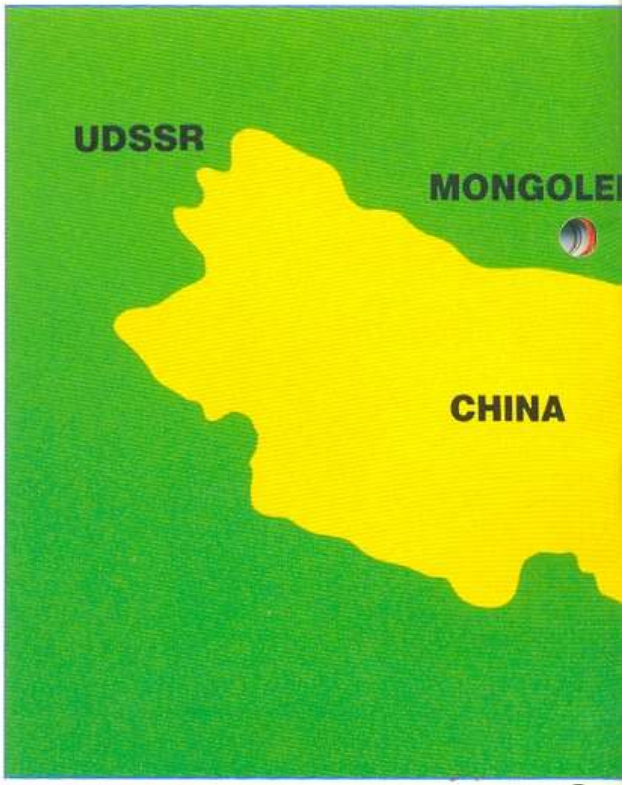
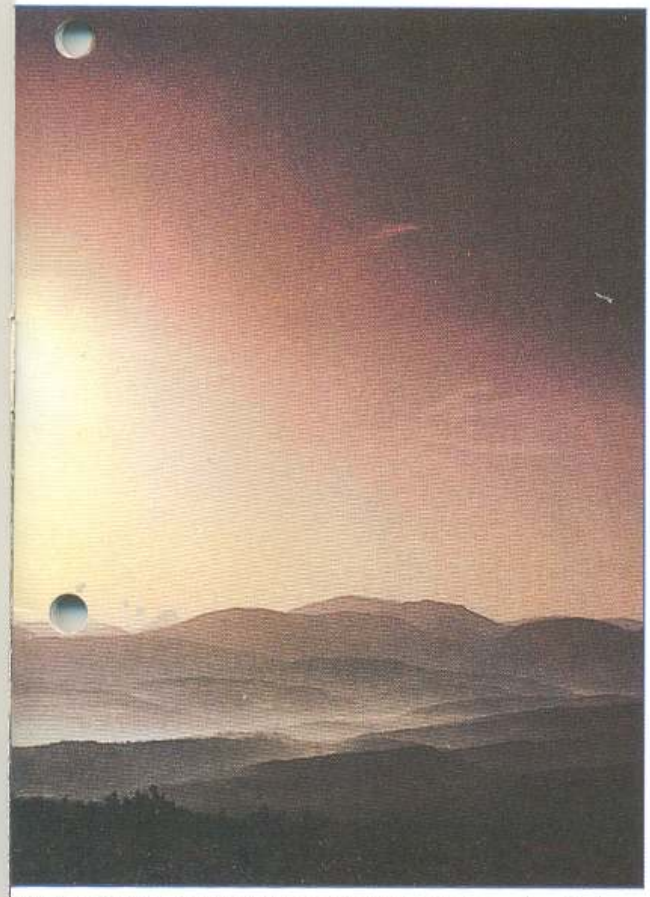
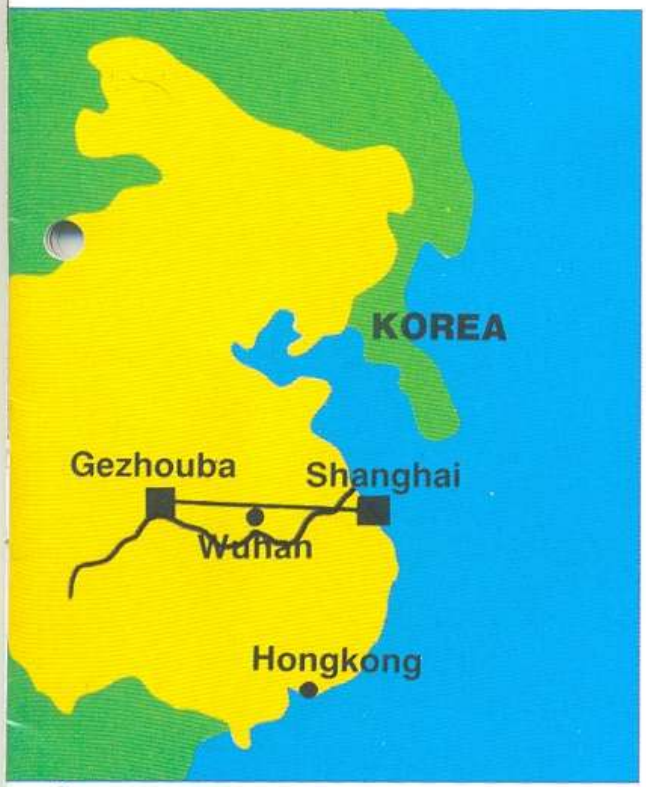


Fig. 3: Although the population density of China is only 89 in
North America together. Economic and industrial activity is co



ke the amplification of the Chinese energy distribution network a true



/km² population still exceeds that of Europe, the Soviet Union and ed in the East of the country.

The power plant

When selecting the best suited site for such an hydroelectric power plant, the Chinese engineers had to take into account not only the geological and morphological conditions but also the traffic infrastructure. Inland waterways are of major importance for the Chinese transport and traffic system. Thus, the dam project must, in no way, impede shipping. The practical implications of such a project become evident in the example of the Yang Tse Kiang, the river on the shore of which the new hydroelectric power plant is to be erected. The Yang Tse Kiang is one of the largest rivers of the world and can be navegated more than 800 km inland with deep-sea vessels.

Therefore, the region past Wuhan, the last big port on the Yang Tse Kiang, was the only possible site for the future power plant.

The dam project was realized on one of the three branches which result from the two islands Gezhouba and Xiba dividing China's largest river. The plant has gigantic proportions: the dam is 2,561 m long, 70 m high, and has three sluices with a loading capacity of 23,000 tons.

After its completion, this enormous dam project will feed 110,000 m^3 of water per second onto the power wheels of the 21 generators of the power plant. This incredible torrent of water makes the generators produce a power output of 2,715 million kilowatt, which results in an annual energy production of 14.1 trillion kilowatt hours.

The Chinese need energy. Here it is.

Fig. 4: As all other rivers, the Yang Tse Kiang is an important component of the transport and traffic system. (The Chinese road network is 700,000 km long, as compared to 180,000 km of navigable inland waterways.)

Where the roaring Yang Tse Kiang passes the Nanying gorge and the 30 meter small and thundering torrent becomes a two kilometer broad and quiet stream, the Chinese engineers have managed to control the enormous power of this 5,800 kilometer long river and to use it for their purpose.

14.1 trillion kWh — Those who do not know what to make of this figure should ask their electricity board how much a daily energy consumption of 400 billion kilowatt hours would cost.

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"The dam seems to lie on the river like a big dragon" — This metapher used by a Chinese technical journal demonstrates very impressively that, even in the most progress-oriented century of mankind, the Chinese do still have a sense of perennial tradition.

Those who always work rapidly and precisely may expect the same from their partners: The extremely short time of construction meant a great challenge for all who wanted to participate in the GESHA project.

The order

As the Gezhouba dam is situated more than 800 km inland, another important aspect had to be taken into consideration during the planning and realisation of the entire project; i.e. the fact that the energy produced at Gezhouba had to be transmitted to Shanghai over a line length of over 1,000 km which is, due to the special geographic and climatic conditions prevailing, a challenge for every specialist in overhead line construction.

Finally, the substation section of the "Gezhouba to Shanghai HVDC Transmission Project" was put up for tender by the China National Technical Import Corporation under the heading "GESHA". From the very beginning, every tender knew perfectly well that this project was extremely challenging as far as technology was concerned and that all participating in it will have to meet requirements of precision, swiftness in adapting to changing conditions and flexibility in order to meet the tight schedule.

At the end of 1984, the ASEA Brown Boveri (ABB) Baden/Siemens-Erlangen consortium was entrusted with the overall planning, delivery and construction supervision of the project. These two internationally renowned firms guarantee that the project is executed on time and with supreme technical reliability.

The major stages in the schedule demonstrate the "busy timetable" for all firms involved:

1984:	Signing of the contract Basic technical planning
1985/86:	Detail planning Tests carried out by Lorünser
1986:	Commencement of construction in China Beginning of production at ABB Siemens

When visualizing the technical requirements, problems and special conditions as well as the consequent amount of R&D work (especially in the field of connector design), one becomes aware of what this tight schedule actually meant.

This brochure aims at giving you an overview on all these challenges. Special attention will be paid to the connectors for the individual substations, which had to be built to facilitate the transmission over a line length of over 1,000 km. At the same time, this publication provides an insight into the technical know-how of LORÜNSER LEICHTMETALLWERK GmbH the expert designing and producing the connectors for the substations.

Fig. 5: The Gezhouba dam.

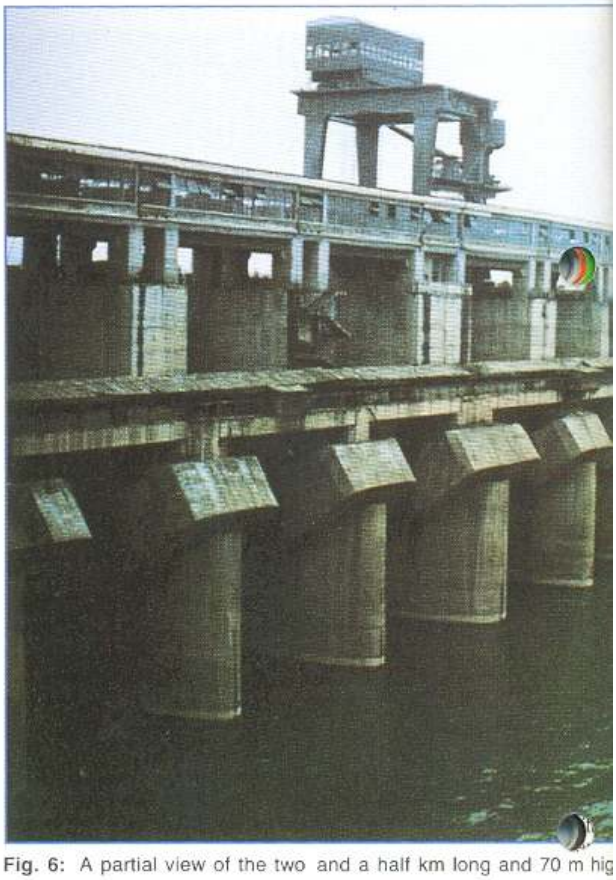
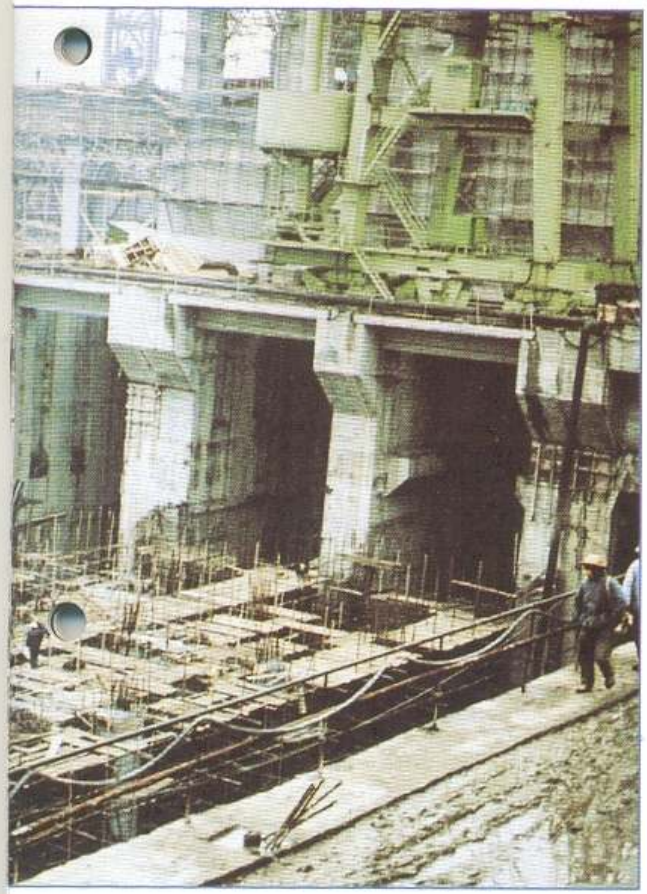
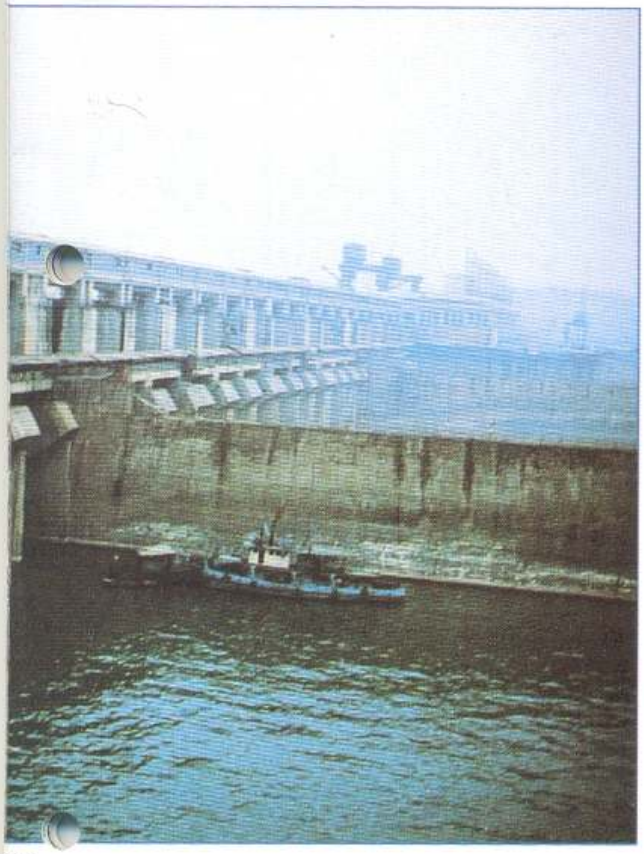


Fig. 6: A partial view of the two and a half km long and 70 m hig





dam.

The requirements

The principles and requirements which form the basis for the whole HVDC transmission project can be summarised as follows:

- Economical energy transmission over a distance of more than 1,000 km, i.e. minimising any kind of energy losses by means of corresponding technical measures.
- The coupling of the two separate AC energy distribution networks.
- Energy transmission in both directions in order to feed the region of Gezhouba from the storage power stations of Shanghai in case of low water at the dam.
- Two 230 kV connections for regional networks at the substation Nan Qiao.

The "standard requirements" were the following:

- Operational switching of the lines.
- The possibility to detect and disconnect short-circuits.
- Measuring equipments facilitating permanent accounting of the energy transmitted.

Fig. 7: If you want to get somewhere in Shanghai, you either take the bike or a ship on the Huang Pu towards the Yang Tse Kiang. A population density of 2,000 inhabitants per km² allows for no other alternative.

Whatever the people of the "Middle Kingdom" decide to do is of high international standard. "The rest of the world" has little to offer which could possibly challenge the GESHA project in size or in quality.

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Problems and experience

Due to the climatic and/or geographic conditions prevailing, many technical solutions which for decades have proved successful in the European energy transmission system can not — or only partly — be implemented in China. This fact had to be taken into consideration when designing, planning and producing the connectors for the GESHA project.

In view of the transmission length and the consequent stability problems as well as the required possibility of synchronisation and control, high voltage DC transmission (HVDC)[1] seemed to be the perfect solution for being an asynchronous transmission system. This means that the AC produced by the generators must be transformed to DC before being switched onto the overhead line and, at the other end of the line, DC has to be retransformed to AC before entering the distribution network.

If energy is to be transmitted over a distance of more than 1,000 kilometers, certain conditions must be created in order not to lose any precious energy on the way.

The GESHA scheme does not differ significantly from the classical HVDC transmission system. It is a two-point connection system with rectifiers at both endpoints which serve as AC-DC or DC-AC converters conditional on the direction of the energy transmission. The two substations are normally connected by means of a double-pole overhead line, in case of a failure in one pole by means of a one-pole line with earth return.

Compared with traditional rotary current transmission, the HVDC transmission systems holds the following advantages:

- Low costs for conductor strings and cables
- Easy and fast control
- No increase of the short-circuiting power
- Asynchronous connection of two networks
- No reactive power of the line

1) HVDC transmission has been practiced in Europe for the past 25 years. Today it is not only applied in long-distance transmission but also for short-coupling of rotary current networks of different frequencies as well as for land and ocean cable transmission.

In Austria, the asynchronous connection of two energy systems has been used in the short-coupling plant of Dürnrohr, Lower Austria, connecting the COMECON network and the West European one.

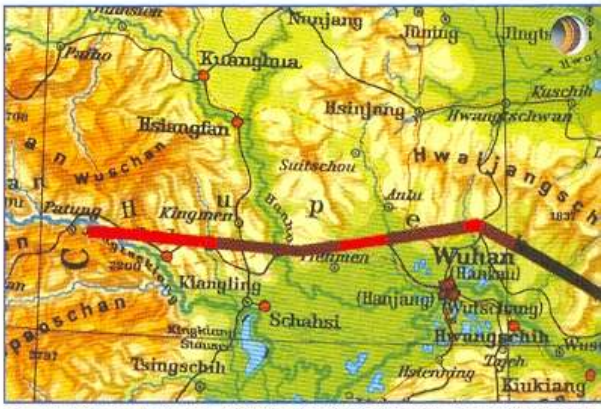

Fig. 8: Diagram of the 500 kV line from Gezhouba to Shanghai:
Planned routing
Sections with possible frost and hoarfrost
Sections with possible icing of the conductors

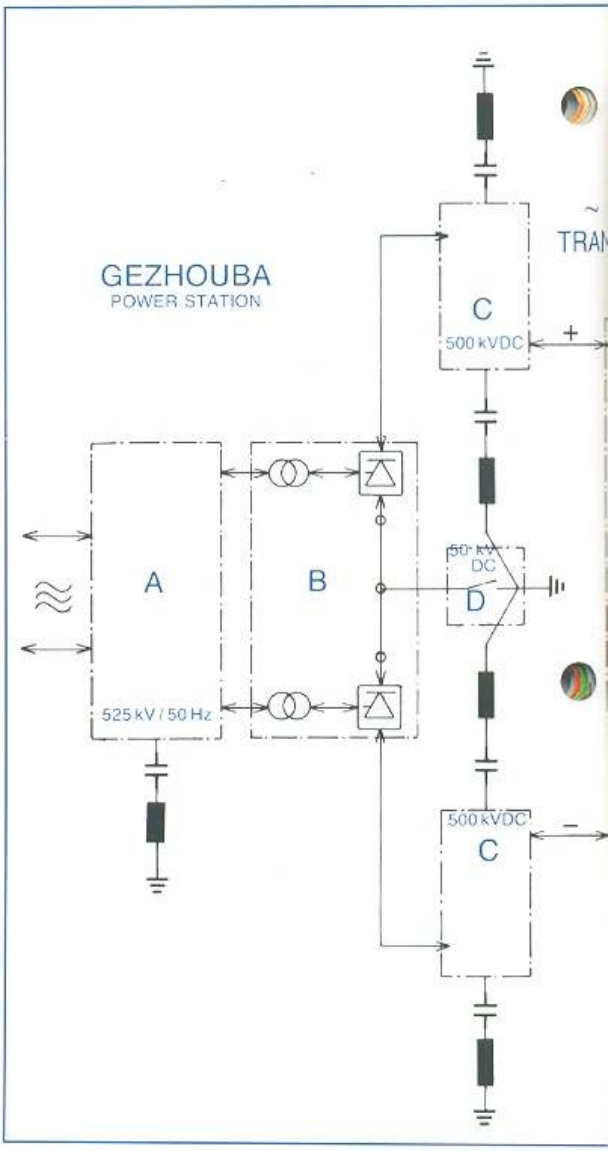

Fig. 9: GESHA block diagram.