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ARTICLES ON THE ELECTRICAL MACHINE INDUSTRY
IN COMMUNIST CHINA

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ARTICLES ON THE ELECTRICAL MACHINE INDUSTRY
IN COMMUNIST CHINA

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ARTICLES ON THE ELECTRICAL MACHINE INDUSTRY
IN COMMUNIST CHINA

/Following is a translation of selected articles from the Chinese-language periodical Tien-chi Kung-yeh (Electrical Machine Industry), Peiping, No. 23, 10 December 1959. Page and author's name, if available, are given under individual article headings./

I. NEW STEAM TURBO-GENERATOR TO AID THE FOUR MODERNIZATIONS
OF AGRICULTURE

p. 13-16

Unsigned article

Agriculture is the basis of our state's economic development. We have greatly supported the technical renovation of agriculture and hastened the mechanization, water conservation, chemicalization, and electrification of agriculture. Speaking of the electrical equipment industry, of primary demand is large-scale supply of electric power equipment. In the development of peoples' communes, the supply of medium- and small-scale electric power generating equipment for the establishment of medium- and small-scale power stations is acute. During the great leap forward of 1958, all areas produced many 750- and 1500-kilowatt convex-type steam turbogenerators. The manufacture of the gear boxes for such equipment is complex and not suitable to large-scale production or the demands of the localities. Therefore it was necessary to design new types of medium- and small scale steam turbogenerators which could utilize ordinarily available materials, avoid complex manufacturing techniques, simplify the structure, use cheaper and less complex gear boxes, and be able to go into production on a nationwide scale.

In February of this year, Bureau No 8 of the First Ministry of Machine Industry organized the technicians of the Shanghai Electrical Equipment Plant, the Hsiao-shan Electrical Equipment Plant, the Ho-fei Electrical Equipment Plant, the Nanking Electrical Equipment Plant, and the

Shanghai Hsien-feng Electrical Equipment Plant into a united design team and after three months of strenuous effort they have completed the design of a stable type 1500-kilowatt steam turbogenerator. Moreover, starting in June trial manufacture was begun in the Shanghai Hsien-feng Electrical Equipment Plant. The workers of this same plant with the assistance of the other plants, especially the Shanghai Electrical Equipment Plant, overcame equipment problems and solved major trial manufacture problems so that in just a little over 100 days the first stable type 1500-kilowatt, 3000 revolution/minute steam turbogenerator was completed. An introduction to the experience of the Hsien-feng plant follows:

A. A Simple Introduction to the Product

This 1500-kilowatt, 300 revolution/minute, 6300 kilovolt, air-cooled, steam turbogenerator can be used in the ordinary thermo-electric power stations in communes, and it also can be used in the illumination of medium and small mines or plants and railway stations. Because this equipment is designed to utilize ordinarily available materials and depends upon easily available processing methods, nation-wide manufacture is possible. A simple introduction to its mechanics follows:

The machine bed and supports are made of welded steel plates with circulating air holes. The intake air holes are covered with wire mesh to prevent the entrance of foreign matter.

The armature is made of ordinary silicon-steel plate with both surfaces laquered for insulation. After being force fitted, they are welded into place, thereby greatly reducing armature vibration and preventing insulation losses due to such vibration.

The stator windings are a refined type of wiring which reduced complicated techniques and also the amount of copper used. The conductors are fiber-glass wrapped. The terminals are screwed directly to the motor bed. The wires leading from the stator are wound into a 6-strand cable.

The rotor windings are of hard, bare copper wire, insulated with layers of mica strip. The terminals are made of bakelite board.

The winding utilizes two terminals of drawn bright-

copper with a center of annealed aluminum. The wire from the winding to the slip ring-has two terminals. The slip-ring is grooved to increase cooling.

The resistor-elements in the grooves on the stator are connected to the exterior of the output line on the motor bed and thence connected to a thermometer.

The rotor body utilizes a one-millimeter thick steel sheet which, after being pressed into the groove, is bolted into a firm unit. Slots are then planed and the rotor shaft heat treated.

The rotor winding terminals are made of magnetic chromium-manganese steel forgings. The slip-ring and the sheathing-ring are made of corrosion-resistant steel. The entire slip-ring and sheathing unit are heat fitted and then in another heat fitting step the unit is heat fitted on the center-ring of the rotor. This final assembly is further mounted on the rotor with a key-slot to prevent movement. This center-ring is fitted with 16 holes to allow cooling air to circulate about the rotor.

The bearings used are made of B83 tin-alloy and are of the plain bearing type. The lubrication is a pressure feed system.

The temperature of the air circulated through the generator and the machine bed is controlled through the use of a mercury thermometer.

B. Experiences in the Trial Manufacture of the Rotor

1. Rotor shaft: The rotor shaft is a domestic product forged from No. 45 corrosion-resistant steel. A metallurgical analysis shows it contains: 0.51 percent carbon, 0.014 percent sulfur, and 0.062 percent phosphorous.

Its mechanical properties are: a tensile strength of 52.5 kilograms/sq. millimeter; yield point of 31.5 kilograms/sq. millimeter; ductility of 14 percent, and a hardness of $H_b = 207$.

After being forged, the rotor shaft is heat treated at 840 degrees C. Its metallurgical properties are sufficiently pure to allow a minimum tensile strength of 58 Kg./sq. millimeter. After the rotor has been machined it once again is heat treated so that its mechanical properties can be somewhat improved.

Utilizing adjustable center settings during cutting operations has reduced the number of times the shaft had to be recentered. The entire processing step was held within 2 millimeters' tolerance. In processing the outside diameter of the turbine shaft, a similar 2-millimeter tolerance was kept. The use of advanced machining kept the eccentricity of the shaft to less than 0.02 millimeters, entirely acceptable. This proves that adjustable centers are acceptable for such operations if held within 0.02 millimeters.

2. Armature: The armature are formed with a one-millimeter thick No. 3 steel sheet. Its characteristics are as follows: a tensile strength of 34.5 Kg/sq. millimeter, ductility of 30 percent; unit loss $P_{10/50} = 7.6$ watts/Kg. and $P_{15/50} = 16.75$ watts/Kg; magnetic inductance $B_{25} = 14,800$ gauss, $B_{50} = 16,400$ gauss, $B_{100} = 18,100$ gauss.

Wiring slots, cooling holes, and threads are stamped and after assembly the inside diameter is lathe cut and then the unit is heat fitted to the shaft. After this step, the wiring cuts are planed smooth. During trial manufacture, it was discovered that the armature was too long, which caused the plates to twist during assembly; consequently, during final planing operations the cuts were coming out one-millimeter too small. Some advocated not pre-stamping the wiring slots and completely planing them in the final operation, however, this would overload the planing capabilities and the work could not be completed on time.

After three discussions by all involved, it was decided that a key slot be cut into the stamp plate so that the slot would be acceptable upon stamping. It was also decided to increase the planing to a depth of 2-millimeters.

The stamping operation was undertaken as follows: the plates were first stamped round, then the inside was stamped round, slots stamped; afterward with the key slot as a base the air holes and threads were stamped. The plates were then rotated 180 degrees and the air holes and threads stamped on the other surface. Finally, the lower line slots were stamped.

For this entire operation the internal cut and key slot are used as the base so that the stamping is entirely dependable. Such dependability reduces the chance for defects in the stamped plates.

There is a danger of gouges appearing on the stamping dies so attention must be paid to the thickness of die insul-

ation and to the use of hand grinders. Such was not done well during the trial manufacture and missalignment appeared frequently during assembly. The use of hand grinders remedied the situation.

The armature was assembled with a 100-ton hydraulic press. Afterward a 6-spindle, $1\frac{1}{4}$ -ton threading bar was used. To prevent warpage due to the threading, heat treatment was then used (260 degrees C. for four hours).

The boring of holes in the rotor armature is accomplished on a 3-meter lathe using an ordinary white-steel tool. Discrepancies in cutting were too easily made due to errors in the construction of the armature. The second cutting was made with a C-type cutter, allowing tolerances of 0.03 millimeter to be maintained. A surface smoothness of 6 was attained, completely satisfactory.

After the boring operation the armature was heat fitted on the rotor shaft. This is a key operation and requires high standards. The heating of the armature must be uniform. After heating, the inner holes should be measured. A temperature of 250-270 degrees C. should be maintained for four hours.

3. Planing the slots of the rotor: This operation is the second key process. Many large problems were encountered. It was found that the slots were inclined as much as 0.5 millimeters. Many of the slots had not been properly processed. In the future, manufacturing processing should be done to a depth of 4-millimeters.

The planing was done on a 4-meter plano-milling machine. In planing the dovetail slots, loose armature plates were discovered. The following three reasons are given for such a phenomenon: (1) inaccuracies in die manufacture, (2) a reduction should be made in the assembly pressure of 100 Kg/sq millimeter, and (3) improper cooling after heat treatment.

4. Rotor windings: the winding utilized 2.44 x 18 millimeter bare copper wire with a conductivity rate of 99.6 percent and a ductility rate of 46 percent. A movable-type winding pattern was used and hence the length and width of the pattern could be freely adjusted. At the completion of each winding revolution an adjustment was made in width. The good points of such a winding method are (1) short manufacturing period for the pattern, (2) low cost simplified structure, and (3) old time specialists claimed that this type is

superior to the fixed type pattern. The shortcoming is that a measurement must be taken for each revolution, causing expended effort and a chance for error.

After the winding is completed it is heat treated. The winding uses a 0.1 millimeter mica insulation wrapping. The copper surface first receives a coating of No 1154 heat resistant varnish and another coat is applied after putting on the mica insulation. Such an insulation provides a very smooth layer. When clamping the wires in place, it was found that the slots were too wide, requiring an extra layer of mica. Care must be taken that the tolerance of the mica is maintained.

After clamping the wire, it is dried. Direct pressure must be applied to enable the wire to lay flat within the slot. Errors were discovered in this respect during the trial manufacture.

5. Sheathing ring: The sheathing ring is made of 35 XMA chromium-molybdenum steel. It is hot-forged into shape and then heat treated at 870-880 degrees C. Actual tests show the following properties: tensile strength of 90.4 Kg/sq millimeter, a yield point of 72.6 Kg/sq millimeter, a ductility of 17.4 percent, contraction of 57.8 percent, and an impact strength of 1.6 Kg/millimeter.

After processing it was again heat treated at 850 degrees (plus or minus 10 degrees) C. for 20 minutes and then oil quenched. It was then immediately reheated to 580 degrees C. (plus or minus 20 degrees) for three hours and then air cooled.

6. Fitting slot wedges: the wedges are made of D16 annealed aluminum alloy and ordinary brass materials. The properties of the annealed aluminum follow: tensile strength of 53.5 Kg/sq millimeter, ductility of 17.5 percent and a hardness of R_p 30-32. The properties of the brass were: tensile strength of 77.5 Kg/sq millimeter and a ductility of 46 percent.

The wedges must be firmly set in the dovetail of the lower slot and the surfaces of the processing tools must be smooth. In this instance of trial manufacture an end-milled slot was substituted for a shaper-cut slot with good results and at a quicker rate.

The fitting of wedges is very important work. It is important that the lower portion of the wedge be even, and that no less than three-quarters of the wedge be in contact.

It is also important during the installation that the wedge not be bent. The difficulty of not enough of the wedge being in contact often encountered during trial manufacture was solved by workers of the Shanghai Electrical Equipment Plant upon request. They found that our wedges were too soft because they were not heat treated. The wedges were subsequently changed.

7. Blowers: the blower support rings are made of No. 35 steel. The blades were likewise to be made of No. 35 steel sheet but our plant changed to boiler steel sheet. The welding rod used was 42A. The blades were set in place on the support rings with small triangular gussets and then heat treated to 250 degrees C. for the welding operation. Continuous welding was used at a heavy current. After welding it was found that the rings had contracted so that the actual outside diameter was slightly smaller than the drawings called for.

8. Center ring: it was forged of No. 45 steel which had been heat treated at 840 degrees C. for four hours. After processing, it again was heated to 830 degrees C. and water quenched. It was then again heated to 550 degrees C. In its heated condition it was placed on the shaft.

9. Precision turning of the shaft: in polishing the outer surface of the shaft, deviations in iron plate were noticed. These were probably due to inadequate pressure while forming the armature. This was especially true at the wedge connections.

C. Technical Experiences in the Trial Manufacture of the Stator

1. Welding and processing of the machine bed: the welding of the machine bed was the first step in the processing and as the preparation was not adequate, the shop did not understand the job requirements. However, due to the urgency of the job they finished two bases in just a little over a week. Inspection showed errors which deviated from the original drawings. To ensure the trial manufacture of this new product we decided that these two bases would temporarily not be used and built two others.

2. Stator armature: the stator plates are made of 0.5 millimeter steel plate. Prior to machining, the specialist held a discussion and determined that neither filing or grinding was necessary. The difficulties in exterior diameter discrepancies was settled by first reducing the plate to a blank form, then punching shaft holes and standard holes. After the pattern was completed, two coats of no 202 paint were

applied and the internal holes made. Discrepancies were cut to less than 0.3 millimeters through the lining up of centers for punching operations.

The force fitting of parts is the key to the stator. Prior to fitting, measurements must be taken of pressure ratios. During initial tests, errors were found in the lining-up of dies. Variances in pressures were also discovered, varying from 13 to 18 Kg/sq millimeter.

3. Stator winding: the wiring used was 2.26x8. it was fiber-glass covered, and coated with No 2240 varnish having a conductivity of 99.7 percent.

The original design called for the use of a jacketed insulator for the stator wiring facilitating the use of the generator in any area of the country. Due to the lack of mica paper, trial use of other wiring was undertaken. The insulation actually used was seven-layers of 0.13 mica, with an outside single layer of 0.15 fiber glass.

Voltage testing after clamping operations, disclosed "sparking". The following four reasons were most prominent:

- (1) inadequate insulation strength.
- (2) poor insulating characteristics in the oiled wrapping tape.
- (3) structure not insulated according to drawing specifications.
- (4) lack of insulation on voltage test leads.

The "sparking" phenomenon was reduced by proper insulation of leads.

II. THE TEN-YEAR ACHIEVEMENT OF THE ELECTRICAL INSTRUMENTS MANUFACTURING INDUSTRY

pp. 17-19 (excerpts)

Ku Hsin-min, engineer,
Electrical Instrument
Research Office, First
Ministry of Machine
Industry

Our electrical instrument manufacturing industry started mainly in 1936 in such places as Tientsin, where relatively small-scale civilian operated plants could only repair instruments and engage in small-scale production of simple instruments for switch boards. Even the materials and parts for these instruments were imported. On the standard scale they would generally be rated class 1.5 and under.

Since the establishment of the Peoples' Republic of China and the rapid development of industrial and agricultural enterprises, the need for electrical instruments has increased. The electrical instrument industry has done much in the fight for liberation, in regards to improving many of Old China's industrial plants. At present it has become one of the newer elements within the electrical equipment industry, but none the less one of the important ones.

With the establishment of the Peoples' Republic in 1949, the party lead our entire nation in a large scale economic reformation. The electrical instrument industry on the one hand actively established and developed state-operated plants and on the other hand under the principle of "utilize, limit, and reconstruct", organized reformed production in privately operated plants.

In a very short three-year period of reformation, the electrical instruments industry developed from a small repair industry employing 200 persons, prior to the liberation, to a manufacturing industry of over 3,000 employees. At that time it could already produce such instruments of under class 1.5 as ammeters, voltmeters, wattmeters, frequency meters, phase meters, simultaneous indicators, and various types of single- and three-phase AC meters (all for switch-boards); and, such instruments of under class 1.0 as ammeters, voltmeters, universal meters, delicate flow indicators registering under $10 \cdot 10^{-6}$ amps unit; and also such instruments of under class ± 0.5 as Wheatstone bridges. This progress created good conditions for the great leap forward by the electrical instrument industry during the First Five-Year Plan.

During the First Five-Year Plan, the modern Harbin Electrical Instrument Plant was built with Soviet assistance. This plan, from design to production, received the assistance of Soviet technicians. The USSR supplied all of the production and construction materials and also trained great numbers of leadership cadre, technicians, and workers. The unselfish assistance of the USSR has left an indelible impression on the Chinese electrical equipment industry.

The completion of the Harbin Electrical Instrument Plant created one of the major parts of our electrical instrument industry. It enabled us to quickly move from a very low technical level to the most advanced levels. This modern plant conducts new product research, design, trial manufacture, testing, and inspections in a modern laboratory. There also are other shops for the manufacture of parts and streamlined, large-scale production shops. The processing of key parts all use the most advanced techniques. In the field of precious stones, from their cutting, shaping, etching, and grinding to polishing, the entire operation utilizes the most advanced semi-automatic and fully automatic machine tools. Not only is productivity increased, but the use of man-made corundum can enable instruments with a tolerance of class 13 to class 14 to be built, such is comparable to that of the United States. Shaft-point manufacture is also being semi-automatic or automatically carried out. The smoothness of these points can reach class 14. Tolerance can be held within 5 millimeters. Utilizing non-corrosive cobalt-tungsten alloy in manufacturing instrument shaft-points can ensure good anti-corrosion and anti-moisture qualities. The manufacture of "floating wires" also utilizes special equipment in wire drawing, washing, stretching, heating, and forming. The wire used in precision equipment such as thickness gauges, which can measure down to 6 microns, is also in production. Therefore, the techniques for the three important elements of indicating instruments, precious stone bearings, shaft-points, and floating wires are within our capabilities. Other important techniques which we can handle include the complex heat treatment and aging of high-conducting magnetic alloys. Because of the high degree of preciseness required in the manufacture of electric instruments and instrument parts, we are utilizing cold punching, precision forming, and bakelite forming machine tools, and automatic, semi-automatic, and hand-operated implements to reduce manual labor and greatly increase productivity and quality. Taking kilowatt-hour meters as an example, one can be produced each 36 seconds.

At the same time, the Shanghai Electrical Instrument

Plant was established (1954) and entered production. With continuous development and technical reform it has already become a large and modern electrical instrument plant. Besides producing general electrical meters and instruments, it has also trial manufactured precision instruments and self-recording instruments for metallurgy, chemistry, geology, and scientific research. Several privately operated plants at Shanghai, Tientsin, and Peiping combined into jointly operated plants, thereby rapidly increasing their development.

Taking the Shanghai public-private jointly operated electrical instrument industry as an example, the total number of workers increased 302 percent in the period from 1952 to 1957, and the total value of production rose 1210 percent. The labor productivity rate at the Ta-hua Instrument Plant alone was up over 100 percent in 1955, as against that of 1954, and its total value of production increased over 200 percent in the same period.

By the end of the First Five-Year Plan, our electrical instrument industry could already supply many new products. At this time there were already in production the 160X160 millimeter, DC and AC, 50 and 100-8000 cycle, 1.5-2.5 percent accuracy indicating meters. In the field of such instruments as distributors, auxiliary resistors or meter transformers we can manufacture pieces of 600 and 3000 amperes capacity (DC) and in 100-46,000 kilovolts (AC).

The Shanghai Instrument Plant has trial manufactured a series of DC ammeters, voltmeters, AC frequency meters, and three-phase active and inactive meters for switchboards. Special marine switchboard instruments are also being trial manufactured at Shanghai. Such marine instruments can operate in temperatures of -40 to plus 60 degrees Centigrade, and under conditions of 98 percent relative humidity; they are also shock resistant. They will be made of a high-platinum alloy. The manufacture of clock-type current measuring devices of 1.5×10^{-9} amps/millimeter/meter sensitivity has begun.

We can now produce in quantity various types and a broad range of capacities of electronic instruments. Among these are some which use ferro-magnetic materials. Not only are they structurally simple, but they continue to receive the praise of all departments which are using them.

After the Harbin plant trial manufactured and produced class-0.5 electro-magnetic scalar indicating instruments,

it also trial manufactured class -0.2 ammeters, the indicator of which was only 300 microns long. They utilized a high-magnetic alloy, an illuminated dial, and a knife type indicating needle. In 1957 a production line assembly system was set up for the full-scale and quantity production of class -0.5 precision meters, which greatly increased production.

With the great development of the electric instrument manufacturing industry and the urgent increase in variety and output of products, our domestic needs were greatly satisfied by the end of the First Five-Year Plan. If the need in 1953 was taken as a base of 100, then by 1957 it had risen to 245 and our self-sufficiency rate was 70 percent for electric meters in 1957. Imports had been greatly reduced. Taking kilowatt-hour meters as an example, in 1952, 140,000 were imported and in 1957 only a little over 1,000 were imported.

Since the great leap forward in 1958, the electric instrument and meter manufacturing industry is like other departments, in that it has greatly developed. Production of meters and instruments is greatly increased and key products continue to be created.

In 1958, a class-0.1 AC dual-use standard ammeter was produced and in 1959 a class-0.1 standard voltmeter and wattmeter were trial produced. Standard class-0.1 meters are also being trial manufactured. These meters are the highest quality now being produced in the world, and at that by few countries. All materials and parts in their manufacture are of the highest levels and quality. We studied Soviet advanced experiences and are utilizing the most advanced construction. The indicator is only 560 microns long. The interior works is of the automatic-return type and uses high-magnetic alloy multi-layer screening. The trial manufacture of class-0.1 instruments illustrates the fact that domestically manufactured indicating meters have already attained present world standards.

Class-0.2 AC and DC line voltage, current, frequency, and power meters and potentiometers have already entered production. Their capacities range in AC current from 25 milliamps to 10 amps; in voltage from 300 volts; in power from 0.5-10 amps, 75-300 kilovolts; in frequency from 45 to 2600 cycles and in DC current from 15 milliamps to 30 amps; and in DC voltage from 45 microvolts to 600 kilovolts. This basically satisfies the need of test facilities in laboratories.

The use of stressed wire and polished structure has raised the selectivity and accuracy of the meters, simplified their structure, and lowered costs. Therefore, the use of such construction is spreading throughout the industry. We will further trial manufacture similar meters in class-0.5 with current capacities of one milliamp and voltages of 1.5 kilovolts.

The use of stressed wire in switchboard instruments is under broad research and trial manufacture. The Su-chou Instrument and Meter Plant, built during the great leap forward, with the assistance of brother units, produced a number of stressed-wire meters on the National Holiday. These meters have not only high technical and mechanical properties but also high economic value due to the savings in bearings, precious stones, floating wires, etc.

To meet the expanded use of medium- and high-frequencies in industry, a series of 1000-8000 cycle meters has already entered production. To reduce the size of instruments used in switchboards, a rectangular meter with an outside measurement of 98 millimeters and a rotation of 240 degrees with an indicator of 130-150 microns was trial produced. The use of such meters can cut switchboard surfaces by 50 percent.

In the field of measuring AC and DC high voltages, a class-1.5 static electric voltage indicator which can be used in a wide range of frequencies was trial manufactured. Beside this, to coordinate the development of magnetic measurement, a megometer with a maximum error of plus or minus 1.0 percent and other very important watt-hour meters will be trial manufactured in the near future.

Under the principle of close coordination of scientific research and production, besides the Instrument and Meter Research Laboratory set up by the Peiping Electric Apparatus Scientific Research Institute, there were also established at Harbin and Shanghai electric meter research labs and electrical apparatus labs in 1958. Under the forementioned coordination, many new products have already been trial produced. A 12-line oscilloscope with an X and Y axis is also in active trial manufacture. Before long, both short- and long-distance measuring devices will be trial manufactured.

In the past two years, electric instrument and meter plants have expanded to several places throughout the country. The working force is now about 15,000, a sizable technical force. Domestic electric meters and instruments, as regards

variety and quality, already can be basically meet present domestic needs. Moreover, we have begun to assist other nations in the establishment of this field.

III. NEW ELECTRICAL PRODUCTS IN 1959

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1. In testing the stability requirements of high voltage cables, the Shanghai Cable Plant utilized a 35 kilovolt single-core, saturated, lead-armored, electric power cable to act as a "pulse" capacitor in the manufacture of a 1500 kilovolt, 22.5 kilowatt heavy-duty "pulse" voltage generator. The testing has shown that at capacities of 2000 micro-microfarads and above, wave forms reached 1.5/43.5 microseconds.

The successful completion of this piece of equipment has solved two key problems. Number one: a method to reduce the internal inductance of electric cables used as capacitors, and number two: created a 330 kilovolt and over, small-scale electric cable.

Economically speaking, the manufacture of such a piece of equipment (not including auxiliary equipment) would cost about 15 percent of the cost of importing a similar foreign product.

A "pulse" voltage generator 20 years ago was a piece of complex technical equipment, quite expensive and available in only a few high-voltage research laboratories. Now it is available for ordinary use by many industrial plants and scientific research organs.

2. The Electrical Porcelain Research Office of the First Ministry of Machine Industry in close conjunction with the Ch'ing-hua University and the Sian High-voltage Electrical Porcelain Plant, on the basis of the great leap forward of 1958, recently trial manufactured an 8.5 ton high-tension suspension-type insulator.

Suspension-type insulators are used on high-voltage transmission lines. The types commonly in use in our country are 10-inch imitation American and TT-4.5 saucer-type Soviet insulators. The mechanical-electrical characteristics of these insulators are comparatively low. The mechanical-electrical load varies between 3.5 and 4.5 tons per hour, far below that required for construction in our nation. Especially in the construction of the San-Hsia Hydroelectric Pro-

ject on the Yangtze River, a hydroelectric power station of great capacity, where transmission voltages are of the 500,000 to 600,000 kilovolt class. With high voltages and great distances to traverse, insulation qualities will be increased and line capacities increased. Such requirements call for increases in the mechanical and insulation qualities of insulators to satisfy the needs of industrial construction.

After the Sian Electrical Porcelain Research Office received these projects, it immediately went into close cooperation with the Sian High-voltage Electrical Porcelain Plant and the Ch'ing-hua University to engage in design and trial manufacture. According to test results, in comparing, this insulator and the Soviet TT-8.5, it has been found that the most important properties are the same. Its mechanical-electrical load is 8.5 tons per hour, surge voltage is 150 kilovolts, mechanical-electrical breaking point is over 11 tons, but its weight is 5.2 kilograms lighter than the Soviet insulator. Its former outside dimensions of a diameter of 300x200 millimeters have been reduced to 280x150 millimeters. Of special note is the height which has been reduced by 1/4. Because less supporting steel is required, a great saving can be made in the steel needed for constructing a high-voltage tower. This insulator, compared with the TT-6 and the TT-7, is lighter, which clearly shows the advanced level of design work.

The successful trial manufacture of such a porcelain insulator will provide a sorely needed item in the design of future ultra-high voltage and large capacity transmission projects. To supply the needs of the long-range development of our hydroelectric network, a 16 ton saucer type suspension insulator is under research.

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END