

ception specify this type in their orders; an illustration is a 34.5 kV 1,000 MVA breaker exported to the Taiwan Power Co. (Fig. IX-5) This was the first of its kind that had been subjected to a large-current breaking test in our laboratory and the results were satisfactory.

As it has been required for the metal-clad panel to house this type breaker, our Company has been supplying various equipment for every electric power company and factories.

IX-4. D-C HIGH SPEED CIRCUIT BREAKERS

Inverse current type and overcurrent type breakers of this kind have been built for electric railways in large numbers; also inverse current types have been delivered to chemical plants. For chemical plant use, they have the auxiliary switches made in oil-immersed type in order to protect the contact surface from chlorine and other gases.

Actual load breaking test has been imposed on these breakers and will continue to be done so that

all their characteristics may be improved and, together with general advance in production technique, uniformity of product quality may be secured.

IX-5. LINE SWITCHES AND DISCONNECTING SWITCHES

From single break 161 kV and 115 kV delivered to the Chosen Electric Power Co. and the Chugoku Electric Power Co. to 11.5 kV ones, large quantities of these switches have been manufactured. Against 80.5 kV or less, horizontal double-break type (Fig. IX-6) was produced in large numbers.

Customers often demand for a line switch capable of breaking exciting current or charging current; the 80.5 kV switch is guaranteed up to 8.25 A exciting and 4.2 A charging currents in the breaking test. The 11.5 kV one has been tested up 1.5 A exciting current, as installed on the panel.

As a synchronizing switch of generator, a load break switch, a kind of simplified water circuit breaker, has been devised; it is popular on account of reduced dimensions.

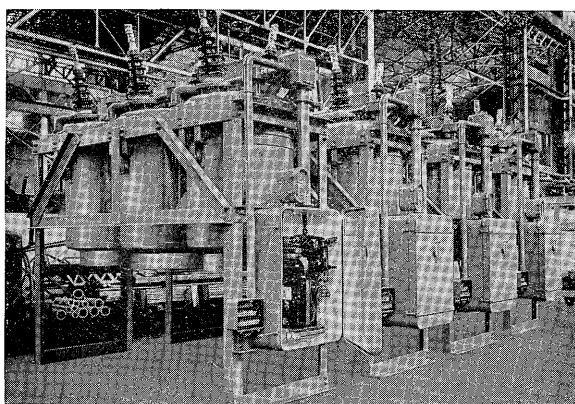


Fig. IX-5. 34.5 kV Oil Circuit Breakers

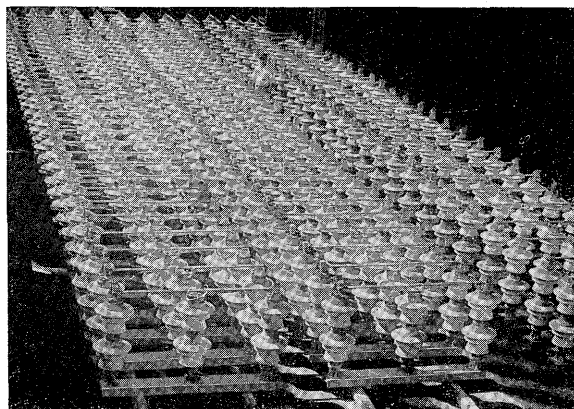


Fig. IX-6. 80.5 kV Line Switches

X. SWITCHBOARDS AND RELAYS

X-1. SWITCHBOARDS

Switchboards are produced in great quantities as control centres of electrical equipment for large-capacity power stations, substations and industries in general. In many cases, a large number of automatic control devices and sequence control devices are used and the one-man control system is adopted that makes it possible to operate every device from a switch board room. For medium to small capacity power stations and substations, the full automatic control or the remote control system is often required.

Switchboards are all fabricated of bent steel plates; well treated for corrosion resistance; and finished in light bluish-gray colour. The indicating meters are all of rectangular type and if required, wide angle meters may be used. Wide angle ones are available in a big type with 140 mm square and a small type with 100 mm square. The scale is 240 mm long for the former and 150 mm long for the latter; considering that the scale of a conventional product with 140 mm square is 120 mm long, these scales are very much extended. The smaller type is chiefly installed on the miniature switchboard which is to be described later. The present trend is to

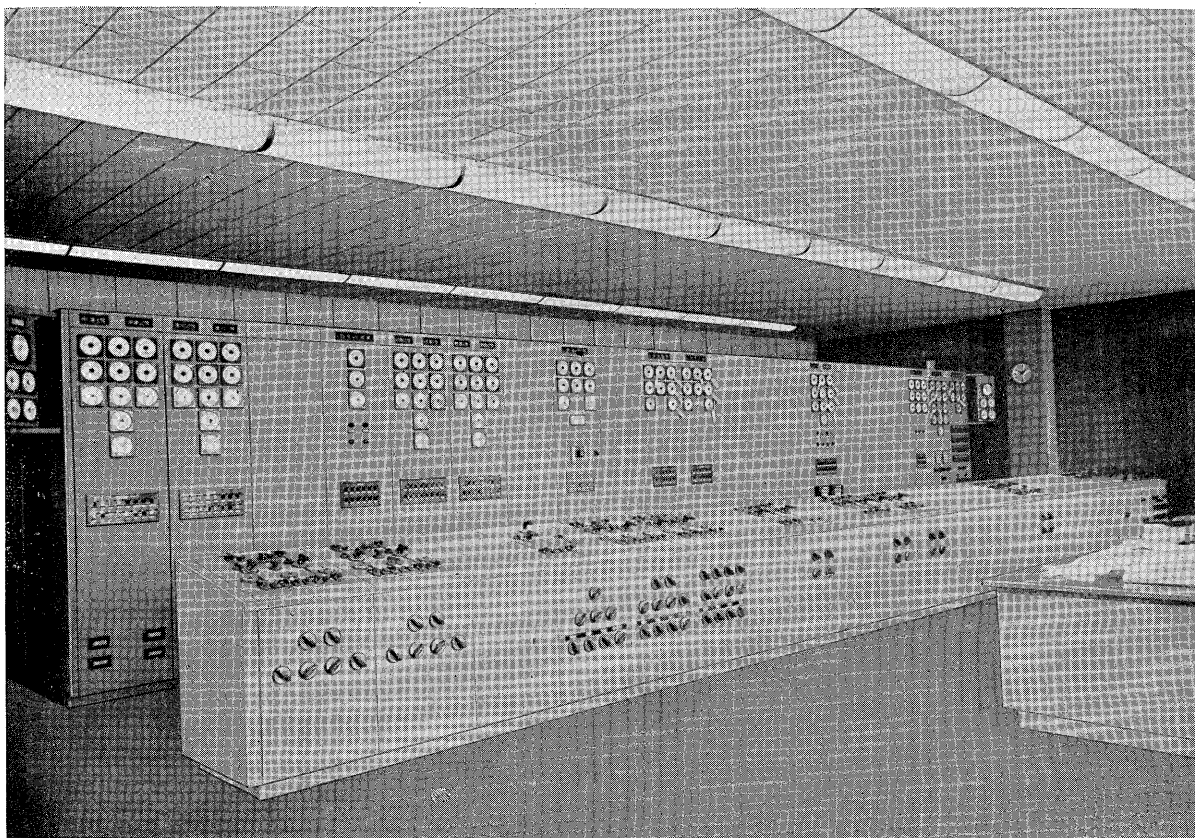


Fig. X-1. Main Switchboard for Nagoya S. S., Electric Power Development Co.

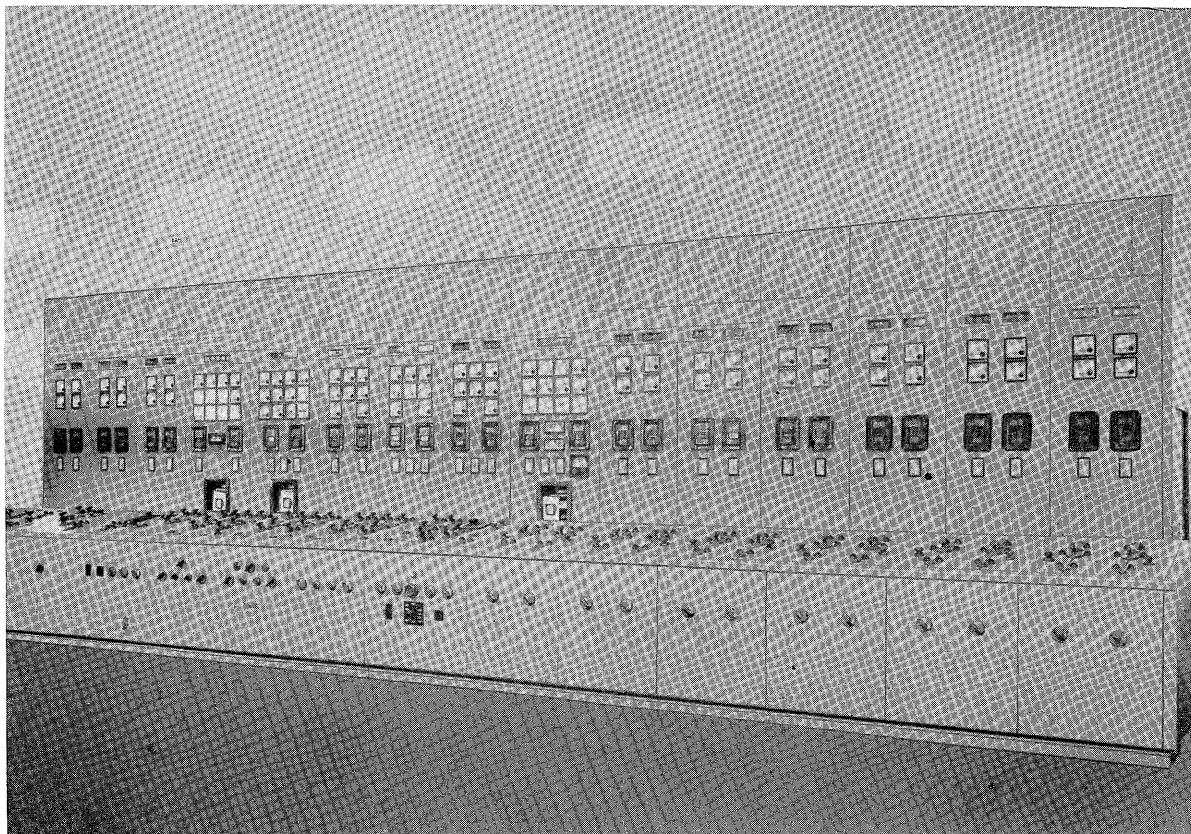


Fig. X-2. Illuminating Diagram Switchboard for Shin-nishi-Kanazawa S. S.,
Hokuriku Denryoku K.K.

use increasingly recording meters instead of indicating meters. Model S12K of single element has surface dimensions, 258 mm × 258 mm; and effective recording width, 120 mm.

By contract, Model S21K of two or three elements has effective recording width, 210 mm, within which a wattmeter and a reactive power meter, and a voltmeter and a frequency meter, three ammeters and so on can be housed, making the switchboard relatively compact. The self-balancing type recorder registers the temperature, pressure, flow quantity, opening and so on, of various equipments; a single recorder can make six or twelve kinds of recordings. For convenience of commercial records, the watt-hours are represented on the digital recorder as figures at certain intervals of time, with the time also indicated. Standard capacity of recording is, in addition to time, three 5-digit indications or four 4-digit indications.

X·2. ILLUMINATING SWITCHBOARDS

It is one of the effective means of securing a reliable control of complicated circuits to have the connection of main circuit and the state under load at large-capacity power stations and substations reproduced all the time before the eyes for confirmation. The illuminating switchboard serves just such a purpose. The Fuji Electric Mfg. Co. Ltd. has twenty-old years back ground in the manufacture of this type of switchboard. The switchboard not only represents the momentary state of main circuit as a light band, but also shows the extent of power failure from the tripped breaker down as a flicker light. Moreover, utilizing the preparatory action that invariably accompanies the on-and-off operation of breaker, it indicates preliminarily the range of circuit to be affected by that operation as a flicker light; this makes it possible to react quickly to an emergency and secure a reliable operation. (Fig. X·2)

X·3. MINIATURE SWITCHBOARDS

A switchboard fabricated as compact as possible will greatly facilitate its watching and controlling. For compact switchboards, small wide angle meters, 100 mm × 100 mm, are used and watthours are given on the small digital indicator as impulse from the watthour transmitter. Control switches, change-over switches and the like on the control desk are 40 mm wide and the single lamps are made extremely small to match. An example given in Fig. X·3 has an illuminating diagram on the upper part. The lower front of the switchboard is crowded with many fault indicator; lower down, a test plug is provided for instrument testing. When the cover is lifted and the plug pulled out, CT circuit

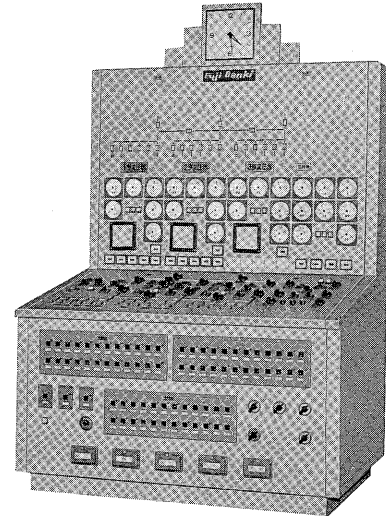


Fig. X·3. Miniature Switchboard for Amagasaki S.S., Kansai Denryoku K.K.

is automatically short-circuited; PT circuit opened. Thus, by inserting a separate test plug, testing can be made very easily.

X·4. CUBICLES AND METAL-CLAD SWITCH-GEAR

In a limited space many instruments are neatly arranged making it possible to watch and control them safe and sure; to maintain and inspect them with convenience. This is the reason why recently metal-clad switch-gear or enclosed type switch-gear that are simplified forms of the former have become so popular. They are enclosed with grounded steel plate. The former is, if necessary, further divided into several partitions by grounded steel plate; the bus bar is in addition to air insulation, further covered with insulating material; and the circuit breaker is a draw-out type that can automatically connect both the main and the control circuit. As circuit breakers, expansion circuit breakers or oil circuit breakers are adopted, with interlocking

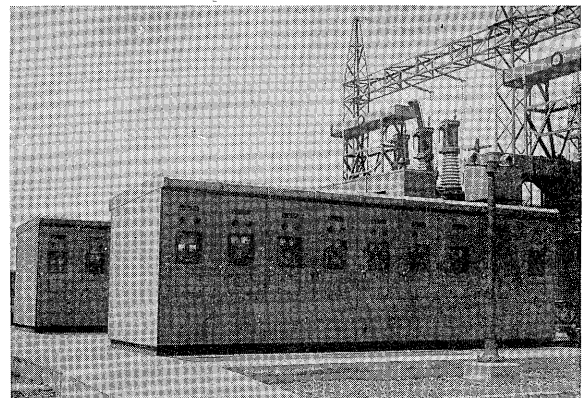


Fig. X·4. Outdoor Type Metal-clad Switchgears for Amagasaki S.S., Kansai Denryoku K.K.

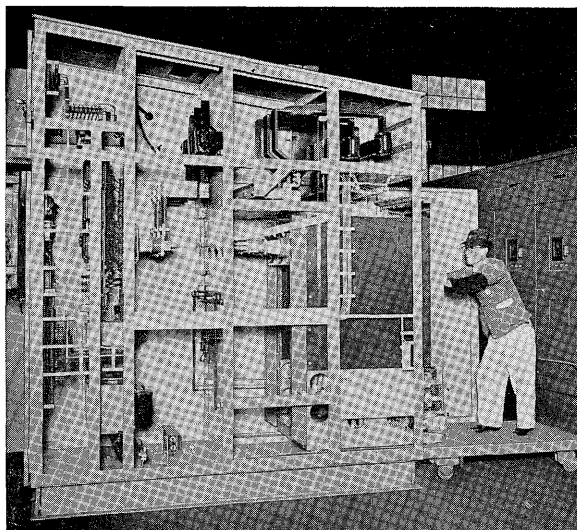


Fig. X-5. Side View of Metal-clad Switchgears
(Cover removed)

devices added to play on the safe side, depending upon the circumstances.

These groups of metal-clad switch-gear arranged for each bank of transformers constitute a unit substation for power distribution. Normally, substation capacity is less than $3 \times 6,000$ KVA; receiving voltage, less than 77 kV.

X-5. RELAYS

As induction type over-current relays, which are most commonly used protective relays, there are available a compact, efficiently-designed, small input model AT3 and a higher sensitivity Model AI2 (see this Journal No. 4, 1956). They have an excellent performance; the former consumes 4.5 VA and the latter 0.2 VA.

Nowadays, distance relays are in heavy demand. Outstanding ones with unique features are an elliptical characteristic high speed directional distance relay, Model RXC1 and a proportional time-limit directional distance relay, Model ZJ1. The former, with an elliptical R-X characteristic, can make distance measurements with high accuracy, being free from the influence of arc resistance at faulty points; therefore it is used in large quantities on major transmission lines. It is also accurate in detecting faults over a short distance. It has an extremely wide scope of application, for varied elliptical shapes and positions are available to suit requirements. The latter is a type which varies operating time-limit with the distance to a faulty point. Its main use is on a local line with branches; on a complex system too, rapid selective rupture can be expected. As so-called auxiliary relay operating at constant input, there is Model HH17 which has 5 sets of

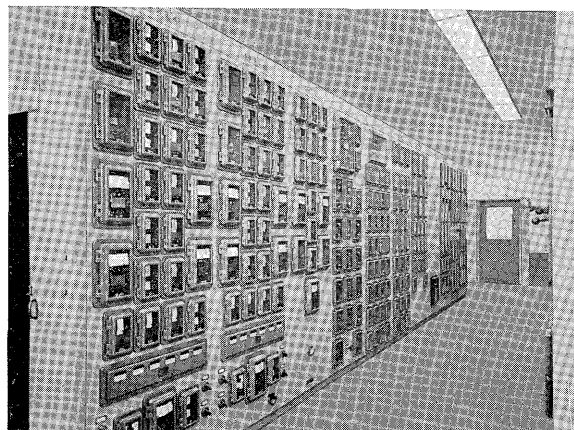


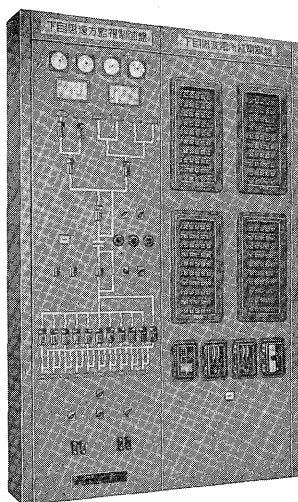
Fig. X-6. Protective Relay Board for Nagoya S.S.,
Dengen Kaihatsu K.K.

change-over contacts that can open or close 20 VA under d-c. inductive load, though its dimensions are identical with a communication relay, $31 \text{ mm} \times 45 \text{ mm} \times 98 \text{ mm}$; and, with 2W input, can assure 2,000 V, one minute against voltage of a-c commercial cycle and 4,500 V against impulse voltage of standard wave form. After 20,000,000 times of switching in a test, it retains a good performance. This relay is available for protective relay as well as general-purpose control relay; also it may serve as remote control device, with a large number housed in a case.

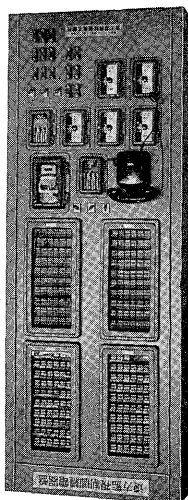
Coming under the same group, a mechanical hold relay Model HK2 is two sets of the HH17 linked together, one set being made to hold the action and the other releasing the action; it is highly reliable in action.

X-6. POLYGONAL TYPE SUPERVISORY CONTROL DEVICES

A Polygonal type supervisory control system is a powerful, quick-acting system that can very speedily select arbitrary ones of extremely numerous controlled circuits by combination of several connecting wires or carrier channels. It can select 50 circuits by 4 connecting wires; 602 by 6 wires. Signal communication including back signal for confirmation takes less than 0.2 sec. If this System is followed, a large number of various sets of equipment located as far as several to tens of kilometers away can be supervised and controlled at will and without time lag as if they were located on the same premises with the control station. The impulse type supervisory control system which is traditionally finding worldwide use needs many impulses for the selection



(a) Controlling Station Panel



(b) Controlling Station Panel

Fig. X-7. Polygonal Type Supervisory Control Device

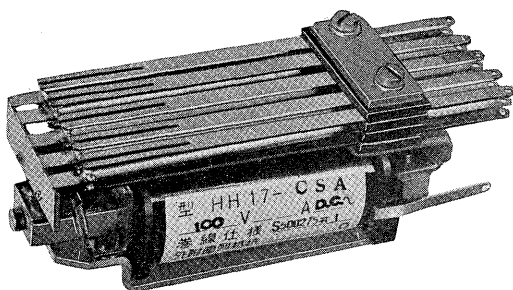


Fig. X-8. Auxiliary relay, type HH 17

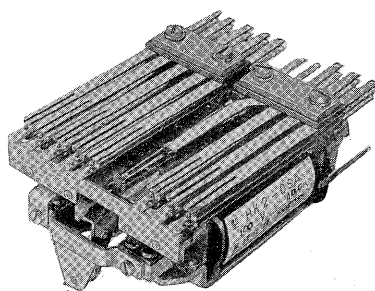


Fig. X-9. Mechanical hold relay, Type HK 2

of one circuit so that there is a considerable time lag of selection and the system must make a complicated, busy action. By contrast, the polygonal type works with great rapidity and the action is quite simple and highly dependable so that its service life is very long. Particularly when selection takes 0.2 sec or so, there is no need for high-speed relays; the system is almost composed of standard auxiliary relays Model HH 17.

It is barely 7 years since this system was developed by Fuji Electric Mfg. Co. and entered into regular production. None the less, the production record shows 30-odd sets delivered with the total number of selected circuits exceeding 2,000; its excellent performance is very much appreciated.

X-7. AUTOMATIC CONTROL DEVICES

a) Electric Governor for Water Turbine

This is an electric device replacing the mechanical actuator of speed governor for large-capacity water turbine generators. It is a high-precision, high-sensitivity device with the characteristic electrically adjusted; and can be remote-controlled at will. Therefore it is very fit for various automatic controls such as electric level governor, output program control, automatic frequency control. As it uses combination of special frequency bridge and magnetic amplifiers and adopts a return circuit by the electro-magnetic method, it is rugged in construction; stable in performance; and very easy of maintenance. According to the operation record, the frequency sensitivity is $\pm 0.01\%$, that is, very satisfactory.

b) Automatic voltage regulator for large-capacity generator

It is composed of nothing but magnetic amplifiers, so that it is highly sensitive, accurate and easy of maintenance (see this Journal No. 1, 1956).