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MODERN INDOOR SUBSTATION

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I. FOREWORD

Electrical power is being widely used as an energy source in various industries but since it cannot be stored, the absolute condition calls for the availability of stable power, both quantitively and qualitatively, at all times. In recent years, normal incoming voltages at substations among the general industries have beed 60 kv and 70 kv and in many cases as much as 100 kv or 140 kv. Because of this, the following problems must be considered when planning a substation.

(1) Reduction of site area
(2) Countermeasures for salt and dust contaminations
(3) Safe and simplified maintenance and operation
(4) Adjustment to ambient circumstances

The indoor and cubicle types are drawing attention as the forms of substations which satisfy these problems and are yet economical.

The 40 kv and 70 kv substations, with a concrete cubicle as the main unit, were recently completed at the Central Substation (in Ube district) and the Sakai Works Substation of the Ube Kosan Industries, Ltd. and their outlines will be introduced here.

II. CONFIGURATION OF MODERN SUBSTATIONS

Although there are various problem points, as previously mentioned, the ultimate aim when planning a substation is to obtain one that is safe and economical. In order to solve each of the problem points and to reach the ultimate aim, it is necessary to conduct an investigation as to the best configuration for the substation.

1. Reduction of Site Area

Even the assurance of the substation site has become difficult recently due to worsening of land conditions and, in order to plan for an economical substation, the main point which must be considered is to reduce the site area of the substation. Because of this, the reduction of the substation site area is being considered by making them indoor types and each equipment component is arranged into a cubicle configuration. Further acceptance of the cubicle technique which was applied to the original 3/6 kv will add compactness and a safety factor to the substation. By making the 60 kv or 70 kv class substation into the indoor or cubicle type, it is possible to reduce the required site area by 40 to 60%.

2. Countermeasures for Salt and Dust Contamination

In Japan, the salty condition exists not only on the coastal areas but reaches inland for several tens of kilometers during typhoons. Also, the substations for general industry are located in the factory areas, thereby requiring considerations for dust and gas contamination. However, the countermeasures for salt contamination become more difficult as the voltage increases. According to statistics, most of the troubles caused by salt contamination are found in the circuit breakers and disconnecting switches for the 60 kv and 70 kv units.

For instance, when considering countermeasures for salt contamination at standard substation with two receiving circuits of 60 kv, the total cost rise will be close to 10% with 3 to 4% for the equipment and 5 to 6% for the insulator washing device. For this reason, when a substation is either the indoor type or cubicle type, it is possible to reduce the required site area mentioned in 1 and also bring the cost down considerably.

3. Safe and Simplified Maintenance and Operation

The maintenance and operation can be effected safely and simply is the most important factor for the substation. The climatic and surrounding influences were great in the case of the original outdoor open type substations and it was also necessary to construct intricate footing when inspecting the equipment which also offered difficulties. When making these into the indoor or cubicle type, the following advantages are available.

1) The influences from climatic and ambient conditions are minimized since it is unexposed. In particular, the influence of salt contamination is removed to greatly simplify maintenace and offer safe operation.

2) The safety factor has been greatly increased

since each unit circuit can be sectioned off.
3) As draw-out type circuit breakers, inspections can be made safely and simply by providing a hoisting device and inspection platforms at suitable positions within the structure.
4) Inspection has been made safe and simple through the provision of inspection touring passage.

4. Adjustment to Ambient Circumstances

An aesthetic sense has begun to be applied recently even for factory constructions. This has also become an item of necessity in the case of substations which have been made into the indoor or cubicle type. In essence, the structural sense, and hence adjustment to the surrounding environment, has been simplified.

As stated above, in order to satisfy the various problems required for the substation as well as making it economical, it is most advantageous to make it the indoor or cubicle type. Consequently, the recent tendencies are to make the 60 kv, 70 kv, or even the 110 kv and 140 kv substations into indoor or cubicle types.

III. PROBLEM POINTS TO BE CONSIDERED WITH RESPECT TO DESIGN AND CONSTRUCTION OF INDOOR SUBSTATIONS

The connection method is determined initially with respect to planning (consideration is given to the simplification of equipment as much as possible) and investigation on equipment selection as well as the arrangement is forthcoming. The points which warrant special considerations at this time are the following.

1) When determining arrangements for the equipment, consideration should be made by all means to make it as compact as possible as well as in the simplicity and safety features for inspections, and, in this case, the study should always include sufficient consideration for economization as well as the problem points with respect to building construction. Also, although it may seem to be a minor problem, the pillar and beam positions will have great effect on the insulation distance, when cubicle arrangement is applied in particular, thereby requiring sufficient care.
2) The equipment is arranged into units for each circuit through consideration accorded to prevent external influence in case of trouble development, which is unlikely to happen. At the same token, suitable partitions are provided between the units so that inspections can be effected safely without affecting other units.
3) Consideration should be accorded for the simplification of carrying on and off of the equipment in cases such as inspection.
4) As for the equipment arrangement, the positioning should be determined with sufficient consideration given to safety features during inspection and maintenance in addition to allowances for the required insulation distances. (Allow distances for human safety factor.)
5) Building arrangements should be determined after due consideration when enlarging or renovating the structure.
6) The circuit breakers and disconnecting switches should be arranged so that they can be operated from the inspection passage or in some cases be provided with a separate operating box. Also, as for equipment accessories requiring observations, consideration should be accorded so that it will be possible to inspect them from the inspection passages. Particularly, in the case of cubicle arrangements, this point should be carefully noted since it is not possible to approach live equipment.
7) As for the equipment, those with a high degree of reliability, easy to inspect and maintain, and which occupies the minimum area should be selected. Especially in the case of disconnecting switches, those sufficiently matching the facility condition should be selected and the effect of space reduction of V-type switches, vertical switches, and other special disconnecting switches are remarkable. Also, there are cases where the circuit breakers are made into draw-out types so that the front and the rear disconnecting switches can be eliminated.

After concluding the equipment arrangement and selection, the designing and construction of the building based on the former are begun and, in this case, the points deserving particular attention equipment-wise are the following.

1) The metallic anchoring pieces for the equipment or bus wire supporting insulators as well as the pulling for lifting hooks used for equipment insertion, should be provided in the building design.

This also applies for the channelings in the floor, ceilings and walls of the building for ventilation pipes, wiring ducts, and bus lines.

2) Consideration should be given to the dimensional errors in the blueprints. Particularly in the case of metallic anchoring pieces for bus line supporting insulator or equipment installation, there are cases where only 5 to 10 mm dimensional errors are permissible with respect to insulation distance, but since it is normal for much greater dimensional errors to appear through the design and actual construction, special considerations are required.
3) Also, since the building construction and the equipment production are being conducted simultaneowsly, sufficient discussions should be held prior to the actual work regarding not only the production process but the submission schedule of the related drawings of the two and it is necessary to positively abide by this. Sufficient care should be given, in particular to the equipment insertion process. The waiting period for the building construction and equipment installation should be eliminated.

IV. EXAMPLE OF CENTRAL SUBSTATION OF UBE INDUSTRIES, LTD.

1. Established Location

The Central Substation is located on the coast of Setonaikai in Ube city, the origin of Ube Industries Co. Ltd., and in its vicinity are located the Ube Nitrogen plant, Ube Iron Works, Ube Chemical Plant, and Ube Caprolactam Plant. Also, much of the Ube Industries Central Substation site is on reclaimed land.

2. Connection Method

The Central Substation receives 110 kv power from the Ube Industries Momoyama Substation adjacent to the Chugoku Electric Power Ube Substation. The incoming voltage is stepped down to 44 kv by the 110/44 kv, 70 Mva main transformer and distributes the electric power to the nitrogen plant and the iron works. The skeleton diagram is shown in *Fig. 1*. The portion enclosed by the broken line constitutes the Central Substation.

3. Configuration of Substation

The established location of the Central Substation is near the sea coast and, since it was subjected to the conditions of the site area, the following measures were taken, (1) countermeasures for salt and dust contamination and (2) reduction of the substation site area.

1) The circuit breaker and disconnecting switch of the power input section were eliminated and it was provided with a transfer tripping system which will break the circuit breaker of Momoyama Substation when fault occurs in the Central Substation.

2) The primary side of the 110/44 kv, 70 Mva main transformer was made an elephant type and 110 kv OF cable was directly connected. The secondary side was made bus duct and connected to the 44 kv concrete cubicle which is mentioned in 3). and the live section was completely shielded.

3) The equipment on the 44 kv side is in the concrete cubicle while the circuit breakers were made to be draw-out types.

4) Distribution to the nitrogen plant and the iron works will be made through 44 kv SL cable.

For the details of the above, refer to *Fig. 2, 3, 4, 5, 6*.

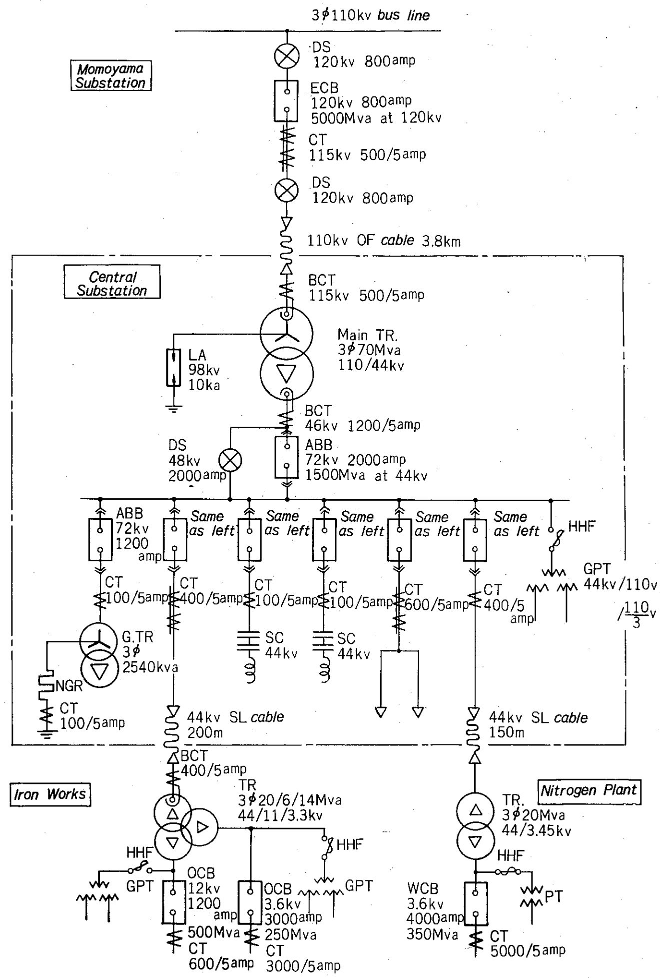

Fig. 1 **Skeleton diagram**

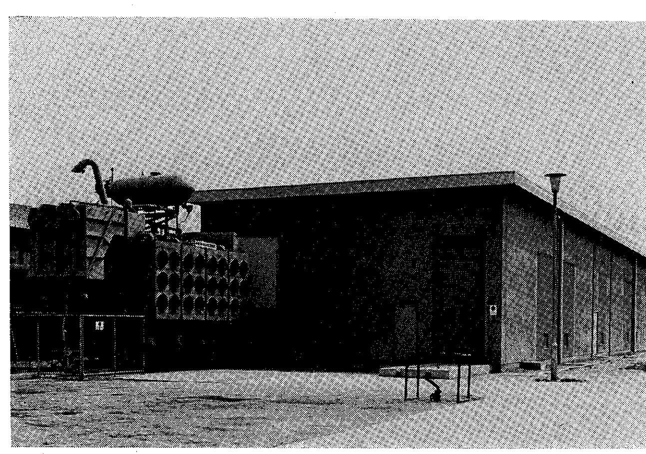

Fig. 2 **External view of Central Substation**

4. Specifications of Principal Equipment

1) Central substation main transformer

Quantity	1 unit
Type	Outdoor use, 3-phase, forced oil air-cooled system, diaphragm conservator and no-voltage switching tap attached
Rated capacity	70 Mva
Rated voltage	110/44 kv (Primary tap voltage 115–110 (R)–105–100 (F) kv)
Rated frequency	60 cps
Connection (Primary)	Star (neutral point drawed out, connected to lightning arrester)
(Secondary)	Delta
Insulation stages	Primary No. 100

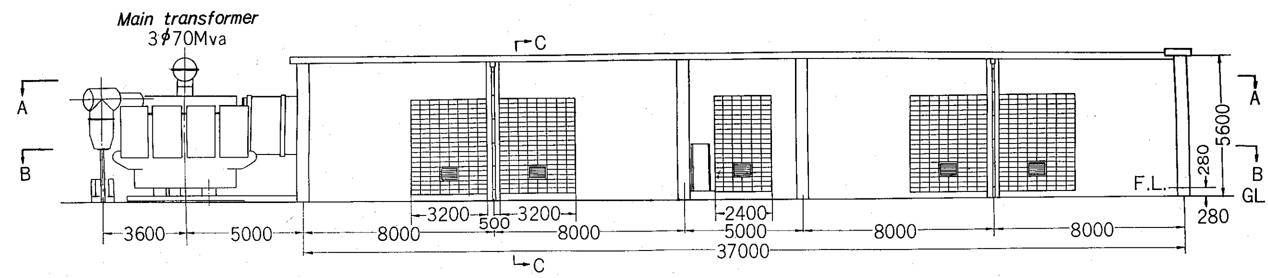

Fig. 3 **Dimension diagram of Central Substation**

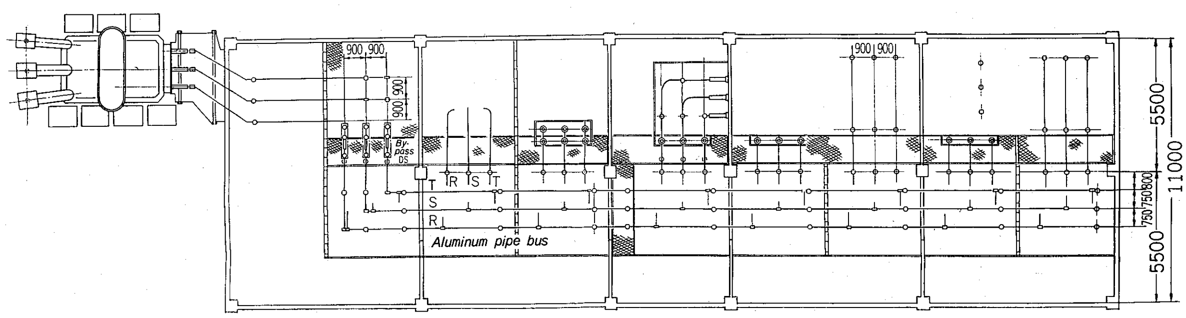

Fig. 4 **Arrangement of 44 kv bus in Central Substation**

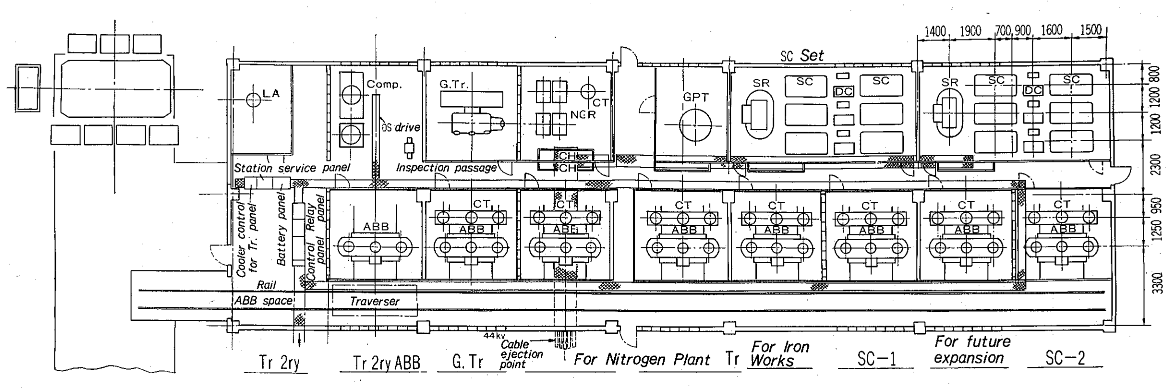

Fig. 5 **Arrangement of equipment in Central Substation**

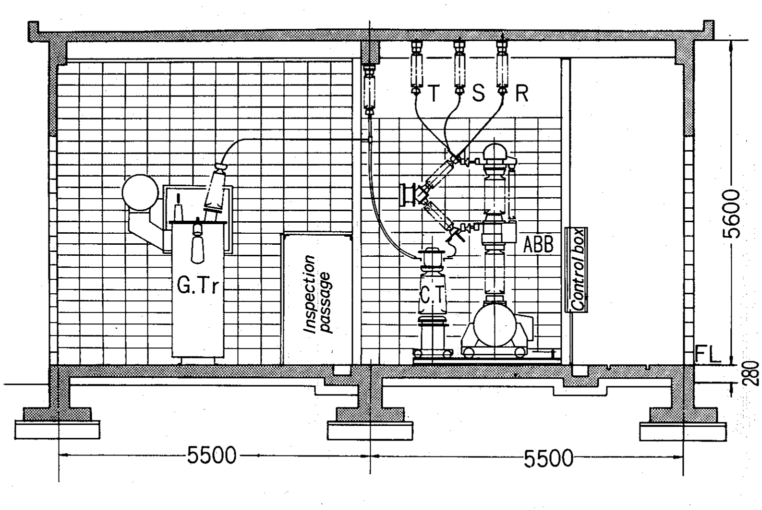

Fig. 6 **Arrangement of 44 kv cubicle**

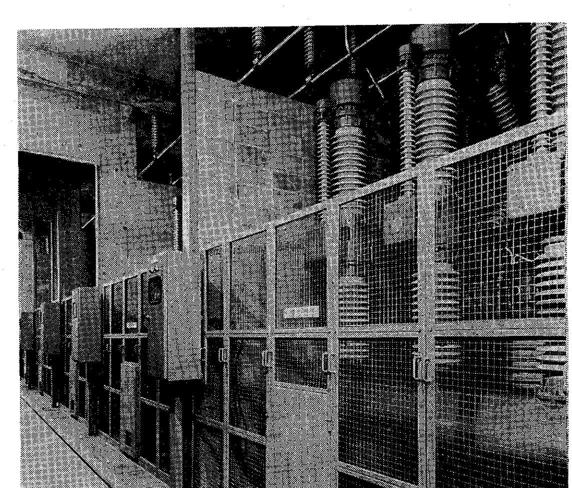

Fig. 7 **Inner view of 44 kv cubicle**

Primary neutral No. 70
Secondary No. 40

Impedance 11% (70 Mva base)

Construction
(Primary) Elephant type
(Secondary) Bus duct type

2) 44 kv concrete cubicle enclosed equipment

(1) Circuit breaker
Quantity 7 units
Type Outdooruse, 3-phase, air-blast circuit breaker RF 720B/60/1200D, RF 720B/60/2000D)
Rated voltage 72 kv, 60 cps
Rated current 1200 amp, 2000 amp (Main transformer secondary only)
Rated breaking capacity 1500 Mva (at 44 kv)
Operating method 15 kg/cm² compressed air operation
Construction Manual draw-out type

(2) Current transformer
Quantity 18 units
Type Outdooruse, single phase, oil immersed type (CTSO 9/60)
Rated voltage 69 kv, 60 cps
Current ratio 600 to 100/5 amp
Rated burden 40 va
Error class 1.0 class

(3) Grounded type potential transformer
Quantity 1 unit
Type Outdooruse, oil tank type
Rated voltage $44\ \text{kv}/110\ \text{v}/\frac{110}{\sqrt{3}}$ v 60 cps
Rated burden Secondary 3×200 va
Tertiary 3×200 va
Error class Secondary 1.0 class
Tertiary 5 G class

(4) Lightning arrestor
Quantity 1 unit
Type Magne-resist valve type (RVLFC–70)
Rated voltage 98 kv, 60 cps

(5) Disconnection switch
Quantity 1 unit
Type Outdooruse, vertical 1 point breaking type (RS 268 CIII/40/2000 D)
Rated voltage 48 kv, 60 cps
Rated current 2000 amp
Operating method 15 kg/cm² compressed air operation

(6) Grounded transformer
Quantity 1 unit
Type Outdooruse, nitrogen sealed type
Rated capacity 2540 kva (30 second rating)
60 kva (continuous rating)
Rated voltage 44 kv/220 v, 60 cps
Connections
(Primary) Star (neutral point drawed out, connected to resistor)
(Secondary) Delta

(7) Neutral point resistor
Quantity 1 unit
Type Indooruse, installing type
Rated voltage $\frac{44}{\sqrt{3}}$ kv, 60 cps
Rated current 100 amp (30 seconds rating)

(8) Compressed air generator
Quantity 1 unit
Type 2-stage compressed 3-cylinder air-cooled type
Rated voltage 30 kg/cm²
Rated supplied air pressure 15 kg/cm²
Air tank 2×650 liters

(9) Dc power supply unit
Quantity 1 set
Type Volta block type alkali battery
Rated capacity 52 AH (1 hour factor)
Input 3-phase 220 v, 60 cps
Output Dc 110 v

(10) Power factor improving condenser
Quantity 2 sets
Rating 3-phase, 44 kv 60 cps 5 Mva

(11) Operation panel, relay panel
Quantity 1 set Site operation panel
1 set-Relay panel
1 set Station service panel
1 set Transformer cooler control panel

3) Nitrogen plant transformer
Quantity 1 unit
Type Outdooruse, 3-phase, oil immersed, self-cooling type, nitrogen sealed, no-voltage switching tap attached.
Rated capacity 20 Mva
Rated voltage 44/3.45 kv
(Primary tap voltage 44 (R)–42–40 (F) kv)
Rated frequency 60 cps
Connections
(Primary) Delta
(Secondary) Delta
Insulation class
(Primary) No. 40
(Secondary) No. 3
Impedance 6.34% (20 Mva standard) (Parallel operation with previously delivered transformer considered)
Construction
(Primary) Elephant type
(Secondary) Bus duct type

4) Iron Works transformer
Quantity 1 unit

Type	Outdooruse, 3-phase, oil immersed, self-cooling system, nitrogen sealed, no-voltage switching tap attached
Rated capacity	20/6/14 Mva
Rated voltage	44/11/3.3 kv (Primary tap voltage 44 (R)–42–40 (F) kv)
Rated frequency	60 cps
Connections	
(Primary)	Delta
(Secondary)	Delta
Insulation class	
(Primary)	No. 40
(Secondary)	No. 10
(Tertiary)	No. 3
Impedance	Between primary and secondary 12% (20 Mva base.) Between secondary and tertiary 24.5% (20 Mva base.) Between primary and tertiary 8.8% (20 Mva base.)

(Note) When set to the above impedances, the impedance of the primary winding will be −1.95% (20 Mva base) and the voltage variation due to load variation of the secondary and the tertiary windings will have practically no effect on the tertiary and secondary windings. In this case, it is for the purpose of dealing with the variation in the light bulb load which is connected to the secondary side.

Construction	(Primary)	Elephant type
	(Secondary)	Bus duct type
	(Tertiary)	Bus duct type

5. Features

1) Simplification of incoming system

As shown in the skeleton diagram (*Fig. 1*), the equipment in the incoming section has been abbreviated and simplified from the fact that distributions between each substation are carried through the cables as well as the improvement in the reliability of the equipment. For instance, all of the primary sides of Central Substation 110/44 kv, 70 Mva main transformer, Nitrogen Plant 44/3.45 kv, 20 Mva transformer and the Iron Works 44/11/3.3 kv, 20/6/14 Mva transformer were made into elephant type and each were directly connected with 110 kv of cables or 44 kv SL cables.

As a result, the site area of the substation, as well as the construction cost, has been reduced greatly.

Furthermore, in the case of an unforeseen fault in the substation, the system is to break each of the circuit breakers at the ejection point.

Since the distance between the Central Substation and Momoyama Substation is 3.8 km, the transfer tripping system was applied.

2) Ground protection system

Although the Central Substation 44 kv feeder circuit is a cable system, the detection grounding faults is difficult in the non-grounded system since the distance is short. Because of this, a grounded transformer is provided for the 44 kv bus line to establish a 100 amp grounded system. Through this, it is possible to detect the ground feeder effectively and simply with an overcurrent relay.

3) Concrete cubicle

With considerations for the problems stated in II, as well as in order to satisfy the demand, the 44 kv circuit was made into concrete cubicle. The main structural advantages are:

(1) The cubicle is made of a reinforced concrete rigid frame with partitions provided for each unit circuit.
(2) The function of the equipment is displayed to the utmost through the solid equipment arrangement with the draw-out type circuit breaker as its main body.
(3) The passage covered with wire net is provided internally to enable safe inspection even during charging and also provided are suitable lighting facilities.
(4) The suspension device and inspection platforms are provided to ease inspection and repair of internally housed equipment.

4) Shielding of live section

As stated previously, the transformer is an elephant type and the 44 kv circuit is a concrete cubicle which is completely shielded during charging. Consequently, it has been treated sufficiently against salt and dust contamination and, furthermore, the external appearance has been beautified.

V. EXAMPLE OF SAKAI FACTORY INCOMING POWER SUBSTATION OF UBE INDUSTRIES

1. General

The Sakai Factory of Ube Industries will be newly constructed on a corner plot of the Sakai reclaimed land. One set of electrical facilities has been manufactured and delivered at this time. The 70 kv indoor switching station of the facility will be briefly introduced here. The power reception point of the factory is only 20 to 30 meters from the shoreline, so close to the water that it is often exposed to spray from the ocean water. Since it is faced with severe saliferous conditions, it has been assumed that saliferous countermeasures such as coating of silicon compound or insulator washing under loading is insufficient for an outdoor substation, and, hence, it was decided to make the incoming power switching station an indoor type. The plant distribution system will be such that 70 kv will be distributed to each plant electrical room. It is of the load center system and the power is distributed to the step down transformer located at each of the plant electrical rooms through cables. The 70 kv side of the transformer is made elephant type while the secondary side is of bus duct construction and is connected at the cubicle in each plant indoor electrical room. Consequently, the live section in its entirety, with the exception of wall penetrating bushing of the 70 kv switching station drawing, is shielded. The wall penetrating bushing is of heavy salt contamination proof type and complete countermeasures for salt contamination is effected through the provision of an insulator washing device under loading. Furthermore, since the objective was to construct an indoor switching station, not only the saliferous countermeasures but the minimization of the actual site area was apparent. Hence, the switching station was made a cubic arrangement construction which includes the cubicle factor with emphasis placed on compactness.

2. Connections

The connections of the incoming power station are shown in *Fig. 8* and the 70 kv indoor switching station facility shown in broken lines.

The incoming power system is the 2-circuit loop type. Its capacity is as follows.

Incoming voltage : 70 kv
Frequency : 60 cps
Incoming transformer :
1 unit: 3ϕ 30/15/15 Mva 70/3.45/3.45 kv
1 unit: 3ϕ 20 Mva 70/3.45 kv
1 unit: 3ϕ 20 Mva 70/11 kv
1 unit: 3ϕ 15 Mva 11/3.45 kv

The 70 kv bus wire is the double bus type and the plan is to establish the tie system of the commercial power system and the generator system for own supply through the bus tie circuit breaker which is scheduled to be provided in the future. The secondary voltages are 3.45 kv and 11 kv with 3.45 kv system for the factory load while the 11 kv is of tie system of commercial and generator system since the private generator voltage is 11 kv.

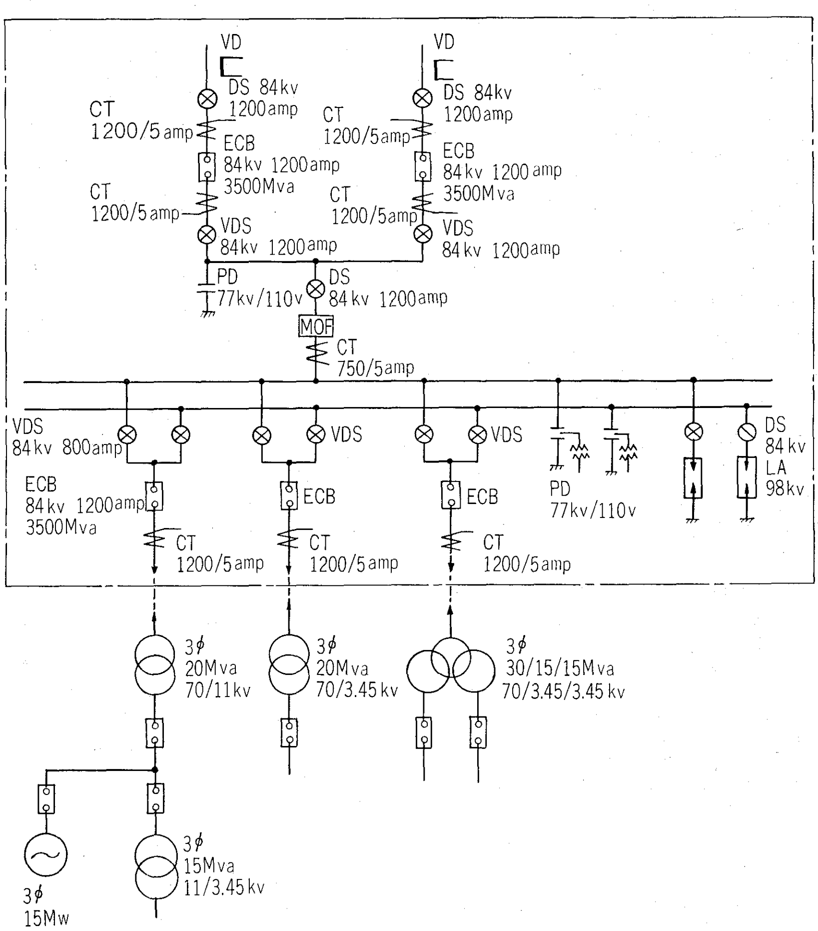

Fig. 8 Skeleton diagram of 60 kv substation at Sakai Works

Fig. 9 External view of 70 kv indoor substation

3. Arrangement of Building and Equipment

The switching station is a 2-story construction of reinforced concrete. The size of the building is 22 meters wide, 16 meters deep, and 11.5 meters high this houses the equipment contained inside the broken lines in *Fig. 8*. Skeleton diagram, as well as the auxiliary system. The outer view is shown in *Fig. 9*.

Also, equipment arrangements are shown in *Fig. 10* and *11*. The power intake is done at the top portion of the first floor of the building through the wall penetration bushing and is passed through the vertical 1 point break disconnecting switch and current transformer installed on the first floor and reaches the incoming power circuit breaker. (Refer to *Fig. 12*). This vertical 1 point break disconnecting switch is attached with a grounded switch and the construction of the combination can be effected from the inspection passage below the floor of the first floor.

As seen from the equipment arrangement sectional view diagram of *Fig. 11*, the incoming power circuit side is to the right of the drawing and the feeder circuit side is installed at the left side of the building. The 70 kv bus wire as well as the disconnecting switch is installed on the second floor while the circuit breakers and the current transformers are located on the first floor. The bus passage between the first floor and the second floor is done by removing the floor on the second floor with the necessary spaces. The disconnecting switch installed on the second floor is the bus supporting tube attached post type V-type disconnecting switch which is arranged in an angle (refer to *Fig. 13*) in order to minimize the spacing between the bus wires as well as the overall space conservation.

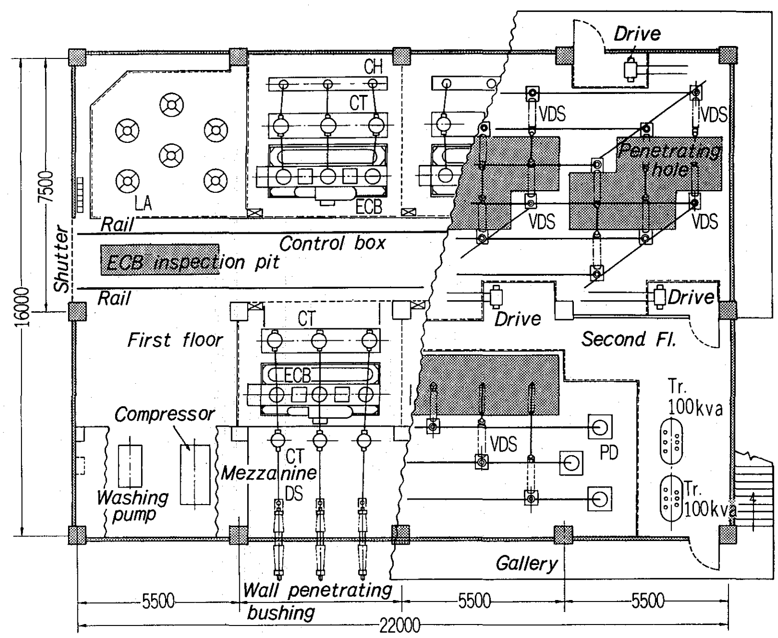

Fig. 10 Arrangement of 70 kv indoor substation

The disconnecting switch is obstructed by the inspection passage and the dividing shelves of the wire netting and operating instrument have been provided on the passage side with an ingenius link mechanism so that safe operation is possible.

Aluminum pipes with diameters of 88 mm and 55 mm are used for the 70 kv bus line. The aluminum pipe is lighter in weight when compared to the copper stranded wire and can be supported directly by the disconnecting switches. When used for indoor substations, many other merits are considered apparent such as the dip and the vibration when shorted. The circuit breaker installed on the first floor is provided with a front draw-out type with wheels and installed on top of rails.

When inspecting, it is pulled out to the central passage and moved to the maintenance and inspection pit at the end of the central passage with the exclusive traverser from that point. It is so arranged that the required inspection can be made while left on the traverser. Also, on the beam at the top of the inspection pit is provided the hook for lifting the interior when inspecting the circuit breaker.

The circuit breaker is partitioned off from the central passage with wire net shelves. Provided separately on the passage side of the shelves is the a control box which provides the tools and pipings required for the operation of the operating valve so that on-the-spot operation can be made from the passage way. In addition, the mimic bus and indicator lamps are installed in this control box so that observation of the switching indication of the disconnecting switch installed on the second floor of this unit is possible. Furthermore, all of the equipment has been unitized for every bus line

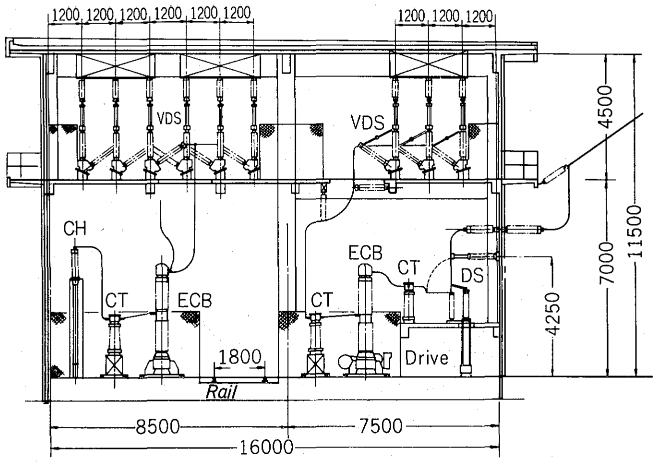

Fig. 11 Vertical section of 70 kv indoor substation

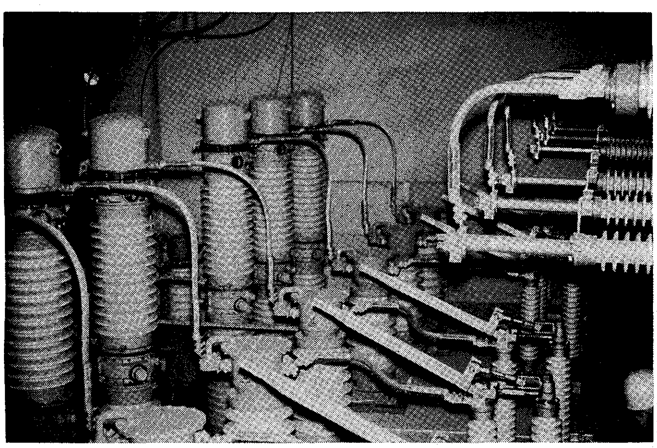

Fig. 12 Equipment installed on the first floor

with a safety shelf provided between each unit so that safe inspection is possible even when the other units are in operation. The metering outfit is installed on the mezzanine while underneath this level is located the compressor and the insulator washing device. On the first floor are installed the switching station control panel, protection relay panel, logger and recorder converter panel, dc power supply unit, the power company pilot wire relay panel, and the meter panel.

4. Specifications of Delivered Equipment

1) Circuit breakers (5 units)

3-pole, single throw, compressed air operation (5kg/cm^2) expansion circuit breaker.

HP 800 C/70/1200 D

84 kv, 1200 amp, 3500 Mva 60 cps

Not only is this unit outstanding in its performance but also exhibits features such as the simplicity of compressed air system and ease of inspection.

2) Disconnecting switches (11 units)

8 units of 3-pole, single throw, compressed air operation V-type disconnecting switch.

HP 265 III/70/1200 D, 800 D

3 units of 3-pole, single throw, compressed air operation vertical 1 break disconnecting switch.

RS 276 III/70/1200 D

The 84 kv, 1200 amp as well as the 800 amp, 32 kva, 60 cps V type disconnecting switches are compact sized themselves and at the same time, in the case of double bus wires, they are very effective. The vertical 1 break disconnecting switch shows the advantages of being widely applicable through various forms and the spaces between them have been minimized.

3) Current transformers (24 units)

Single phase, oil sealed, insulator type CTSO9 80.5 v 1200/5 amp 750/5 amp, 40 va, 1.0 class.

4) Lightning arrester and arrester disconnecting switch 6 phase

Lightning arrester: Perm blast type

HF432/98E, 98 kv, 10 ka with explosion-proof device

Lightning arrester disconnecting switch:

Single-pole, single-throw, hook operating type RF 263/84, 84 kv, 400 amp (2 seconds)

5) Capacitor type potential transformer 9 phases

Single-phase, oil sealed type 77 kv/110 $\Big/ \frac{110}{3}$ v, 200 va and 50 va, 1.0 class.

6) Distribution panel (4)

Switching station control panel, in-house panel, dc power supply panel, converter panel.

7) Auxiliary unit 1 set

Insulator washing device, compressor.

5. Control Protection Relationship

Although the 70 kv switching station can be controlled through the station distribution panel, principally, the switching station is unmanned and the normal supervisory control is done at the central control panel at the power plant electrical room facility. Since the number of controlling points are few and the distance is just 1 km, the simple remote control system as shown *Fig. 12* was applied.

According to this system, only one cable, the type normally used for communications, is required for 1

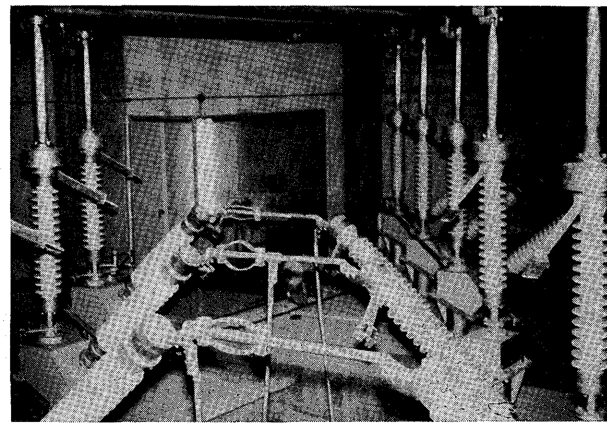

Fig. 13 V-type D.S. on the second floor

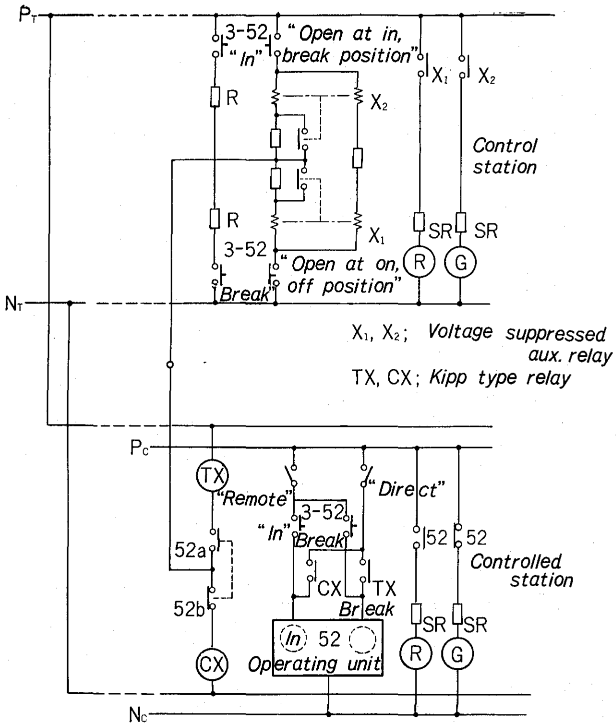

Fig. 14 Tele-control system

unit of circuit breaker or disconnecting switch including the operational indication. When explaining this operation based on *Fig. 12,* CX is operated by the current which passes through PT→CS " in " →R→control connection line→CB a contact→CX→ NT and CB is closed.

At the time CB is activated, the auxiliary contact of CB becomes switched and the current is passed through PT of the controlled location→TX→contact of CB→control connection line→O coil of X1→CS " open at on, off position "→NT to operate X1 and the R (red) lamp of the control point becomes illuminated and indicates the condition of CB closed. At this time, the current will also pass through TX but TX will not operate since part of the voltage is borne by X1.

As for the " break operation ", TX and X2 will operate in accordance with the above "in operation". During the break operation at the controlled location or CB automatic breaking, the current will flow through controlled location NT→CB a contact→ control connection line→O coil of X2→CX " open at in, break position "→control point PT routing and hence, X2 operates and illuminates the G (green) lamp of the control point and the condition of the CB main unit is transferred to the control point reliably.

As for protection, the 70 kv bus wire is provided with the rectified type differential protection relay of this company, since it is outside the power company pilot wire relay protection area, and in the case of trouble the break is made effectively and swiftly.

As for the separation of the commercial power and the generator system, for own supply reverse power relay as well as the frequency lowering factor relay are provided. Besides these, an operational recorder has been provided which records rapidly at the time of trouble data concerning frequency, power, voltage, and current and, at the same time, the operational conditions and the sequence of each circuit breaker and disconnecting switch.

VI. CONCLUSION

Introduced above were two examples of modern indoor substations where cubicle type cubic arrangements have been applied.

It is assumed that the indoor substations hereafter will be made more compact through the application of such as gas sealed bus wire, fixed insulation bus wire, or completely sealed type switching device or perhaps the substation itself will become sealed with high insulation gas such as SF6 gas or liquid. However, these are reserved for future techniques. At on the present time, emphasis is being placed compactness through the application of solid arrange-ment of the equipment, special disconnecting switches, and draw-out type circuit breakers.

Recently, factories and steam power plants are being constructed on land reclaimed from the sea and the substations are being made into indoor types as countermeasures against salt contamination. Also, there are many cases where they are being constructed underneath the buildings, due to site conditions in the urban areas, and the above mentioned examples may be of some use as references in such cases.

Last, but not least, we would like to express our appreciation to Division Chief Sasano, Section Chief Sakata, and Group Leader Utsunomiya of Ube Industries, Ltd., for their advice throughout the planning of this substation.