ON THE CONTACT CONVERTER EQUIPMENT OF 304V, 10,000A DELIVERED TO NOBEOKA WORKS, ASAHI KASEI INDUSTRY CO.

By

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Synopsis

It was in 1951 that the first 250 V, 5,000 A contact converter in Japan was completed by our company and since the next year the actual load test has been performed by the same machine in Nobeoka Works, Asahi kasei Industry Co. Based on this operating result, 3,040 kW (304 V, 10,000 A) single output machine which is the new record in Japan was manufactured to be delivered to the same works with the accessories, operating in good condition since March 1954.

We are intending to introduce simply outline of the same machine, adding several characteristic which the same machine possesses.

For reference, this is the third outstanding contact converter equipment successive to the 250 V, 6,000 A and 250 V, 10,000 A machine which are delivered to Dowa Mining Co. and Kureha Chemical Co. respectively.

I. INTRODUCTION

In 1951, our Company completed the experimental manufacture of the first 250 V, 5000 A contact converter in Japan and since the next year, tests under actual load have been carried at the Nobeoka Works, Asahi Kasei Industry Co. of our customer. Based upon actual operation results thus obtained, the present equipment has been ordered, manufactured and delivered after being put through various factory tests in the end of last year. Since March of this year, the set has been in continuous service with satisfactory results.

This equipment is the third contact converter set in our country after the 250 V, 6,000 A equipment delivered to Dowa Mining Co. and 250 V, 10,000 A set delivered to Kureha Chemical Co. and is a record set, the single unit output of the A. C. machine proper being 3,040 kW. Otherwise, the set has many special features which will be explained simply in the following pages.

II. RATING AND SPECIAL FEATURE OF THE EQUIPMENT

This converter equipment will be used as D.C. source for horizontal mercury cells for salt electrolysis and the total combined rating is as follows:

Input : 3-phase 11,500 V 50 C

Output : D. C. 304 V 10,000 A

Overload : 304 V 12,500 A for 2 hours
304 V 20,000 A instantaneously

Range of Voltage Regulation :
D. C. voltage can be continuously regulated 304 V to 245 V even when source voltage varies between 12,000 V to 10,800 V

Total combined efficiency :
At 125% load 97.05%
100% load 97.22%
75% load 97.27%
50% load 97.23%

Power facter : more than 92%

Main special features of the equipment when enumerated are as follows:

(1) Converter proper (contact mechanism) has a single unit output of 10,000 A and is driven by a synchronous motor and has 12 contacts.

(2) Contrary to the hitherto contact mechanism of the type where piston makes an up and down motion, in this machine the piston moves horizontally fore and aft and the contacts are mounted sidewise.

(3) Overload withstanding capacity is 125% load for 2 hours and 200% load instantaneously.

(4) Stability against load fluctuations is very great, switching in full load from no-load state or full-load switching-out from full load without regulation for overlapping angle being possible without any hitch.

(5) The whole equipment is made totally enclosed or with an oil immersed construction wherever

possible, by which, efforts are taken to prevent corrosion due to chlorine gases. Also, for exposed copper conducting parts, terminals, etc. electroplating with nickel-chrome is done, and further, special care is taken in the outer painting.

The equipment is composed of:

(1) Converter proper (contact mechanism)
(2) Commutating reactor
(3) Main transformer
(4) Short-circuiting apparatus
(5) D. C. choking reactor
(6) D. C. reverse current limiting reactor
(7) A. C. side expansion circuit breaker and line apparatus
(8) D. C. high speed circuit breaker and line apparatus
(9) Pre-exciting device for commutating reactor
(10) Control switchboard

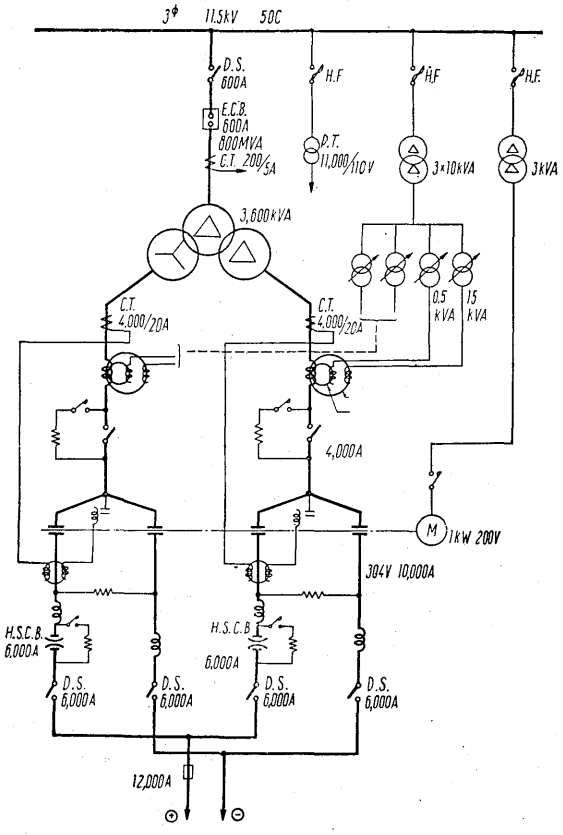

Fig. 1 Skeleton Diagram of 304 V, 10,000 A Contact Converter Set

Formation of the main circuit is as shown in the skeleton connection diagram Fig. 1. That is, secondary winding of main transformer is composed of 2 sets in delta connection and in star connection each respectively being connected to the 6 contact points of converter proper through commutating reactor and starting resistance. Converted current from both delta side and star side is connected to D.C. total combined busbars through reverse current limiting reactor. From secondary of main transformer to D. C. totalizing busbar, both delta side and star side, considered as a circuit, are each independent being able to operate singly by either of them alone. However, voltage regulation, being done by under-load tap change-over device provided in primary winding of main transformer and angle control of converter proper, actuates in common for delta side and for star side.

III. CONTACT MECHANISM (CONVERTER PROPER)

The contact mechanism has the function to convert A. C. to D. C. by breaking and making the contacts mechanically and synchronously with the source voltage and A. C. and D. C. busbars, contacts, driving synchronous motor, eccentric shaft, piston rod, adjusting shaft, etc. are the main parts.

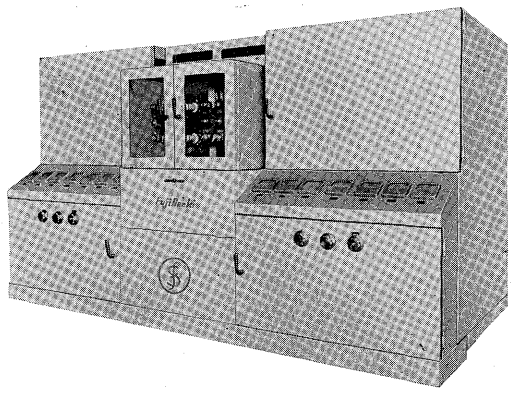

Fig. 2. K-former Proper
Twelve contacts are fixed within centre window of plastic glass

D.C. and A.C. busbars are arranged symmetrically right and left in two sets for 5,000 A. to each of which 6 contacts are attached. The two sets of busbar groups are respectively connected to delta winding and star winding of main transformer and each of them are made to take charge of 5,000 A output. Contact driving mechanism is common for these two sets of busbar groups, or in other words, for the group of contacts. The eccentric shaft is directly coupled to the rotor shaft of synchronous motor which is overhung to the side of contact mechanism and the degree of eccentricity has an angle difference of 30° between delta side and star side. Accompanying the rotation of eccentric shaft, piston rod through help of connecting rod and 3-point lever is driven reciprocating fore and aft horizontally breaking

and making contacts mounted on the busbar group surface in a regular manner.

Length of duration when contacts are closed are at the same time regulated by rotation of eccentricity adjusting shaft penetrating through the centre of 3-point lever. Adjustment of each contact individually is done through change of length of each piston rod from outside by worm gear.

Beside the above-mentioned main parts in the contact mechanism, accessories such as the followings are attached which respectively carry out functions of an auxiliary nature. That is:

(1) Cooling apparatus: A. C. and D. C. busbars are hollow and are cooled by oil flowing through the inside and further the oil is cooled in a recooler by water. Required cooling water quantity is about 20 litres per minute. The oil is circulated by a pump coupled to a motor. (250W)

(2) Lubricating oil apparatus: In order to supply lubricating oil for driving mechanism, a gear pump (1/4 H.P.), oil filter, etc. are provided as accessories.

(3) Automatic controlling apparatus: α angle controlling apparatus for regulating D. C. output voltage and μ angle controlling apparatus for regulating during the period contact is closed are provided in both of which the Thoma regulator forms the main body.

The former converts change of contact converter load current to mechanical output of Thoma regulator and transmits this to stator of synchronous motor for contact driving and by shifting this, makes the period when contact is closed lag behind source voltage phase, thus regulating the output voltage and maintaining the load current always at a constant value.

The latter converts change of load current, change of α angle, change of overlapping angle of commutation due to change of source voltage to change of mechanical output of Thoma regulator and transmits this to regulating shaft penetrating through centre of 3-point lever and to stator of synchronous motor by which the period when contact is open is regulated and contact is made to open always at the middle part of the flat step.

The automatic regulator mechanism is able to be switched over for hand regulation by means of a clutch.

Though the above described apparatus is similar to the set delivered previously to Messrs. Kureha Kagaku K. K., in the point that it can be regulated simultaneously on both the delta side and the star side, that is, simultaneously for 10,000 A, it is different.

(4) Phase shifter for contact making reactor: The commutating reactor is composed of contact breaking reactor and contact making reactor, both of which in order to improve their hysteresis features of the iron core, are provided with secondary windings to which A. C. voltage of suitable magnitude and phase is impressed for the preliminary excitation. Of these, contact making reactor performs the role of preventing wear of contacts by suppressing rise of current in the instant when contact is closed, but the instant when contact closes, will be earlier or later according to the magnitude of α angle control. In order to cut the capacity of contact making reactor down economically and display its function effectively, it is desirable to adjust phase of pre-exciting voltage suitably corresponding to the degree of α angle control. In order to accomplish this, 500 VA, 200/200V 3-phase induction phase shifter is provided in the pre-excitation source on both delta side and star side and the two made to overlap one another are mechanically connected and further they are linked to the α angle regulating device.

(5) Cabinet: The whole contact mechanism is enclosed in a polished steel sheet cabinet on the front side of which a window of plastic glass is provided by which contact parts can be easily supervised from the outside.

Also, for facilitating inspection of the interior and maintenance, the whole cabinet has a construction which enables it to be moved to the rear on rails imbedded in the floor. Air inside the cabinet is ventilated by a small blower mounted on the rear part of the cabinet.

(6) Contact supervision device: On the front surface of cabinet, there are in total 12 overlap angle meters, one each for each contact and in total 2 contact meters, one each for 6 contact groups on delta side and star side are mounted. The former utilizes change of voltage taken from the search coil of commutating reactor during opeation corresponding to the period the contact opens and indicates at what position of the flat step the respective contacts are open. The latter is for measuring the duration contacts are closed by impressing D. C. control voltage between contacts when adjusting length of the respective individual piston rods, and is attached with a change-over switch for six contacts.

As stated above, the present equipment, compared with the hitherto types has been changed and improved in several points of which the most fundamental alteration made is that direction of motion of piston has been changed to a horizontal direction. Though the merits

and demerits of this compared with the hitherto types where motion is up and down cannot be determined for some time to come, with the present type, change of contacts is easy and moreover it can be acknowledged that the construction has the merit of making it difficult for dust to come in the way on the surface of contacts.

IV. SHORT-CIRCUITING DEVICE

It is needless to mention the importance of the short-circuiting device as a protective apparatus for the contact converter. For this device, not only reliable and instantaneous as possible action is required, but moreover its own contacts must have a short-circuit strength which is ample to withstand short-circuits produced by itself. Actuating time of short-circuit device at present is about 1.5/1,000 second but subject to more or less change according to operating conditions.

When one group of contacts from delta side or star side of converter proper fails in rectification, the short-circuiting device of that side actuates immediately but on account of A. C. voltage drop on the healthy side due to this short-circuit current or unbalance, etc. of voltage when switching off primary side circuit breaker, there may be cases when even contacts on the healthy side will be damaged. In order to prevent this, when one of either side short-circuit device actuates, it is so made that D. C. voltage will be impressed in the release circuit of healthy side short-circuit device by its auxiliary contact and by interlinkage of action, primary side circuit breaker will be released after then.

V. MAIN TRANSFORMER AND COMMUTATING REACTOR

The main transformer is a indoor use internally water cooled type having the following particulars:

Capacity	:	3,600 kVA
Primary Winding	:	11,500 V Delta-connection
Secondary Winding	:	Corresponding to D. C. 304 V Delta and Star connection
Tap Voltage	:	Converted into D. C. Voltage 324-314-304-295 286-277-268-235 V
Tap Change-over	:	A. C. Motor operated Under-load tap-changing type

As for windings, primary windings and secondary windings are arranged alternately in sandwich form, careful consideration being taken to make leakage reactance as small as possible and also to make fluctuations when changing taps as small as possible.

The commutating reactor is composed of contact breaking reactor and contact making reactor. Both have ring core of iron-nickel alloy and the two are overlapped and common main winding is wound. The contact breaking reactor has an ample capacity to produce a flat step of over 25° electrical angle at rated voltage. The commutating reactor is contained in the same tank with the main transformer inside but because iron-nickel alloy has magnetizing characteristics which are relatively sensitive to mechanical shocks, the reactor is supported above and below and sidewise by buffer springs and flexible conductors are used for connecting conductors, which make the construction considerably complicated. Also, in the reactor, pre-exciting winding and search coil are wound on each phase and these many auxiliary winding terminals are brought together and led out of the tank through an oil-tight bushing in the middle of tank.

The main tank is attached with a nitrogen gas filled type compensator.

VI. SWITCHBOARD

The switchboard is composed of the following 4 sets:

(1) Control desk: This is equipped with main control switch, switch for emergency stop, D. C. voltmeter, D. C. ammeter, Braun tube oscilloscope, transformer tap changing switch, etc. and operation of the whole equipment, start, stop or regulation of output, etc. are all performed from this desk.

(2) Enclosed type vertical panel: This is equipped with A. C. side voltmeter, ammeter, wattmeter power factor meter, recording meters for A. C. voltage, D. C. current, overlapping angle of contacts, fault indicator, etc. and otherwise control source switch, etc. on the front board and on the rear board, as relay panel, various protective relays, automatic control relays, magnetic contactors for various auxiliary circuits, etc. are mounted.

(3) Enclosed type auxiliary running panel: This is a cubicle of steel sheet with door in which commutating reactor, choke coil for pre-excitation circuit, selen rectifier for by-path circuit, resistance, reactor, etc., selen rectifier for short-circuiting device circuit, magnetic amplifier for automatic regulation, etc.: That is, auxiliary circuit apparatus that do not require supervision and adjustment are contained.

Pre-excitation circuit for commutating reactor

is divided into that for contact breaking reactor and for contact making reactor. The former transformes the 200 V voltage obtained from the 30 kVA auxiliary transformer by a 15 kVA step-up transformer and together with main transformer secondary voltage into about 400 V, and impresses this on the pre-excitation winding after dividing it into delta side and star side.

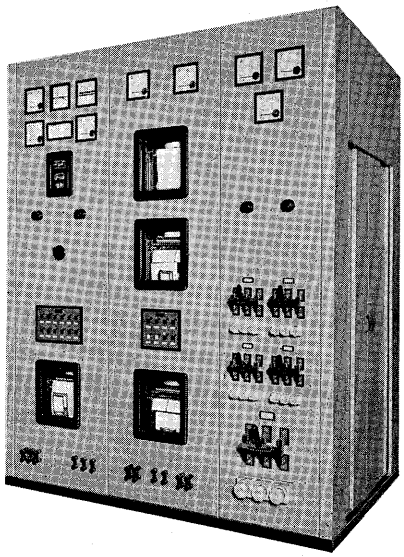

Fig. 3 Enclosed Vertical type Main Switchboard

Voltage phase adjustment is carried out by a 15 kVA induction phase regulator inserted in the 400 V circuit. The latter similarly impresses the 200 V voltage obtained from the auxiliary transformer on the pre-excitation winding by the 500 VA phase shifter mounted on the converter proper while adjusting phase corresponding to α angle in the same way as stated above.

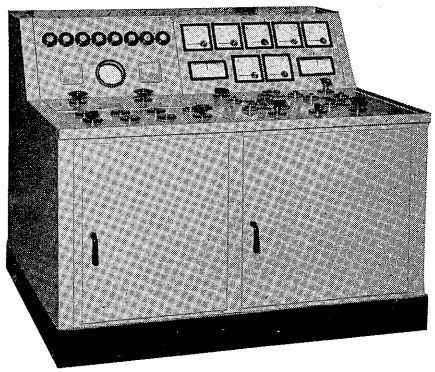

Fig. 4 Control Desk
Right Side on Panel : Control Sw., Instruments
Left Side on Panel : Braun Tube Oscilloscope, Pilot Lamp of Transformer Tap.

(4) D. C. busbar case: This is a large type switchbox of sheet steel with door containing inside inverse current high speed air circuit breaker for D. C. main circuit, disconnecting switch, shunt, choking reactor, D. C. busbar, etc. As this switchboard is made as an enclosed type, the size is taken considerably large in order to prevent danger from heat generated by the apparatus inside and from arcs formed when air circuit breaker operates.

In all the various apparatus and instruments mounted on the above switch panels, various precautions have been taken in order to avoid corrosion due to chlorine gases. For example, all controlswitches are made oil-immersed and signal lamps also are contained in air-tight casing. Further, relays and magnetic contactors also are enclosed in casing provided with covers having special rubber packing and terminals, contacts, etc. are all plated with nickel-chrome plating.

VII. ARRANGEMENT OF EQUIPMENT, ETC.

The building is a reinforced concrete 2-story one, the first floor containing extra high tension side circuit breaker, apparatus, main transformer (containing commutating reactor inside), secondary side motor operated type disconnecting switches and the converter proper, controlling switch panels being installed on the second floor. Because specific gravity of chlorine gas is heavy, comparatively delicate switchboard apparatus, converter proper, etc. are installed as high as possible above the ground and it is desirable to have the

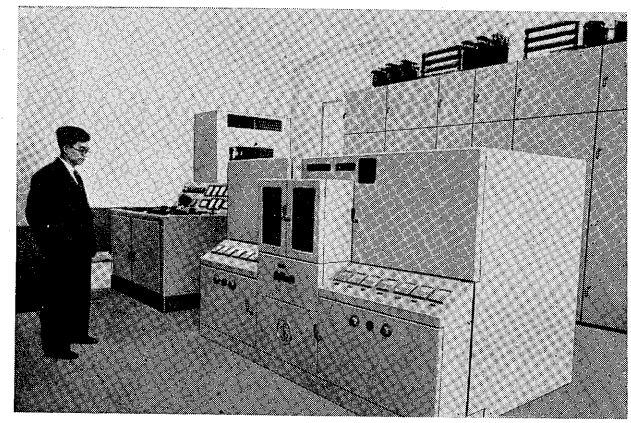

Fig. 5 Arrangement of Equipment in Actual Plant (2nd Story)
In Front : Contact Converter
Just Under the Converter : Main Transformer (1st Story)
Back of Converter : Enclosed Type Auxiliary Switchboard
Left Side : Control Desk
Back of Control Desk : Air Conditioner

room containg these enclosed. An air conditioner has been installed in the second floor room by the customer who makes it a principle to regulate the room temperature and keep the room constantly enclosed.

We feel very gratified that the present equipment which is the third contact converter plant in our country and also which has the record capacity has been set in full operation. Further, in the near future, 250 V, 10,000 A equipment for extension for Messrs. Kureha Kagaku Co., 300 V 10,000 A equipment for Messrs. Kanegafuchi Kagaku Co., 125 V, 6,000 A equipment for Messrs. Edogawa Kagaku Co. etc., will all be put into operation one after the other and we are convinced that the contact converter will be the only type of converter equipment for electrolytic source requiring large current at low voltage for future installations.

7,000 HP TWIN DRIVE ILGNER SET FOR KAWASAKI IRON WORKS COMPANY

By

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Synopsis

In July 1953, we delivered 5,000 kW Ilgner set to Nippon Kokan K. K., and in January 1954 4,500 kW Ilgner set to Yahata Iron Works. Recently, we completed 7,000 HP twin drive Ilgner set for blooming mill by the order of Kawasaki Iron Works, which was made by United Engineering Foundry & Co. U. S. A. and installed at Chiba Plant and obtained the unexpectedly excellent results by the test at our works. Here we describe the outline of the set for reference as follows.

I. GENERAL DESCRIPTION OF TWIN MOTOR TYPE

It is well known that main motors for reversible blooming mills are the most severely used ones among the large capacity electric motors. Excess overload and shock is electrically and mechanically sustained because of frequent and rapid accelerating, reversing, and the rolling load. In order to sustain overload, good commutation must be arranged, and to ease rapid reversing, the GD^2 must

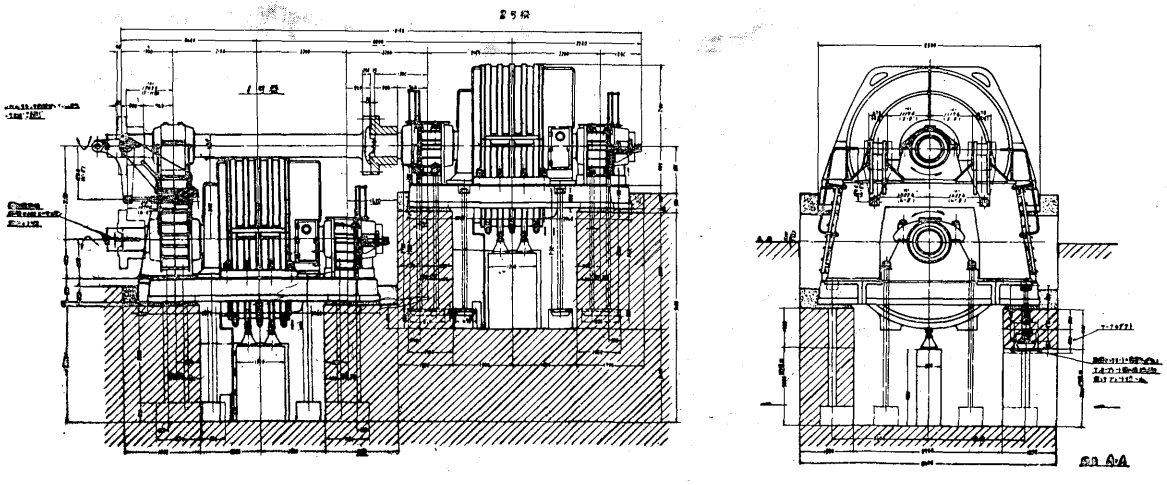

Fig. 1. Arrangement of Twin Drive Main Motor