ELECTRICAL EQUIPMENT FOR 4.2 m PLATE MILL DELIVERED TO KAWASAKI STEEL CORP.

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I. PREFACE

Since the operation has successfully started after adjustment test during about one month since the end of April 1961, we wish to introduce the content of the equipment. The top-forward system has been adopted for the first time in Japan on twin motor type DC motor of $2 \times 3{,}750$ kW for the main mill.

In the conventional system of twin motor type, the lower roll motor is arranged closely to the rolling mill and the upper roll motor arranged behind it. In this system, when overhauling the lower motor especially when inspecting the bearing metals at the driving side, the spindle shaft and bearing pedestal of the upper roll are needed to be taken off, which is very inconvenient for maintenance and inspection.

In the top-forward system, contrary to the above, the upper roll motor is arranged closely to the rolling mill and the spindle shaft for the lower roll is so constructed as to pass through the lower side of the upper roll motor, whereby it enables the maintenance and inspection very convenient.

Rotating amplifier "Rapidyne" and magnetic amplifier are used for the main machine control to make the reversing time, from positive base speed to negative one, approximately one second. For the variable voltage DC auxiliary motor control, Rapidyne and magnetic amplifier having saturable character in its voltage control system are adopted to improve acceleration and deceleration characteristics.

Edger roll opening adjustment is made by the automatic follow-up with pulse control syetem using transistors, because no mechanical tie is provided between both side rolls.

The main rolling machines and the shearing machines are manufactured by U. E., U. S. A. and Schloemann, W. G., respectively, while other machines are all by Japanese manufacturers. The electrical equipment are all manufactured by our Company and the installation and wiring of these equipment are conducted by the Fuji Electric Construction Co., one of our affiliated companies.

Fig. 1 shows the arrangement of the electrical equipment in No. 1 electric room.

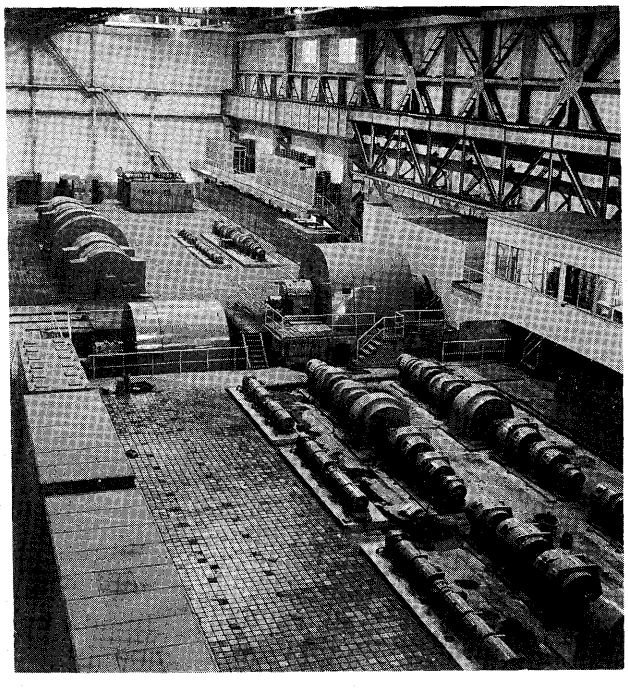
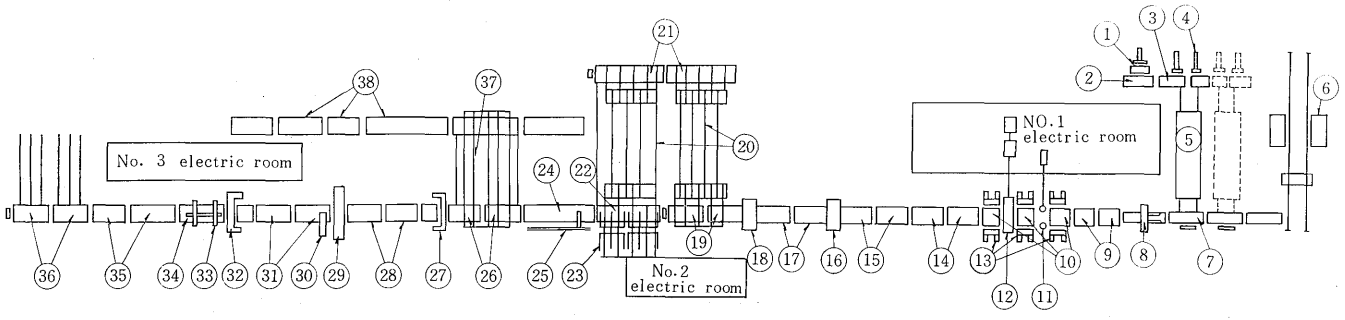


Fig. 1 Arrangement of main electric room

II. OUTLINE OF MACHINES

The arrangement of machines is illustrated in *Fig. 2*. The whole length of this line extends as long as approximately 600 m. The finished product is 6.0 mm in minimum thickness, 3.9 m in maximum width, 25 m in maximum length and 16 tons in maximum weight. The equipment has rolling capacity of 600,000 tons/year in finished product.

Standard size slabs and non-standard size slabs are heated in the continuous furnace and the Batch furnace, respectively, then transfered to the furnace delivery table. Descaling is carried out by jetting the high pressure water of approximately 100 kg/cm^2. This method is considered to be an advanced one redeeming such a defect of usual roll system scale breaker as scales bite into the plate surface, and giving rather low installation cost. The main mill is 990 & $1{,}700 \times 4{,}200$ mm 4 H reversing mill, of



① Slab depiler
② Depiler table
③ Furnace entry table
④ Furnace pusher
⑤ Continuous furnace
⑥ Batch furnace
⑦ Furnace delivery table
⑧ Descaling
⑨ Edger approach table
⑩ Mill table
⑪ Vertical roll
⑫ Horizontal roll
⑬ Centering side guide
⑭ Mill runout table
⑮ Light leveller entry table
⑯ Light leveller
⑰ Light leveller delivery table
⑱ Heavy leveller
⑲ Cooling bed entry table
⑳ Cooling bed
㉑ Cooling bed delivery table
㉒ Inspection table
㉓ Inspection machine
㉔ Marking table
㉕ Making
㉖ Crop shear entry table
㉗ Crop shear
㉘ Crop shear delivery and rotary shear entry table
㉙ Rotary shear
㉚ Slitter
㉛ Rotary shear delivery & end shear entry table
㉜ End shear
㉝ Shear gauge
㉞ End shear delivery table
㉟ Scale & inspection table
㊱ Piler table
㊲ Transfer
㊳ Flame cutting line table

Fig. 2 Arrangement of machines

which back-up roll diameter 1,700 mm is the maximum one in our country. Such a big diameter of back-up roll permits to produce high quality plate of uniform thickness. The plates of 6.0～15 mm thick and those of 10～40 mm thick are formed by the 4H light leveller and 2H heavy leveller, respectively. The plates passed through the cooling bed are turned over and inspected by the inspection machine. The plates can be transfered on the inspection table as it is turned over, too. Marking is carried out on the marking table. The plates of less than 20 mm thick are placed on the crop shear, rotary shear, slitter and end shear to form a finished product. The new rocking system is adopted on the crop shear and the end shear to prevent from bending when shearing. Then the plates are weighed on the scale table and delivered through the piler. The plates of above 20 mm thick is transfered to the flame cutting line by the transfer and cut by the newly developed multi-burner system series cutter.

III. MAIN ELECTRICAL EQUIPMENT

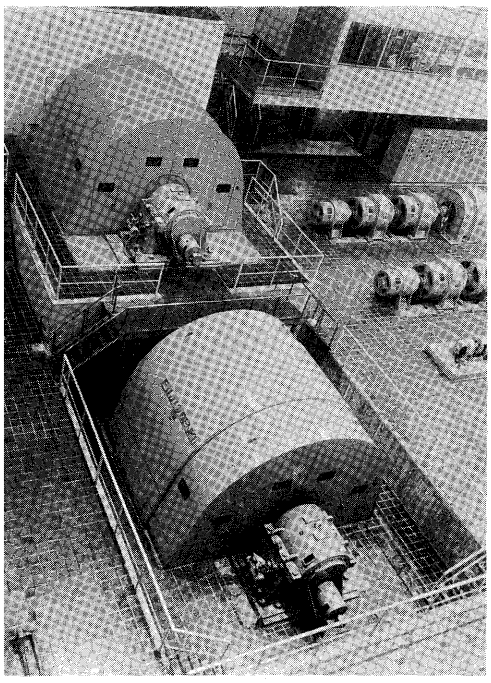
The specifications of the main mill motor are shown in *Table 1*. On this motor, the twin drive top-forward system has been adopted for the first time in our country. The output of 3,750 kW 40 rpm as a single armature is the record making one next to the 5,000 kW 50 rpm motor delivered to Kawasaki Iron Works, Nippon Steel Tube Co., Ltd. Twin drive system has been much adopted on blooming mills, slabbing mills and plate mills since our Company adopted this system for the first time in Japan in 1954 on two sets of 3,500 HP motor delivered to Chiba Iron Works, Kawasaki Steel Corp. The conventional twin drive system so far adopted is of shaft-over construction, i.e., the upper roll motor is set behind the lower roll motor and the spindle shaft of the upper motor traverses over the lower motor. In this construction, the lower motor is set in the pit, and the space under the upper roll spindle shaft and the foot of foundations are limited, which prevents easy removal of the commutator cover of the lower motor and necessitates to divide the cover into several pieces in case when cleaning or overhauling. Furthermore, as the drive side bearing is housed in the intermediate bearing pedestal, inspection of the bearing under operation is difficult and overhauling works are needed in a big way when some fault occurs in the bearing. The bearing cover of this system is accordingly divided into several pieces to redeem the above-mentioned defect to some extent.

***Table 1* Specifications of main mill motor**

Quantity	2	Excitation	Separate excited 220/440 V
Output	3,750 kW	Rating	Continuous
Voltage	±750 V	Insulation class	Class B
Current	5,380 A	Temperature rise	50°C
Speed	±40/80 rpm	GD^2	255 t-m^2
Max. working torque	204 t-m (225%)	Armature weight (for 1 set)	66 t
Max. emergency torque	250 t-m (275%)	Total weight	448 t

The top-forward system, on the contrary to the shaft-over system, is to set the upper roll motor closely to the rolling mill and to pass the spindle shaft of the lower roll motor directly under the upper motor, whereby the above-mentioned defects of shaft-over construction are completely redeemed. *Fig. 3* shows the installation view of the top-forward system main mill motor and *Fig. 4* shows the outline construction of this motor.

By adopting the top-forward system, we could have the following advantages as well as eliminating the defects just described above, i.e., the bearing pedestal of approximately 30 tons could be neglected, exposed rotating part such as the spindle shaft could be protected, the back side motor so far installed in the center of electric room on high position as a upper motor could be sunk down into the pit as a lower motor to command a wide vision in the electric room,



ig. 3 Twin drive type main mill motor (top-forward)

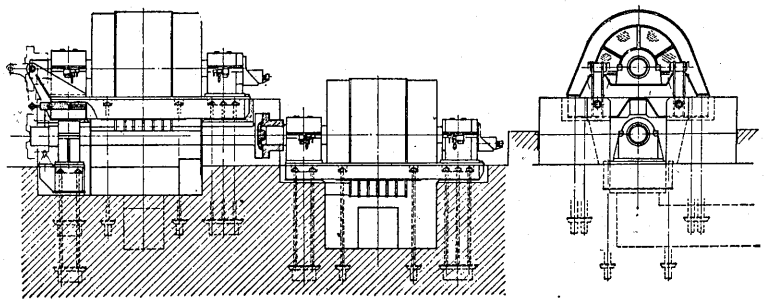


Fig. 4 Outline view of main mill motor

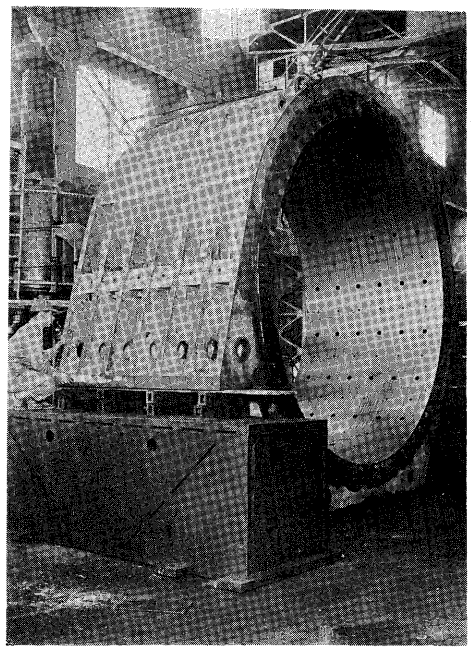


Fig. 5 Laminated yoke of main mill motor

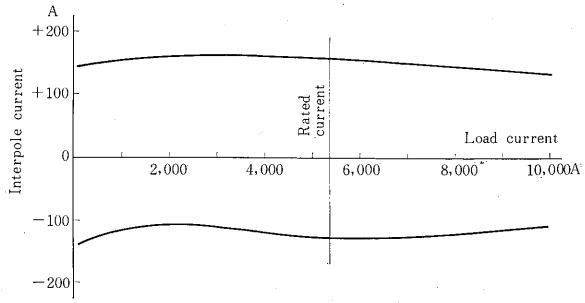


Fig. 6 Black band of main motor at 80 rpm

ıd between both motors the passing way could be ·ovided which afforded much convenience for ıssing and accessing. The center distance between ıe upper and lower motor's shafts is 94 in. ',387.6 mm).

As the problem on top-forward system, the pro-ems caused by cutting a part of the upper motor's ıundation immediately under the bearing pedestal ı pass the spindle shaft through the foundation, the ethod of taking out the spindle shaft and bearings case of emergency and the method of supporting ıe bell crank etc. should be considered. This time, ıch a consideration has been paid in designing that .e spindle shaft can be taken out together with the ;aring toward the mill room and the bearing ;destal as well as the bearing cover and bearing etals can be segregated each other and taken out aving the spindle shaft as it is. The spindle shaft completely protected with a cover in the pit, which iminates danger even in case someone enters into e pit. Into the gap between the spindle shaft and e cover, clean air in the electric room is blown to ·event dust accumulation.

Regarding the windings, class B insulation is adopt-l on the armature windings and, furthermore, special tention is paid on cooling of windings because of e extremely long armature core length, and the ;w insulation method having high heat resistivity ;veloped by using Epoxy resins tape is adopted.

egarding the yoke, laminated construction is adopted shown in *Fig. 5*. This is more effective in transient ımmutation, because the time constant of interpole agnetic circuit in case of laminated yoke is 1/5∼1/10 ' that in case of non-laminated yoke. Actually, the motors this time delivered are free from spark even when such a quick accelerating and decelerating operation as reversing time of one second under actual rolling operation. In the result of commutation test in our factory, no spark was confirmed under maximum working torque 225% at base speed 40 rpm, and superior black band was obtained at the maximum speed 80 rpm as shown in *Fig. 6*.

The specifications of the edger roll motor is shown in *Table 2*. This motor is of double armature construction to reduce GD^2. Since the commutators of both armatures are faced each other in center as shown in *Fig. 7*, inspection of the commutators can be carried out at the same time and, furthermore,

Table 2 **Specifications of edger roll motor**

Output	2×560 kW	Max. working torque	16.3 t-m (225%)
Voltage	±2×375 V	Max. emergency torque	20 t-m (275%)
Current	1,630 A	Excitation	Separate excited 220/440 V
Speed	±150/375 rpm	Rating	Continuous

Table 3 **Specifications of Ilgner converter**

	DC generator	DC generator	Induction motor	Fly wheel
Quantity	4	1	1	1
Output	2,250 kW	1,250 kW	6,700 kW	168,000 kW-sec
Voltage	±750 V	±750 V	6,600V	480 t-m²
Current	3,000 A	1,670 A	690A	—
Speed	400—485/500 rpm			
Rating	Continuous			—
Max. output	275%	275%	300%	

maintenance such as brush replacement etc. can be easily conducted because of doubling the space around the commutators.

The specifications of Ilgner converter is shown in *Table 3*. Arrangement of the equipment is, as shown in *Fig. 8*, that the main induction motor and fly wheel are placed in the center of this set, both side of which two or three sets of DC generator are coupled together to balance the both sides of load. The DC generators are of laminated york to enable no-spark condition even at 225% load. To facilitate the maintenance and inspection, the opening space for commutator inspection is greately widened.

1. Main Machine Control

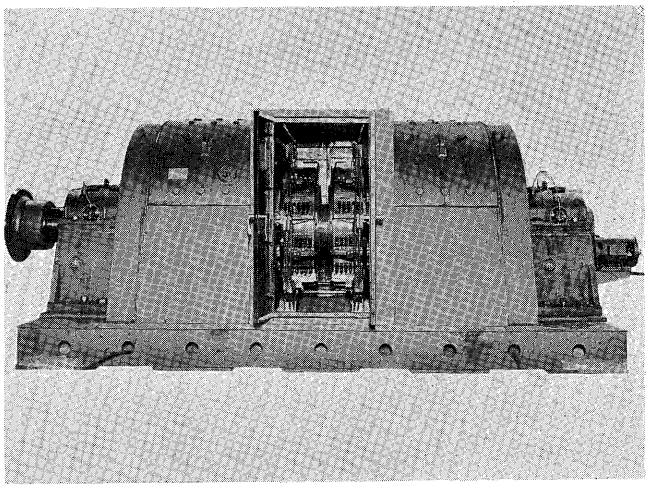


Fig. 7 Edger roll motor

Fig. 8 Arrangement of Ilgner converter

Because our Company had manufactured so many electric equipment of this kind, we made a good use of the rich experience on control system and studied the circuit constants by an analogue computor to secure the successful control. As we have before described the deteils of the control circuit operation in separate cover, only an outline is introduced in the following columns.

Fig. 9 shows the control circuit of the main mill motor. The lower motor M_1 and and the upper motor M_2 are normally supplied with the power from DC generators G_1, G_2 and G_3, G_4, respectively. When either one of the generators becomes out of order by any chance, it must be disconnected from the circuit and three common disconnecting switches must be thrown in, which permits regular operation of both upper and lower motors by supplying the power from three generators in common. The speed control system of the main motor is voltage control up to 40 rpm, and by field control from 40 rpm to 80 rpm. The operation is made by a foot operated master controller having three notches within voltage control range and four notches within field control range.

2. Voltage Control Circuit

Rapidyne *MGC* for voltage control makes excitation of two exciters MGE_1 and MGE_2 for the main generators. And the exciters MGE_1 and MGE_2 make excitation of the main generators G_1, G_2 and G_3, G_4, respectively. The generator voltage is fed back from one of four generators. A voltage pilot *MVP* is provided in the feed-back circuit as usual for the purpose of steep increase of voltage. In case of the circuit shown in *Fig. 9*, voltage unbalance between G_1 and G_2 or between G_3 and G_4 is out of question because of cumulative series field action, while voltage unbalance between the upper and the lower motor comes into question. Rapidyne *MVB* is, consequently, equipped to obtain voltage balance between

both motors. *MVB* is to detect the voltage difference between the upper and the lower motor and to make excitation of MGE_1 and MGE_2 to minimize the voltage difference. The fields of MGE_1 and MGE_2 are both connected to a bridge circuit to eliminate the mutual interference between the outputs of *MGC* and *MVB*. The Rapidyne *MVB* is so designed as to raise the gain of voltage balance system and to quicken the response rather than the loop of voltage control system for the purpose of obtaining not only the voltage balance between the upper and lower motors in normal condition, but also that in transient condition and the favorable characteristics for the stability of feed-back system. However, by thorough design, manufacturing and careful adjustment at site, *MVB* actually produces only a little voltage, which means that the same characteristics of the motors are obtained.

Where two feed-back systems, i.e., voltage control system and voltage balance system are mutually combined as in the case of this control system, balance on circuit and mutual interference on circuit should be thoroughly studied. In this connection, ample consideration has been paid on this control system to get a favorable action of damping circuit by taking out the sum of two exciter voltages MGE_1 and MGE_2 and also by taking out the difference of these voltages.

Fig. 10 shows the oscillogram of quick acceleration and deceleration of the main roll motor within voltage control range. The reversing time between +40 rpm to −40 rpm is only 1.08 sec.

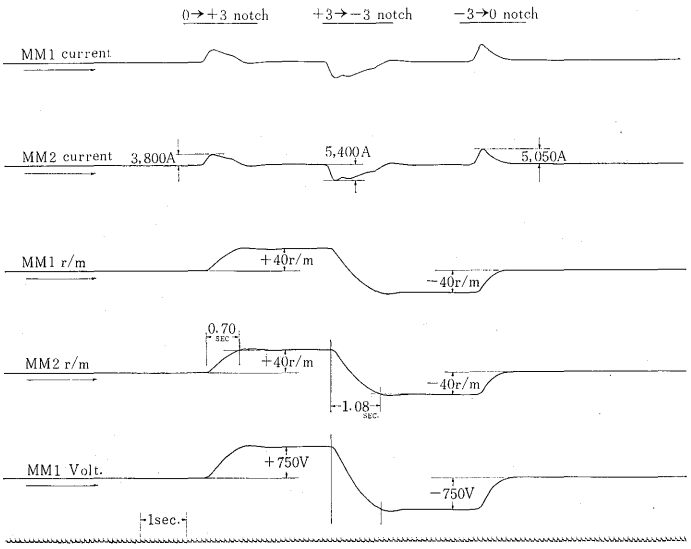


Fig. 10 Oscillogram of main roll motor

3. Field Control Circuit

Rapidyne *MMC* makes excitation of two exciters MME_1 and MME_2 which excite the main mill motors M_1 and M_2, respectively. The field control system has such a feed-back that the sum of current flown in MME_1 and MME_2 is fed back to the field of a field pilot *MFP* through a *DCCT*.

Same characteristics are practically obtained between M_1 and M_2 as in the case of voltage control system. The setting of field current is made by the potential division of resistance which is compared with the feed-back signal, i.e., *MEP* output. Generally, within the range of field control, field time constant is changed by the saturation effect of field magnetizing characteristics. In damping circuit, ampere-turn and

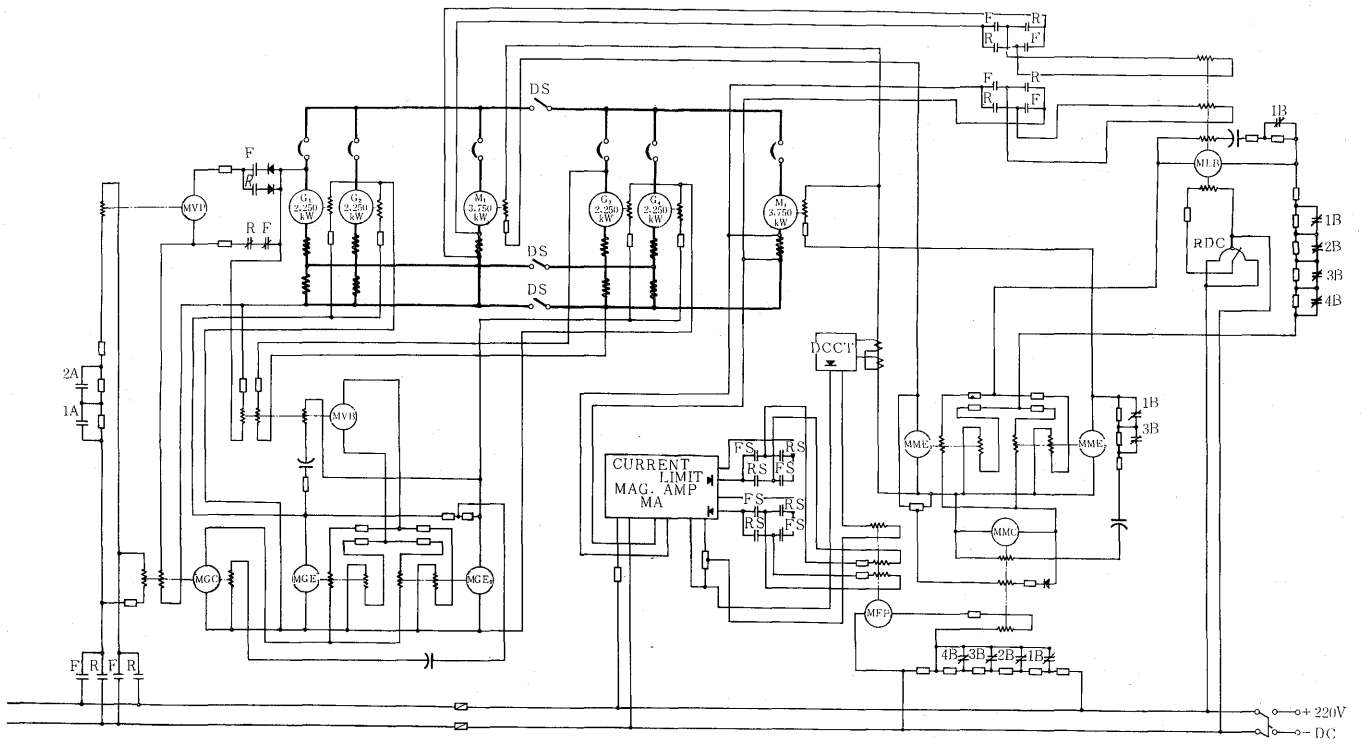


Fig. 9 Control circuit of 2×3,750 kW plate mill motor

time constant are suitably adjusted by the notch change-over relays *1B* and *3B*, corresponding to the field time constant. The circuit in which output of *MME* is fed back to *MMC* through a rectifier, is to make the current change at deceleration time coincide to the ideal curve. Since, generally, the current direction in *DCCT* cannot be identified, an aditional circuit is provided to keep back the current at the normal direction automatically even when the current is reversed by any chance.

4. Roll Diameter Compensating and Load Balancing Circuit

Rapidyne *MLB* is for roll diameter compensating and load balancing. The change-over of resistances at *MLB* output circuit by the field notches is to obtain the constant ratio of roll diameter compensating effect at any notch. In case when various controls are conducted in field circuit, because of non-linearity of field saturation curve and speciality of motor's characteristics, the transfer character to motor armature current is generally changed. Accordingly, same countermeasure for this problem should be taken. It also causes a little fluctuation of loop gain in the load balancing circuit by changing the notches to keep the roll diameter compensating effect constant, which however out of question in practical use. In the load balance circuit, by changing the field current, armature currents are balanced and outputs of the upper and lower motors are kept constant. *MMC* output and *MLB* output are connected in bridge not to interfere each other. *Fig. 11* shows the oscillogram of the load balancing.

5. Overload Limiting Circuit and Protection Circuit

Such a consideration has been taken that the operation could be continued without tripping ACB, even when overload, by either increasing or decreasing the field current by a magnetic amplifier. For the overload at rolling, to reduce the generator voltage is only to reduce the motor speed without reducing the main circuit current. Current limiting is applied only on field control side to reduce the main circuit current by increasing field current. Field demagnetizing circuit and other protection circuit have been thoroughly studied as the case before.

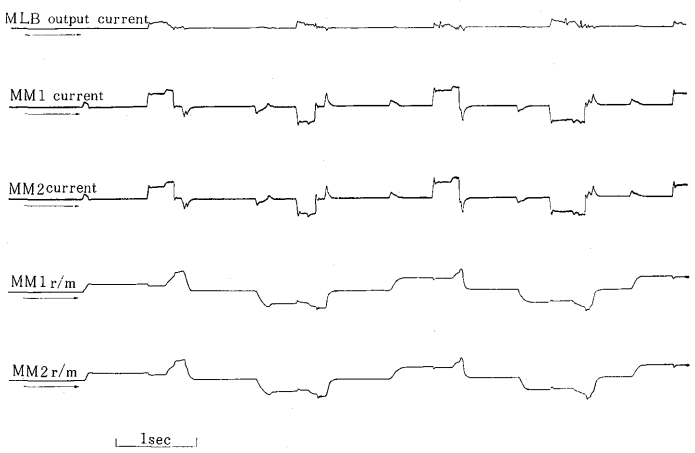


Fig. 11 Oscillogram of load balancing

6. Edger Roll Motor Control

Two motor's armatures are connected in series, to which the power is supplied by one generator. Control circuit is nearly same as the main roll motor.

Draft compensation against the main roll can be adjusted, besides the speed matching to the main roll is effected by giving the drooping characteristics on generator voltage by a feed-back circuit.

IV. AUXILIARY ELECTRICAL EQUIPMENT

The auxiliary electrical equipment comprises 100 sets of variable voltage DC motor (total output 2,926 kW), 21 sets of constant voltage DC motor (total output 1,015 kW), 96 sets of AC motor (total output 4,552 kW) and 345 sets of AC roller motor etc. Respective specifications of these motors are shown in *Table 4, 5, 6 and 7*, and the group of AC roller motors is shown in *Fig. 12*.

When the operation efficiency of roll equipment is to be rised it is necessary not only to shorten the acceleration and deceleration time but also to take an ample consideration on co-ordinating the auxiliary machines with the main machine. In this respect, we have adopted a progressing system based on rich experience.

1. Variable Voltage Control Aux. Motor

For variable voltage control aux. motor, a current limiting circuit is provided to have a quick response which effectuates motor's function to the maximum

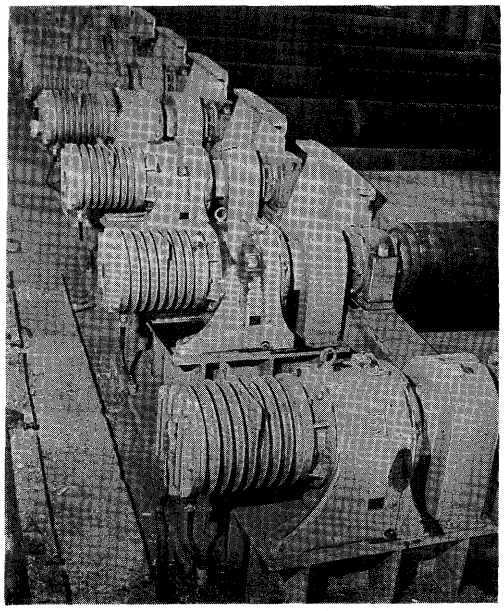


Fig. 12 AC roller motors

Table 4 **List of variable voltage DC aux. motors**

Machines	DC motors							
	Output (kW)	Rating	Speed (rpm)	Voltage (V)	Type (AISE)	Ventilation	Q'ty	Brake
Edger approach table	110/220	Cont.	460/920	220/440	616	Forced	2	—
Edger front table	110/220	Cont.	460/920	220/440	616	Forced	2	—
Front & back mill table	110/220	Cont.	460/920	220/440	616	Forced	4	—
Front & back mill individual roll	25.7	Cont.	171.4	193	614	Forced	6	—
Mill feed roller	25	Cont.	156	185	614	Forced	6	—
Front & back gauge roller	7.54	Cont.	180	169	608	Forced	2	—
Mill screw-down	110/275	Cont.	460/1,150	220/550	616	Forced	2	Air
Edger roll opening adjust	75/150	Cont.	485/970	220/440	614	Forced	2	Shunt
Mill run-out table	110/220	Cont.	460/920	220/440	616	Forced	2	—
Light leveller	65	Cont.	400/1,200	220	Nearly 614	Forced	1	—
Light leveller entry & delivery table	44	Cont.	500	220	Nearly 612	Forced	4	—
Cooling bed entry table	44	Cont.	500	220	Nearly 612	Forced	2	—
Heavy leveller	200	Cont.	400/1,200	220	Nearly 622	Forced	2	—
Light leveller replacing table	1.8	Cont.	1,400	220	Industrial flange	Totary enclosed	3	—
Rotary shear entry & delivery table	1.8	Cont.	1,400	220	Industrial flange	Forced	54	—
Rotary shear	60	Cont.	400/800	220	Nearly 614	Forced	2	—
Scrap chopper	60	Cont.	400/800	220	Nearly 614	Forced	2	—
Slitter	60	Cont.	400/800	220	Nearly 614	Forced	1	—
Plate holder travel	6	40% ED	500/1,000	220	Nealry 606	Totally enclosed	1	Shunt

N.B. 1) Field: DC 220 V

2) Class B insulation, temperature rise less than 75°C.

extent when accelerating or decelerating operation is performed. Generally, since the ratio of load's GD^2 to motor's output in case of auxiliaries is greater than that in case of main machine, this point comes into problem. After control switch is quickly operated and input signal becomes a unit function form, the input signal comes to peak at its initial time of current response. Therefore, time relay and other apparatus are generally attached to the input circuit to delay the input signal.

This time, we have conducted various analysis on this problem and by the suitable selection of various constants and characteristics of each amplifier, we have improved the characteristics so that the ideal response wave of current could be obtained even when the control switch was quickly operated.

There are generally two kinds of the control circuit system, one is combination of a 400 c/s magnetic amplifier and a single Rapidyne and the other is combination of a 50 c/s magnetic amplifier and a double Rapidyne. This time, the former is adopted for the main roll screw-down and the edger roll opening adjustment, and the latter is for other variable voltage auxiliaries. The former was already adopted for the auxiliaries of temper mill delivered to Mizue Iron Work, Nippon Steel Tube Co., of which characteristics were described in another volume. Therefore, only the characteristics of the latter will be introduced in the following columns.

The outline of control circuit is shown in *Fig. 13*. By setting a magnetic amplifier at the first step, only a small input is required, which makes the control very convenient. Response characteristics are shown in *Fig. 14*. Taking motor's overload characteristics

Table 5 **List of aux. M-G**

Group	Output (kW)	Rating	Voltage (V)	Field	Q'ty	Service
1 • 2	150/300	Cont.	240/480	2 kW Rapidyne	4	4×110/220kW motor, Edger approach, Mill front table
	150/375	Cont.	240/600	2 kW Rapidyne	2	2×110/275 kW motor, Mill screw-down
	110	Cont.	210	2 kW Rapidyne	2	6×25 kW motor, Mill feed roller
	100	Cont.	230	Magnetic Amplifier	2	Constant voltage source
	11	Cont.	180	2 kW Rapidyne	2	2×7.54 kW motor, Gauge roller
	Synchronous motor: 850 kW 6,600 V, 50 c/s, 1,000 rpm, p.f.=0.8 leading, 2 sets					
3 • 4	150/300	Cont.	240/480	2 kW Rapidyne	6	6×110/220 kW motor, Edger front, mill back, mill run-out table
	110	Cont.	210	2 kW Rapidyne	2	6×25.7 kW motor, Mill indivisual roll
	100/200	Cont.	240/480	2 kW Rapidyne	2	2×75/150 kW motor, Edger opening adjust
	55	Cont.	240	2 kW Rapidyne	2	2×44 kW motor, Light leveller entry table
	Synchronous motor: 850 kW, 6,600 V, 50c/s, 1,000 rpm, p.f.=0.8 leading, 2 sets					
5	500	Cont.	480	2 kW Rapidyne	1	2×200 kW motor, Heavy leveller
	80	Cont.	240	2 kW Rapidyne	1	65 kW motor, Light leveller
	55	Cont.	240	2 kW Rapidyne	4	4×44 kW motor, Light leveller delivery, cooling bed entry table
	50	Cont.	230	Magnetic amplifier	1	Constant voltage source
	8	Cont.	240	2 kW Rapidyne	1	3×1.8 kW motor, Light leveller replacing table
	Synchronous motor: 900 kW, 6,600 V, 50 c/s, 1,000 rpm, p.f.=0.8 leading, 1 set					
6 • 7	160	Cont.	480	2 kW Rapidyne	2	4×60 kW motor, Rotary shear, scrap chopper
	80	Cont.	240	2 kW Rapidyne	1	60 kW motor slitter
	35	Cont.	240	2 kW Rapidyne	4	54×1.8 kW motor, Rotary shear entry & delivery table
	50	Cont.	230	magnetic amplifier	1	Constant voltage source
	8	Cont.	240	2 kW Rapidyne	1	6 kW motor plate holder travel
	Induction motor: 350 kW, 3,300 V, 50 c/s, 980 rpm, 2 sets					
8	150/300	Cont.	240/480	2 kW Rapidyne	1	Spare
	110	Cont.	210	2 kW Rapidyne	1	Spare
	55	Cont.	240	2 kW Rapidyne	1	Spare
	Induction motor: 350 kW, 3,300 V, 50 c/s, 980 rpm, 1 set					

N. B. 1) Class B insulation, temperature rise 50°C

into consideration, the circuit is so designed that the motor's current is to be reduced according to the rise of the armature voltage. The current value to be limited can be adjusted in accordance with mechanical condition and accelerating and decelerating speed etc., and in the case of *Fig. 14* it is set at rather low current.

By the improvement of accelerating and decelerating characteristics, the table motors around the main roll are synchronized to the main roll through the Tacho-dynamo, by which good result can be obtained.

2. Constant Voltage Aux. Motor, Aux. Circuit

For the constant voltage DC aux. motors, normal system of RPDB, RDB+ASSD etc. are adopted. For the constant voltage AC aux. motors, RP control using plugging relays is adopted to improve the characteristics. *Fig. 15* shows the skeleton diagram of this circuit.

Since there are large number of aux. motors and also such aux. apparatuses as solenoid valves etc., the control circuit is much complicated having vari-

ous interlocks, operative conditions, etc. However, it is made in compactness and has high reliability by adopting the aux. relays for AC circuit, type RC 3631–5–1 having good reputation among users, and the heavy duty aux. relays for DC circuit, type RC 51–3 (with 4 a+2 b contacts) and type RC 51–5 (with 6a +4 b contacts) newly developed for this equipment. *Fig. 16* shows the DC aux. relay, type RC 51–3.

3. Edger Roll Opening Adjustment

Automatic follow-up position control is adopted for the opening adjustment of two edger roll motors because no mechanical-tie is provided between them. The follow-up error of within ±1 mm against the roll travelling distance 1,700 mm can be obtained by adopting the pulse generator (analogue-digital converter) using photo-transistor and the transistorized digital computor. *Fig. 17* shows the block diagram of edger roll adjustment.

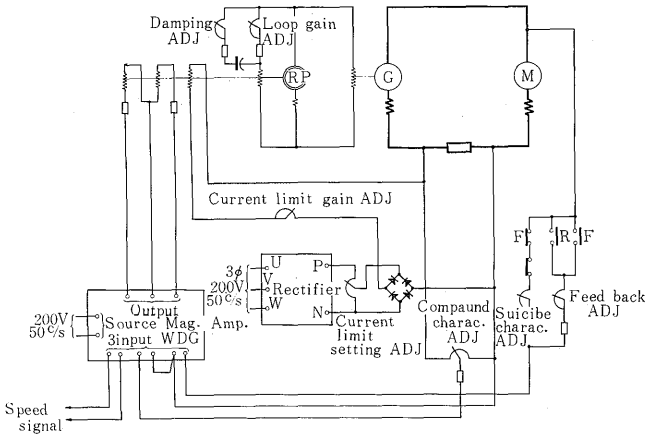


Fig. 13 Skeleton diagram of variable voltage DC aux. motor

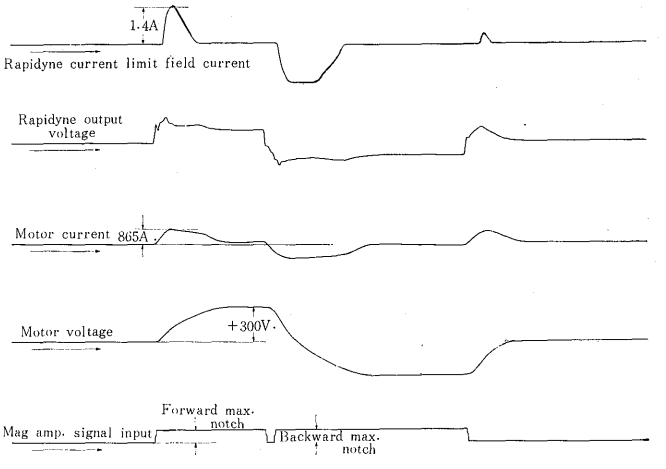


Fig. 14 Characteristics of edger front table control

***Table 6* List of constant voltage DC aux. motors**

Machines	DC motors							
	Output (kW)	Rating (hr)	Speed (rpm)	Field	Type (AISE)	Q'ty	Brake	Control
Slab depiler	75	1	485	Compound	614	1	Series	RDB ASSD
Slab depiler pusher	26	1	575/1,150	Shunt with stabilized series	608	1	Series	RDB ASSD
Depiler table	37	1	550	Compound	610	1	—	RPDB
Furnace entry table	37	1	550	Compound	610	2	—	RPDB
Furnace pusher	110	1	460/1,035	Shunt with stabilized series	616	2	Series	RDB ASSD Duplex
Furnace delivery table	75	1	485/970	Shunt with stabilized series	614	2	—	RPDB
Descaling table	75	1	485/970	Shunt with stabilized series	614	1	—	RPDB
Slab receiving table	75	1	485/970	Shunt with stabilized series	614	1	—	RPDB
Descaling table side guide	11	1	725	Compound	604	1	Series	PDB ASSD
Roll changing rig	37	1	550	Compound	610	1	—	PDB ASSD
Mill centering slide guide	37	1	550	Compound	610	6	Series	RDB ASSD 2-armatures in series
Mill screw-down fine adjust	13	1	287.5/575	Shunt with stabilized series	Nearly 608	2	Air	RDB ASSD

N.B. 1) Voltage: 220 V
2) Class B insulation, temperature rise 75°C
3) Control abreviation
RDB: Reversible Dynamic Brake
ASSD: Armature Shunt Slow Down
RPDB: Reversible, Plugging and Dynamic Brake
Duplex: Co-ordinating operation of two motors

Table 7 **List of AC aux. motors**

Machines	AC motors							
	Output (kW)	Rating	Speed (rpm)	Voltage (V)	Type	Rotor	Q'ty	Control
Grease pump for depiler	0.75	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Grease pump for table	1.5	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Grease pump for descaling	930	Cont.	1,500	6,600	Enclosed self-ventilated	Wound	2	NR
Descaling air compressor	7.5	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Morgoil pump	3.7	Cont.	750	200	Totally enclosed fan-cooled	Cage	2	NR
Circulating oil pump	11	Cont.	750	200	Totally enclosed fan-cooled	Cage	2	NR
Roll & spindle balance pump	30	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	2	NR
Grease pump	1.1	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Hydraulic pump for edger pull-back	7.5	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Circulating oil pump	5.5	Cont.	750	200	Totally enclosed fan-cooled	Cage	2	NR
Oil pump for descaling pump bearing	0.75	Cont.	1,000	200	Totally enclosed fan-cooled	Cage	2	NR
Light leveller roll adjust	30	40% ED	1,000	400	Totally enclosed	Wound	1	RP
Light leveller air fan	22	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Light leveller oil pump	5	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	2	NR
Light leveller travel	20	40% ED	750	400	Totally enclosed	Wound	1	RP
Heavy leveller roll adjust	11	40% ED	1,000	400	Totally enclosed	Wound	3	RP
Hydraulic balance pump for heavy leveller	10	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Heavy leveller oil pump	11	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Cooling bed transfer	38	40% ED	750	400	Totally enclosed	Wound	8	RP
Cooling bed chain transfer	125	40% ED	600	400	Totally enclosed	Wound	4	RP
Inspection turn-over	90	40% ED	600	400	Totally enclosed	Wound	2	RP
Marking car travel	1.4/2	Cont.	1,000/1,500	200	Totally enclosed flange type	Cage	1	R
Marking	0.5	Cont.	1,500	200	Totally enclosed	Cage	2	R
Crop shear	200	40% ED	750	400	Totally enclosed	Wound	1	RP

(Continued)

***Table 7* List of AC aux. motors**

Machines	AC motors							
	Output (kW)	Rating	Speed (rpm)	Voltage (V)	Type	Rotor	Q'ty	Control
Oil pump for hold-down device	11	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Gear oil pump	1.1	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
Rotary shear & slitter housing adjust	22	40% ED	750	400	Totally enclosed	Wound	3	RP
Scrap conveyer	8	Cont.	1,000	200	Totally enclosed fan-cooled	Cage	3	R
End shear	400	40% ED	750	3,300	Enclosed forced-ventilated	Wound	1	RP
Oil pump for end shear	19	Cont.	1,500	200	Totally edclosed fan-cooled	Cage	1	NR
Gear oil pump	1.1	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
End shear pull-back	22	40% ED	750	400	Totally enclosed	Wound	1	RP
Shear gauge travel	7.5	40% ED	1,000	400	Totally enclosed	Wound	1	RP
Plate Shifter travel	10	40% ED	1,000	400	Totally enclosed flange type	Wound	10	RP
Magnet Shifter lift	5	40% ED	1,000	400	Totally enclosed flange type	Wound	16	RP
Oil pump for Shear gauge	3	Cont.	1,500	200	Totally enclosed fan-cooled	Cage	1	NR
End shear disappearing Shifter	6	40% ED	1,000	400	Totally enclosed	Wound	1	RP
Plate aligning	12	40% ED	1,000	400	Totally enclosed	Wound	2	RP
Table roller for shear	4.4 kg-m	Cont.	750	400	Totally enclosed flange type	Cage	286	RP
Flame cutting chain transfer	125	40% ED	600	400	Totally enclosed	Wound	2	RP
Thick plate transfer lift	40	40% ED	600	400	Totally enclosed	Wound	4	RP
Pusher	10	40% ED	750	400	Totally enclosed	Wound	2	RP
Table roller	4.5 kg-m	Cont.	1,000	400	Totally enclosed flange type	Cage	43	RP
Table roller	6.5 kg-m	Cont.	1,000	400	Totally enclosed flange type	Cage	16	RP

N.B. 1) Frequency 50 c/s
2) Class B insulation, Temperature rise 75°C
3) Control abreviation
RP: Forward & reverse run and plugging
NR: Non-reverse,
R: Reverse

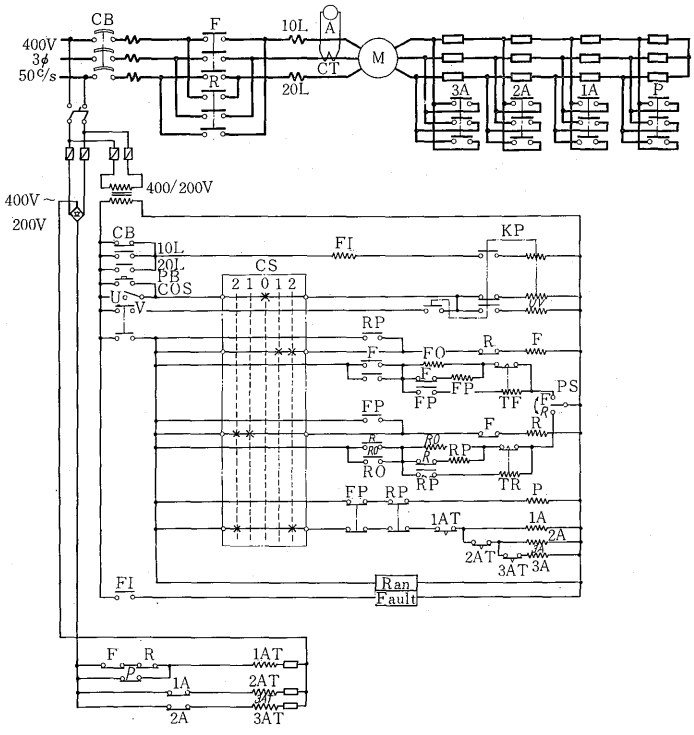


Fig. 15 Skeleton diagram of constant voltage AC aux. motor

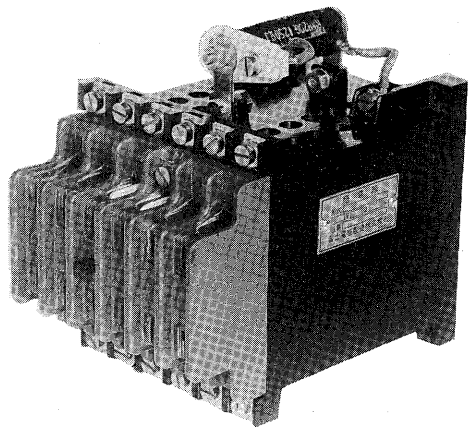


Fig. 16 DC aux. relay, type RC 51-3

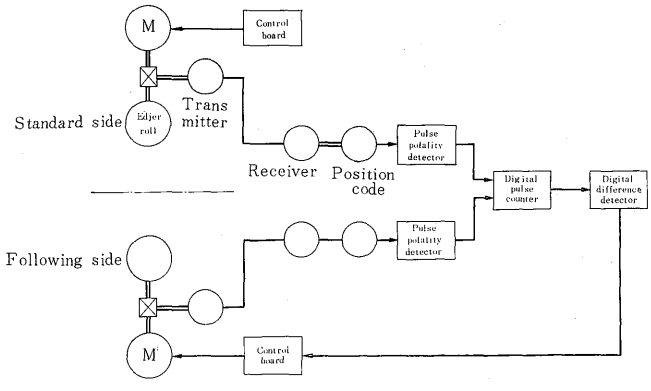


Fig. 17 Block diagram of edger roll adjustment

V. ASSOCIATED EQUIPMENT

1. Ventilation

For the ventilation of electric room, non-circulating down-draft system is adopted. As the air filters, multi-duty automatic type of AAF company is adopted. The No. 1 electric room is equipped with Sirocco fans together with air filters on the top of ceiling so as to distribute the blow directly into the room, thus permitting elimination of air duct and maintenance of beauty in the room. Air supply is 240 m^3/s in No. 1 electric room, 30 m^3/s in No. 2 electric room and 60 m^3/s in No. 3 electric room.

2. Auxiliary Power Source

Three sets of 333 kW DC 230 V mercury-arc rectifier for DC aux. motors, four sets of three-phase 1,000 kVA transformer and two sets of three-phase 300 kVA transformer for AC aux. motors, and one set of 300 AH DC 110 V storage battery for control circuit have been supplied.

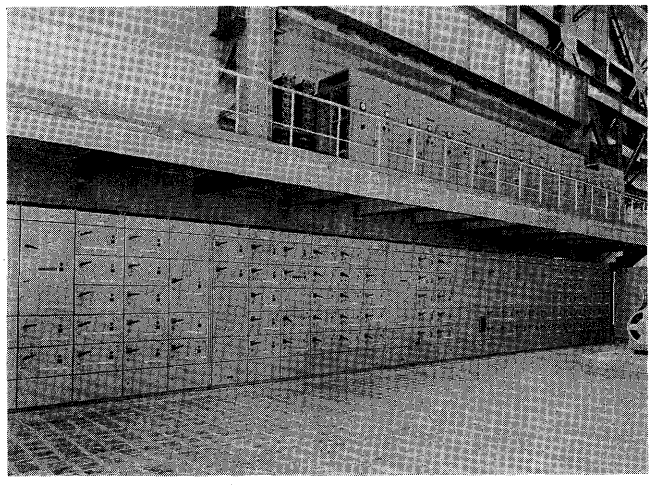


Fig. 18 Control center type switchboard

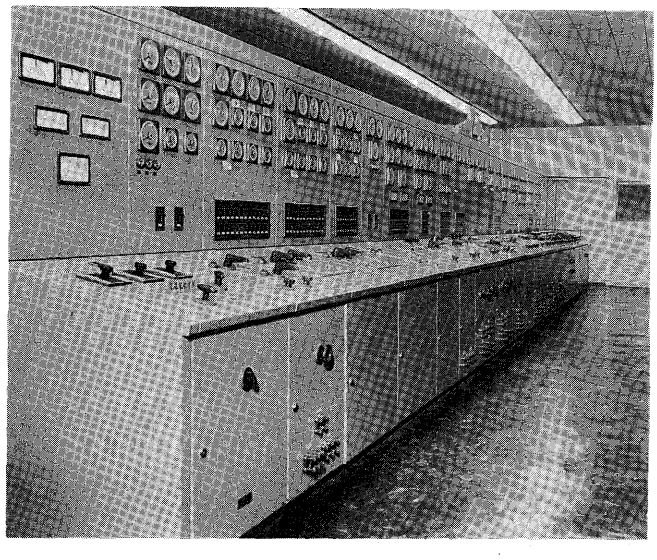


Fig 19 Main control board of No. 1 electric room

3. Switchboard

Metal-clad switchgears as H.T. switchboard and pneumatic operated water circuit breakers as H.T. circuit breaker have been supplied. Load center type and control center type switchboards, as shown in *Fig. 18*, have been supplied as L.T. switchboard. The central supervisory control board in No. 1 electric room is shown in *Fig. 19*.

VI. CONCLUSION

The universal slabbing mill which will supply slabs to the above-mentioned plate mill is now under construction. The main electrical equipment, which is also manufactured by our Company, comprises $2 \times$ 4,500kW 750V 40/80rpm top-forward, and $1 \times 3{,}000$ kW 750 V 60/150 rpm mill motors.

We believe, together with this equipment, the above-mentioned electrical equipment for plate mill will much contribute to the series production from ingot to plate in the steel works in near future.