MPS/ED - Note 68-1
18.3.1968

PROPOSAL FOR WEST HALL BEAM TRANSPORT POWER SUPPLIES

by R. Mosig

This report is an attempt to describe a possible scheme of the West Hall magnet power supplies and some suggestions regarding future control and electronic systems. It is intended to act as a basis for discussion.

PS/6453

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1. COMPARISON BETWEEN PRESENT AND FUTURE POWER SUPPLIES

The South and East Experimental Areas used in the first period of operation motor-generator sets as power supplies for the beam transport magnets. In both areas rectifiers were added later in order to satisfy the increasing demand. At the beginning the rectifiers were installed in the experimental halls and also in the generator buildings. Later, as the demand increased further, the construction of rectifier buildings became necessary. The lay-out of these buildings was heavily influenced by the restricted space available. Therefore the cubicles had to be stacked, the dimensions of the supplies kept as small as possible and parts with considerable heat dissipation (transformers and thyristors) watercooled. The stacking of air cooled units required complicated air guiding systems.

The result was a series of rectifiers having a rather special design and sometimes also very limited access. The regulation and control circuits were influenced by the fast development in the semi-conductor field and the beginning of miniaturization . The remote control principles were dictated by these chosen for the rotating machines in 1959. It is obvious, that after some years experience and the much more favorable semi-conductor price situation, the design of a power supply which is not bound to historical facts, would have a somewhat different appearance. If the equipment should be manufactured in 1969 to 1971, and serve in the 1970's, then one would risk being out-of-date again. It is anticipated that conventional components like transformers, circuit breakers, etc., will neither change in principle nor in price considerably. However, thyristors will most probably show a further tendency to price reduction, so that power circuits not very common today (making more use of semiconductors than usual in order to obtain other advantages) will then have a good chance of being up-to-date. So far as electronic circuits are concerned the chance of obsolescence is much greater. To use today "brand-new" components (even if they are still expensive) and sophisticated circuitry reduced this chance somewhat.

Finally some other facts have to be put into consideration : the educational background of an operator five to ten years later; the practice of trouble shooting at that time and the amount of equipment for which an operator is responsible. The increasing gap between applied techniques and its understanding can only be bridged if system comprehension is obtained from an operator rather than understanding of discrete circuit features. In consequence of this trouble shooting will stop at the defective block and it will only be expected that the defective chassis will be exchanged. Specialists will replace the defective components and test the unit in conjunction with a power supply simulator. For a given failure rate the beam interruption will be reduced and the amount of equipment for which an operator is responsible would be increased.

The efficiency of operation depends largely on the suitable separation into functional units so that fault detection is facilitated.

2. DESIGN PRINCIPLES FOR WEST HALL SUPPLIES

The West Area will be equipped with rectifiers exclusively. The proposals for the rectifier buildings include cranes for easy displacement of the rectifier cubicles which will not be stacked. Air cooled units will have, for the thyristors, a vertical air stream orientation and the transformer ventilators will suck the air from directly underneath. This results in a more efficient cooling and gain of space in the unit. Furthermore, the use of industrial prefabricated thyristor sets will be facilitated. The power-level at which water cooled thyristors are more economical than forced air cooled ones will increase in future except when there are stringent conditions such as very restricted space and limited heat dissipation permitted. From the maintenance point-of-view air cooling needs less care (no condensation and draining if the unit is switched off in the winter); therefore, all rectifier types are proposed with air cooled thyristor sets.

Rectifier transformers, rated for 300 kVA and higher, even if forced air cooled, become rather large compared with the other equipment. Clophene transformers equipped with water heat-exchangers become more favourable the higher the rating. This has led to the construction of "double units". The transformers (and interphase transformers) for two supplies are located in a common tank.

For supplies with higher precision, shunts (or other current measuring devices) will necessarily be water cooled. For this reason, the rectifier buildings have to be supplied anyway with water (ordinary town water). When transformers, greater than 300 kVA, are executed in the way mentioned above, the possibility is given to construct all power supplies with a uniform depth. This has quite an advantage for the arrangement of the supplies in the building [1]: equal distance from one row to the other which results in better use of the floor space. The units with higher ratings become under these conditions about 2 ½ times longer than deep - the present units are more square - which improves the access considerably.

The controls and electronics will be designed according to the basic considerations mentioned under chapter 2. Further more, some circuits still using mechanical components could be replaced by static or semi-mechanical circuits. The recent development of precision resistors (improvement of temperature coefficient and tolerances) leads to digitalized reference sources (instead of motor driven potentiometers). Not only reliability will be improved, but also the overall performance and remote control facilities (current pre-selection and programming). Some relays, in the circuits will certainly increase, but attention should be paid to the low threshold level of digital IC's. The neighbourhood of rectifiers, having during commutation a di/dt up to 10 A/µs, produces a high noise level. On the other hand, the high operating frequency offered by IC's could not be used. The future has to show, whether other series of IC's will be available which would better fit together with industrial electronics or the present series has to be combined with suitable filters or adapters.

3. RATINGS AND PRECISION OF THE POWER SUPPLIES

The standard bending magnets and quadrupoles lenses in the West Hall will again have a resistance of approximately 0,2 ohm and a nominal current varying between 600 and 850 A. The time constant will be in the order of 1 ÷ 4 sec. The magnets are not as yet designed, but it is not expected that the parameters will differ greatly from those indicated above and therefore will not basically affect the power supply

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1) H. Reitz, Les bâtiments de redresseurs et la distribution de c.c. et c.a. pour la zone d'expérience Ouest du PS. MPS/PO - Note 68-1

design. A current stability (ripple included) in the order of 10^{-3} to 10^{-4} satisfy not all, but a great proportion of the beam transport requirements. For this kind of normal operation a 12 phase rectifier (type R2) is proposed, having essentially the same features as the type already in use in the South and East Experimental areas. The thyristors type used in this circuit would permit the dc-current of 1000 A and therefore the transformer was designed for this current. Very often two beam transport elements are connected in series and powered with 50 ÷ 75 % of their nominal values. To cover this demand the maximum out-put voltage of the R2-rectifiers was chosen to be 230 V, which allows it also to power special magnets with 0,2 ohm resistance up to 1000 A even in remote places (up to 300 m distance). The voltage ripple (and for a given time-constant the current ripple) shown in diagram 126-1346-4 a.

If standard magnets are powered higher than 500 A, the current ripple will be lower than 10^{-4} but the overall stability (compensation of mains variations and long term stability) will not be better than 10^{-4} , which is for most of the cases sufficient The current reduced to 250 A might give, for some cases, a still tolerable current ripple ($2,5 \times 10^{-4}$); however, if the experiment can permit it, the supply should not be used in this region. A rectifier of the type R1 is more advantageous : not only current ripple will be lower but also the reactive power consumption will be reduced. This type could power à 0,2 ohm-magnet up to 500 A and two magnets of the same type up to 250 A. The resulting current ripple will be obtained, by dividing the Udc-scale in diagram 126-1346-4 a by 2. Again the overall stability will not be better than 10^{-4}.

The rectifier type 2 R3 (two independent R3 units) serves for series connection of standard magnets for currents higher than 500 A. Current ripple will be obtained from diagram 126-1346-4 a if the Udc-scale is multiplied by $\frac{430}{250} = 1,72$. For the same reasons as the type R2 should be replaced by R1 in the lower current region, R3 rectifiers should be replaced by the type R2.

For special magnets with higher dissipation than the R3 units could handle the type R4 is proposed. With the possibility of series and parallel connection of two bridges and further the parallel connection of two R4 units, the power range from 300 ÷ 1500 kW would be covered. Precision and current ripple correspond to the other types discussed (scaling up the Udc-coordinate in 126-1346-4 a).

For magnets which require a higher precision than 10^{-4} especially in conjunction with a low time constant, the rectifiers R1 + R3 should be replaced by special types equipped with transistor-series regulators. With this kind of circuit a precision of 2×10^{-5} for magnets with a time constant greater than 0,5 sec., and 10^{-4} precision for a few millisec. time constant could be obtained. Type R2 sp corresponds to the type R2 with the exception of 20 V lower output voltage (transistor bank) and the type RO sp is mainly intended to cover the lower current region (max. current 250A). This gives the possibility to replace the type R1, if the current ripple becomes prohibitively high.

4. POWER CIRCUIT AND MECHANICAL ARRANGEMENT

For all supplies the same rectifier connection is proposed. The transformers will have two $\pm 15^{\circ}$ phase shifted secondaries so that with two 3 phase thyristor bridges connected in parallel by an interphase transformer a 12 phase rectification will be obtained. Freewheeling diodes will not only improve the power factor (important for areas equipped with rectifiers exclusively), but also the rectified voltage will have less ripple. For the R2 units (and larger ones) the proposed circuit will be very economical; however, for the R1 unit the 12 phase gate control set will be relatively expensive compared with the thyristors, but it is hoped that gate control sets will also be made cheaper in the next years (see chapter 6). The special supplies RO sp and R2 sp intended to be used for higher precision requirements, have the same rectifier circuitry as the others, but have in addition (diagram 126-1313-4) a dc-filter and a series transistor bank. There is no doubt that RO sp unit using a roller transformer combined with diodes would be less expensive than the proposed 12 phase thyristor circuit, but the advantages offered by uniformity of all supplies, however, would balance the costs certainly.

The dc-filters in the special units are probably over-dimensioned for a high precision regulated magnet with a time constant of a few hundred milliseconds; for ohmic loads (or a few milliseconds time constant) the filter design depends on the band-width which could be obtained with the transistor series regulator. Tests would have to be carried out, to determine L and C more precisely.

The mechanical arrangements of the supplies proposed are shown in the drawings 126-1319 through 1324. The position numbers indicated correspond to these in the part list.

5. MAGNET INTERLOCKS

The magnet interlocks will be centralized either in the main rectifier building or in the West MCR (see drawing 126-1334-4 a). All rectifiers obtain from this center the tripping signal (magnet de-excitation, and disconnection of the power supply from the magnet). Before the power supply is put again into operation a series of 100 μs-pulses generated in the power supply will be sent through the dc power cables via Terminal box to the magnet, and then transferred to the Interlock cable which returns the signal via terminal box and interlock center to the power supply. The signal received there will then be compared with the leading edge of the sent signal and will, if successful, permit the power supply to go into operation. The check will take place automatically before every switching-in, so that crossing of interlock cables will be avoided. This system requires only condensers and small well isolated pulse transformers but no semi-conductors to be mounted on the magnet (radiation damage).

6. CONTROLS AND ELECTRONICS

The control circuits will be similar to these used in the South and East Halls. However, the polarity will be selected directly : buttons for "normal" and "inverted" will be used instead of buttons for "start" and "polarity change". The corresponding circuits are simpler and for programmed remote control almost a necessity.

The current adjustment will consist of a 4 decade thumbwheel switch (binary coded), which will be connected to a memory. The position of the switch will only be shifted to the reference source if the "transfer" button is pressed. The current adjusted will be indicated by Nixie tubes.

This system has, especially for programming, an advantage : for a number of beam transport elements the setting for the different power supplies (i.e. next measuring point) could be made in sequence, the transfer (new adjustment) in parallel. In some cases the hysteresis effect becomes important especially if magnets are energized with lower currents. Under these conditions a direct adjustment (every decade follows separate the setting) could cause additional errors to the flux-current relationship. Example : current is to be increased from 199,9 A to 200,0 A By the usual setting from left to right the current might reach the value 299,9 A, which would be avoided with the memory and transfer (all relays will reach their new configuration within milliseconds). In the proposed system, the correspondance of thumbwheel and reference-relay position would be indicated remotely. The linearity of the current adjustment system (absolute calibration of the shunt or dc-current transformer and the decade resistors in the reference source, amplifier offset aging og these components, etc.) will certainly be somewhat lower than the stability obtained. Tests will be carried out to find a good compromise between equipment costs and sufficiently simple adjustment methods for the physisist. At present a linearity of somewhat better than 10^{-3} could be obtained without too much effort, however, a linearity better than 10^{-4} would also need a recalibration from time to time.

The thumbwheel switch installed on the regulator chassis in the power supply would serve as a current limiter when the unit is controlled remotely (only in steps of 100 Amps), which would avoid thermal tripping of the magnet. Furthermore, a great proportion of errors in the regulation loop would be detected by the "Amplifier saturated" signal, i.e. interruption of the current feedback, failures in the gate control system, etc. This protection will also respond to an open magnet circuit. The "Amplifier saturated" signal will switch off the supply after a delay of 2 sec. The 12 phase gate control set is still a rather expensive device, especially if equipped with all the trimming-facilities in order to obtain a consecutive pulse precision better than $0,5^{\circ}$el. Integrated circuits might improve the situation somewhat, but other principles (i.e. use of a voltage to frequency converter to obtain a mains independent pulse generation) should be investigated.

7. REMOTE CONTROL AND PROGRAMMING

Two modes of remote control are envisaged (see drawing 126-1334-4 a) :

- a very simple "short distance control", which repeats the local controls and adjustments on a "rectifier control box" via multicore cable which is similar to the present system;
- a flexible remote control system using for instance multiplex in an extended way.

The remote control system would use an ordinary multicore cable (4 + 5 conductors) for about 100 power supplies together. It would link the rectifier building with the experimental area. Each plug station would permit to plug in on convenient places either power supplies or remote control boxes. A certain power supply would be linked with a remote control box by introduction of two tuned sets of multiplex transmitters and receivers on each side. Both sets would carry the same number, which would be the terminal box number, in order to correlate the magnet with the supply, the interlock cables and the remote control box. It might be desirable to have in a centralized place the possibility to check the situation for the whole experimental area; then a third set of tuned transmitters and receivers would have to be installed (having the same terminal box number).

The signals for current adjustment, polarity selection, etc., would be sent (or received) one after the other, so that about 20 signals per second would be transmitted. Under worst case conditions signal transfer may be delayed by a few seconds; fast enough if compared with the slow de-excitation of a magnet. Signals would be synchronized by a clock pulse generator. The transmission system also proposed for the Intersecting Storage Ring project is still under development and the details given here may be subject to change.

The final version must consider, firstly, that it is obviously desirable from operation point-of-view to have the remote control systems for West Hall and Beam Transfer (ISR) similar if not identical, and secondly that it should be easily adapted to computer control. The computer type(s) to be used in the West Hall will probably be still under discussion during the construction period of the West Hall. Two basic solutions could be imagined : one large computer for the whole area or several smaller ones (in-line computers): In both cases the interface equipment would probably be different, the transmission system from physisist to power supply, however, would not be influenced, since it has to be designed also for "normal" remote control.

One problem still in the air is the current measurement system of 10^{-4} accuracy. Anyway, the physisist should be informed about the magnet current and not just rely on the reference setting. A digitalization of the shunt (or current transformer) voltage in each power supply may prove prohibitively expensive. A single instrument (digital voltmeter combined with a chanel selector) checking sequentially each magnet current installed in the rectifier building and connected to the supplies through ordinary twisted cables, would be more economic; however, leaving the problem of multiplexing the digital output. Either of the above systems would satisfy the basic requirements, and a current check system or even closed loop control could probably be derived from it.

<u>Distribution</u> (open)

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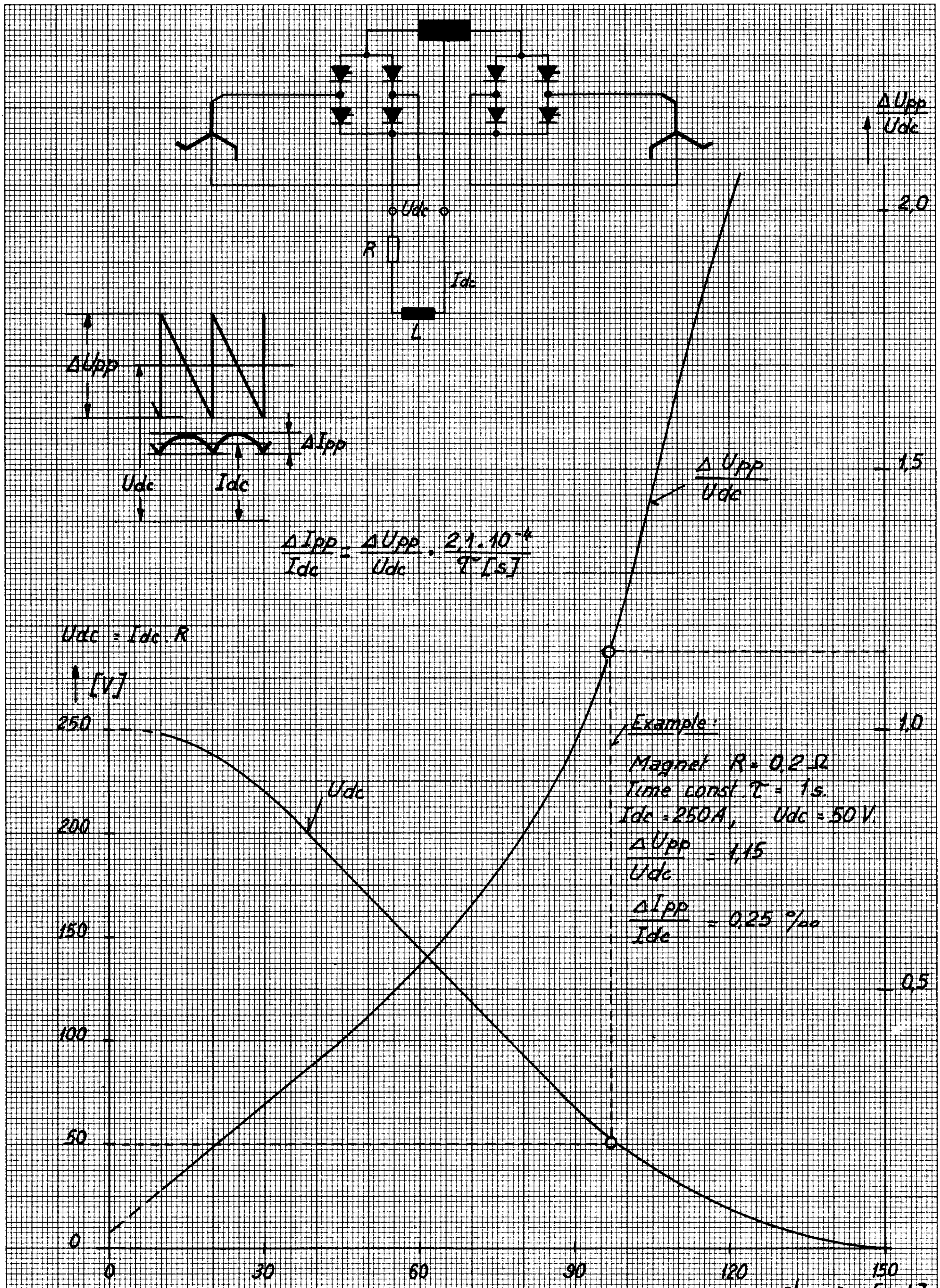
POS.	DESCRIPTION	RECTIFIER TYPE RO sp	R 1	R 2	R2 sp	2 R 3	R 4
1	Main circuit breaker 3 phase 380 V with overcurrent and overload release equipped with aux. contacts	manual 25 A	manual 100 A	motor driven 400 A	motor driven 400 A	motor driven 650 A	1500 A breaker installed in the low voltage distribution
2	Fuses for 3 phase Auxiliary circuits	10 A	15 A	25 A	25 A	25 A	25 A
3	Auxiliary main switch	10 A	15 A	25 A	25 A	25 A	25 A
4	Blowers for forced air cooling						
	transf., Interph. Tr, Chokes	-	-	1	2	water cooled	water cooled
	Thyristors, Diodes	-	2	2	2	2 x 2	4
	Shunt	water cooled	1	1	water cooled	2 x 1	water cooled
	Electronic cabinet	1	1	-	1	1	1
5	Rectifier transformer 380 V	convection cooling	air cooled	air cooled	air cooled	clophene transf. with heat exchanger	clophene transf. with heat exchanger
	Type rating (kVA)	16,5	68	270	270	2 x 425 (two in the same tank)	980
	Primary connect. delta						
	I_L : Line current (A)	25	105	410	410	2 x 640	1470
	secondary connect. two $\pm 15^{\circ}$ shifted stars						
	I_s : current (A)	102	204	408	408	408	1020
	U_s : voltage (phase to neutral) (V)	26,5	53,5	107	107	183	164

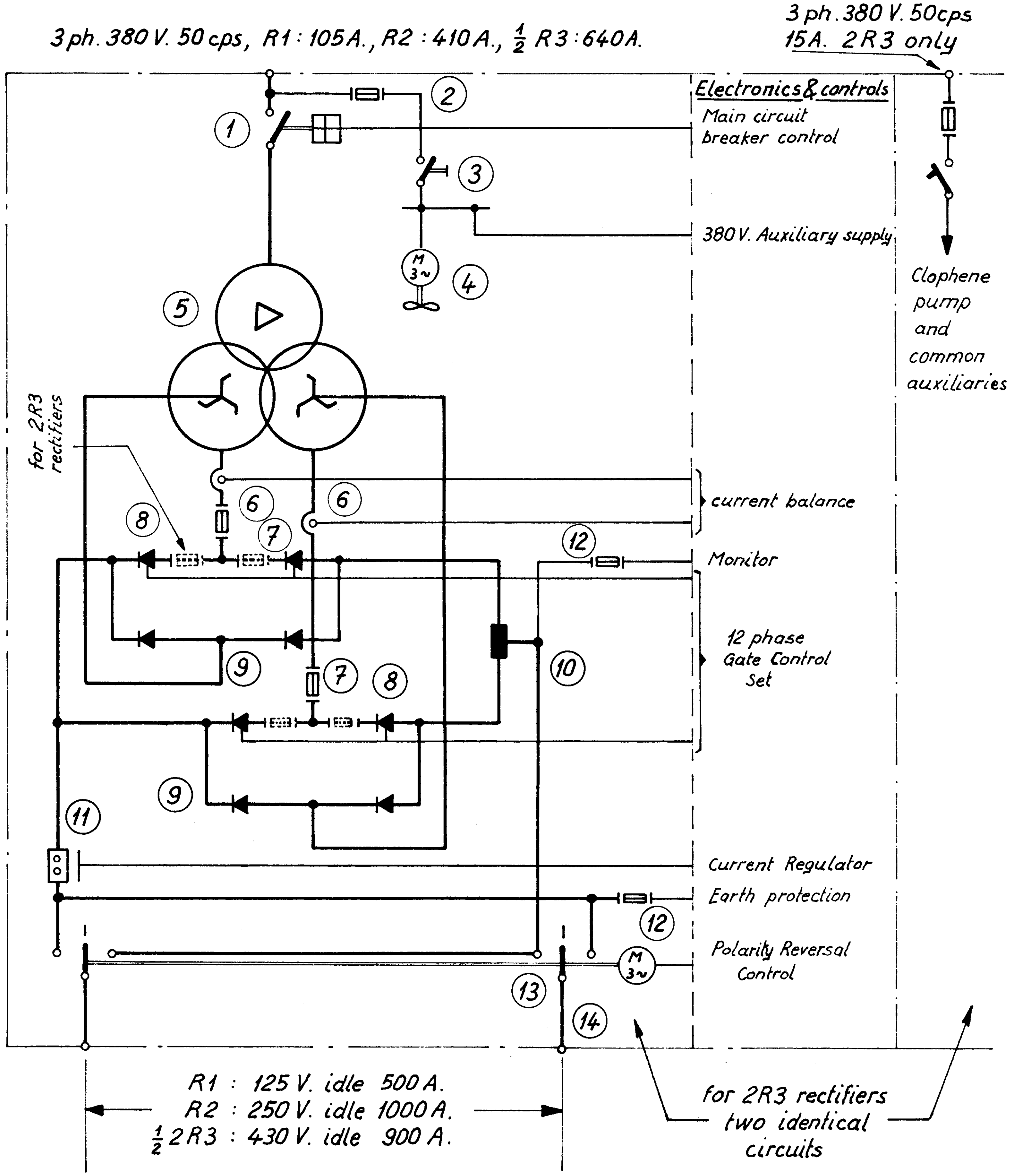
POS.	DESCRIPTION	RECTIFIER TYPE RO sp	R 1	R 2	R2 sp	2 R 3	R 4
6	2 x 3 Current Transformers for current balance 15 VA	100/0,07 A	200/0,07 A	400/0,07 A	400/0,07 A	400/0,07 A	1000/0,07 A
7	Thyristor Fuses with aux. contact 300 V ac. 50 cps	line 125 A	line 250 A air cooled	line 500 A air cooled	line 500 A air cooled	branch 315 A	branch, depends on thyristor type used
8	Thyristors two 3 phase bridge connect. Average current (A) (120^0 cond. angle) repetitive blocking and inverse voltage (V peak)	42 A convect. cooling 170	84 A forced air cooling 330	170 A forced air cooling 660	170 A forced air cooling 660	170 A forced air cooling 1150	2 x 220 A 415 A 3 x 140 A forced air cooling 1000
9	Free-wheeling diodes Average current (A) (I/3, 180^0 cond. angle) repetitive inverse voltage (V peak)	42 A 100	84 A 200	170 A 400	170 A 400	170 A 650	415 A 600
10	Interphase Transformer Current (A) equivalent 50 cps - voltage (V) $(\frac{1}{2} \cdot \sin \frac{\Pi}{12} \cdot \frac{2,34}{1,35} \cdot U_s) = \frac{U_{IT}}{2}$	convect. cooling 125 2 x 7	air cooled 250 2 x 13	air cooled 500 2 x 25	air cooled 500 2 x 25	two in the same transf. tank 500 2 x 43	two identical interph. Tr. (in the transf. tank) 1250 2 x 39

POS.	DESCRIPTION	RECTIFIER TYPE					
		RO sp	R 1	R 2	R2 sp	2 R 3	R 4
11	Precision shunt $2 \times 10^{-5}/^{o}C$ Voltage drop at nominal current : 1 V	water cooled 4 mΩ	air cooled 2 mΩ	air cooled 1 mΩ	water cooled 1 mΩ	air cooled 1 mΩ	water cooled 0,4 mΩ
12	10 A Fuses 500 V						
13	Commutator for polarity reversal motor driven with neutral position equipped with auxiliary contacts	500 A type	500 A type	1000 A type (2 contacts in parallel)	1000 A type (2 contacts in parallel)	1000 A type (2 contacts in parallel)	-
14	D C terminals No of M16-bolts per pole	1	1	2	2	2	A, B 5 C, D 3
15	Separation links	-	-	-	-	-	3 x 1500 A
16	Current transformers	-	-	-	-	-	1500/1 A
17	Chokes for current sharing between parallel connected thyristors	-	-	-	-	-	depends on No of parallel connected thyristors
18	Links for series/ parallel connection	-	-	-	-	-	1250 A

POS.	DESCRIPTION	RECTIFIER TYPE					
		RO sp	R 1	R 2	R2 sp	2 R 3	R 4
19	Change over links (Polarity reversal)	-	-	-	-	-	2500 A
20	Short circuit for second Interph. Transf.	-	-	-	-	-	1250 A
21	Filter choke (Attenuation : 30)	7,5 µF, 250A	-	-	1 mH, 1000A	-	-
22	Condenser bank 1 with fuses	10000 µF 200 V electro-lytics	-	-	75000 µF 500 V electro-lytics	-	-
23	Condenser bank 2 with fuses	330 µF 200 V electro-lytics	-	-	2500 µF 500 V electro-lytics	-	-
24	Damping resistor	17	-	-	2,2	-	-
25	Transistor bank water cooled	10 V, 250 A	-	-	20 V , 1000 A	-	-
26	Thyristor for overcurrent and overvoltage protection Average current (A) Blocking voltage (V) Surge current (A)	 100 100 2000	-	-	 330 100 6000	-	-



Voltage & Current ripple for R2 - rectifier.



Rectifier Type R1, R2 and 2R3
Block diagram power circuit

SIS/R/15 767

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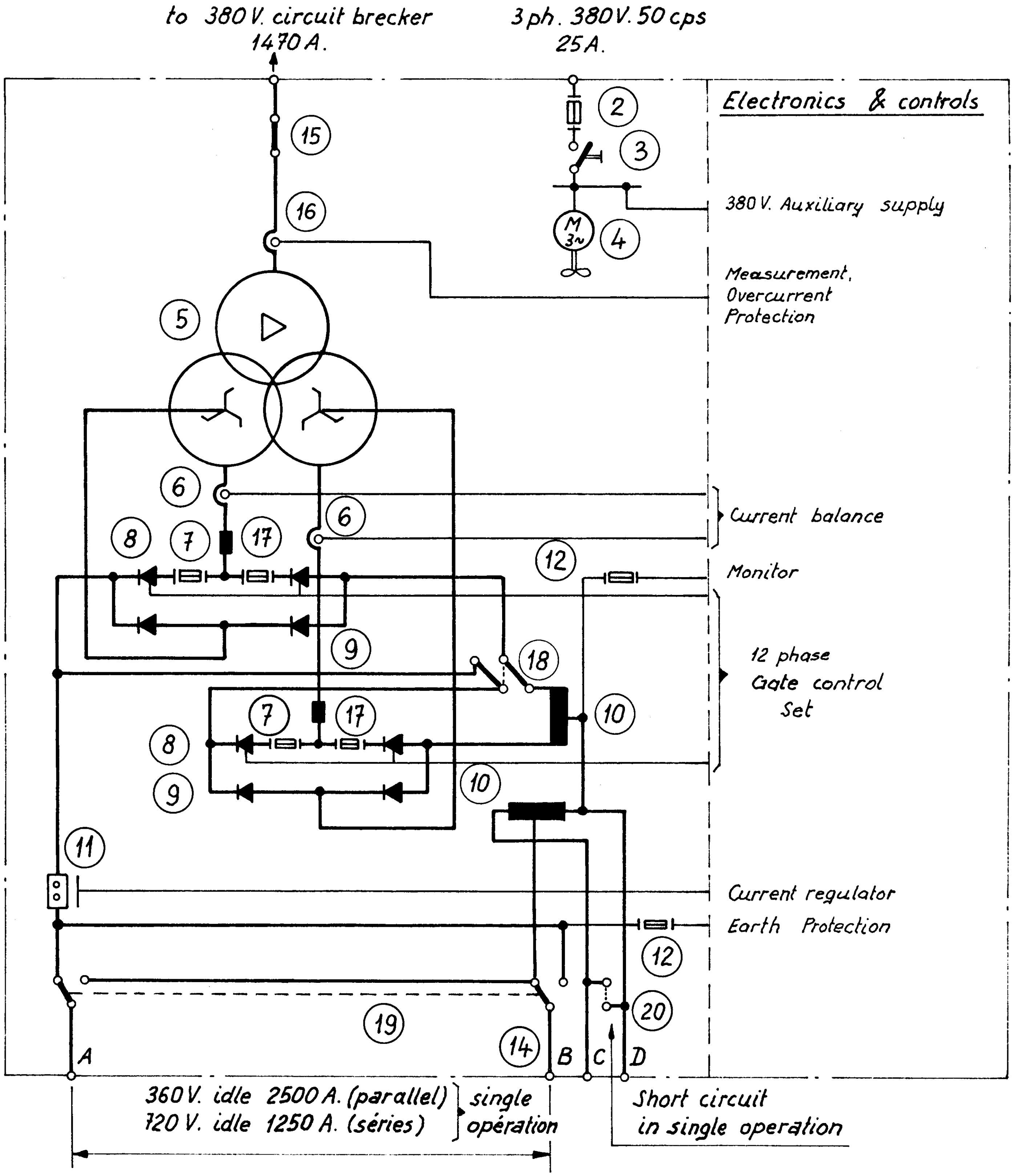
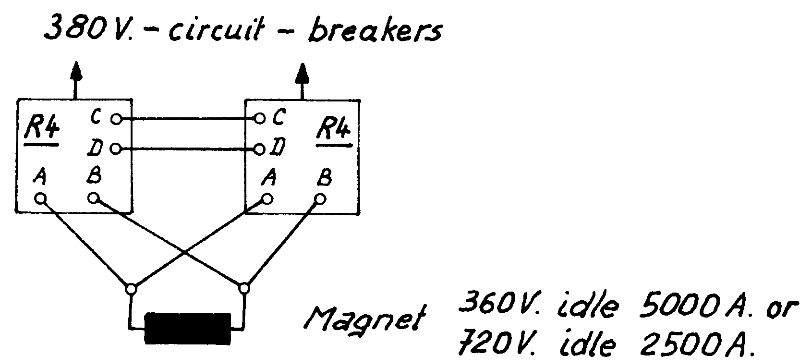
126 - 1312 - 4

24.1.68 Mäder C.



Parallel operation of two R4 supplies



Rectifier type R4
Block diagram power unit

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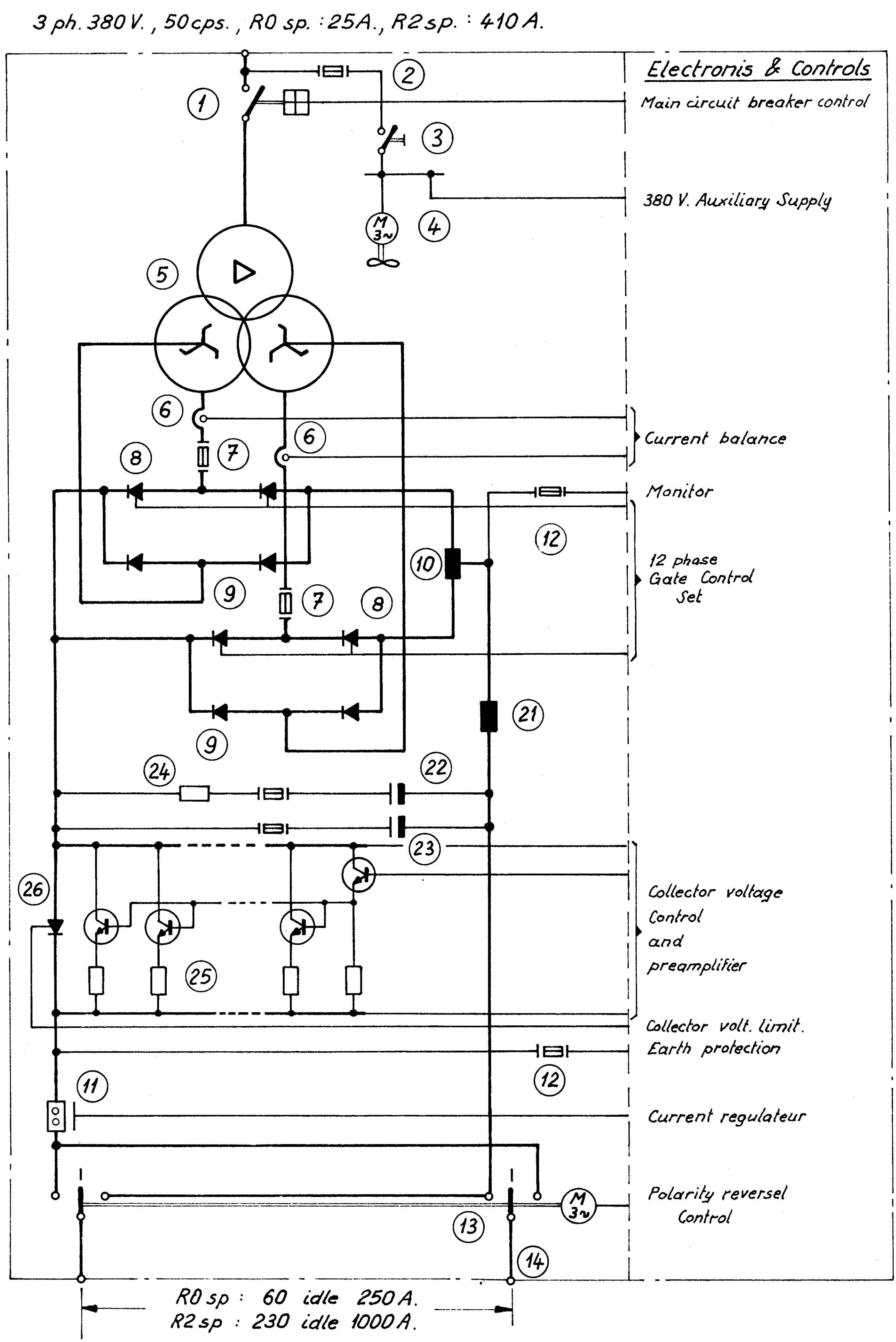

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Rectifier Type R0 sp. and R2 sp.
Block diagram power circuit

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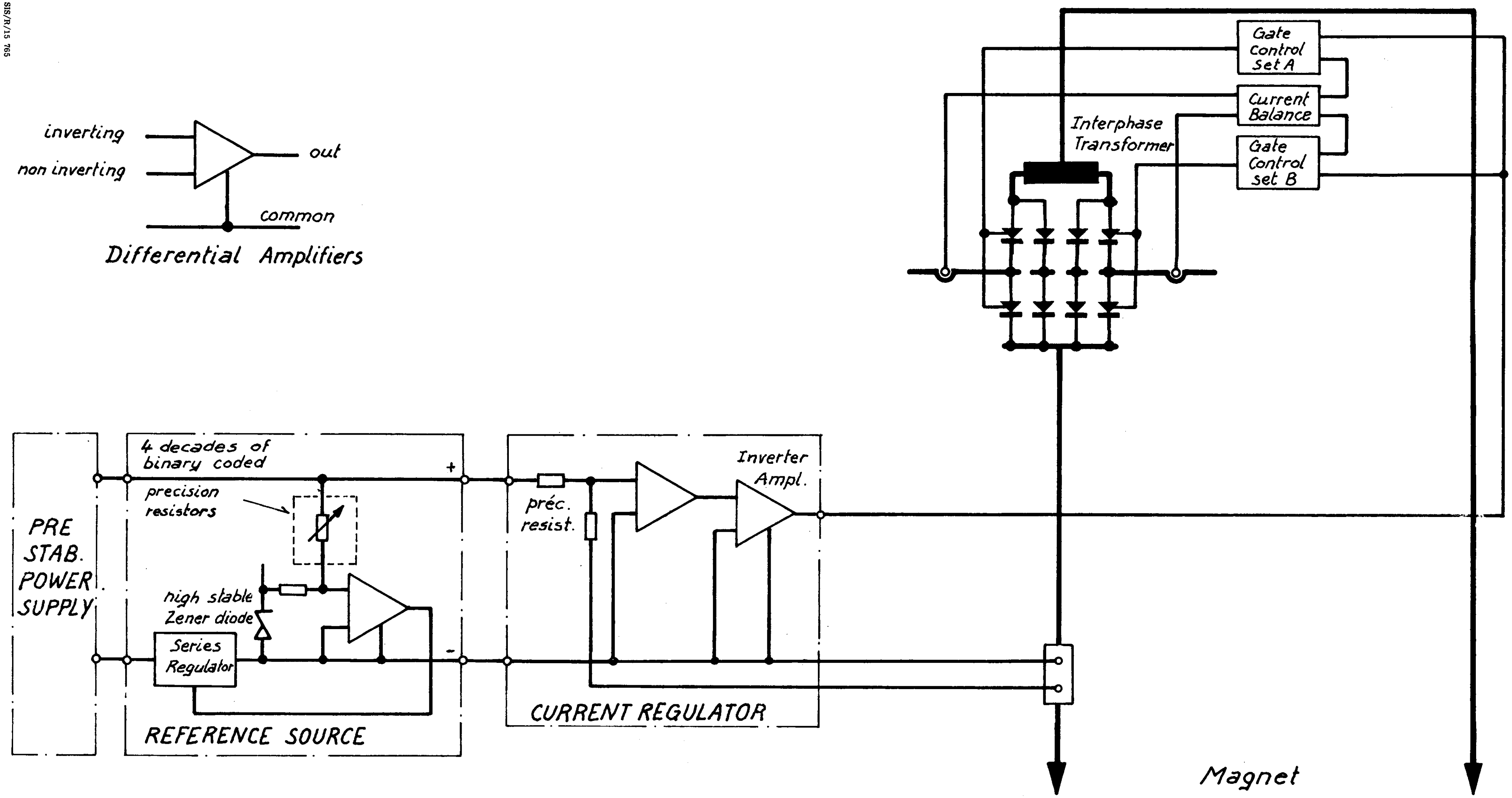
126-1313-4



Regulation Block diagram for Rectifiers Type R1, R2, 2R3 and R4.

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126-1316-4

.1.68 Mäder C.

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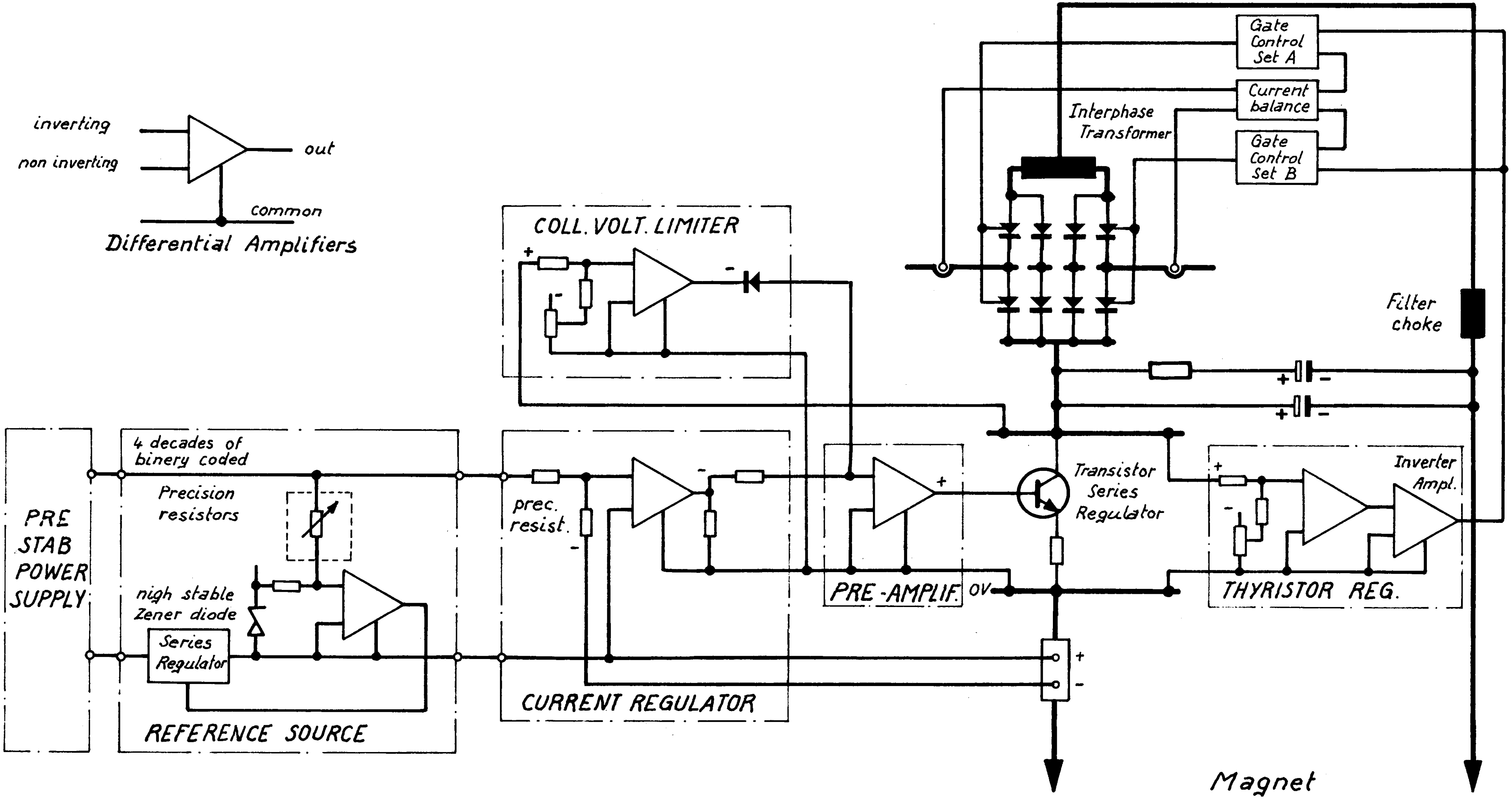

Regulation Block diagram for Rectifiers Type R0 sp and R2 sp.

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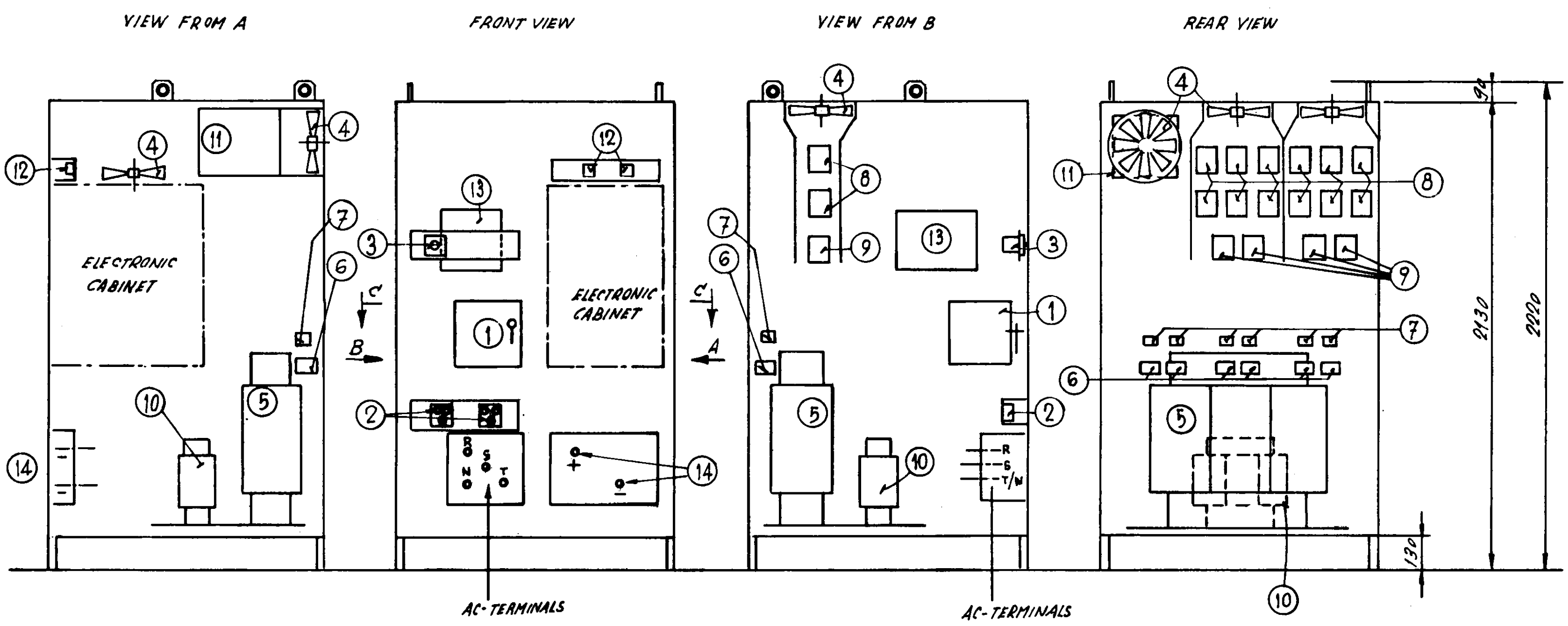
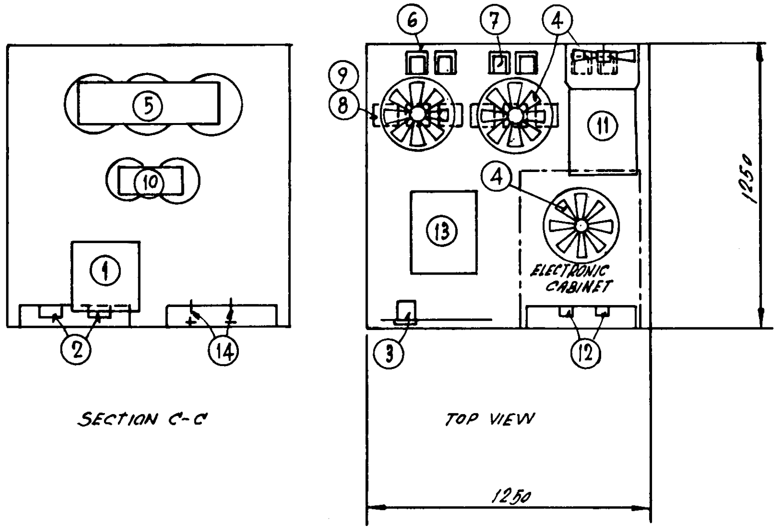
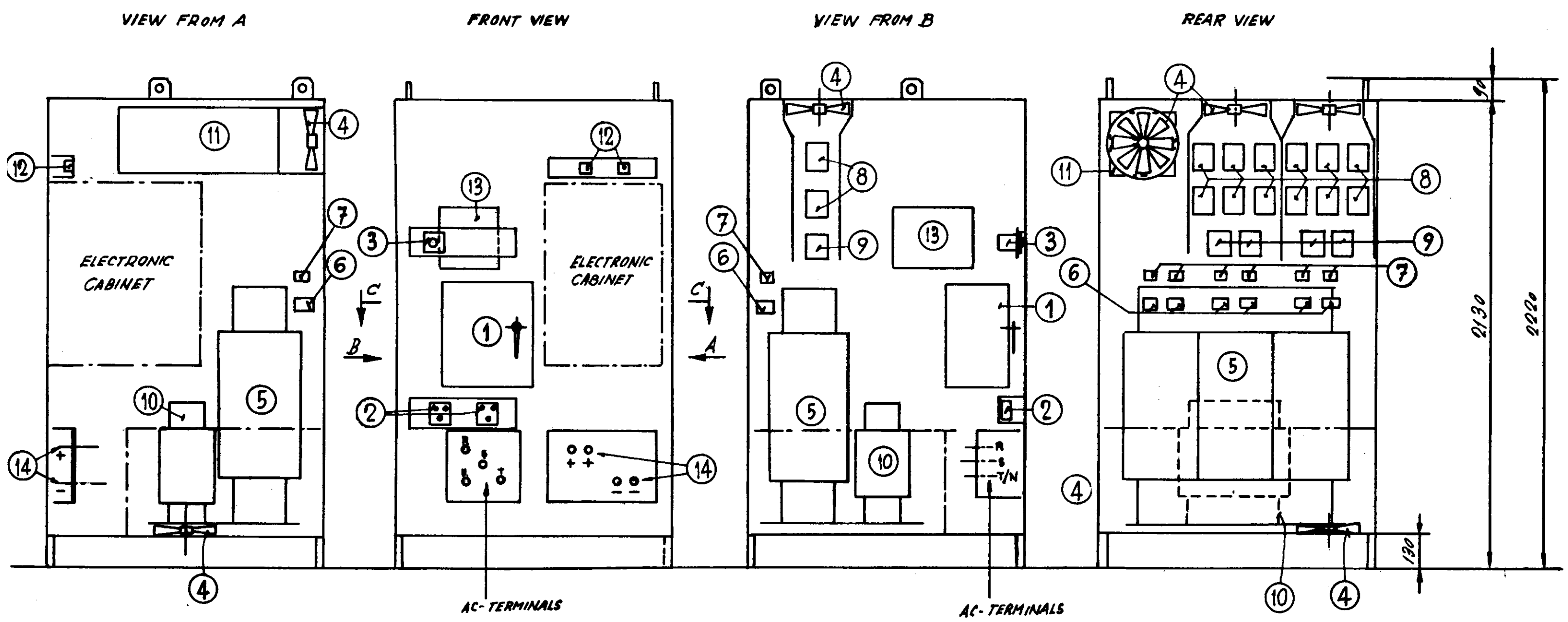


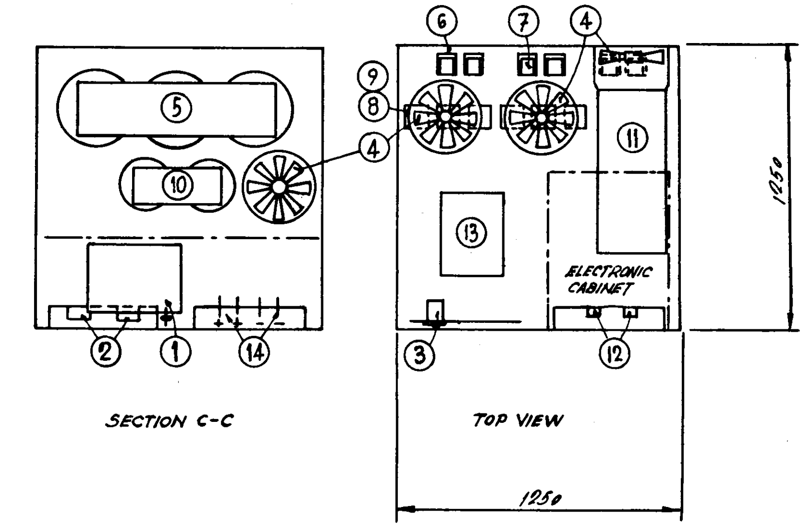


NOTE: The reference Nos. 1...14 correspond to those given in the specifications as well as in Power Circuit Block Diagram 126-1312-4

Nombre de pièces			Designation	Pos.	Matière	Poids	Observations
III	II	I	Mod. Date Nom — Tolérances générales				Etat des surfaces selon VSM 10 320; Rugosité en μ" VSM; Abréviations VSM 10 319
Dossier No	Dossier No	Dossier No	A — de à ± / B — de à ± / C — de à ±				Dessiné 26.1.68. / Controlé / Vu
			Ensemble — S. Ensemble				Remplace / Remplacé par / Réduction
			PROPOSAL FOR WEST HALL — RECTIFIER TYPE R1 — PROJECT ONLY	Echelle 1/33			
			CERN ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE - GENÈVE				126-1320-4

ORIGINAL SEE 126-1320-3

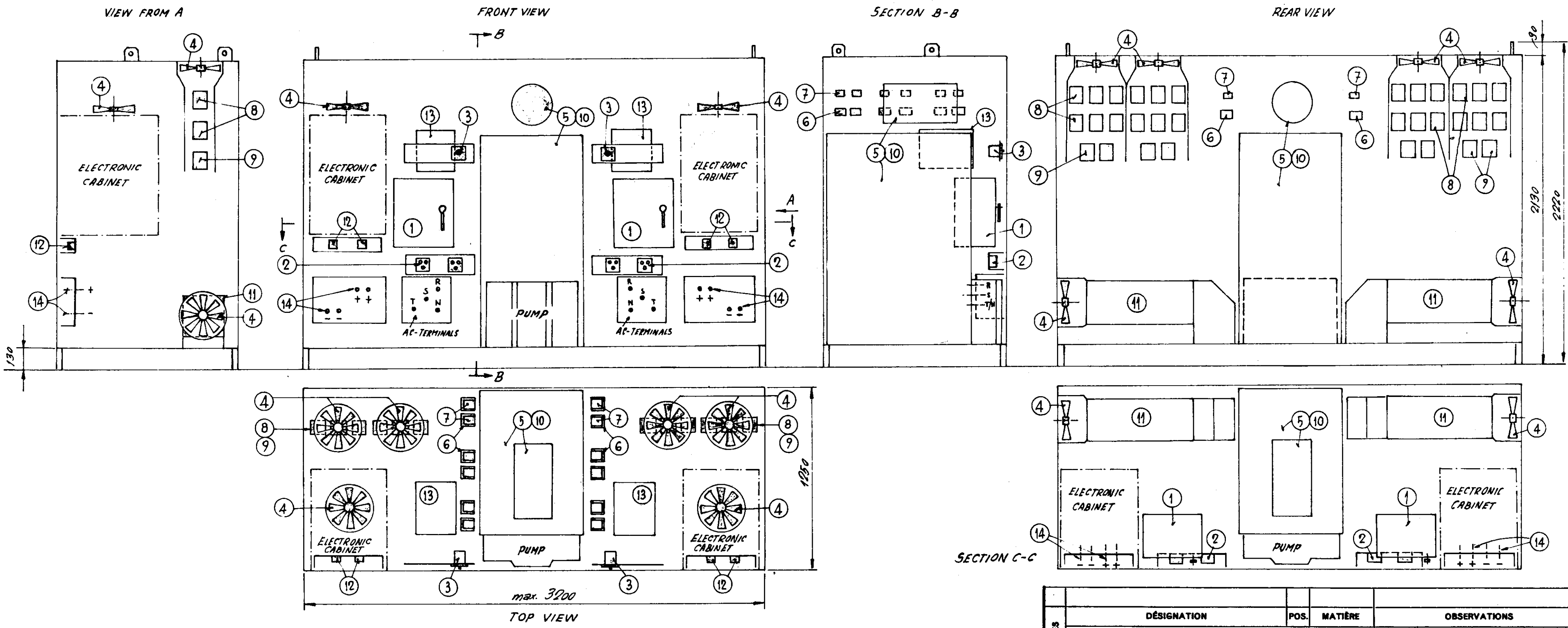




NOTE : The reference Nos. 1...14 correspond to those given in the specifications as well as in Power Circuit Block Diagram 126-1312-4.

Nombre de pièces			Designation	Pos.	Matière	Poids	Observations
III	II	I	Mod. / Date / Nom	Tolérances générales			Etat des surfaces selon VSM 10320; Rugosité en μ" VSM; Abréviations VSM 10319
			A	de à ±			
			b	de à ±			
			C	de à ±			
			Ensemble	S. Ensemble			Dessiné 26.1.68.
			PROPOSAL FOR WEST HALL	Echelle			Contrôlé
			RECTIFIER TYPE R8	1/33			Vu
			PROJECT ONLY				Remplace; Remplacé par; Réduction
Dossier No	Dossier No	Dossier No	CERN ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE - GENÈVE				126-1319-4

ORIGINAL SEE 126-1319-3



NOTE: The reference Nos. 1...14 correspond to those given in the specifications as well as in Power Circuit Block Diagram 126-1312-4.

NOMBRE DE PIÈCES	DÉSIGNATION	POS.	MATIÈRE	OBSERVATIONS	
	PROPOSAL FOR WEST HALL		ECHELLE	DESSINÉ	8.2.68.
	RECTIFIER TYPE 2R3		1/40	CONTROLÉ	
	PROJECT ONLY			VU	
				REMPLACE	
				REMPLACÉ PAR	
				RÉDUCTION	

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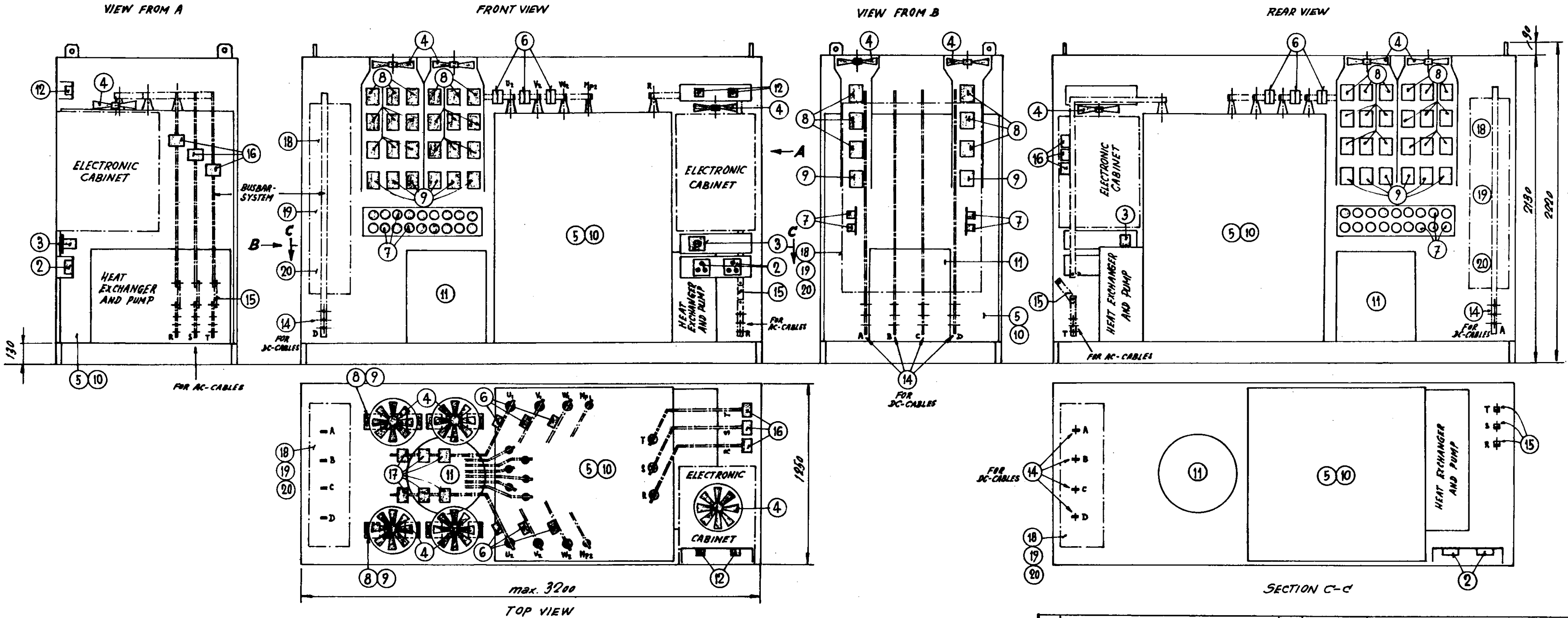
M.P.S. 126-1323-4

ORIGINAL SEE 126-1323-2



NOTE: The reference Nos. 2...12 and 14...20 correspond to those given in the specifications as well as in Power Circuit Block Diagram 126-1314-4.

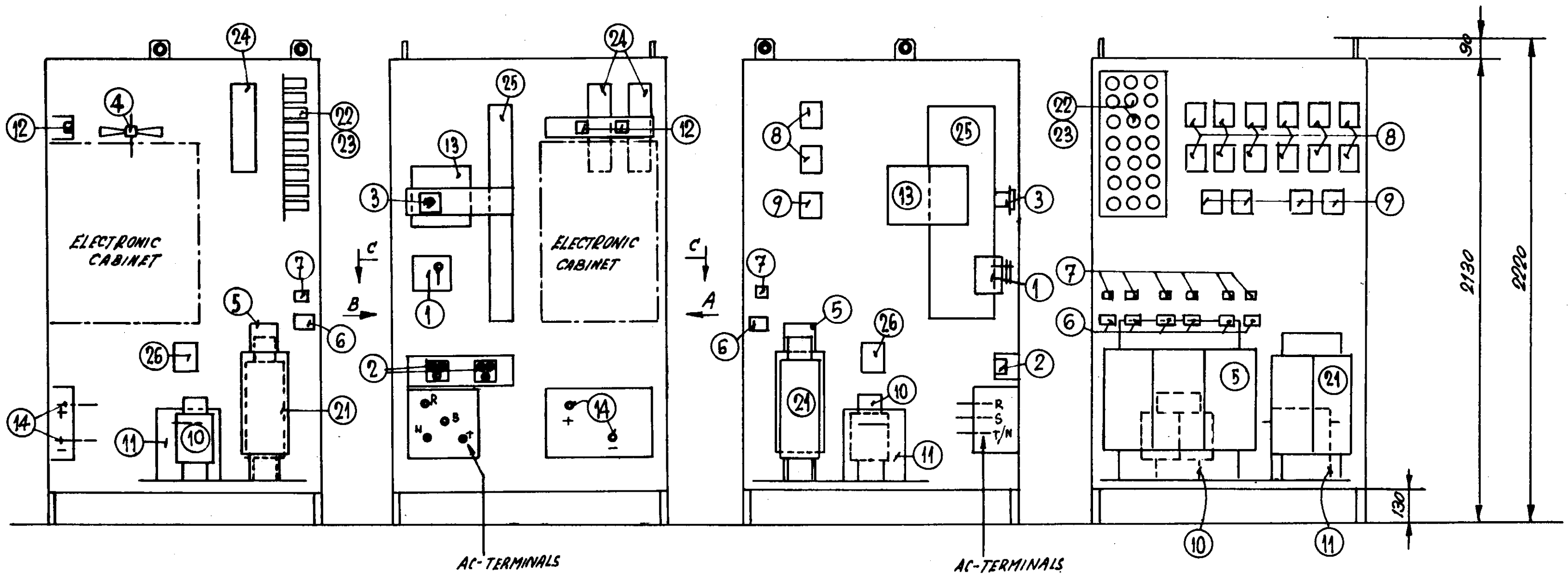
NOMBRE DE PIÈCES	DÉSIGNATION	POS.	MATIÈRE	OBSERVATIONS		
	PROPOSAL FOR WEST HALL			ECHELLE	DESSINÉ	14.2.68.
	RECTIFIER TYPE R4			~ 1/40	CONTROLÉ	
	PROJECT ONLY				VU	
					REMPLACE	
					REMPLACÉ PAR	
					RÉDUCTION	

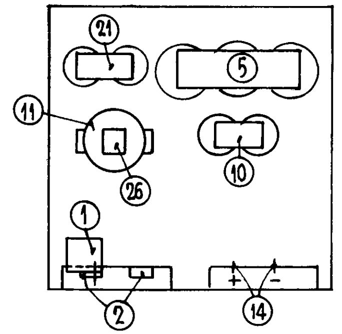
CERN ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE · GENÈVE — M.P.S. 126-1324-4

ORIGINAL SEE 126-1324-2

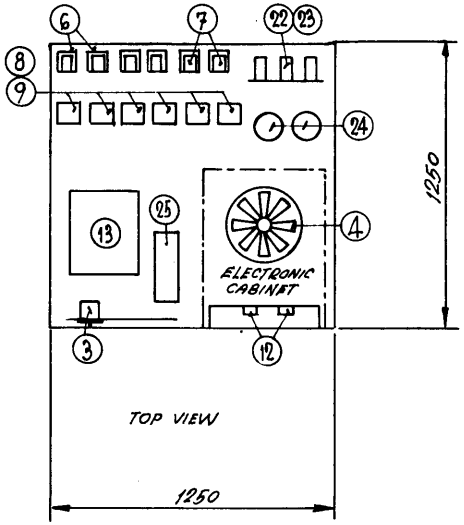
SIS/R/15 757

VIEW FROM A — FRONT VIEW — VIEW FROM B — REAR VIEW





SECTION C'-C'

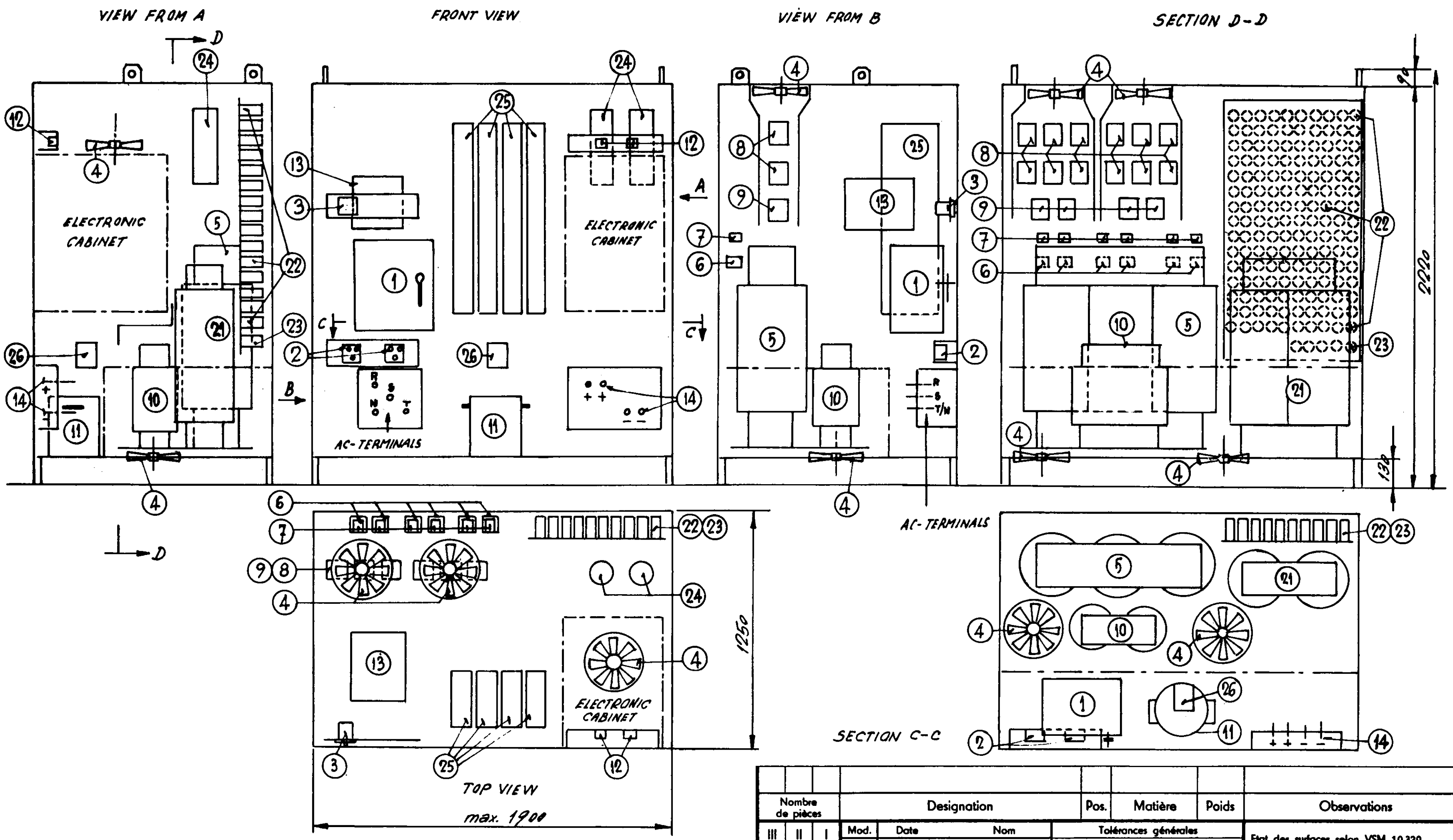


TOP VIEW

NOTE: *The reference Nos. 1...14 and 21...26 correspond to those given in the specifications as well as in the Power Circuit Block Diagram 126-1313-4*

Nombre de pièces			Designation			Pos.	Matière	Poids	Observations
III	II	I	Mod.	Date	Nom	Tolérances générales			Etat des surfaces selon VSM 10320; Rugosité en μ" VSM; Abréviations VSM 10319
			A			de à ±			
			B			de à ±			
			C			de à ±			
			Ensemble			S. Ensemble			Dessiné 2.2.68.
			PROPOSAL FOR WEST HALL			Echelle			Controlé
			RECTIFIER TYPE RO SPECIAL			1/33			Vu; Remplace; Remplacé par; Réduction
Dossier No	Dossier No	Dossier No	PROJECT ONLY						
			CERN ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE - GENÈVE						126-1322-4

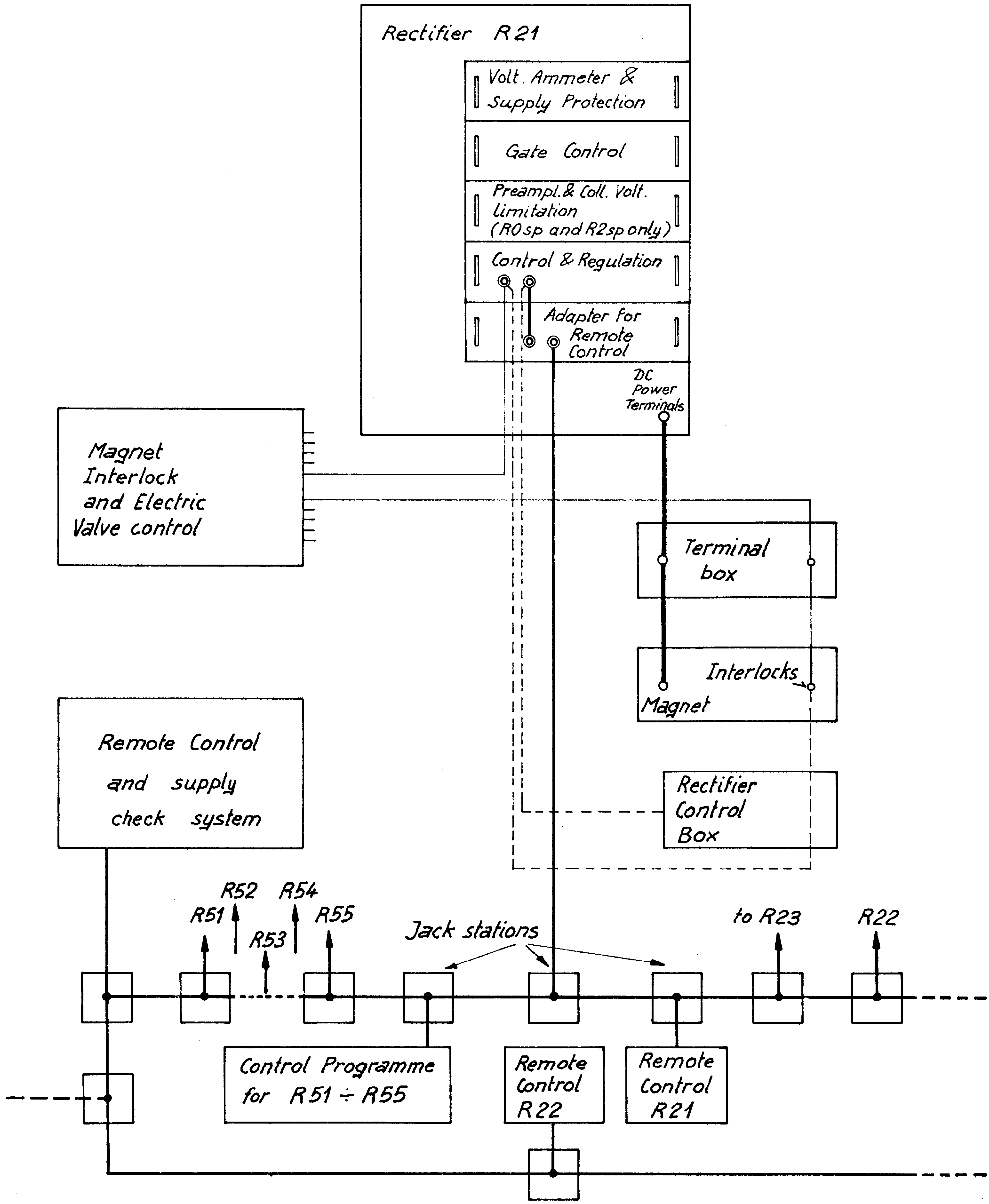
ORIGINAL SEE 126-1322-3



NOTE: The reference Nos. 1...14 and 21...26 correspond to those given in the specifications as well as in Power Circuit Block Diagram 126-1319-4.

Nombre de pièces			Designation		Pos.	Matière	Poids	Observations
III	II	I	Mod. / Date / Nom	Tolérances générales				Etat des surfaces selon VSM 10 320; Rugosité en μ" VSM; Abréviations VSM 10 319
			A	de à ±				
			B	de à ±				
			C	de à ±				
Dossier N°	Dossier N°	Dossier N°	Ensemble	S. Ensemble				Dessiné 31.1.68.
			PROPOSAL FOR WEST HALL		Echelle 1/33			Controlé / Vu
			RECTIFIER TYPE R2 SPECIAL					Remplace / Remplacé par / Réduction
			PROJECT ONLY					
			CERN ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE - GENÈVE					126-1321-4

ORIGINAL SEE 126-1321-3



Remote Control and Programming.

SIS/R/15 764

6.2.68 Mäder C.

CERN-MPS/ED-126-1334-4-a