DANFYSIK
JYLLINGE·DENMARK

MANUAL

MAGNET POWER SUPPLY 823

UNIVERSITY OF WASHINGTON

ORDER NO.________DF 7665

1/80/br

L I S T   O F   C O N T E N T S

I. INTRODUCTION

The Danfysik Magnet Power Supply Model 823 is a result of more than 10 years development work on power supplies in order to reach a high performance, high reliability, and easy servicing product.

The current stabilized supplies are specially designed for powering magnets used for scientific applications.

Each sub-assembly and each complete power supply are individually tested with respect to specifications before leaving the factory.

2. SPECIFICATIONS

Input voltages:	
Control power:	120 V, 60 Hz
Main power:	3x 208 V, 60 Hz
Voltage range:	
Slow variations:	+/- 10%
Fast variations:	+/- 5% (within the slow range)
Input power (max):	17.9 KVA
Power factor (min.):	0.85
Output current:	240 A
Output voltage:	50 V
Current stability[x]:	
Short form (30 min.):	+/- 5×10^{-6}
Long term (24 hours):	+/- 2×10^{-5}
Regulation[x]:	
Line var. +/- 10%	+/- 5×10^{-6}
Load var. +/- 10%	+/- 5×10^{-6}
Temperature coefficients[x]:	
Ambient temperature:	+/- 2×10^{-6}/°C(15-35°C)
Cooling water temperature:	+/- 2×10^{-5}/°C(10-35°C)

[x]The figures refer to max. output after 30 min. warm up

Cooling water:	
Flow (min.):	8 l/min.
At diff. pressure	4,5 Atm.
Max. pressure:	15 Atm.

3. GENERAL DESCRIPTION

The Magnet Power Supply 823 is housed in a grey modular steel cabinet with doors at front and rear and removable side plates. At the top of the front a control panel in a 19" inch cabinet is situated. Connections for power, water and output is at the bottom on the rear.

The circuits on the power supply can be divided into the following main parts:

A. The transformer and rectifier circuit, which converts the input three-phase AC voltage to a DC voltage of proper level.

B. The transistor bank, which acts as regulating element in series with the load.

C. The reference shunt which gives a voltage proportional to the output current for the regulation circuit.

D. The D.C. amplifier circuit with reference supply and over-load circuit, which compares the setting with the shunt voltage and regulates the output and additionally protects against mal-function.

E. The control panel which besides the D.C. amplifier contains all the necessary control and interlock circuitry.
The individual circuits will be described separately.

4. CIRCUIT DESCRIPTION

4.1. Transformer and rectifier

Four main configurations for transformer and rectifier lay-out exist:

A. Main transformer and 3-phase rectifier, see dwg. 80947.
B. Main transformer and 6-phase rectifier, see dwg. 80948.
C. Vario transformer, main transformer and 3-phase rectifier, see dwg. 80949.
D. Vario transformer, main transformer and 6-phase rectifier, see dwg. 80950.

The configuration used in the individual power supply depends mainly on the output ratings.

A. The set up with a main transformer followed by a 3-phase rectifier is the most simple and is used for low output currents and voltages.
B. The 6-phase rectifier system is used where high current and low voltage is required.
C. The vario transformer with 3 phase rectifier is used where low current and high output voltage is required, or where the load resistance is variable.
D. The configuration with both the vario transformers and the 6-phase rectifier is used where both high current and voltage is required.
The 6-phase system is made by use of two independent secondary output on the main transformer. The two secondaries are identical, but both provided with two sets of outputs shifted + and - 15^{o} from the primary. By connecting the two opposite outputs from the two secondaries to the 3-phase tectifiers connected with an interphase transformer which improves the current sharing of the rectifiers a very low voltage ripple is achieved.

The vario transformer is operated by a small AC-motor controlled by the vario control print in the control cabinet.

4.2 TRANSISTOR BANK

The transistor bank acts as the series regulating element in the power supply, and is constructed of a Danfysik designed modular system of water cooled heat sinks.

The number of heat sink modules depends on the maximum power to be dissipated. The maximum power per module is normally 1 kW.

Each module carries 17 transistors, where the first is coupled as Darlington driver for the remaining 16, which are coupled in parallel with current equalizing emitter resistors. The single drivers of the modules are also coupled in parallel with emitter resistors as well as there is a connection between the modules for the bases of the 16. The second transitor of the first module is separated from the other and coupled as main driver for the single drivers on the modules. It is connected to the DC amplifier in the control panel and controls the complete transistor bank.

The Type 2N3773 is normally used as power transistor.

All transistors have the collectors at the same potential. No electrical insulation to the heat sink is thus necessary and the transistors are mounted directly on the modules obtaining an excellent cooling.

The emitter resistors are mounted on the fuse boards which also carries the fuses and diode gates for the transistor failure circuit.

The transistor failure is a safety feature mounted on the basic transistor level. Fuses in emitter and base of each transistor will in case of a break down failure blow out and release the transistor from the others. A diode gate circuit will sense the blow fuses and approx. 100 µA for each failing transistor is send to the transistor failure amplifier in the control panel. Here 1 % failing transistors will turn on the TRANSISTOR FAILURE indication, which is a reminder telling that the power supply should be inspected and the failing transistors exchanged by first possible occassion, but the power supply is still safely operable. For 10 % failing transistors the OVERLOAD indication and interlock is activated, and this means that the power supply can not be operated before the transistors have been changed.

4.3. REFERENCE SHUNT

The reference shunt provides a voltage proportional to the output current for the DC amplifier circuit.

It consists of one or several Manganin rods in a water cooled assembly, or a water cooled Manganin tube.

The shunt is tailor made to give 1.0 Volt for maximum output of the power supply, and measurement is made as a true 4 terminal system with stress released power connections.

4.4. CONTROL PANEL

The control panel contains all the control electronics and circuit boards, as well as controls and indications necessary for the operation of the power supply.

It can be grouped into:

A. Controls and indications on front panel
B. Interlock circuits and relay boards
C. Power supply +-15 V, +24 V
D. Vario transformer control (only power supply with vario)
E. Remote control connection
F. DC amplifier circuit, see section 4.6

A. Controls and indications on front panel

Control switches/push buttons
CONTROL POWER, ON - OFF
MAIN POWER, ON - OFF
INVERTER, IN - OUT

Selector:
CONTROL, LOCAL - REMOTE

Status and failure indications (LED's):

CONTROL POWER ON	yellow
MAIN POWER ON	yellow
REMOTE CONTROL	yellow
INVERTER IN	yellow
POWER FAILURE	red
COOLING FAILURE MPS	red
COOLING FAILURE MAGNET	red
OVERLOAD	red
TRANSISTOR FAILURE	red

Potentiometers:

CURRENT SETTING, COARSE	10 turns, 100 % range
CURRENT SETTING, FINE	1 turn, 1 % range

Meter:

Output current	scale 0 - 100 %

B. Interlock circuits and relay boards

The interlock circuit protects the power supply in case of a failure condition, by automatically switching off the main power contactor. It also provides information of the failure type by a front panel indication.

Four types of failure conditions are detected by the interlock system.

1. Power Failure:

   a) One phase relay sense the presence of all three input phases.
   b) A thermal switch on the 3 phase input wires senses input overcurrent.
   c) In power supplies with vario transformer, a thermal switch on the vario senses output overcurrent.
   d) In power supplies with vario transformer a micro switch senses the vario position, when the main contactor is off. This feature only prevents switching on at a too high vario position.

2. Cooling Failure MPS:

   a) A flow switch in the output of the cooling water system senses the water flow.
   b) A number of thermal sensors are distributed on diode and transistor heat sinks sensing overtemperature.

3. Cooling Failure Magnet:

   An external input from flow switch and/or thermal sensors are available.

4. Overload:

   An electronic overload circuit senses:

   a) Output over current (10 %)
   b) Transistor bank load line
   c) Number of failing transistors less than 10 %

   For each failure type a small relay circuit is activated. A series connection of relay contacts in series with the auxilliary relay for the main contactor gives the failure interlock. If a failure occur, the corresponding relay drops out opening the loop for main contactor which then drops out too. The failure relay will remain out after the failure has disappeared, untill it is reset by an main power ON or OFF command.

   The relay circuits are situated on the two circuit boards.

   Schematic no. 80271B RELAY BOARD no. 0
   Schematic no. 80268B RELAY BOARD no. 1 - 3

These boards contain the complete relay circuits for power ON - OFF, inverter IN - OUT, LOCAL - REMOTE control as well as resistors for the LED's on the front panel, and relays activated from the ready, transistor failure and overload circuits on the DC amplifier board. From all relays a spare contact for remote monitoring is available, as well as all commands are available in remote control. All relays are operated at 24 V DC.

C. Power Supply +-15 V, +24 V

Schematic no. 80259.
The power supply board contains an unregulated 24 V DC supply for the relay circuits and two 15 V DC positive and negative stabilized supplies for the DC amplifier and vario control boards. The power supplies are powered from a common transformer with double shield.

D. Vario Transformer Control

Schematic no. 80694.
The vario transformer control circuit senses the voltage across the transistor bank, and by controlling the output voltage of the vario it keeps the transistor bank voltage constant within a desired window.

The input from the transistor bank is after a filtering which senses on the bottom or the ripple voltage compared with the setting of R3 by amplifier A1. The gain of A1 is determined by R13 which together with the zener voltage of D6 - D7 gives are exceeded the corresponding up or down relay is pulled activating the vario motor. R6 and R7 gives a hysteresis to avoid flickering of the relays. When the main power is switched off, the 15 V is automatically by a relay switched to the input, turning the vario down. A print switch enables manual operation for service purposes.

Adjustment procedure:
Connect a meter across the transistor bank, control power ON, main power ON, output approx. 10 %. By changing the output and watching the meter and the vario, adjust R3 which controls the level, and R13 which controls the window to achieve

Vmin = _______ V; Vmax = _______ V

E. <u>Remote Control Connection</u>

Two sockets on the rear of the control panel yields remote control and monitoring of all necessary controls and status/failure indications.

The remote control connections can be used either in connection with a Danfysik remote control panel option, a Danfysik MPS Control System or any system which matches the functions.

Remote control socket No. 3, CONTROL, contains relay outputs for all indications. They are permanently present independent of the position of the local/remote selector, while the control inputs for main power and inverter only are accessable in remote position. 24 V for external LED indications or relays are also

Socket No. 3, CONTROL

PIN	INDICATION/COMMAND	FUNCTION
1	CONTROL POWER ON	closed for power on
2	MAIN POWER ON	closed for power on
3	POWER FAILURE	closed for no failure
4	REMOTE CONTROL	closed for remote
5	COOLING FAILURE MPS	closed for no failure
6	COOLING FAILURE MAGNET	closed for no failure
7	OVERLOAD	closed for no failure
8	TRANSISTOR FAILURE	closed for no failure
9	INVERTER IN	closed for inverter in
10	READY	closed for ready
11) 12)	COMMON FOR 1 - 10	
13	NC	
14	MAIN POWER ON	closing contact for ON
15	MAIN POWER OFF	opening contact for OFF
16	INVERTER IN	closing contact for IN
17	INVERTER OUT	closing contact for OUT
18) 19)	0 V, COMMON FOR 14 - 17	
20) 21)	+ 24 V	
22	NC	
23) 24)	CONTROL POWER RELAY OPTION	
25	SHIELD	

Remote control socket no. 4, REFERENCE, contains the reference voltage input, the 10 V reference supply voltage and the 1 V shunt voltage. The 10 V reference supply should only be used for a external control potentiometer. The reference input is position remote, while the shunt voltage is permanently present. A high input impedance meter should be used for the shunt voltage. The socket is a standard D25 type, male. Parallel leads should be used to reduce cable resistance.

Socket No. 4, REFERENCE

PIN	
1-8	10 V REFERENCE SUPPLY
9	NC
10-13	REFERENCE INPUT, 0 - 10 V
24-21	REFERENCE GND, 0 V
22	NC
23	SHUNT VOLTAGE, -1 V
24	SHUNT GND, 0 V
25	SHIELD

4.5. D.C. AMPLIFIER CIRCUIT

Schematic No. 80262 B
Assy no. 80261A

The circuit on this board can be divided into 5 sections:

A. Reference supply
B. D.C. Amplifier
C. Ready circuit
D. Transistor failure circuit
E. Overload circuit

A. Reference supply:

The reference supply provides the coarse and fine output setting potentiometers on the front panel with a highly stable voltage for the generation of the reference voltage which controls the output.
Three different circuits are used as reference supply depending on stability requirements:

1. For a power supply with a class 10^{-5} stabtlity a small separate circuit board, which is mounted on the main board, is used. Schematic no. 80207 positive reference unit.* This units yields a temperature stable supply voltage of + 10 V DC selected to a tolerance os less than 2% and a temperature coefficient of less than 1 ppm/$^{\circ}$C. Furthermore an cir. voltage of -10V is available. It consists of a reference bridge circuit and an inverting amplifier for the aux. voltage. As reference element is used a LM 399 H (A3) precision reference with built in heating supply output of which is nominally 6,95 V. The bridge circuit is consisting of precision resistors R4, R6, and R5, and the A3. The low drift amplifier A1 is used as bridge detector and feeds T1 through Z1. Because of the used ratio between R4 and R6 an output voltage of 10V is obtained. This voltage is also used for supplying the reference element with a stable current. R3, D1, and R1 are inserted in order to start up the bridge. The aux. voltage curcuit consists of a simple 1:1 inverting amplifier A2, R9, R10.

* From February 1984 superseeded by 81086.

2. For a power supply with a class 10^{-4} stability an integrated reference unit P.M.I. REF-01E is used. This unit yields a temperature stable reference supply of 10V with a tolerance of $3^{o}/00$ and a typical temperature coefficient of 3 ppm/^{o}C.

3. Where the power supply is provided with a DAC option or controlled by an external reference voltage an integrated reference unit N.S. LH 0070 is inserted for service reference supply purpose.

D.C. AMPLIFIER

The D.C. Amplifier compares the reference voltage setting with the voltage across the reference shunt and regulates through the transistor bank the output.
The input reference voltage goes to a voltage follower A1 which through T1 drives the precision resistor R5. Another precision resistor R9 gives direct feed-back from the reference shunt. The ratio between R5 and R9 is 10:1 corresponding to a shunt voltage of 1V and the junction of the resistors is fed to the input of a very stable amplifier A2 which is the first stage in the main amplifier loop, which due to the high D.C. gain yields the high stability. To this input is also aux. inputs facilities for yield feed back or reference summing purpose.
The output range of A2 is limited by diodes D5 and D6 and then reduced by R14 and R15 to a max. level of approx. +/- 100 mV. Together with the RC set up of R16-R17 and C2 which gives A.C. feed back from the shunt, this arrangement gives 2 modes of operation. When the output is inside the range the R-C link just acts as a lowpass filter which ensures stability in spite of the high loop gain, but if the reference voltage is changed faster than the loop can follow, the output of A2 will clamp and give a constant voltage input to the integrator which is now formed by R16-R17, C2 and the last stage of the amplifier. As a result the shunt voltage and thus the output current will change with a constant range until the output level, where A2 again is active, is obtained. This current rate control feature is adjustable with R16.

The last stage of the amplifier consists of operational amplifier A3 with driver transistor T2. To ensure the stability of the loop the amplifier has capacitive feed back as well as the output is provided with a filter. It should be noted that, in order to avoid instability due to voltages across common loads, the amplifier has three separate common or zero levels, one for the reference and input circuit, one for the output filter and one for the power supply and other incritical circuits. The connection between those levels are at the transistor bank and reference shunt and not at the circuit board.

C. READY CIRCUIT

The ready circuit senses the amplifiers of operation and provides the ready indication telling when the output is stabilized on the desired value.
It consists of operational amplifier A4 which is coupled as a window detector sensing on the output of A2. If this output is inside the alarming levels, transistos T3 is activated turning on the ready indication.

D. TRANSISTOR FAILURE CIRCUIT

The transistor failure circuit senses the amount of failing transistors in the transistor bank. For 1% failing transistors the transistor failure is provided and at 10% the overload indication and interlock is activated too.
It consists of operational amplifier A5 which receives approx. 100 μA per transistor released by its fuses. The sensitivity is adjusted by R 32 and transistor T4 turns on the transistor failure indication while D 21 activates the overload circuit.

E. OVERLOAD CIRCUIT

The overload circuit senses the output current and the transistor bank voltage and activates the overload indication and interlock if either the output current exceeds the maximum with more than 10% or the transistor bank due to a wrong load resistance works on a load line which gives a too high power dissipation in the transistors. The overload can also be activated through the tran-

If overcurrent occurs, diode D 27, which is directly sensing on the reference shunt, will trip level detector A8 comparing with the setting of R 44.
The shunt voltage is also going to A6 where it is inverted and amplified and then in A7 summed with the voltage of the collector of the transistor bank. The output of A7 will remain constant as long as the transistor bank works on a proper load line. If not D19 will activate level detector A8.
The level detector A8 which can also be activated by the transistor failure circuit through D 21 releases in case of failure the overload relay in the interlock system through T5.
If the power supply is provided with a vario transformer the transistor bank voltage will be held constant. The load line control is here reduced to a max. voltage protection.

Adjustment procedures

Please refer also to the adjustment procedure on schematic no. 80262A.

Zero setting:

Switch control power on and let the circuit warm up for at least 15 min.

R2: Adjust point A to zero (<50 μV) with pin 29 and 23 shorted.

R12:Adjust point B to zero (< 10mV) with pin 29 and 23 shorted.

R19:Switch main power on and adjust point B to zero (< 10mV) during operation at approx. 50 % output.

Rate control:

R16:When the amplifier is running in constant rate mode, the sweep time for zero to max. output is determined by R16 inside the range 1-100S. It should be adjusted according to the following:

In a normal power supply the voltage induced to the inductance of the magnet will for decreasing current add to the voltage across the transistor bank stressing the transistors. The maximum induced voltage should normally not exceed 5V.

In a power supply with vario transormer the induced voltage can also cause hunting of the vario, if it is too high compared to the control window for the vario. The induced voltage should not exceed 3V.

If the inductance of the magnet is known the sweep time can be calculated from:

$$T = L \times I_{max} / V_{ind.}$$

If it is not known it can be observed on an oscilloscope when changing the input reference fast.

In many cases where a fast response of the power supply is not essential it is convenient to use a slower sweep time while this reduces the Eddy-currents in the magnet iron and thus improves the field homogenity and field versus current reproducibility.

Overload, power supply without vario transformer:

R 44: Increase the output current to 110% by applying an external reference voltage of 11,0V to pin 29, and adjust to the overload relay is just released.

R 40: Adjust point C to -0.95V for zero output, but with main power on.

R 38: Adjust point C to -0.95V for 100% output.

Overload, power supply with vario transformer:

R 44: As for a power supply without vario transformer.

R 38: Turn clockwise (max. resistance).

R 40: Adjust point C to -0.55V for 100% output and the vario in top of the window (apply a little over current and reduce to 100% output to achieve this.)

Transistor failure:

R 32: Remove 10% of the emitter fuses with main power off and adjust to the over load relay is just releases. Check that the transistor bank failure is activated for 1% (at least 1) released fuses.

4.6. OPTIONS

4.6.1 Reverse Current Option

See schematic 80125 A

This optional circuit delivers 2 Amp DC reverse current, which can be used for compensating and steering in case of deflection magnet with a straight-through port is used. It is only activated when the mains contactor is on.

Under normal operation the supply will be cut off because of the connection from the collector of the output transistor Q3 to the base of Q1 via R3. When the output current and thus the output voltage of the MPS increases the zener will gradually be pulled down by A1. The reason for this cut-out circuit is power limitation of the output transistor.

4.6.2 Inverter

As option a current inverting relay can be delivered. The inverter can only be operated when the main power contactor is deactivated. In order to ensure that the magnet is without current a time delay (adjustable, 2 - 10 sec.) prevents the inverter relay from being activated before this preset time has elapsed after deactivating the main contactor. The inverter relay is latching and does not drop out in case of power failure.

5. SERVICE AND TROUBLE SHOOTING

If a malfunction occurs first observe the indicating lamps of the front panel.

Please consult chapter 4.4 for a detailed description on the Interlock System. Check specially that cooling water is supplied both to the magnet power supply and if necessary to the magnet coils in sufficient quantities.

The following hints can be helpful if the problem is not evident from the failure indication on the control panel.

1) The supply output current goes to max. and eventually cuts out the supply without possibility for control from the potentiometer. Remove the output connection from the DC amplifier to the base input of the driving transistor on the transistor bank.

   When switching on power, the output current shall remain zero; if so the error must exist in the DC amplifier. If the current goes high, the problem must be sought in the transistor battery. The transistor failure indication takes care of the lowest level of the transistors while the driving transistors are not included in this circuitry as they are shifted in level. In this case remove the load (the magnet) from the power supply terminals and connect a 220 V or 110 V (dependent on max. output voltage) 60 W lamps as load. When switched on the lamp will glow and the base and emitter connections are then disconnected row by row until the lamp extinguishes. The control transistor of this row can then be suspected.

2) No output current possible. Connect a small supply able to give up to 5 V positive to the base of the input transistor for the transistor bank. Increase the voltage slowly from 0 and check that it is possible to drive an output current through the power transistors. If this is the case the DC amplifier should be suspected.

DC Amplifier

If the DC amplifier has to be suspected, the following procedure can help to find the trouble. Switch on the control power only. Reduce the input from control potentiometer to 0. Then connect a potentiometer of say 50 kOhm between +-15 V in the DC amplifier, see schematic no. 80262B. A 1 MOhm resistor is connected between the arm of the potentiometer and the AUX. PIN 17 on the DC amplifier. If the DC amplifier is properly operating it must be possible to switch the output between max. positive and max. negative turning the potentiometer close to 0 output. If not, trace through the amplifier following the schematic.

Transistor Failure Indication

If this is indicated but not switching off the supply repair can wait until it is convenient. Proceed as follows when repair is needed:

By visually inspection find the blown fuses and exchange the fuses and the connected transistor. If blown fuses can not be found visually use the following procedure:

With control power on only measure the voltage with a low impedance (i.g. 1 k /V) on the anode of the transistor failure output diode for each transistor row. It has to be 0 V and it will raise to approx. 1.2 V if a failure occurs. Then short the emitter fuses on one by one to see the voltage go to 0 V.

Note:
After repair check with power on that the voltages on the individual emitter resistors are identical with +-10 % at max. output current. If a reading is missing the bonding in the transistor may have opened and the transistor has to be exchanged.

In case of presistent problems, please consult our local representative or DANFYSIK directly.
Please always state magnet power supply type and series number.

6. INSTALLATION AND START UP

6.1 Installation

Upon receiving the power supply check that the specifications mentioned in chapter 2, correspond to your mains voltage and frequency; furthermore check cooling water requirements.

Finally check that no physical damage has occured during transportation ; also check plugs and that prints remain fixed.

Connect the mains voltage as follows:

Power line phases to terminals marked R, S, T.
Control power: phase to terminal P
neutral to terminal N

As indicated above a separate phase can be used for control power, but it can also be taken from any of the terminals R, S, T.

The ground connection terminal labelled GND can either be grounded in the mains wall outlet or a common ground rail according to local safety and power authority regulations.

If the magnet is provided with thermal switches for overtemperature protection and eventually a separate flow switch for monitoring the flow, these contacts can be connected to terminals A and B. If these interlocks are not used, short-circuit A and B.

The output terminals are labelled + and -. In case the inverter option has been requested, then the labels are true with the inverter: out.

NB: Be careful to use cables of sufficient square for connecting the supply and load to keep the cable drop below the specified maximum value. (.i.e. the difference between magnet voltage and supply output voltage at max. current).

Finally connect cooling water to the supply; the connections are either marked with arrows or labelled inlet and outlet. If the magnet has not been connected with cooling water already, please make connections.

6.2 Start Up

a) First activate the control power switch: ON
b) Reset the interlock relays by pushing main power OFF.
c) Observe that no errors are indicated. If error(s) are indicated, trace down the problem. Refer to chapter 4.4 for debugging.
d) Turn the coarse current setting on zero (counter clockwise).
e) Activate the mains contactor: ON.
f) Observe that the current meter displays zero. If not, refer to trouble shooting chapter 5.

g) Turn the coarse current pot. meter on max. setting and observe that the supply can deliver the rated current. If it can not give sufficient current, check that the cable drop does not exceed the permitted value.

If the mains contactor drops out while overload is indicated, the output is probably shorted. Check with a volt meter that the specified voltage exist on the output terminals prior to de-activation of the mains contactor. The supply is now ready for use.

In case of persistent problems with blown output transistors, the reason might be a too high setting on the current rate limit; check with an oscilloscope that the voltage induced in the magnet does not exceed the permitted value. Readjust sweep rate limit if necessary, see chapter 4.6, DC Amplifier Adjustments, time constant.

7. SUPPLEMENTS

7.1 SCHEMATICS

[X]	80947	MAGNET POWER SUPPLY 823 with single rectifier
[ ]	80948	MAGNET POWER SUPPLY 823 with double rectifier
[ ]	80949	MAGNET POWER SUPPLY 823 with vario transformer and single rectifier
[ ]	80950	MAGNET POWER SUPPLY 823 with vario transformer and double rectifier
[X]	80262B	DC AMPLIFIER
[X]	81086	REFERENCE UNIT
[X]	80271B	RELAY BOARD NO. 0
[X]	80268B	RELAY BOARD NO. 1 - 3
[ ]	80694	VARIO TRANSFORMER CONTROL CIRCUIT
[X]	80259	POWER SUPPLY
[ ]	80253	REMOTE CONTROL PANEL
[ ]	80125A	REVERSE CURRENT OPTION

7.2 ASSIES

[X]	80261A	DC AMPLIFIER
[X]	81085	REFERENCE UNIT
[X]	80270B	RELAY BOARD NO. 0
[X]	80267B	RELAY BOARD NO. 1 - 3
[ ]	80693	VARIO TRANSFORMER CONTROL CIRCUIT
[X]	80258	POWER SUPPLY