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REPORT ON THE ACTIVITIES OF THE PS MAGNET SECTION OF THE SYNCHROTRON RING GROUP FOR THE PERIOD

1st JANUARY - 31st DECEMBER 1968

by

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This report has been written with the intention to indicate essentially the works executed during the main summer shut-down 1968. The edition has been delayed due to more urgent work.

1. INTRODUCTION

The PS magnet section is responsible for the maintenance of a large number of installations covering various techniques. In the following a brief review of the installations.

1.1 Places of activities

- whole PS ring upper and lower tunnel (magnets and lenses)
- subsidiary generator room (SGR) (rotating machines)
- reference room (magnet field display)
- Ejection Building (pulsed power supplies, semi conductors)
- Old Power House (control amplifier for rotating machines)
- Central Building (cable connections for the ring)
- South Hall extension (magnetic measurements, mechanics)
- MCR (remote control and signal distribution, etc.)
- Labo 18 (laboratory for electronics and small mechanics)

1.2 Magnets and lenses

101	PS magnet units
20	quadrupoles (high power)
20	skew quadrupoles (low power)
40	injection quadrupoles (low power)
20	kickers
20	sextupoles
20	octupoles
241	magnets and lenses in the ring.

1.3 Power supplies (current stabilized)

11	75V/5A	transistorized for injection quadrupoles, programmable
4	30V/3A	for P.F.W. correction, programmable
2	30V/3A	for skew quadrupoles
1	830V/270A	pulsed, controlled rectifier for the SE-quadrupole in S.S.55
2	360V/650A	pulsed, controlled rectifier for bump coil systems 58 and 62
1	1600V/2000A	pulsed capacitor discharge for SE-quadrupole in S.S. 61
1	1000V/650A	pulsed capacitor discharge for FE-bump for S.S.74 ejection
1	360V/320A	pulsed, programmable, bipolar, controlled rectifier for general purpose
4	600V/100A	rotating amplifiers, amplidyne type B
2	600V/360A	rotating amplifier generator set type A
1	2000V/1400A	pulsed P.F.W. generator
30	5,3 MVA	

1.4 Remote controls in the MCR

MR 90	P.F.W. injection and skew quadrupoles
MR 93	injection quadrupoles
MR 50	P.F.W. generator
MR 51	rotating machines
MR 122	controlled rectifiers, mainly for ejection
MR 121	programming of rotating machines

1.5 Displays in the MCR

- B-pulse train derived from 101st magnet unit
- Flat top signal
- dB / dt signal
- current and voltages of the 30 supplies in MR 50, MR 33 + MR 123
- sample and mold measurements on all signals in MR 51.

2. MAINTENANCE

2.1 Maintenance of the 101 PS magnet units

2.1.1 Cooling circuitry

- Modification of the cooling circuitry of 30 magnet units including modification of stainless steel covers, replacement of rubber tubes, easier fixation of protection hose, inference with new cooling ducts installed in the tunnel,etc.

- All the 100 magnet units in the PS ring are now equiped with aluminum pipes and the O-ring seals are the only critical material remaining in the neighbourhood of the beam.

- The water flow has been checked on all units. The normal tolerances have been found.

2.1.2 Temperature interlock

- The functioning of the temperature interlock on the excitation coils has been checked systematically.

- Some thermometers have been changed (units 1, 2, 26, 76).

2.1.3 Bus bars

The following connections have been changed :

60 to 61: new bar for long straight section replacing high voltage cables installed previously, manufactured by ACEC. Acceptance tests in the factory.

83 to 84: new bar for short straight section replacing high voltage cables, manufactured by ACEC.

12 to 13, 24 to 25, 84 to 85, 87 to 88 :

Bus bars repaired after breakdown at less than 10 Kilovolts. Insulation Samica band and Araldite 905 polymerized at 80° C. Testet after repair at 20 KV ac in water.

The origin of the breakdowns are insufficient impregnation and water.

2.1.4 Insulation of main exciting coils

On the coils of the magnet units 1, 58 and 64 traces of electrical breakdowns have been detected. It turned out that only the surface was effected and therefore the repair was easy. However, some coils give the impression that the mica-paper-mica layers start swelling at certain places.

2.1.5 High voltage tests on the whole magnet

A dc-voltage of maximum 10000 Volts has been applied to the magnet connections.
After repair of the insulation which broke down at different places 7000 Volts could be maintained during at least one minute. The resistances to earth are 200 Kiloohms for the upper and 50 Kiloohms for the lower pancakes (and bus bars).

2.1.6 Magnetic measurements on all 100 magnet units

The field and field distribution at injection level have been checked on all 100 magnet units by comparing each one of their values with the field in the 101st unit. No excessive eddy current loops nor defect P.F.W. corrections were detected. This means, that at the end of August 1968 the magnetic field was correct everywhere.

2.1.7 Modification of the covers of the 100 magnet units

The installation of new computer - controlled backleg windings on the 100 units made it necessary to facilitate the passage of the cables through the covers. Accidental earthing by damaged insulations should no longer occur even by wrong handling of the covers. Ten big covers have been modified in order to facilitate unmounting and remounting (units 2, 6, 8, 10, 26, 58, 62, 63, 74, 80). Several covers had to be changed too, due to narrow tolerances chosen for various constructions in straight sections (ejection, tanks, etc.). The covers on the 100 magnet units are often considered as a banality and it is frequently ignored that they protect a high power installation (12000 Volts, 6400 A, 70 MVA), which is essential for the acceleration of the protons.

2.1.8 Earthing of the covers

The earthing of the covers on all 100 magnet units has been checked and was found to be in good order at the end of August.

2.1.9 Cleaning and painting of excitation coils

The upstream end of the excitation coils has been painted in order to avoid penetration of water through the mica splitting insulation.

2.1.10 New backleg windings (orbit correction at injection)

Except the magnet units 5, 65 and 66 all magnet units have been equiped with two-turn backleg windings. The chosen cables should resist to radiation better than the old ones.

2.1.11 220/380 Volt installation on the magnet units

The SB division has been asked to perform the maintenance of the distribution of electricity, town water and compressed air mounted on the magnet units. Fuses and all rubber tubes have been exchanged.

2.1.12 Bump coils (high power backleg windings)

The mechanical fixation of the bump coils has been checked. The insulation resistance to earth of all systems is of the order of 20 Megohm. However, a deterioration was observed on the coils particularly exposed to radiation (units 58 + 62). Due to vibrations some contacts deteriorated and therefore all electrical connections are now tightened up with special spring washers.

2.1.13 Radiation measurements

Dosemeters with different sensitivities have been fixed on 50 magnet units. It is intended to recuperate them after one year and to measure the dose absorbed by the excitation coils and P.F.W. In the same package a lot of devices like diodes, NTC, PTC, transistors, capacitors, vetronit, araldite, rubber, etc. have been filled in. The samples have been measured prior to mounting and the difference of the characteristics will be related rather precisely to the radiation dose.

2.1.14 Moving of magnet units

The vacuum chambers in the magnet units 1, 64 and 74 were exchanged. For this, the respective units had to be moved. The consequences for the PS magnet section were : mechanical, electrical and hydraulic disconnection and reconnection. New resistor networks for eddy current compensation had to be calculated, fabricated, checked and mounted.

2.2 Lenses in the PS-magnet structure

2.2.1 Injection quadrupoles

Most of the 40 injection quadrupoles have been installed in 1965. Two of them, the lenses No. 10 and No. 30, were damaged by radiation and therefore have been replaced by new ones. All screws for electrical connections have been tightened. The geometrical alignment of all quadrupoles has been checked and corrected. Several quadrupoles had to be unmounted and remounted due to exchange of the seals on vacuum chamber connections (introduction of metallic seals).

2.2.2 Quadrupoles Rade Končar

The quadrupole for S.S. 79 has been reinstalled and connected in series with the 4F quadrupoles. Several quadrupoles had to be moved due to the introduction of metallic seals on the vacuum chamber connections.

2.2.3 Quadrupole in S.S. 61

The interlocks on this quadrupole have been checked (earthing, ventilators, temperature, optical signal).

2.2.4 Sextupoles

Two watercooled sextupoles have been prepared for the installation in S.S. 35 and S.S. 95. Several check-ups have been made before installation (interlocks, water tightness, insulation, magnetic field, etc.). These two sextupoles have separate cable connections (2 x 25 mm^2) to the new patch panel in the S.G.R. The number of turns per pole is 32 instead of 36 of the original air cooled sextupoles. A peak current up to 180 A can be applied without serious saturation effects, in spite of using the original iron. The cooling water comes from the new ring cooling duct, at present connected to the East Hall heat exchangers. It is supposed to pulse the two sextupoles in series with the new 12-phase bipolar programmable 100 kVA controlled rectifier in S.G.R. The location in S.S. 35 and S.S. 95 is most advantageous for SE 62 but other places could be chosen as well without difficulties.

2.2.5 Kickers in octupoles

A vertical kicker has been placed in S.S. 98 on the demand of L. Henny.

2.2.6 Bus bars for general purpose around the PS ring

A cable (4 x 50 mm^2) has been installed in the ring tunnel. Every 10th straight section the conductors pass through a junction box. This cable will be used for special (mostly provisional) cabling of lenses essential for Machine Developments. All types of lenses can be connected to the cable very quickly. Four different lenses may be connected and pulsed simultaneously.

2.2.7 Cannon plugs on sextupole - octupole sets

All of the 17 octupoles, sextupoles and kickers are now equipped with cannon plug connections. This enables quick disconnection and removal of the lenses. Together with the bus bars for the lenses, it is also possible to make rather quickly special connections for MD's. The polarity of the cabling has been checked.

2.2.8 Repair of damaged cables

In course of civil engineering work for the Booster and ISR junctions a large number of lense cables burnt out in the region of S.S. 20. It has been checked that no mixing of circuits may have occured.

2.2.9 New patch panel in S.G.R.

The old patch panel in S.G.R. had a too small capacity for accepting the new connection and was not practical for modifications. Therefore, a new panel of double size has been installed in the wall separating S.G.R. and South Hall extension.

As a consequence, the cabling of the lenses and power supplies had to be changed. The polarity of the new connections has been checked.

2.3 Rotating machines

2.3.1 Amplidynes type B

The amplidynes B2 and B4 have been overhauled (bearings, collector, alignment, cleaning, etc.). The old P.F.W. amplidyne has been installed in the place of the B2 machine. The ends of the rotor windings of the B2 machine have moved somewhat outwards due to the centrifugal forces.

The electrical connections and contacts of the control circuitry have been tightened and cleaned (because of vibrations).

2.3.2 P.F.W. generator

The P.F.W. motor generator set, as well as its accessories, have been overhauled completely.

- Exchange of bearings on the motor
- Alignment of the whole set
- Exchange of all contacts of the start resistor
- Checking of the oil quality and exchange of the oil in the start resistor
- cleaning, etc.

Spare parts have been ordered and a planning for systematic maintenance is being established in cooperation with the manufacturer.

A new electronic control circuitry replaces the old regulation chassis.

The construction of a dummy load for the P.F.W. generator has been finished. (This dummy load consists of two spirals of stainless steel tubes. It is watercooled, has 1,4 ohm, can dissipate 100 kW and is insulated for 2000 V)

2.4 Static pulsed power supplies

The pulsed, controlled rectifiers, installed in the ejection building, worked for three years now. The maintenance mainly concerns the mechanical construction (not electronics).

- Exchange of cooling fans
- Tightening of screws (vibrations)
- Cleaning of contacts, insulators, heat sinks, etc.
- Lubrification of roller transformer.

Spare parts for all supplies have been ordered and the documentation on the supplies (drawings, reports) has been amended.

The patch panel in the Ejection Building has been improved. (Increased safety)

A PS-intercom station has been installed on the power supply E 2001 for better communication with MCR.

With the introduction of automatic blocking on the supply C 652, all supplies of type C are blocked automatically during injection.

The condenser discharge supply E 2001 for the ejection quadrupole in S.S. 61 has been further improved :

- Additional safety against misfires
- Improvement of cabling
- Definitive installation of the shunt
- Plug-in construction for the flat top supply.

Tests have been performed by G. Heritier in order to detect the limits of the supply. In consequence, new thyristors with improved dU/dt characteristics have been installed on the 3rd of December 68. An instruction manual has been issued.

2.5 B-pulse generator

The instruments used for the B-pulse train generator have been overhauled by the Instrument Services. The integrating digital voltmeters required special efforts after several years of daily operation.

The electronic circuits, such as auxiliary power supplies, counters, peaking strips and cabling have been checked.

2.6 Installations in MCR

2.6.1 Signal distribution

The instruments, such as scopes and digital voltmeters have been overhauled. The cabling has been improved in the racks 46, 47 and 33. Lemo connectors are used throughout all installations. They replace the double pin symmetric UHF connectors formerly used.

2.6.2 Remote programming

The 30V/3A transistorized power supplies, used for correction at injection, have been moved to the old power house. The supplies for the skewed quadrupoles have been moved as well from the MR 49 to the old power house PR 39.

New remote control units have been built and installed in the rack MR 60.

The remote program generator for the 10 supplies for the injection quadrupoles has been checked and readjusted.

The program generator for the P.F.W. machine, installed in the MR 50, has been improved (better stability, easier adjustment).

3. NEW INSTALLATIONS

3.1 Cooling circuit for the PS straight sections

The PS straight sections are being used more intensively.
Two stainless steel pipes of 65 mm diameter are installed around the PS tunnel. The initial cooling capacity is 1 MW for a temperature drop of 30° C. The pressure of the cold water is 20 kg/cm^2. A welded nipple is installed every 6 meters (i.e. every straight section), a valve every 20 meters (i.e. every third straight section). The demineralized water is taken from the heat exchanger of the east zone. The cooling capacity can be tripled by introduction of two diametrical pipes from S.S. 100 to S.S. 50.

3.2 Pulsed power supply for bumpcoil system 74 (installation of supply fabricated in the ED group)

The bumpcoil system 74 is used for fast ejection only. The bumpcoils for ejection 58 are used for fast and fast-slow ejection. The ratio of the time constant to the current rise time is approximately 5 for both systems. Therefore, the 74 system will be excited by a 900 V / 650 A capacitor discharge power supply. It can be used as a spare supply for the 58 fast and fast-slow ejection.

The supply is dimensioned for a load of 0.1 Ohm and 18 millihenries. It features a 10 millifarad capacitor bank, rated for 2 kV. The minimum resonant frequency is 10 $^{C}/S$. The current takes approx. 25 msec to reach the peak value. The control circuit stabilizes capacitor voltage to one part in 1000. It is assumed that the characteristics of the load are stable within $\pm$ 3 $^{o}/oo$. It is possible to stabilize the peak current if necessary. The r.m.s. value of the output current is 100 A.

The supply is located in the Ejection Building. The remote control chassis is fixed in the MCR rack MR 123.

3.3 Pulsed power supply for sextupoles (installation of supply fabricated in the ED group)

Attempts have been made to find an adequate replacement for the rotating amplifiers (type A and B). Two 12-phase controlled rectifiers have been assembled to a bipolar supply. The control input receives a program voltage, and the output current is kept proportional to this program. The maximum rating is 360 V / 350 A with a peak power of 120 kVA. The r.m.s. value of the current is 160 A.

This supply is designed for pulsing the sextupoles in S.S. 35 and S.S. 95 for the slow ejection 62. However, it can be used for any inductive load, such as bumpcoils, quadrupoles, dipoles, etc. The supply is placed in the S.G.R. and can be remote-controlled from the MCR rack MR 123.

3.4 New B-pulse train generator

The old generator indicated the PS magnet field at the end of the first acceleration period of the PS cycle. Two pulse trains are now generated : one for positive dB/dt and the other for negative dB/dt.

A pulse is generated at every change of 1 Gauss of the flux density in the 101st unit. The actual field value can be determined by using a bidirectional counter taking into consideration both the "rising" B-pulse train and the "falling" B-pulse train. This bidirectional counter has been fabricated with taking into account the possibility of reading-out the position of the counter at two different instants (e.g. beginning and end of flat top). The B-pulse generator features a voltage to frequency conversion of picked up dB/dt and additions of the pulses for the initial condition of the integration given by a peaking strip pulse.

4. SPARE MAGNET UNITS FOR THE PS

4.1 Fabrication of magnet blocks

Bonding : 80 samples have been irradiated at the CEA in Grenoble. Polyester, polyurethan and epoxy type resins have been tested. The epoxy resin was chosen for the bonding of the laminations. The shearing force did not decrease significantly up to 10^9 rad.

Insulation : The insulation of the individual sheets of the block was difficult due to the deformation of the steel delivery. Finally, the sheets were phosphated and the resin was mixed up with short glass fibres to retain the resin.

Pole profile : The PS profile has been measured and compared with the profile given in previous reports. Slight differences exist in the region outside the narrow gap. The laminations, punched by Siemens, have been checked by the manufacturer as well as by the Central Workshop (with less precision).

4.2 Magnetic measurements on the prototype block

Block measuring machine : Most of the parts belonging to the original BMM were missing and a new measuring device had to be built. The items involved are : girder for the four blocks, excitation coil, measuring support, measuring probes, calibration of probes, processing of the data, etc.

Results : The prototype block can not be accepted due to the fact that the filling factor is too high. This result is very annoying for the manufacturer who wanted to avoid, if possible, the introduction of insulating layers between the laminations. A new prototype block with thicker layers of epoxy will be available at the end of February 69.

4.3 Excitation coils for the spare magnet units

Fabrication: The coils are fabricated by ACEC. A new type of insulation has been used (epoxy type pre-impregnated bands).

Testing : The tests made at the factory showed several difficulties (high voltage breakdown, mechanical tolerances not respected, etc.) It seems that the company is not very interested in this fabrication, and the delivery time has increased remarkably. Since the tests made in January 69 were not satisfactory, further tests are planned for the end of February.

4.4 Poleface windings for the spare magnet units

40 sheets have been ordered at BBC in Mannheim. The drawings for the manufacture of the sheets will soon be completed. The selection of the p.f.w. connecting cables turned out to be very difficult because of the small cable length required. It is foreseen to use the same insulation as used in the ISR construction. BBC has promised to deliver the first series of 16 sheets until August 69.

5. NEW DIPOLES FOR THE PS (project)

5.1 Dipole magnet

Calculations : Further calculations have been made on various aspects of the construction (inductance, cooling, eddy currents, physical length, etc.).

Analog models : Several models of stainless steel sheets have been measured to detect the relations between the stored magnetic energy and the homogenity of the field.

Reduced scale models : Three-dimensional models have been assembled by means of transformer cores. Characteristic values like field distribution, inductance, influence between adjacent magnets, stray field, etc. have been measured. The use of separate radial and vertical dipoles turned out to be more advantageous.

Mechanical design : The mechanical design of a combined radial-vertical dipole has been finished. Problems like construction of core and coils, cooling circuits, electrical connections, alignment, etc. had to be solved.

5.2 Pulsed power supply for the dipoles

Preliminary specifications : Based on the design of the combined radial - vertical dipole, a preliminary specification has been isued. As many as 26 companies have been asked for offers, but only four companies showed an interest in the manufacture of this supply. The problems of the manufacture have been discussed with 2 companies.

Laboratory model supply : A 12-phase-controlled rectifier model has been manufactured in our laboratory for investigation of ripple problems.

6. SHIELDING PIPE FOR THE M8 AND THE d29 BEAM

Model measurements : By means of a stainless-steel-sheet analog model the following problems have been solved : optimum shape, flux densities in the shield, influence on the PS magnet field, magnetic forces, etc.

Design and fabrication : The shield has been fabricated in the Central Workshop.

Magnetic measurements : The finished shield has been mounted on the PS magnet unit 88 and has been measured (mechanical fixing, remaining field in the pipe, influence on the PS field).

7. PULSED POWER SUPPLY FOR THE BOOSTER PROTOTYPE MAGNETS (bending and quadrupole magnet).

Specification : The requirements for current and voltage, ripple, etc. have been specified together with the MA group of the SI division. A large number of companies have been contacted for offers.

Study of the offers : After studying the different solutions and offers, the order has been passed to BBC Mannheim.

Contact with the manufacturer : Details for manufacturing the supply have been defined together with BBC. The delivery is foreseen for spring 69.

8. PARTICIPATION TO THE PS OPERATION

Trouble shooting : Failures which occured during the operation had to be corrected immediately (on pulsed power supplies, remote indications, etc.).

Instructions to operators : Due to the complexity of the equipment it was necessary to spend a considerable amount of time in the MCR for instructions. The main subjects were the remote control of the pulsed power supplies and the signal distribution.

Machine Developments : Special circuits have been prepared for MD's (e.g. kick-amplifying quadrupoles for FE, lenses for 6 1/3 resonant ejection, programming of injection quadrupoles for space-charge tests, etc.).

The bending power of the kickers in the octupoles had to be verified by magnetic measurements.

9. VARIOUS ELECTRONIC DEVICES

The replacement of the vacuum valves by transistors in the pulse shapers has been studied.

The regulation circuit of the p.f.w. machine required the study of amplifier circuits.

The timing for tests on pulsed power supplies, etc. had to be arranged.

10. COMPACT QUADRUPOLE

Calculations and magnetic measurements have been made on the Rade Končar quadrupoles in the PS straight sections. It is intended to manufacture a compact quadrupole this year.

CONCLUSION

The activities of the PS magnet section are spread out on a large scale. It was difficult to follow a given planning. The problems concerning the maintenance were solved with priority. A lot of tasks, started in 1968, are being continued this year.

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