IEEE Transactions on Nuclear Science, Vol. NS-26, No. 3, June 1979

ELECTRIC POWER AND COOLING SYSTEMS FOR PETRA

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Summary:
For 19 GeV operation the PETRA storage ring and its experiments need 25 MW of electric power. The different power distribution systems at medium voltage and low voltage level are described. For powering the PETRA magnet system individual high precision dc-power supplies are employed, all centrally located near the PETRA control room. Details will be given about the magnet circuits and the rf-power supplies.

Water cooling of the PETRA magnets, vacuum chambers and rf-components is made by 2 systems consisting of pumps, heat exchangers etc and concentrated in 2 cooling centers together with a cooling tower and a cooling spray pond. Cooling equipment for individual experiments is located near the experiments. Utilization of part of the electric energy for heating is provided.

At the peak energy of 19 GeV the PETRA storage ring and its experiments need about 25 MW of electric power. Power consumption of the most important components is as follows:

rf	7,5 MW
dipole magnet circuit	2,1 MW
quadrupole and sextupole magnet circuits	5,5 MW
magnet circuits for experiments, expecially for the solenoids of the TASSO and JADE experiment,	6,5 MW

The rest will be needed for cryogenics, electronics, water pumps, etc. Power consumption of the pre-accelerators and intermediate storage rings and their beam transport system adds another 4 MW, but will not be discussed in the following.

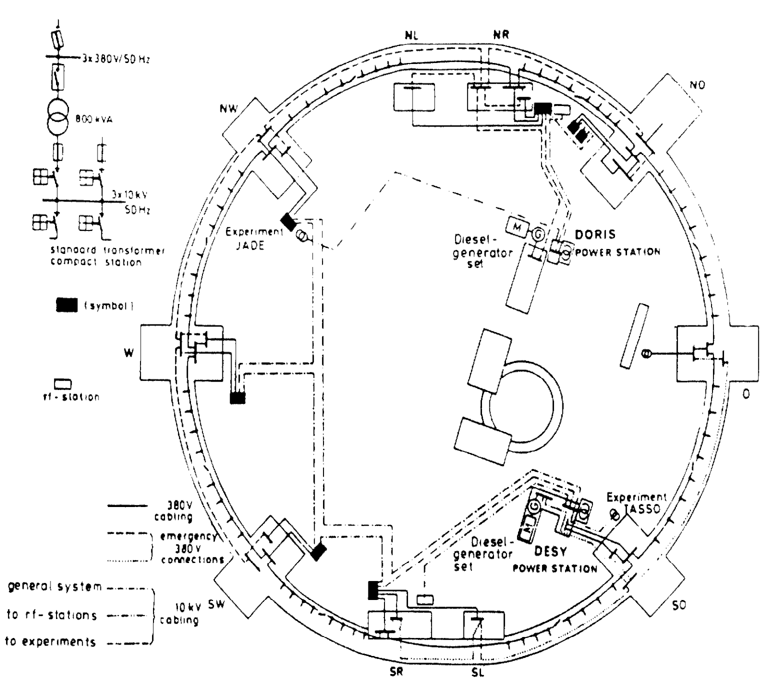

Fig. 1 PETRA 3-phase ac-distribution system

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1) 3-phase ac-system

Power for components in the PETRA ring tunnel and the experimental halls is supplied by the two existing 10 kV 3-phase ac-DESY and DORIS nets. They are operated separately because of their rated short circuit capacity. Each is powered by a 110/10 kV, 40 MVA transformer.

Fig. 1 gives a summary of the distribution systems. Large equipment like the power supplies for the rf transmitters and the solenoids for the experiments TASSO and JADE is connected directly to 10 kV. All other equipment is fed from local 380 V 3-phase ac nets by outdoor 800 kVA transformer stations which include high and low voltage switch gears. Thus only minimum space in the experimental halls is needed for low voltage distribution boards. A 200 A 3-phase cable around the whole PETRA ring feeds small 380 V distribution boards under the dipole foundations.

2) rf power stations[1]

Fig. 2 shows a principle diagram of one of the 2 rf power stations located near the rf halls north and south. They consist of two 12-phase diode rectifiers each, rated for 2,4 MW output, 58 kV dc and feed two 500 MHz klystrons. Together with a tap changing 3-phase auto-transformer with 10 kV input and a smoothing dc choke this equipment is oil-immersed and placed in two vessels for outdoor location. Thus indoor space is only needed for smoothing capacitors, resistors, isolators, and a spark gap crowbar system. The latter protects the klystrons from the effects of the capacitor load and the line short circuit current in case of an internal discharge. The short circuit currents are kept small by the large reactance of the rectifier transformer. Short circuit operation is terminated by tripping the 10 kV circuit breaker. The high operation frequency of these breakers would make application of vacuum circuit breakers advantageous, a step to be taken in the near future.

3) Magnet Circuits

There are 1 dipole, 18 quadrupole, and 6 sextupole circuits. The power supplies for quadrupoles and dipoles are of the same type as the ones used for DORIS. They have active and passive filters and high precision servo loops[2] and are located in the power house near the common DORIS-PETRA control room. The disadvantage of the large cable length between the power house and the components in the ring tunnel is compensated for by the advantage of the common power supply stock and the much better conditions for maintenance. Most circuit cables pass a busbar link board which allows a fast replacement of power supplies in case of failure, the possibility of connecting circuits in series for other beam optics, and the central location of a multiple ground switch. Distribution in the ringtunnel and through the experimental halls is done by aluminum bus bars. The bus bars offer the possibility of an easy change of connections to quadrupoles and sextupoles thereby providing a maximum flexibility for the beam optics.

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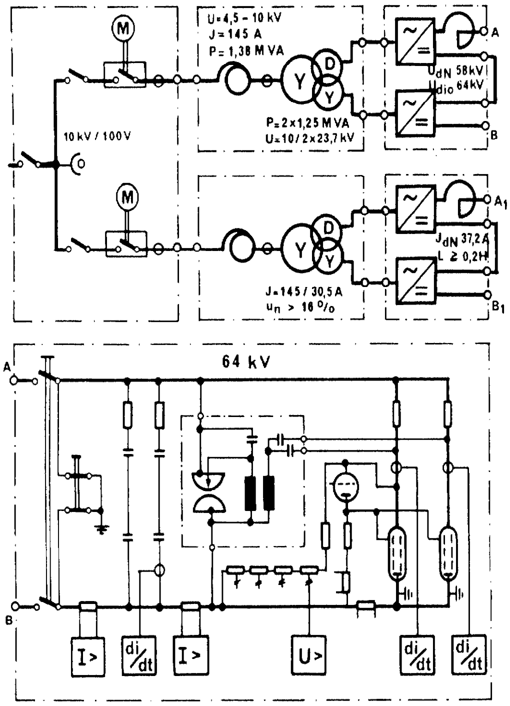

Fig. 2 Principle diagram of one rf power station

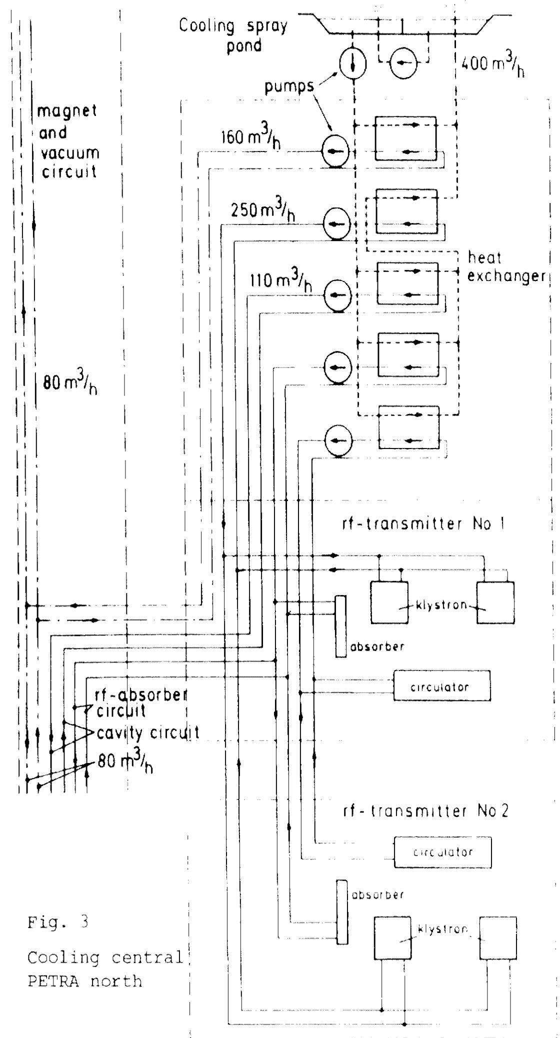

Fig. 3 Cooling central PETRA north

4) Water cooling

There is a common water system in the PETRA ring tunnel for magnets and vacuum absorbers. The absorbers are arranged in series with the dipole windings. All connections from the main pipe to the magnets are made by hoses without any stop-cock or valve. Only the main pipes can be separated by eight cut-off valves for better maintenance. For water cooling of the rf components 4 circuits for klystrons, absorbers, cavities, and circulators are used. Two of them are installed in the straight sections of the ring tunnel.

Cooling equipment such as pumps, heat exchangers, ion exchangers, etc. is concentrated in two machine rooms adjacent to rf transmitter halls. Fig. 3 shows the principle diagram of station north. Water distribution for the main ring system is done in 2 parallel branches for each cooling station and 4 in total. Maximum power in the main ring system occurs at 16 GeV due to the absorber losses; and the nominal temperature gradient is 40^{o}K.

Power dissipation is done by evaporation cooling. The south central station uses an existing DESY cooling tower, whereas a spray pond has been built for the north station, consisting of two sections for double spraying. Each section has 4 rows of nozzles which can be operated separately for adjusting to load and atmospheric conditions. With a total surface of 3300 m^2 the rate of cooling is 12 MW, 297^{o}K/315,5^{o}K.

In a similar manner the primary cooling system for large experimental magnets are connected either to the spray pond or to the DESY cooling tower. The other cooling equipment is located near the experiments.

5) Ventilation and waste heat utilization

Ventilation of the PETRA ring tunnel takes place as shown in Fig.4. Depending on the ambient temperature ventilation is done only with outdoor air in summertime, only with recirculated air in wintertime, or with a mixture of the two. The temperature gradient between 2 ventilating stations is at worst 8^{o}K. The

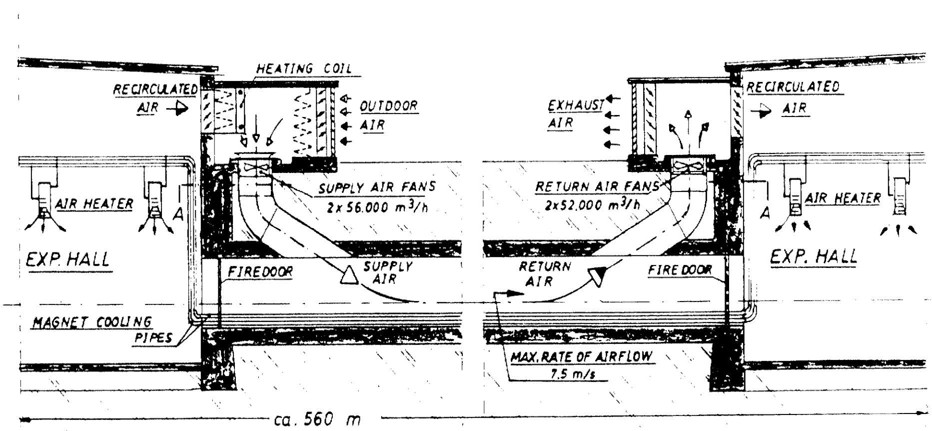

Fig. 4 Principle of the PETRA ventilating system

experimental halls can be heated by the recirculated air in wintertime. Additional heating in these halls if needed will be provided by means of air heaters supplied from the main cooling system pipes which pass the experimental halls. For this purpose the temperature level has to be kept sufficiently high by temperature regulation of the whole water system.

Waste heat generated by 2 PETRA-experiments will also be used. To make this possible the nominal temperature level of the cooling water is rated at 313°K/353°K. Heat will be used either for direct heating via heat exchangers or heat pumps.

References

1) H. Narciß: DESY-specification B2.447, 1975
2) W. Bothe: dc power supplies for the DORIS storage rings Proceedings 5th Intern.Conf. on Magnet Technology, Roma 1975. 81-84