AR/Int - SG/63-25
July 2nd 1963 - OB/HR/fd

STUDY ON THE ELECTRICITY DISTRIBUTION SYSTEM

for a

300 GeV PROTON SYNCHROTRON

by

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INTRODUCTION

The various problems involved in designing the electrical distribution network for a 300 GeV Proton Synchrotron, are treated in the present note. As will be seen, these problems are not particularly difficult from a purely technical point of view, but the project considered is nevertheless unusual as far as the amount of power, the equipment requirements, the installation time and the cost are concerned. In the following an attempt is therefore made to give some more or less reliable information as to :

a) The power requirements for the different parts of the machine and for the experiments to be performed with the machine later on.

b) The most suitable way of distributing this power, the size and location of the various substations, the choice of voltages and switchgear components.

c) The total initial cost of the whole system.

The present study is limited to the electrical distribution network for the machine proper and three experimental areas including also all general services in these regions. This network, as far as it is considered here, would begin at the terminals of the supplying overhead line and would extend down to the low and medium voltage feeders.

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1. BASIC INFORMATION AND LIMITATION OF THE STUDY

1.1. Basic information

This preliminary study of the general power distribution scheme for a 300 GeV Proton Synchrotron is based on the tentative parameters and the machine layout generally accepted at the present stage (see reference 2). The injector is supposed to be a booster of 6 GeV, the preinjector a linac of 150 MeV.

The cost estimates presented in the following are based on the response to a large scale inquiry on switchgear components, transformers and cables made among the most important firms in Europe.

1.2. Limitation of the study

This study is limited to the electrical distribution network from the main feeder substation down to the secondary low voltage bus bars of the step-down transformers. The low voltage distribution has not been studied in details, but the cost given in paragraph 5, has been increased by an empirical value of 33 o/o in order to allow for the total cost of the electrical distribution. including the low voltage network.

The direct current generation and distribution is not treated here, neither are the merits of power generation on the site. This latter question, whether it would be worth-while, or even essential to have a power station on the site, depends to a large extent on the rate and cost at which power can be supplied. A decision in this respect can only be made when the conditions at the future site are known.

The study is limited to :

- the Proton Synchrotron, the booster and the linac, and their auxiliaries.

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- two normal experimental areas,
- one experimental area for studies on Neutrinos,
- the laboratories, administrative and service buildings

In view of the possibility of a future addition of storage rings to the 300 GeV machine a later increase of the total power rating to 300 MVA has been considered.

2. SIZE AND CHARACTERISTICS OF THE VARIOUS LOADS

The power requirements for the various parts of the machine and for the experimental areas have been established on verbal information received from various people engaged in the project. A particular rate of growth has not been taken into account, but it is assumed that in all main substations provision would be made for a future extension.

The ratings indicated in the following tables represent the installed capacity.

2.1. Power requirements for the Machine and for General Services

Injection			
- Linac	(incl. related General Services)	1,6	MVA
- Booster	(incl. magnet power supply, HF, vacuum + General Services)	7	MVA
Machine			
- Magnet power supply		40	MVA
- HF		8	MVA
- Vacuum		2	MVA
- Services in ring building	(incl. ventilation, cooling, illumination etc.)	13	MVA
	carry forward	71,6	MVA

brought forward	71,6	MVA
General Services		
- Buildings	8	MVA
- Pumping Station	3	MVA
Total for Machine + General Services	82,6	MVA

2.2. Power requirements for experiments

Since it appears to be very difficult to determine the power requirements for experiments to be performed with a 300 GeV machine the following ratings must be considered to be arbitrary and subject to further discussions. Our estimates give an installed total rating of about 80 MVA, for all experimental areas together. The distribution scheme described in Chapter 3, allows a free distribution of the total available power among the three experimental areas. Each of the two normal experimental areas, which are supposed to be situated one near the other, can be connected to the total power of 80 MVA at the time. The maximum power rate for Neutrino experiments is limited to 20 MVA, which means that in this case 60 MVA would be left for the two other experimental areas. The installed power inside one normal experimental area is assumed to be distributed as follows :

- Experimental Hall + Ejection	40	MVA
- Long beam path	20	MVA
- Track chambers	20	MVA
- General Services	3	MVA

Regarding the Neutrino experimental area the following distribution is assumed :

- Beam transport	10	MVA
- Track chambers	8	MVA
- General Services	1,6	MVA

3. DESCRIPTION OF THE PROPOSED SYSTEM

3.1. Layout of the electrical distribution network

It is assumed that the power required on the site would be tapped from an over-head line at a very high voltage. The main feeder substation for the site would be located in the ring centre. From there, the power would be brought at an intermediate voltage in a more or less radial distribution scheme to a large number of substations distributed all over the site. The interconnections between the main feeder substation and these distribution substations shall in the following be called "subtransmission network". All these substations, their rating, and the region which they would serve, are listed in the following table :

Designation	Location	Installed Capacity (MVA)	Serves :
Substation M	Ring centre	180	Main feeder substation (tapped to the transmission line), 2 alternators for magnet supply.
Substation R	Ring centre	20	General services in Central Building, HF, feeders for booster and Linac substations, exiters for main alternators
Substation GS	Near main buildings	40	General services for buildings, ring, pumping station and experimental areas
Substation B	Booster	8,5	Booster and feeder for linac substation
Substation L	Linac	1,6	Linac
Substation P	Pumping station	3	Pumpmotors + Services
Substations $N_1 - N_2$	Neutrino Area	20	Experimental power supplies
Substation ME	Experimental areas	80	Main feeder substation for experiments
Substations E 11 - E 26	Experimental Halls + long beam paths	10 - 20 each	Experimental power supplies

The layout of the machine and the experimental areas are shown on the attached drawing No. 200 - 108 - 0.

The reasons for installing the main feeder substation in the ring centre are : load concentration in the ring centre (main magnet power supply with necessary auxiliaries, distribution to the ring building etc.), the symmetrical distribution to all the other substations gives the most economical cabling possibilities for easy extension (e.g. adding of other experimental areas at any other straight section of the ring). In order to reduce the losses in the large transformers during machine shut-downs it is considered to be necessary to separate the supply lines for all general services from the feeders for machine and experimental facilities already in the main substation. During a general shut-down only the general services substation will remain in operation.

In addition to this radial subtransmission scheme, the principle of loop circuit distribution at an adequate medium voltage is used to a large extent. It may be mentioned here that a radial distribution at 380 V in such a large machine must be excluded due to the large cable cross sections and the correspondingly high cost involved. The loops would be normally supplied by one feeder which extends from a distribution substation to a group of load centre substations and back to the same distribution substation. The interconnection between the distribution substation and load centre substations shall in the following be called "distribution network".

The total number of load centre substations is

- 84 with a 6 kV service voltage
- 152 with a 380 V service voltage

These load centre substations will have comparatively small individual ratings with correspondingly low breaking capacities.

The following main loop circuits are considered :

Designation	Number of load centre substations per loop	Location	Total power (MVA)	Serves :
Loop L 1	38	Machine tunnel	15	General services in ring building, vacuum, HF, etc.,
Loop L 2	38	Machine tunnel	5	HF (high tension)
Loop L 3	6	Buildings	4	General building services
Loop L 4	6	Buildings	4	General building services
Loops L 5 - 20	10	Experimental Halls, Ejection	16 x 5	Experimental power supplies
Loops L 21 - 24	12 - 10	Long beam paths	4 x 10	Beam transport power supplies
Loops L 25 - 26	6	Neutrino experimental area	2 x 5	Experimental power supplies
Loops L 27 - 28	4	Experimental area	2 x 3	Services in experimental areas

Details on the substations are given in paragraph 3.3.