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# SPECIFICATIONS FOR CAPACITOR BANK.

The European Organisation for Nuclear Research (CERN) is constructing a pulsed electro-magnet that will be used for deflecting charged particles. Current will be supplied to this magnet by discharging a capacitor bank into it. These specifications are concerned with the capacitor bank.

## 1. RATINGS.

| | | |
|---|---|---|
| Total capacity | : | 2600 μF |
| Maximum working voltage | : | 11,5 kV |
| Total stored energy | : | 170 kJ |
| Maximum discharge current | : | $5.10^5$ A |
| Discharge cycle | : | see fig. 1 |
| Voltage overswing | : | 40 o/o |
| Repetition rate | : | 1 pulse per 2 sec continuously |
| Short-circuit ringing frequency of the bank complete with connections | : | minimum 50 kc/s |

## 2. CIRCUIT.

The circuit is shown in fig. 2.

The capacitor bank must be divided as shown into a number of sections. The exact number can be chosen by the manufacturer, but it must be between 8 and 12.

Each section will be connected to the load by an ignitron. The load will consist of a number of damping resistors equal to the number of sections, and the electro-magnet, which can be considered as a pure inductance.

Each section must be subdivided into two subsections, normally connected in parallel. This subdivision is required in order to provide a possibility of doubling the number of ignitrons, if this would appear to be necessary. In this case, the subsections would be disconnected from each other at one terminal. The number of damping resistors would remain the same, as well as the total discharge current.

Each section will be connected to a charging supply through a rectifier. The effect of the rectifiers will be to separate the sections effectively in case of a short-circuit in one of them, or in case of ignition of part of the ignitrons only.

## 3. PROTECTIVE RESISTORS.

Each subsection could be built up by connecting several capacitors in parallel. Each capacitor must be provided with a protective resistor connected in series with it, in order to avoid too high a dissipation in the capacitor in case of a short-circuit. The time constant RC of the protective resistor with the capacitor should be 1.5 μsec.

The heat capacity of these resistors must be such that each of them can absorb the stored energy of the whole capacitor bank once without overheating dangerously. Moreover the cooling must be sufficient to prevent overheating during long-time normal operation (1 pulse per 2 seconds with the total current as shown in fig. 1).

## 4. CONNECTIONS.

The connections between capacitors must be sufficiently strong to withstand the electrodynamic forces between them. Their inductance should be kept low. The short-circuit ringing frequency of each section must be higher than 50 kc/s if measured between the terminals of the section, i.e. including the connections and protective resistors.

## 5. MECHANICAL CONSTRUCTION.

The capacitors must be built into a frame by the manufacturer. For purposes of transport, this frame may consist of several parts, each containing an integral number of sections. The maximum height of the crane hook, to be used for assembly at CERN is 2.58m.The access to the assembly area has a cross-section of 2.50 x 2.10 m.

## 6. TESTS.

The following tests must be arranged by the manufacturer and performed at his premises in the presence of a representative of CERN.

1. Insulation test during 1 min with a voltage proposed by the manufacturer.

2. Discharge test. Each capacitor is charged to 11,5 kV, and then short-circuited without protective resistor. This test must be repeated 10 times with an interval between short-circuits at the choice of the manufacturer.

3. Measurement of ringing frequency. This may be combined with the discharge test.

If interconnections and protective resistors are included in the contract (see par. 7, the following tests will in addition be arranged by CERN and performed at Meyrin, in the presence of a representative of the manufacturer :

4. The short-circuit ringing frequency of each section will be measured.

5. The complete capacitor bank will be charged with 11,5 kV, all sections being connected in parallel. A short-circuit will then be made across one capacitor, between the capacitor and its protective resistor, as shown in fig. 3. Capacitors, resistors and connections must withstand this discharge without damage.

6. The capacitor bank will be charged and discharged 1000 times with the normal operating cycle and repetition rate as specified. No damage or overheating may result.

## 7. SCOPE OF THE CONTRACT.

CERN would prefer if the capacitor bank could be delivered complete, with protective resistors and interconnections. The tenderer is therefore invited to submit an offer for the manufacture and delivery to CERN, Meyrin, of the complete capacitor bank, including the interconnections and protective resistors. However, offers excluding these items will also be taken into consideration.

## 8. PRICE BREAKDOWN.

The tenderer is requested to specify separately the price of :

1. Capacitors, per section
2. Spare capacitors, per capacitor
3. Frame
4. Protective resistors and interconnections
5. Transport and insurance

## 9. ALTERATION OF SPECIFICATIONS.

All offers must, of course, be made on the assumption that these specifications are final, but CERN is still studying the problems connected with the ignitrons and the load. As a result of these studies it may be necessary to make some modifications to the present specifications at the time a contract is negotiated.

If it appears to the tenderer that a significant saving can be effected by a slight modification of either the working voltage or the number of sections, he is invited to make a proposal accordingly.

## 10. CALENDER FOR TENDERS AND DELIVERY.

The closing date for the receipt in Geneva of tenders to these specifications is fixed at 12 noon, April 16th, 1961. It is hoped to negotiate a contact with the successful tenderer soon afterwards.

The capacitor bank must be delivered within 8 months of signing the contract. An earlier delivery will be appreciated.

## 11. GUARANTEE.

After 2 million cycles (as specified in fig. 1) at least 95 o/o of the capacitors must be intact, and the capacitance of each section must be greater than 95 o/o of the original value (see Appendix, question 11).

All connections and protective resistors must meet their original specifications one year after delivery.

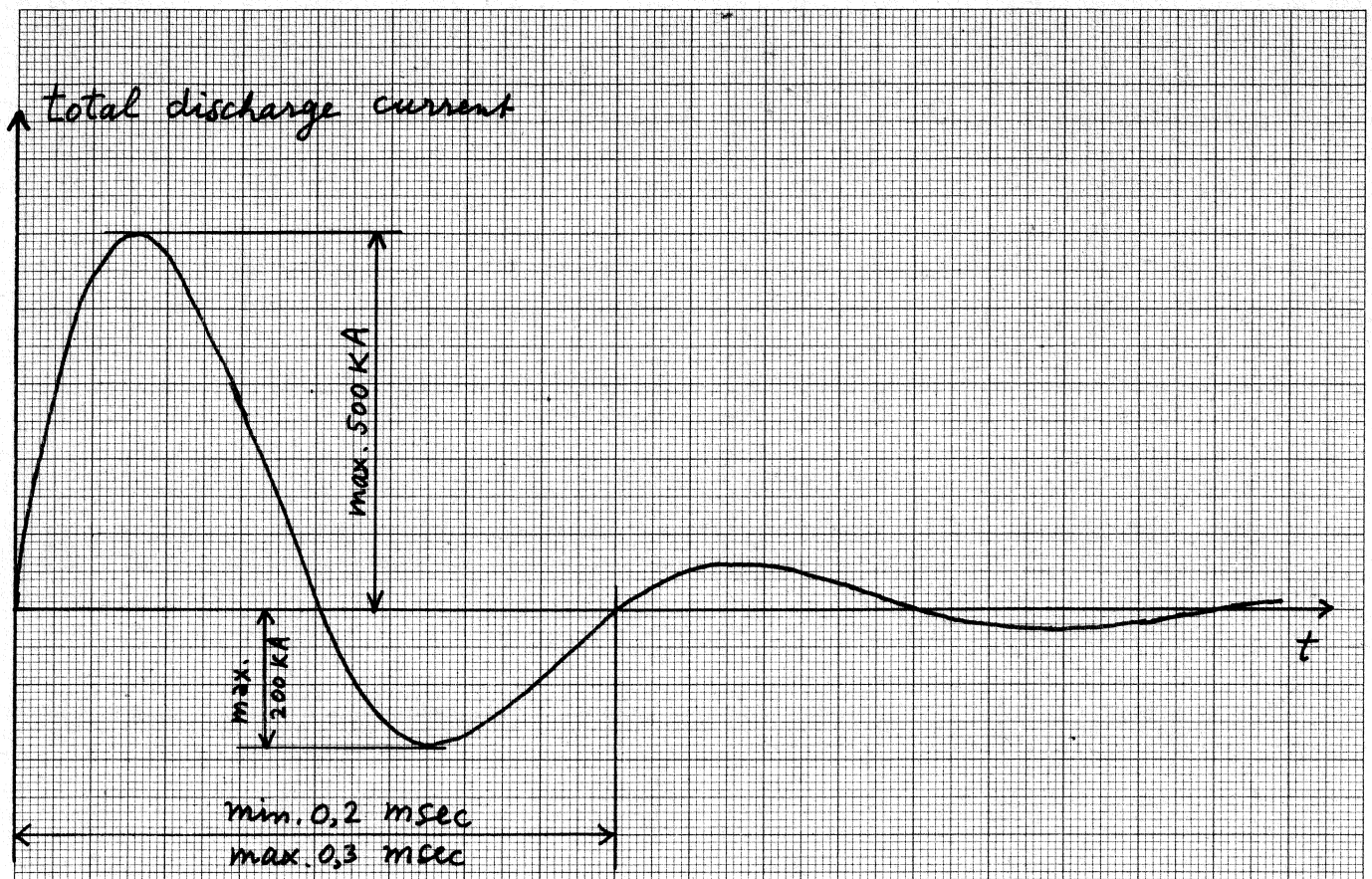
/fv S. van der Meer

PS/2377

APPENDIX.

Since each tenderer will no doubt submit proposals with special technical features, CERN would be particularly appreciative if each offer included, in addition to the detailed proposals and specifications, an answer to the following questionnaire.

1. Can the delivery date mentioned in par. 9 be met ? What are the possibilities of earlier delivery ?
2. What number of sections and of capacitors is proposed ?
3. What is the proposed test voltage ?
4. What is the resonance frequency of the capacitors ?
5. How will the protective resistors and interconnections be constructed ?
6. What is the maximum dissipation of the protective resistors under d.c. conditions ?
7. Will both terminals of the capacitor bank be insulated with respect to the frame, or is it proposed to use capacitor units with one insulated terminal only ?
8. What is the dielectric material of the capacitors ?
9. What is the electrical stress in the dielectric material at 11,5 kV charging voltage ?
10. With what material are the capacitors impregnated ?
11. What saving could be effected by reducing the number of cycles guaranteed to one million ?
12. What is the weight of the capacitor bank ?
13. Drawing with connections, dimensions of frame, etc.


total discharge current
max. 500 kA
max. 200 kA
t
min. 0,2 msec
max. 0,3 msec

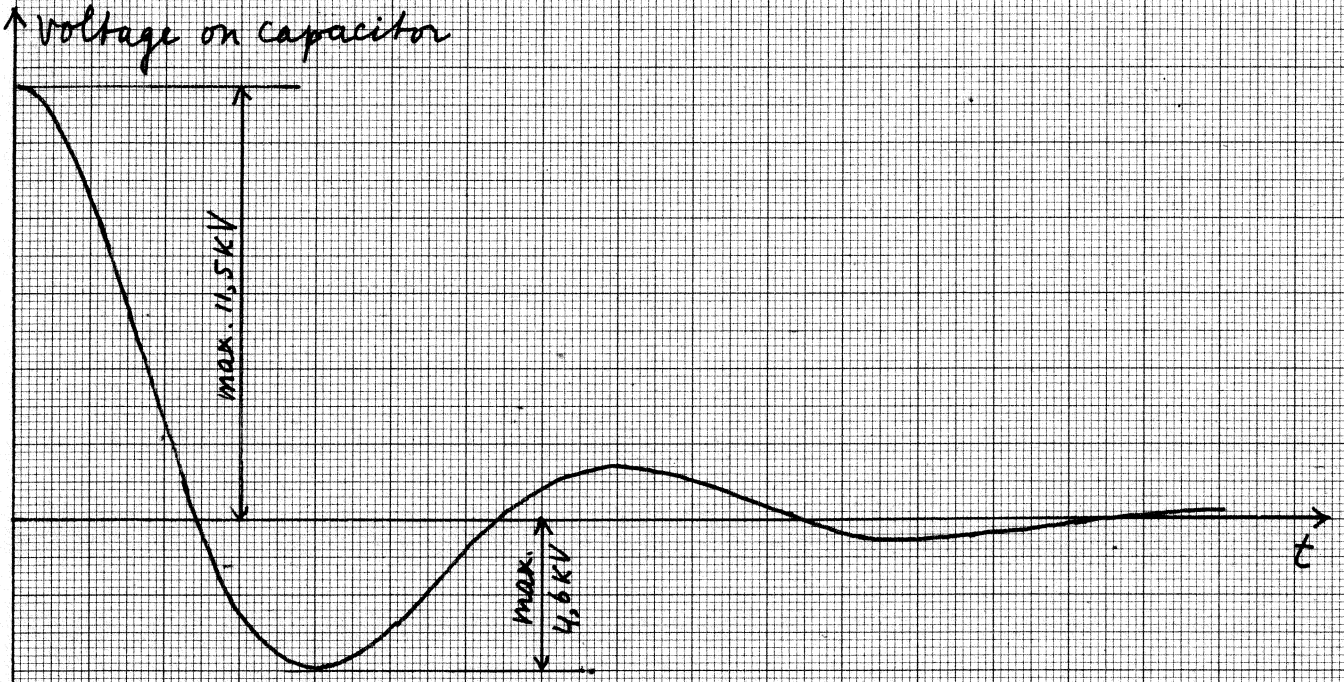

voltage on capacitor
max. 11,5 kV
max. 4,6 kV
t

Fig. 1

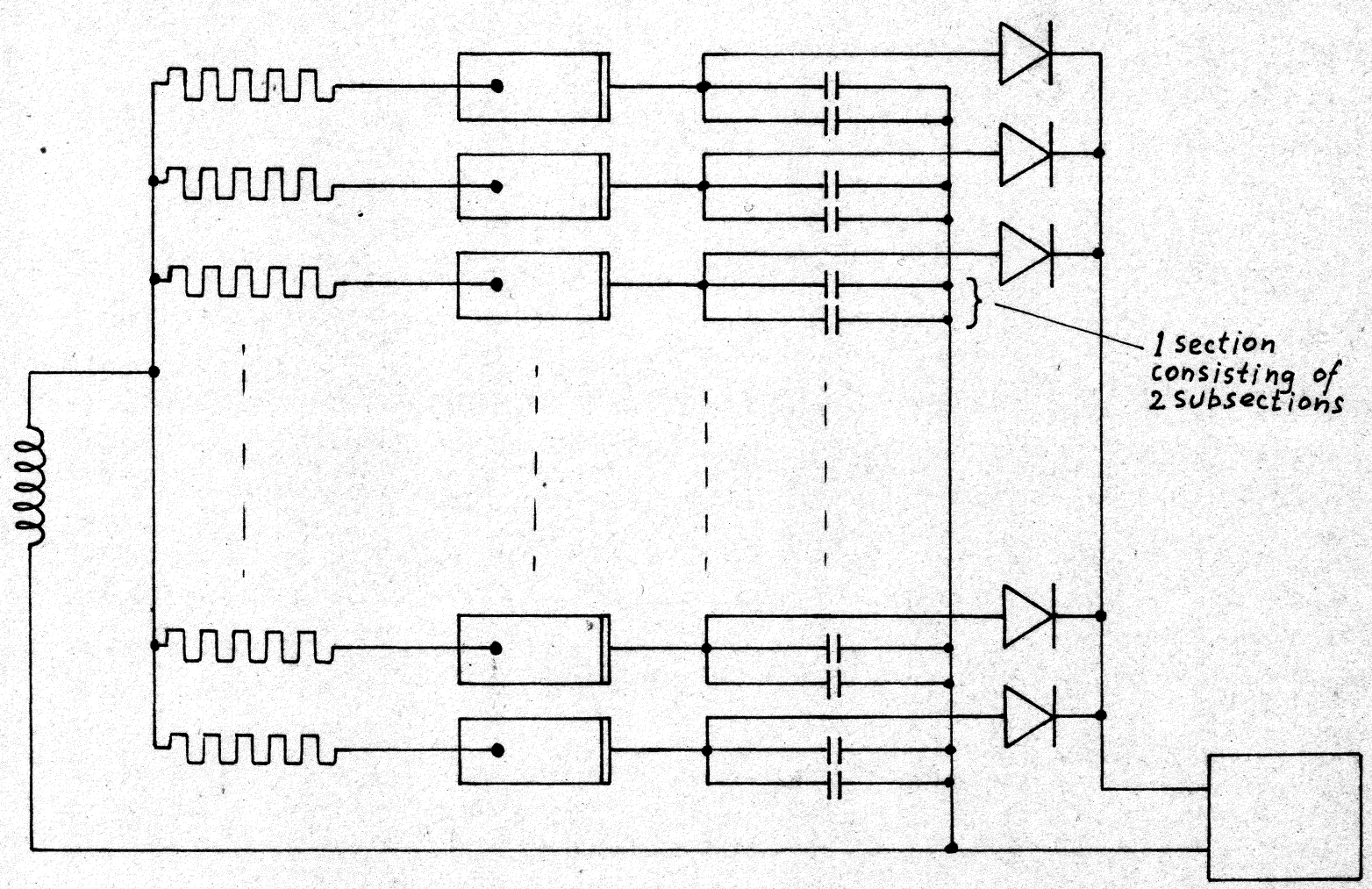

1 section consisting of 2 subsections
magnet
damping resistors
ignitrons
capacitor bank
(protective resistors not shown)
rectifiers
charging supply

Fig. 2

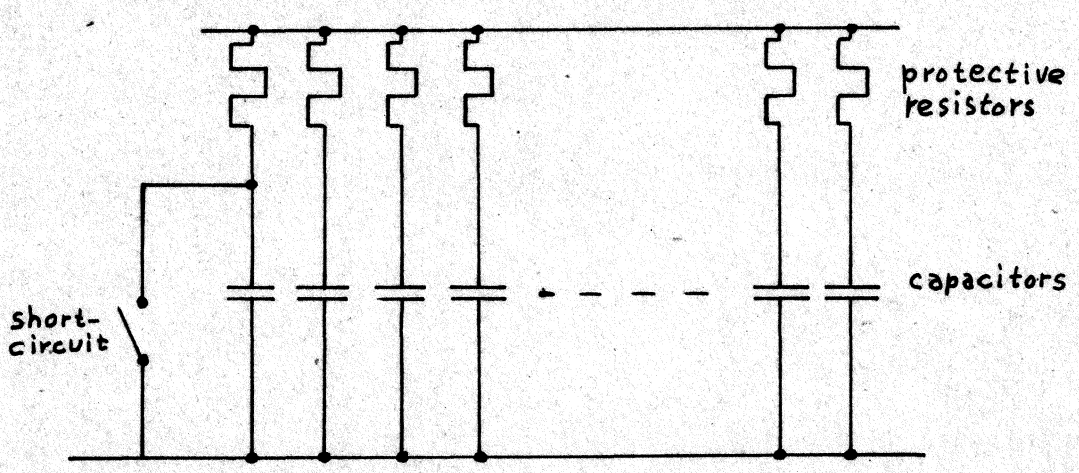



Fig.3