SET-UP FOR TESTING CERAMIC FEEDTHROUGHS

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A. Generalities

After the failure of the first series of ceramic feedthroughs, two new versions have been developed. Four prototypes of each have been made by Feldmühle (see FES/TN-351).

A long and serious period of tests should be carried out before taking a final decision.

The testing period may be divided in two parts:

- The 8 feedthroughs are tested separately in a special machine built for this purpose at CERN;
- If no serious difficulties arise, the "good" feedthroughs are placed in the tank for a final test (see FES/TN-353).

We hope, in this way, to obtain sufficient confidence for ordering the final series at a very low risk.

In this note, the set-up for the first testing is described.

B. Character of the First Test

The preliminary test is a rough check to verify that no fundamental mistakes have been made in the development and construction of the prototypes. The feedthroughs at the input of the kicker magnet are kicked by two pulses of opposite polarity of ≃ 70 KV N·160 ns apart (N being the number of bunches to be ejected). The shape of these pulses is shown in Fig. 1 in the case of 1 bunch ejection.

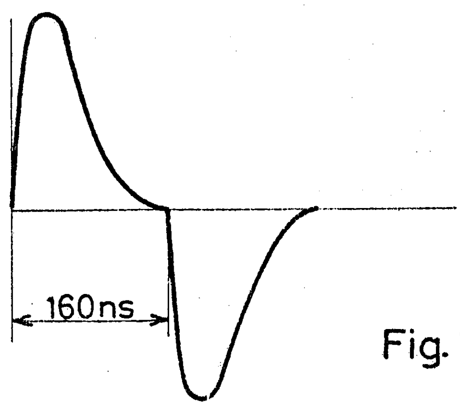
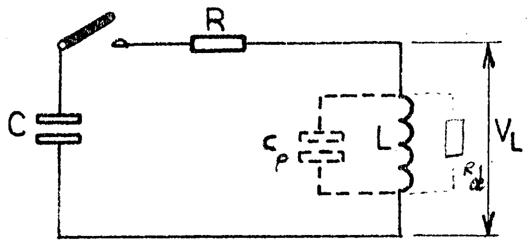


Fig. 1

This case seems to be the most severe by the very fast inversion of polarity, as compared with longer pulses where the inversion comes later.

To apply the same pulses in the preliminary test, the set-up would have been very complicated: a delay line + long cables + the equivalent of the kicker magnet should have been built.

We have chosen a much simpler way: to kick the feedthrough with a voltage pulse (Fig. 2) which can easily be obtained by discharging a capacity into an R,L circuit.



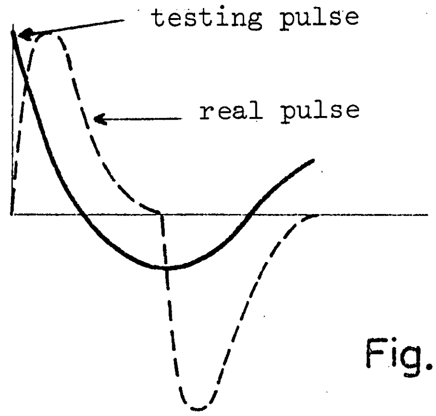


Fig. 2

The second pulse has only 50 % of the amplitude of the first one: a compromise must be made between the number of inversions and the amplitude of the oscillations.

C. Circuit Parameters

Once L has been chosen equal to the inductance of the kicker, the two conditions to be respected (the peak voltage of the negative pulse equal to 50 % of the positive one, and the distance between the peaks equal to 160 ns) give the values of the other parameters:

$$R \simeq 5\ \Omega$$

$$C \simeq 4\ \text{nF}.$$

Low voltages tests have shown that the parasitic capacity Cp (in particular of the feedthrough) across the inductance determines high frequency oscillations, whose peak is 70 % higher than the DC voltage

(Fig. 3). Since it is known that a very high dV/dt is strongly increasing the risk for surface discharges on high ε materials, and the life-time of any technically-produced dielectric depends on these phenomena, it seems important to avoid these high-frequency oscillations which do not resemble the real pulses. A damping resistor Rd across the inductance reduces these oscillations very much. Figures 4 and 5 give the pulse shape for two values of the dumping resistor R_d = 150 and R_d = 40 Ω

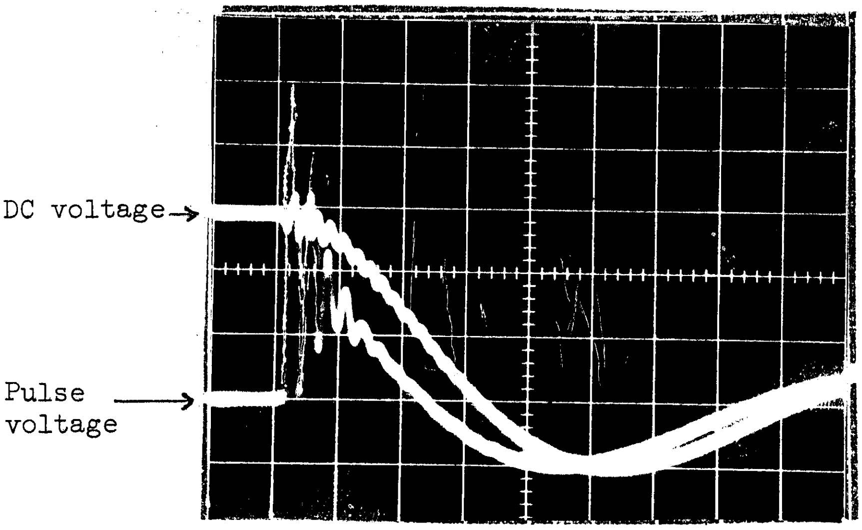


Fig.3. x = 50 ns/□

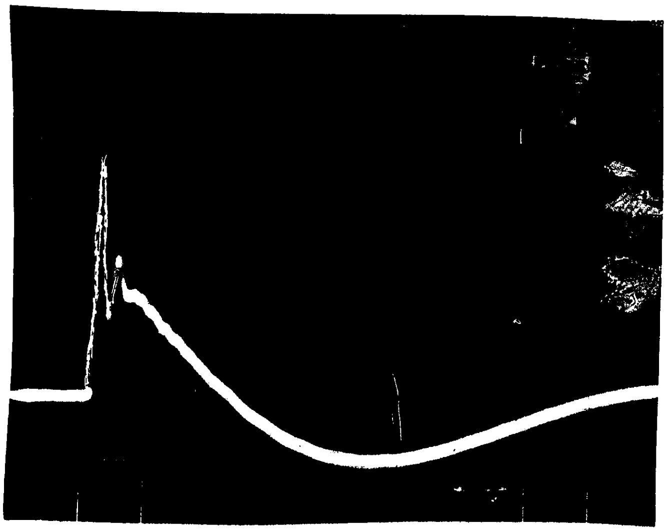


Fig. 4 Rd = 150Ω, x = 50 ns/□

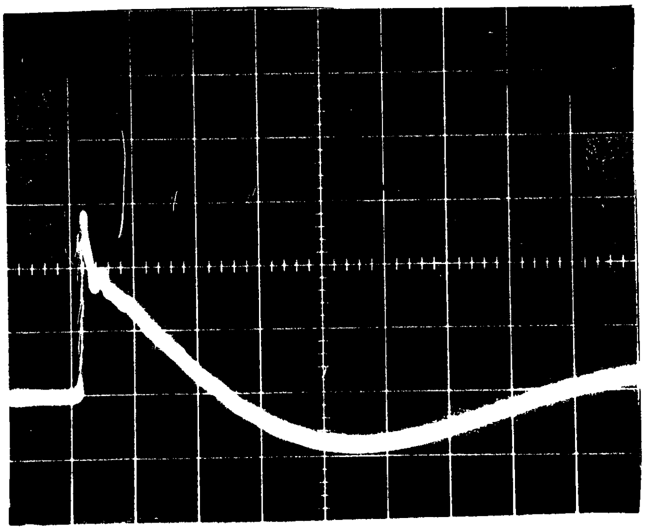


Fig. 5 Rd = 40Ω, x = 50 ns/□

As it can be seen from these pictures, the voltage rise time is very fast (less than 10 ns) and the time of the presence of this voltage across the inductance very short (≃ 10 ns). There is therefore some ambiguity about which is the test voltage: the fast peak or the start of slower cosine shaped decreasing voltage. An R,C circuit (Fig. 6) at the output of the spark gap can smooth the voltage rise time and increase the time during which the voltage is applied to the bushing. Figures 7

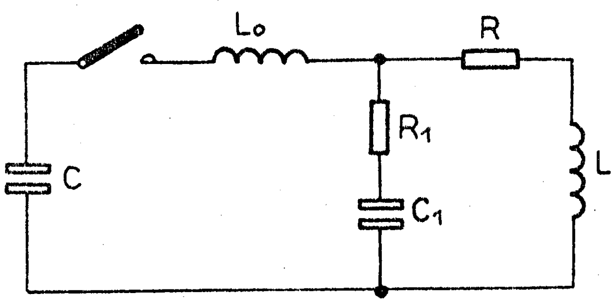


Fig. 6

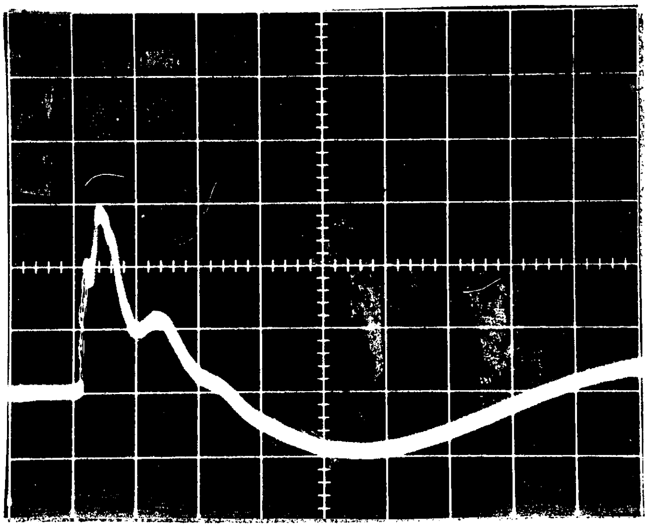


Fig. 7 $R_1 = 13\Omega$, x = 50 ns/□

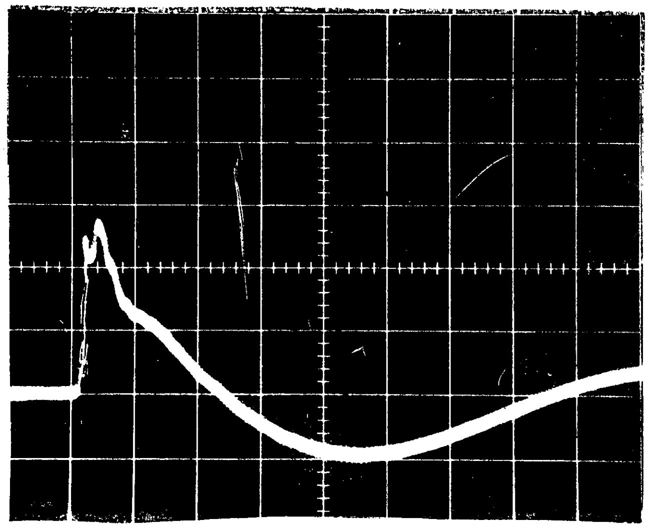


Fig. 8 $R_1 = 10\Omega$, x = 60 ns/□

and 8 are taken for two different values of the R_1 parameter (10 and 18Ω) and with the same capacity C_1 (330 pF). The proper value of R_1 depends on the stray inductance (L_o) of the circuit and must set experimentally. The optimum value seems to be of the order of 10 Ω, as in the case of Fig. 8.

D. Testing Equipment

The layout of the testing equipment is given in Fig. 9. A cylindrical tank contains the whole system, except for a smaller housing where the feedthrough and the inductance are placed.

The equivalent electrical scheme is given in Figures 10 and 11.

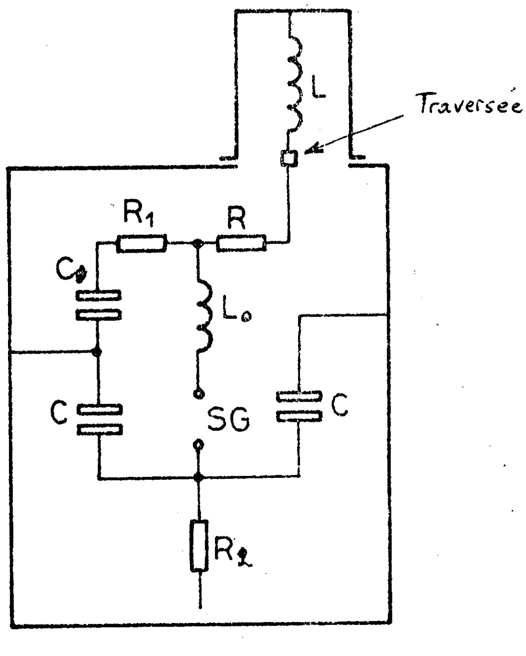


Fig. 10

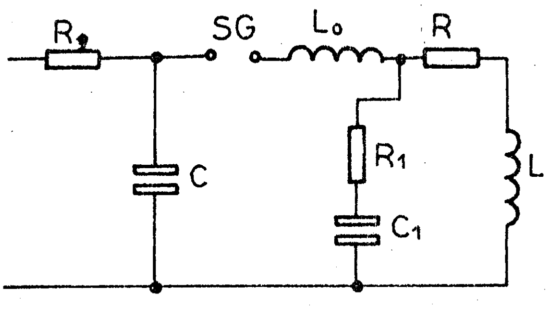


Fig. 11

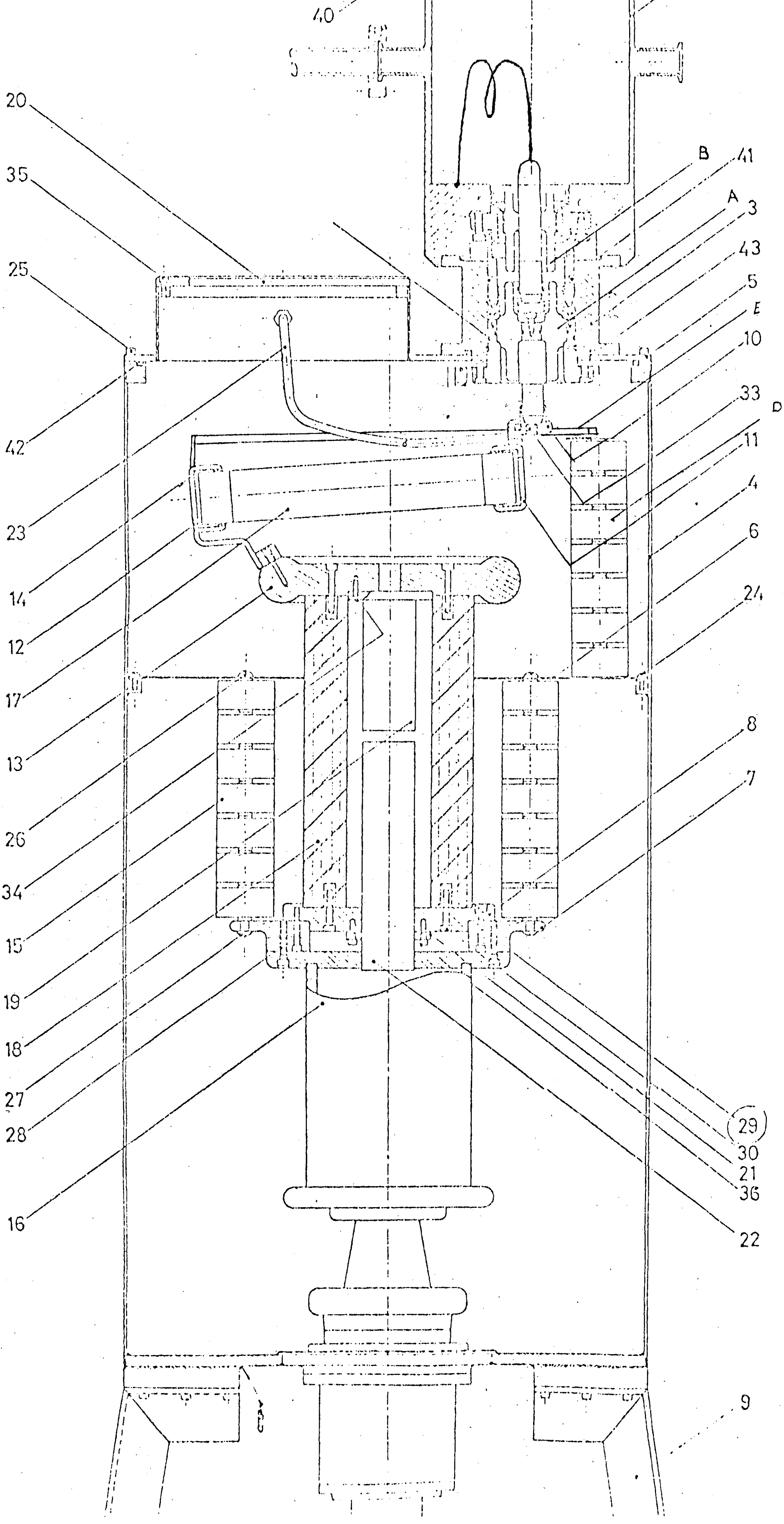

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Fig. 9

The DC voltage charges the capacitors bank C [15] (ten groups in parallel of seven 20 KV - 2200 pF capacitors in series) through the charging resistor R_2 [16]. The pressure in the two-electrode spark gap [18] can be regulated (0 - 5 kg 1 cm^2) for firing at the required voltage. The distance between the electrodes can be adjusted to have the required range of firing voltages by moving the lower electrode [22].

The capacitors discharge through the dumping resistor R [17] (two high voltage 10 Ω resistors in parallel), the feedthrough and the inductance L, located in the upper housing [2]. A vacuum of 10^{-6} torr can be easily obtained in this housing in a few hours. The lower part of the first feedthrough (A) (in araldite) must be in oil to avoid breakdowns: the filling of the reservoir must continue until the oil escapes from a special hole foreseen in the body [3] for this purpose.

As in the final version, compressed air is introduced between the ceramic feedthrough and the araldite one: in case of failure, no oil will be introduced in the tank. The components and the assembly of the upper part (body and housing) are the same ones used in the final mounting in the tank.

A resistive divider [23] (10 KΩ electrolytic resistor + 50Ω carbon resistor) monitors the pulse shape at the bushing. The divider must be calibrated against the line voltage.

The capacity C_1 (D) is one of the stacks used in the capacitors bank [15]. The [illegible] is a very [illegible]

E. Testing Procedure

A proposal for a programme for testing the prototypes can be found in the document TN-353. Once the testing equipment has been assembled and tested at Protvino (the system has already pulsed at CERN), this programme can be easily realized. A 80-120 % range of the nominal voltage will be changed by modifying the pressure in the spark gap. The failure of one feedthrough will be detected by pressure increase in the housing.

When a feedthrough must be changed, the operation is quite simple: the housing must be lifted; the copper ring and the indium wire acting as a metallic seal must be replaced.

As already said, we have tried to keep everything as near as possible to the final conditions. The whole procedure and care used in mounting the feedthroughs in the tank have to be followed. Figures 12, 13 and 14 give the details of the testing machine and the final version of the ceramic feedthrough.-