DEMOUNTABLE E/H-FIELD HIGHER-ORDER-MODE COUPLERS FOR THE NIOBIUM-SPUTTERED 4-CELL LEP CAVITY

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Abstract

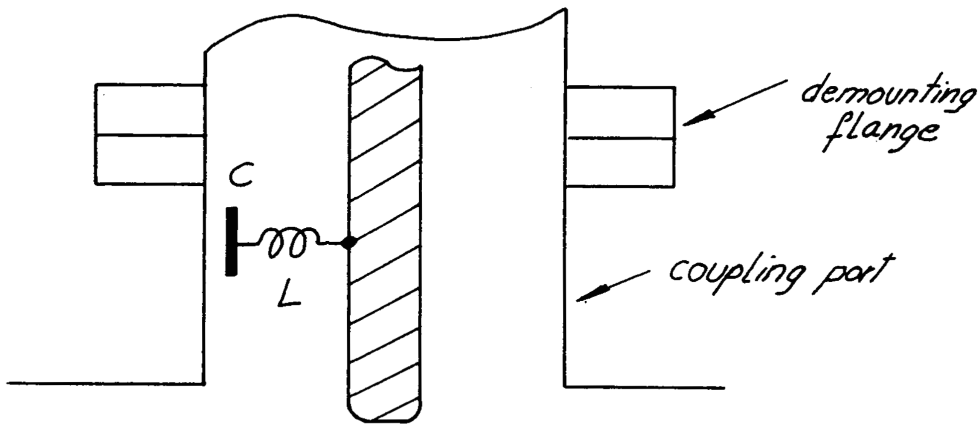
Within the LEP 200 program, new HOM couplers which match the requirements of superconducting sputtered Nb-Cu cavities have been developed. Their special features, their damping action on the principal cavity modes and constructional details are described here.

1. INTRODUCTION

The application of sputtering techniques to produce cheaper and more stable s.c. LEP cavities required changes in the higher-order-mode (HOM) coupler design to ease the sputtering process.

A geometry was sought for, which would allow to demount the couplers, leaving behind only short tubular coupling ports which could be easily sputtered together with the cavity. The demounting flange had to be kept free of fundamental mode current to avoid contact problems and any unnecessary heating.

A suitable fundamental mode filter configuration for a coaxial line type coupler is then a series resonator in shunt position located between the demounting flange and the coupler's front end as sketched below.

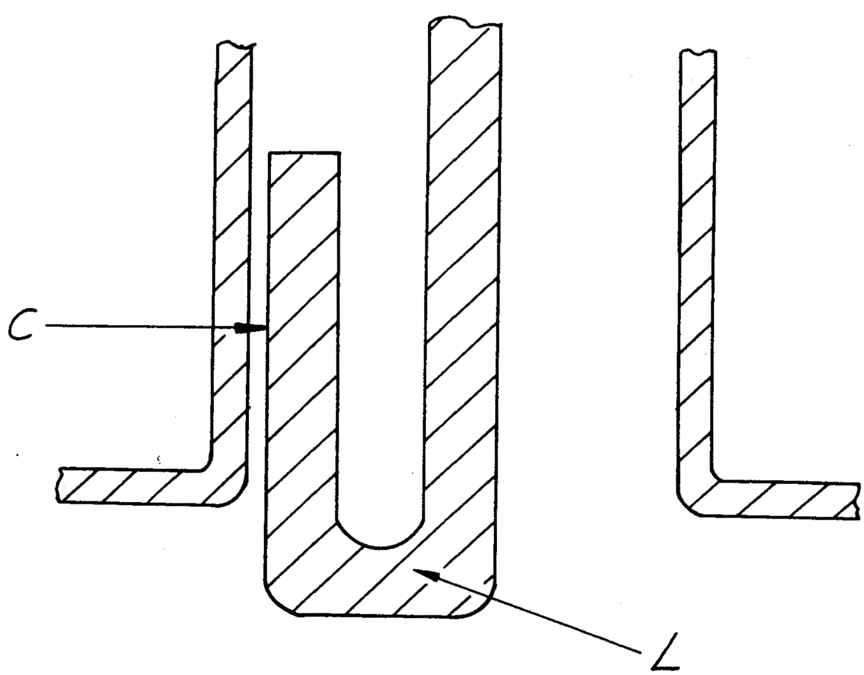


This concept was first used when designing the demountable "type 2" coupler [?] which equips the two 350 MHz Nb-Cu cavities of the SPS.

2. THE TYPE 5(a) COUPLER

It was then realized [2] that magnetic coupling to the Bz component of TE dipol modes in the beam tube would be very effective and that this type of L–C series resonator filter naturally forms a loop if advanced to the tip of the coupler's antenna.

This loop couples to Bz, if oriented perpendicular to the beam tube axis, but not to the transversal By of the fundamental mode. With the filter capacitor C made from a piece of open-circuit low-impedance transmission line the front end of the coupler gets the shape of a fishing hook.



Supporting its back by a ceramic annular disk we obtain the layout of the type 5(a) coupler shown in fig. 1 with its main constructional details. It is built from Nb tube elements. The 100 mm ∅ stainless-steel demounting flange is a standard CF type and brazed to the Nb tube. A second broadband ceramic window leads to the $Z_0 = 50\ \Omega$ cable which evacuates the HOM power. The space between the two windows is filled with LHe, from where it is admitted to the interior of the fishing hook, which is made from 16 mm ∅ tube.

Due to the capacitive loading by the uncompensated ceramic support disk the E-field coupling characteristic of the design exhibits a $\lambda/4$ type resonance which, by proper choice of the coupler's length, has been tuned onto the cavity's TM_{011} mode frequencies. This assures adequate damping of these high R/Q modes.

The transfer between a small capacitive probe (which simulates cavity E-fields) and the coupler output is shown in fig. 2. The frequencies of modes with significant coupling impedances are indicated by markers.

A second critical choice concerns the length of the filter's condenser line. Slightly above its parallel line resonances parasitic filter notches are formed. The shorter the line the higher their frequency and the smaller their bandwidth. The dimensions chosen here put the first parasitic notch above the TM_{030} mode into a frequency range where mono modes and dipole modes propagate and URMEL predicts only low coupling impedance.

The distance between condenser line tube and coupling port wall is then 1.8 mm. In view of the relative fundamental mode filter bandwidth of some 10^{-3} this narrow gap appears to be a very critical parameter.

But errors of several percent in filter tuning can be "compensated" in turning the loop away from its perpendicular position thus admitting the right amount of magnetic coupling which substracts from the spurious electric one.

This coupler has been built by industry in a small series and equips 3 accelerating modules in LEP with four 4-cell cavities each. Its damping action on modes with significant R/Q is given in table 1.

3. THE TYPE 5(b) COUPLER

For the main body of the LEP 200 program it will be superseded by a variant which eliminates its main drawback, the use of brazed ceramics between vacuum and LHe.

For that purpose, the back side of the type 2 coupler has been joined to the fishing hook front end, i.e. a lateral post serves as support and coupling to the load is via a capacitive gap as shown in fig. 3.

This allows admission of LHe through the post and has a beneficial effect on the E-field coupling sensitivity curve which now shows two lower frequency resonances (fig. 4) that allow to combine a broader notch with good coupling of the first two dipole modes of higher R/Q.

Higher-order-mode power from this coupler is extracted by two parallel $Z_0 = 50\ \Omega$ coaxial cables with 7/16 inch connectors to prepare for future higher beam currents in LEP. It is expected that this power extraction system and the obtained HOM damping figures (given in table 1) can cope with 2×16 bunches giving a total beam current of 24 mA in LEP.

Acknowledgements

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REFERENCES

[1] G. Cavallari et al., proc. of the 3rd Workshop on RF superconductivity, ed. K.W. Shepard, Argonne (1987) 565.

[2] A. Mosnier, proc. of the 4th Workshop on RF superconductivity, ed. Y. Kojima, KEK (1989) 377.

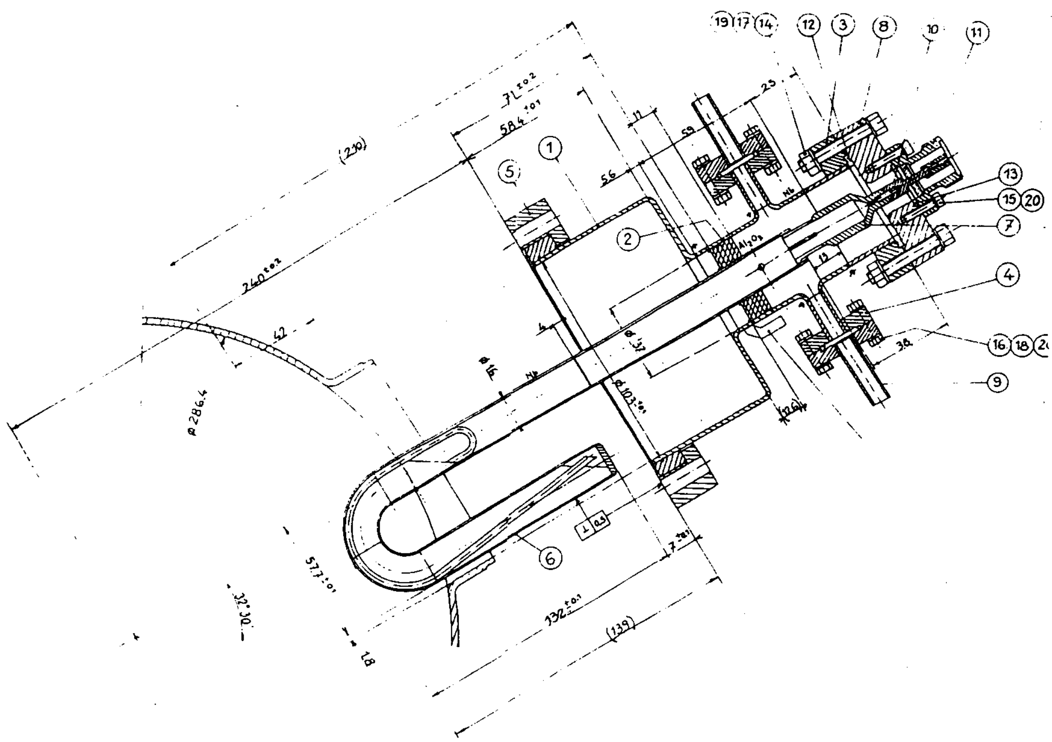

Fig. 1

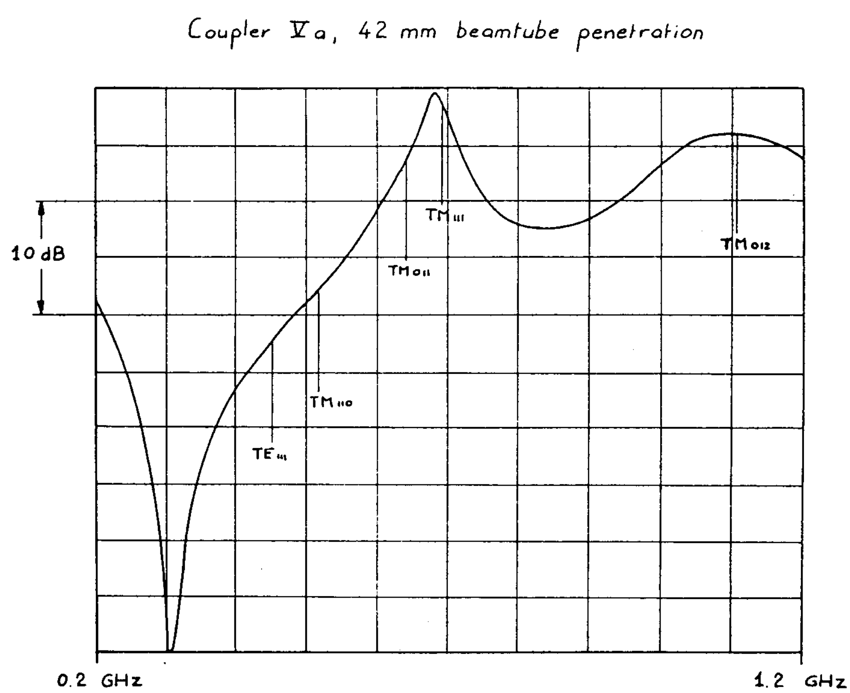
Coupler Ⅴa, 42 mm beamtube penetration
10 dB
TM111
TM011
TM012
TM110
TE111
0.2 GHz
1.2 GHz

Fig. 2

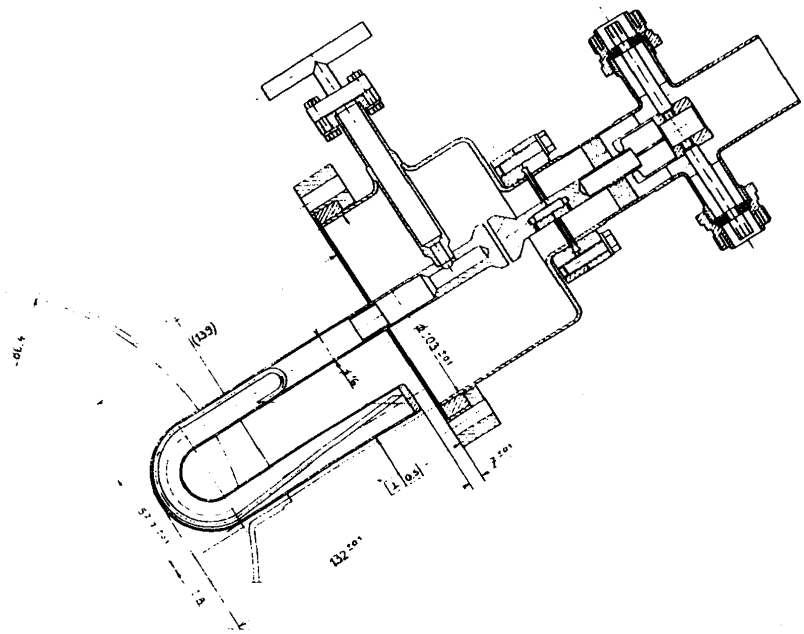

Fig. 3

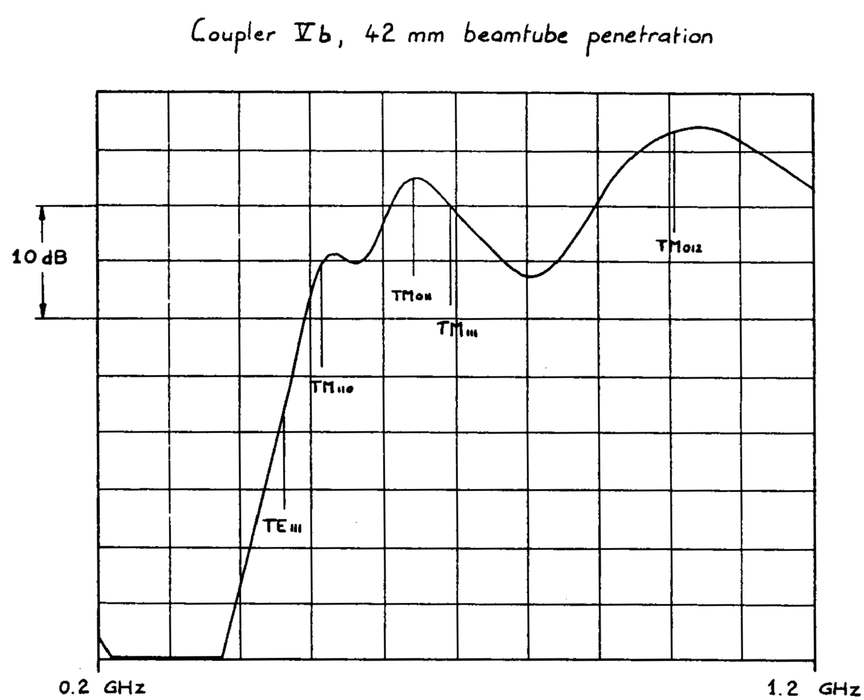

Fig. 4

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Table 1

f/MHz	Mode	$R/Q/\Omega$	Q_{ex} Coupleur 5a	Q_{ex} Coupleur 5b	Comments
461	TE 111	18	8 000	17 000	
476		15	9 500	14 000	Dipol modes: $\frac{R}{Q} = \frac{1}{2} \frac{1}{k^2 R^2} \frac{V_{acc}^2}{\omega U}$
506	TM 110	20	15 000	5 600	Monopol modes: $\frac{R}{Q} = \frac{1}{2} \frac{V_{acc}^2}{\omega U}$
513		13	70 000	5 700	
639	TM 011	56	8 000	7 000	
688	TM 111	25	9 500	1 000	
1 006	TM 012	16	7 000	2 000	

Test results with Type 5 couplers