Crab crossing concepts; some qestions and remarks
F. Caspers (CERN AB-RF-BR)

- In the crab crossing cavity scheme we have a cavity which gives a crab kick and another one for the compensating crab antikick (unless we talk about a „global"crab crossing scheme with just one single cavity)
- There are worries about beam blow up due to imperfect cancellation of the kick and the antikick, leading to very tight timing and phase noise requirements (a few femtoseconds in certain cases)
- The crab kick and antikick takes place with the revolution frequency but in transverse phase space (deflecting cavity) and should only have a second order effect in longitudinal phase space.
- There are certain analogies to stochastic cooling systems (coasting beam) where for longitudinal cooling the travel time of a „slice"of particles is measured with the notch filter method and the slice gets a kick and one turn later an antikick.(not exactly the same as for crab cavities where kick and antikick are in the same turn)
- Note, that also for (longitudinal and also transverse) dampers often periodic notch filters are applied. The damper system is just running on a different gain as compared to a cooling system.

Crab crossing concepts; some qestions and remarks (2)

- Are we really sure that repetitive kicks with the revolution frequency can lead to transverse blowup? Normally in order to cause a blow-up we have to be in the longitudinal or transverse Schottky bands(respectively) with the excitation signal. Any excitation outside those frequency bands is leading to a forced oscillation but no or very little blowup.
- One can image that due to imperfections and /or second order effects (beam not centered in the cavity) kicks and antikicks with frev can cause ***longitudinal*** blow-up….
- In stochastic cooling, mixing (=change of particle population in a sample slice of the beam due to finite η plays a very important role, both the good mixing (travel from kicker to PU) and the bad mixing (travel from PU to kicker). How about mixing for the crab crossing schemes? Any need for consisideration?
- Could we possibly predict some blowup using the crab crossing formulae and test it in a coasting beam machine like the AD or maybe on some other machine with a damper and notch filters on f_{rev} (kick/antikick)?

A comparison with longitudinal stochastic cooling

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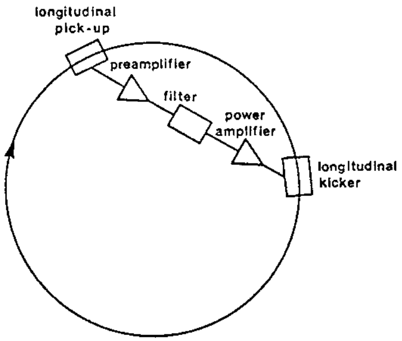


Fig. 7 Filter cooling.

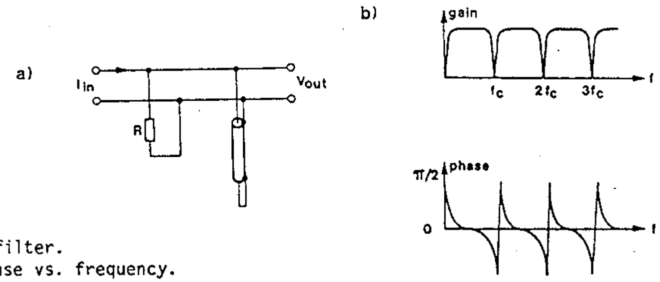


Fig. 8a Simple transmission-line filter.
8b Amplitude and phase response vs. frequency.

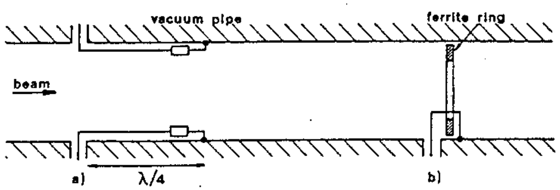


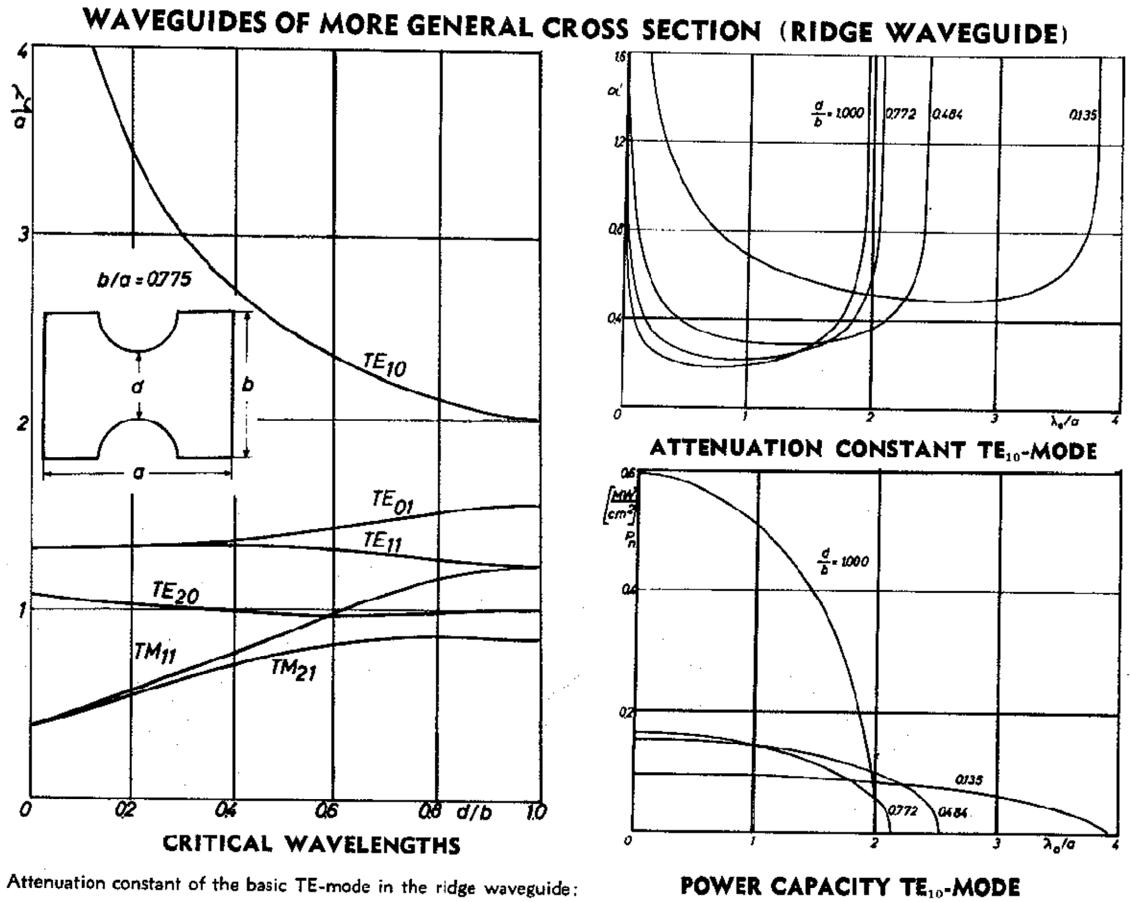
Fig. 9 Loop-type and ferrite ring-type pick-ups (or kickers). Note that for loop-type kickers the beam direction should be inverted.

From: Simon van der Meer , Nobel lecture 1984

Basic concept of stochastic cooling using the filter method:

This is very similar to a longitudinal damper except for the electronic gain.Note that in the HTF (hardware transfer function) one would obtain in the time domain for a (positive) pulse excitation from the PU a negative pulse at the kicker and one turn later a positive pulse.
„Mixing“ is vital for stochastic cooling and should perhaps also be considered for crabbing schemes

A few examples of ridge waveguide structure (1)



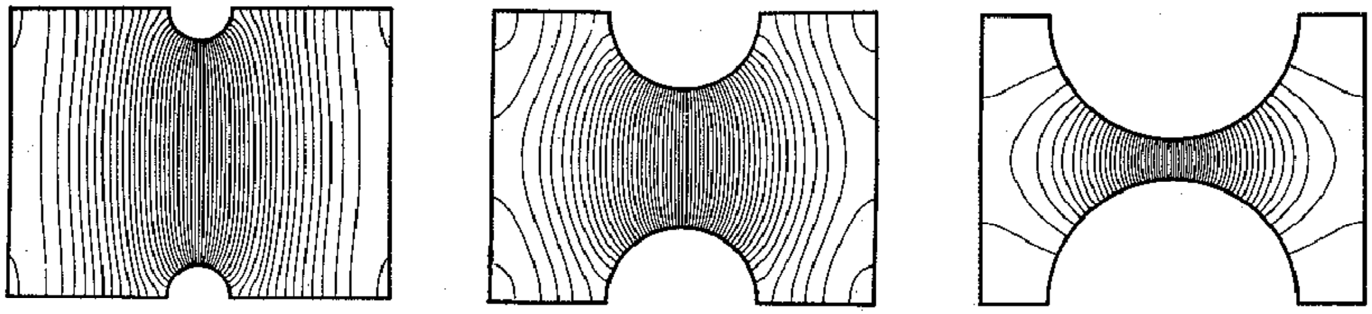
Attenuation constant of the basic TE-mode in the ridge waveguide:

$$\alpha = 8.69 \cdot \alpha' / \sqrt{\sigma \cdot a^3} \quad \text{dB}$$

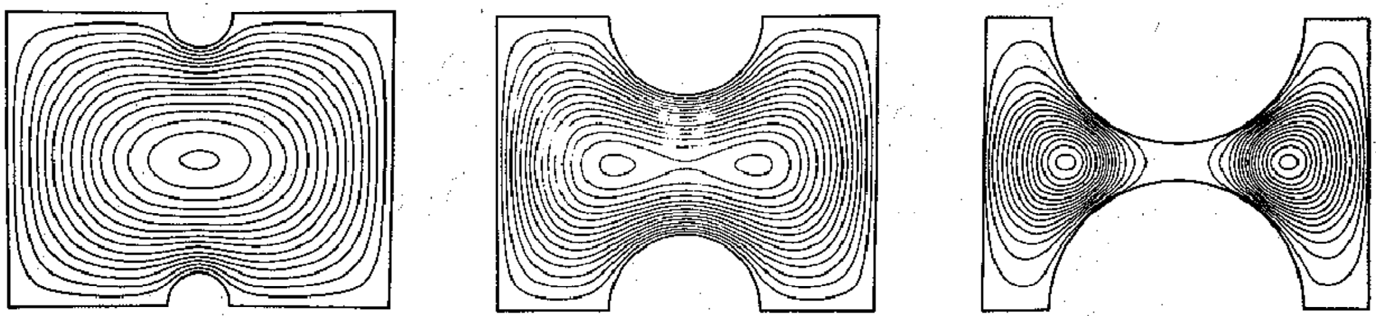
a = inner broad side dimension of the ridge waveguide in cm

σ = specific dc-conductivity of the waveguide material in Mho/cm

A few examples of ridge waveguide structure (2)



TRANSVERSE ELECTRICAL FIELD LINES TE_{10}-MODE



TRANSVERSE MAGNETICAL FIELD LINES TM_{11}-MODE

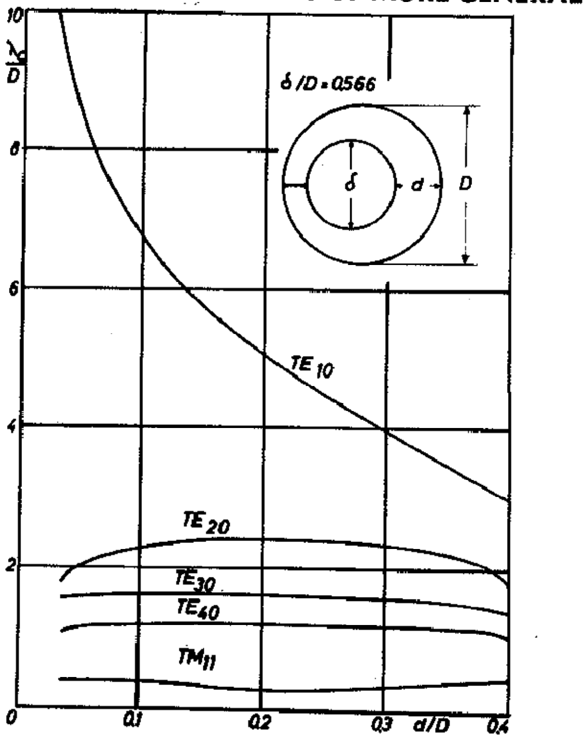
H. H. Meinke and W. Baier, courtesy of Institut fur Hochfrequenztechnik der Technischen Hochschule Munchen.

Microwave Engineers'

A few examples of ridge waveguide structure (3)

WAVEGUIDES

WAVEGUIDES OF MORE GENERAL CROSS SECTION (LUNAR GUIDE)



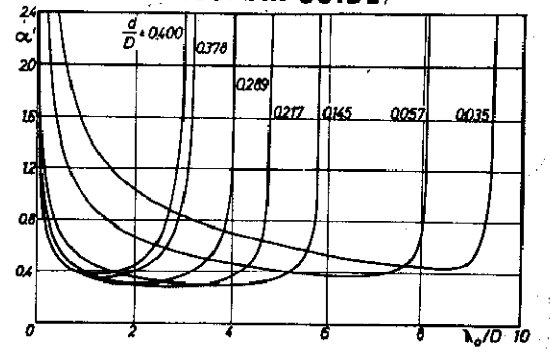
CRITICAL WAVELENGTHS

Attenuation constant of the basic TE-mode in the lunar guide:

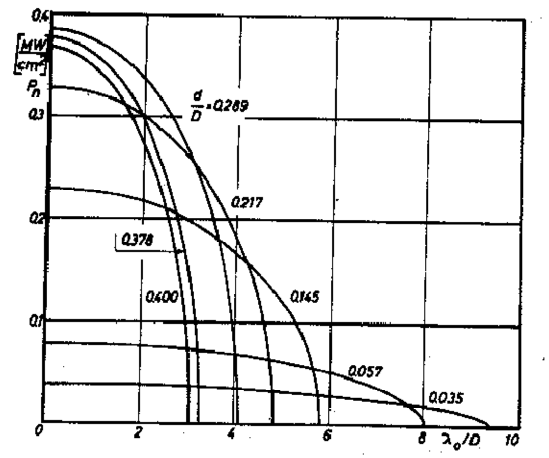
$$\alpha = 8.69 \cdot \alpha' / \sqrt{\sigma \cdot D^3} \qquad \text{dB}$$

D = inner diameter of the lunar guide in cm

σ = specific dc-conductivity of the waveguide material in Mho/cm

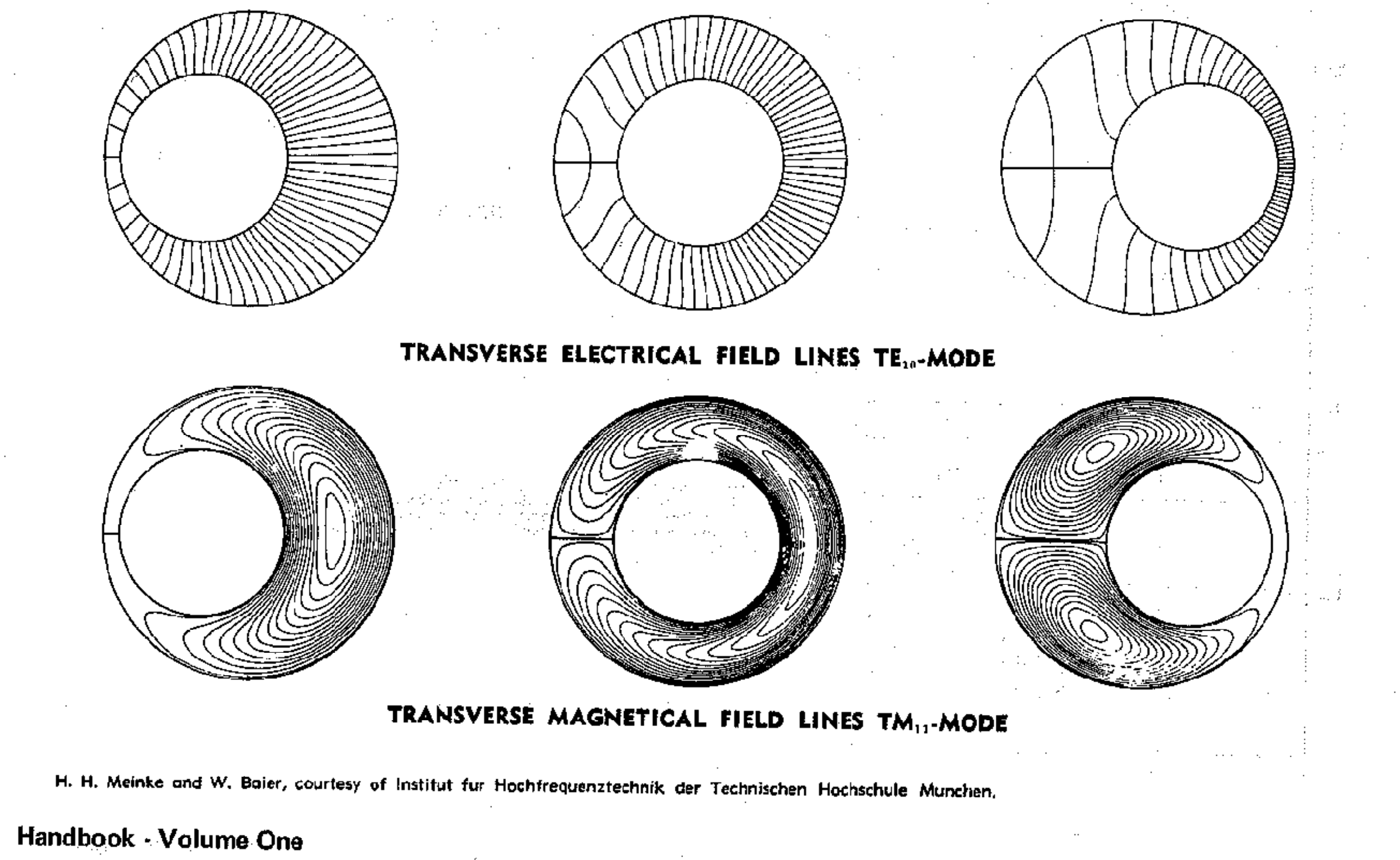


ATTENUATION CONSTANT TE_{10}-MODE



POWER CAPACITY TE_{10}-MODE

A few examples of ridge waveguide structure (4)



A few examples of ridge waveguide structure (5)

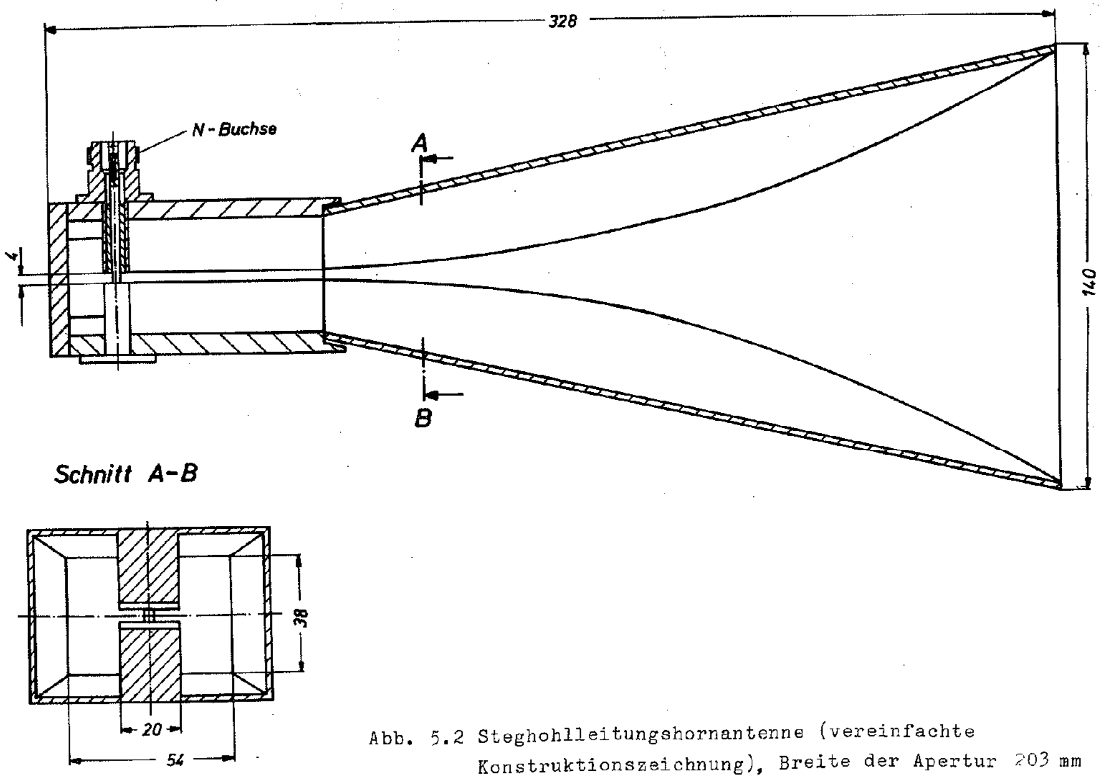
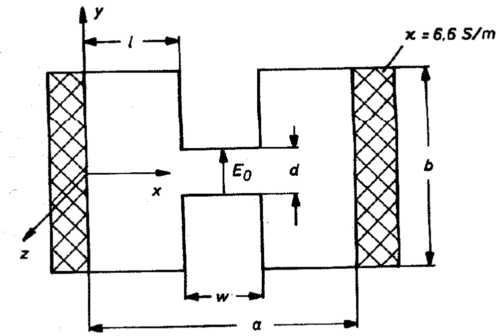


Abb. 5.2 Steghohlleitungshornantenne (vereinfachte Konstruktionszeichnung), Breite der Apertur 203 mm

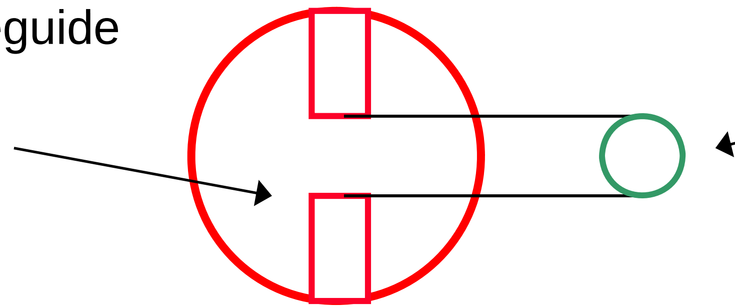


From: PhD Thesis F. Caspers

A crab crossing cavity based on ridge waveguide technology (1)

- Motivation: Simple mechanical design and low longitudinal loss factor
- If we can use a circular (pillbox) cavity with vertical ridges we dont need an elliptic design to break polarisation symmetry for deflecting modes.
- The ridges (if their aperture is equal to the diameter of the incoming and outgoing beampipe) can act like a bypass for for the image current and minimizing step like discontinuities at the entrance and exit of this cavity. Such discontinuities produce longitudinal loss factors.
- But we can still get a nice deflecting mode…..(cavity length about lamda/4 if phase velocity =c)..comparison to stripline kicker

Double ridge waveguide pillbox type cavity (cross-section)



In and out going beampipe

Would this be suitable for SC technology?

A crab crossing cavity based on ridge waveguide technology (2)

- Note that the deflection in this case is due to the transverse electric field of the quasi TEM wave between the ridges
- This is similar to a stripline pair kicker , except that here the ends of the stripline are not connected to feedthroughs.
- However there is a conflict:
  - A normal stripline kicker has a length of lamda/4 for optimum performance (and for a highly relativistic beam); this can be nicely visualized from the fact that for a TEM wave like kicker the deflection is mainly caused by the opposite traveling wave and for TEM wave travelling with the beam the deflecting effect of E and H cancel.(if E/H=377 Ohm)
- In our case we would have a lamda/2 type resonance to get a standing wave on the ridge structure which is shorted at both ends.
- We have to find out by numerical simulation, how the transverse loss factors of such a structure can be optimized and what Q values we can get…so far this design is just based on an intuitive approach (result of yesterdays coffee discussion)…we need numbers..and numerical simulations..perhaps a compromise would be a cavity length close to lamda/2 of the ridged waveguide and equal to ¾ free space lamda (seen by the beam) as we cannot easily make it ¼ lamda seen by the beam