S. Hancock PS

PS/OP/Info 89-1
02.02.89

NEW RF-GYMNASTICS FOR THE ANTI-PROTONS PRODUCTION BEAM

Presented by R.Garoby (02.02.89)

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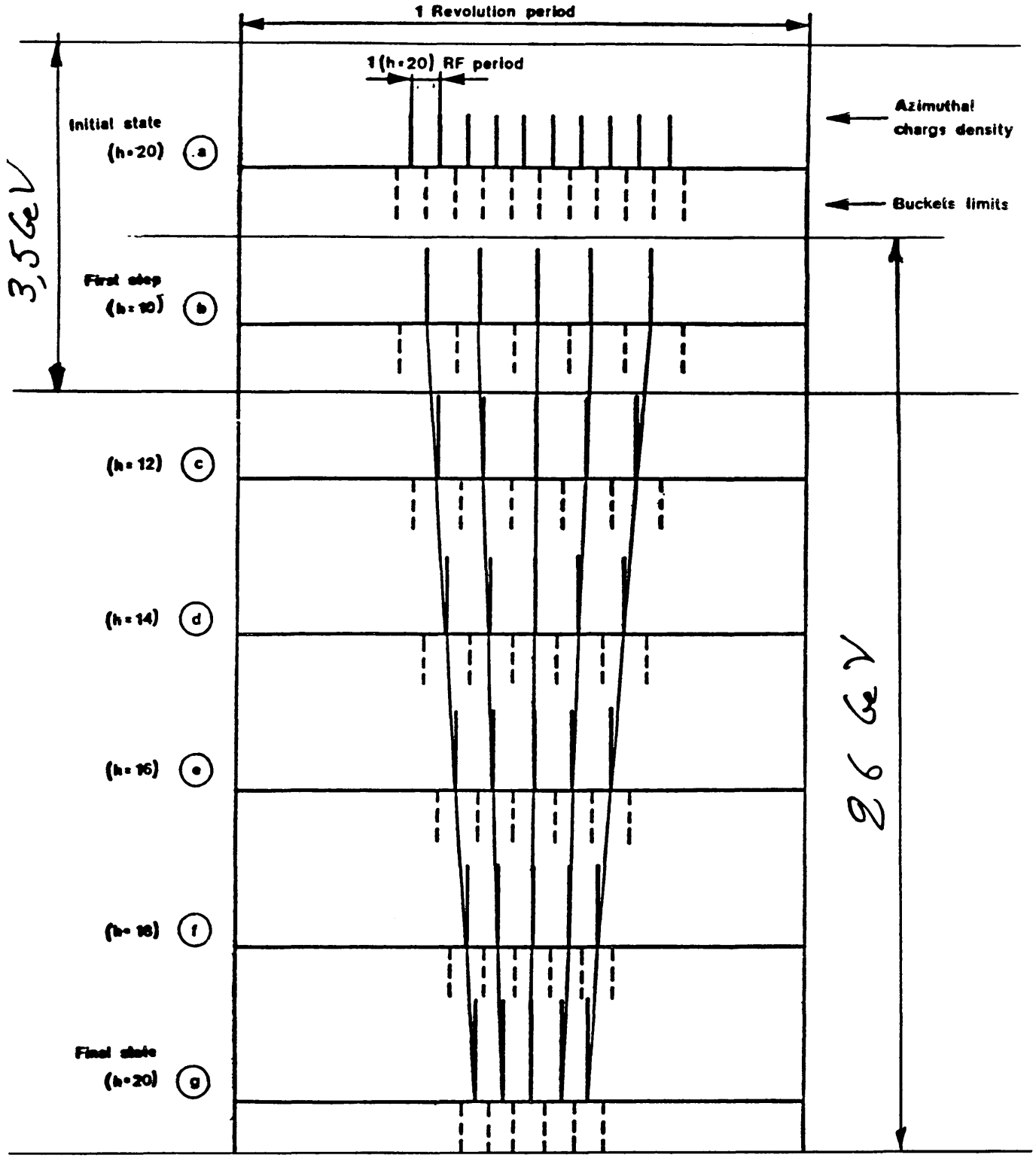
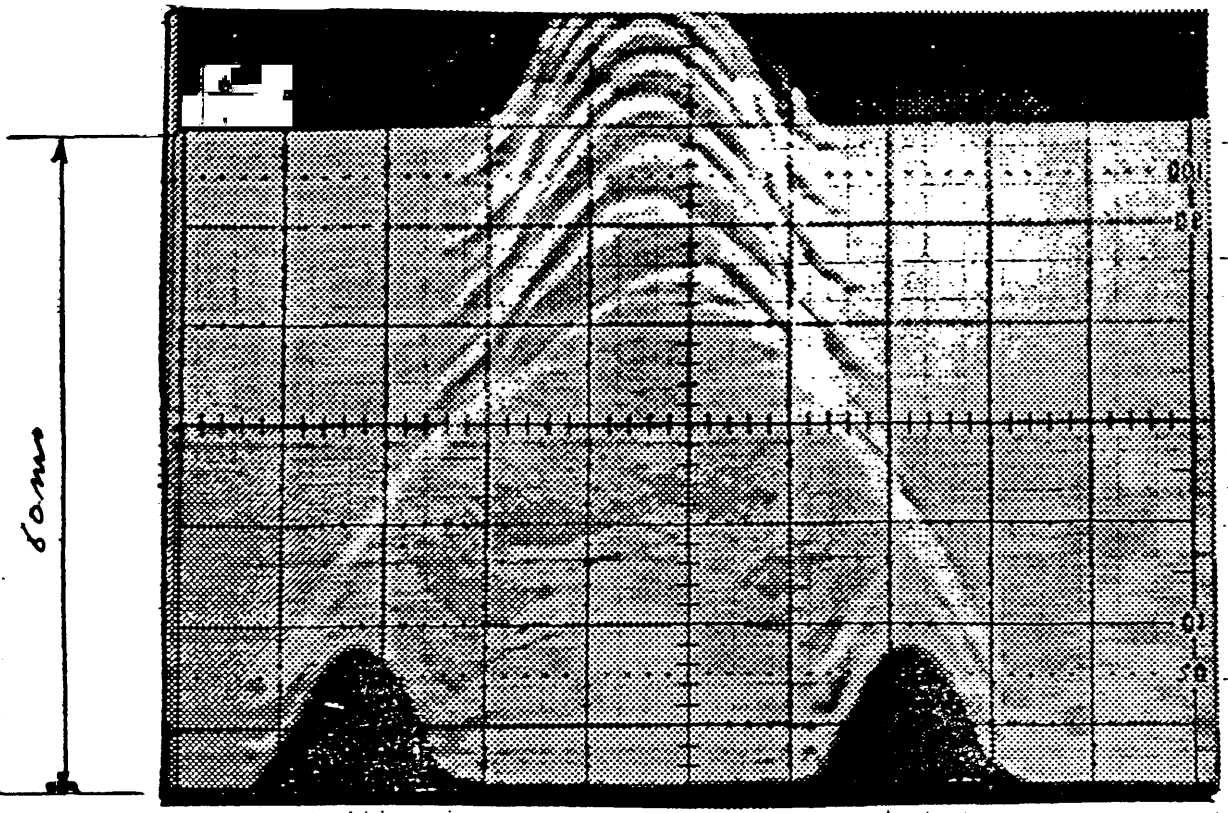
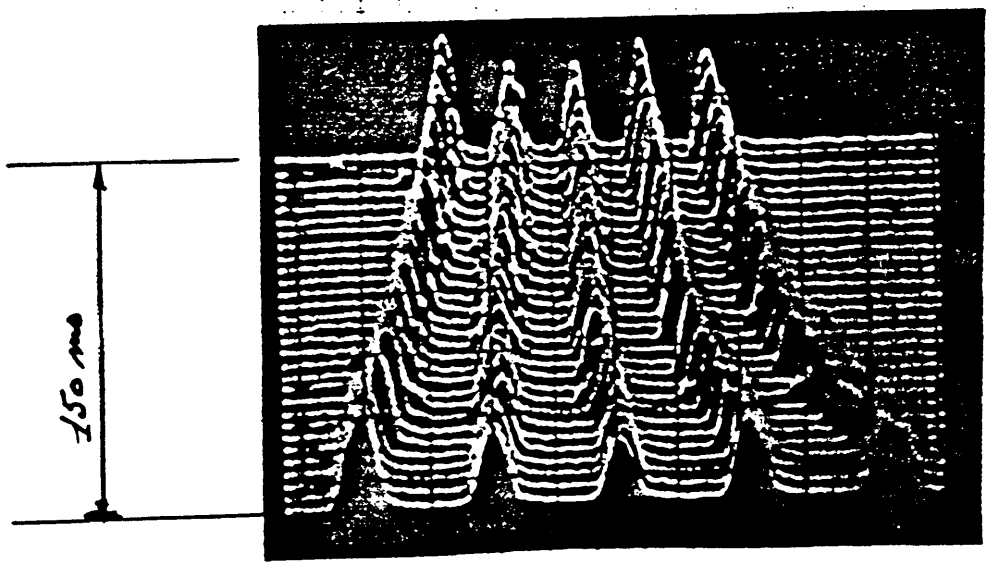


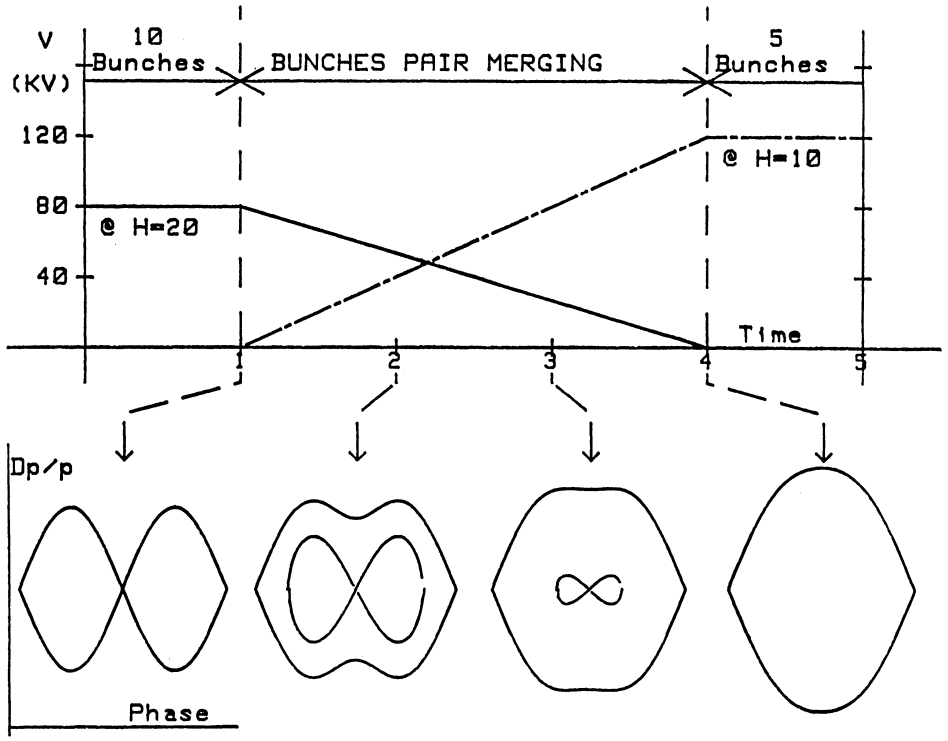
Fig.1: Coarse description of the azimuthal charge density during the process



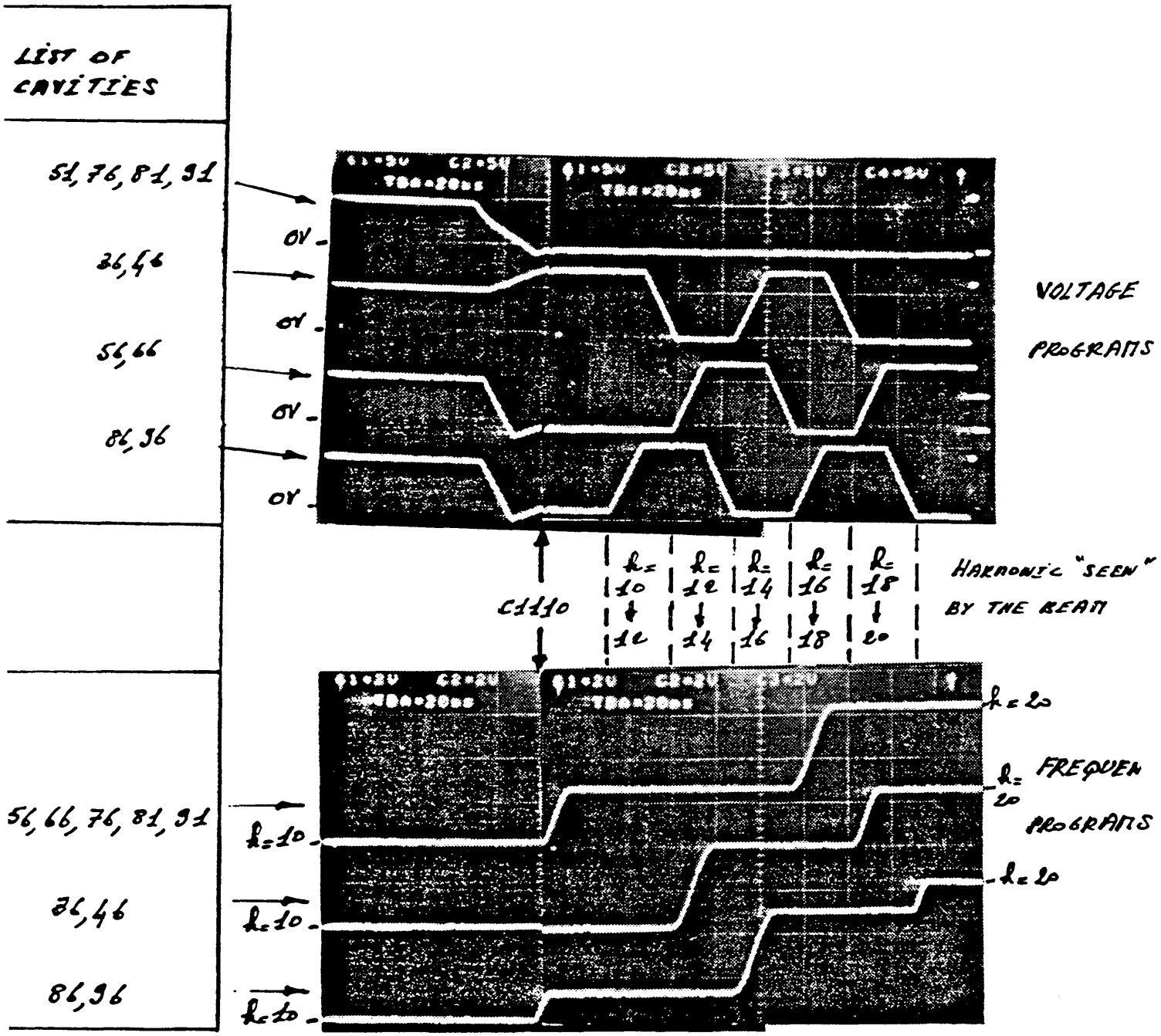
"B.P.M." (Bunches pair merging)

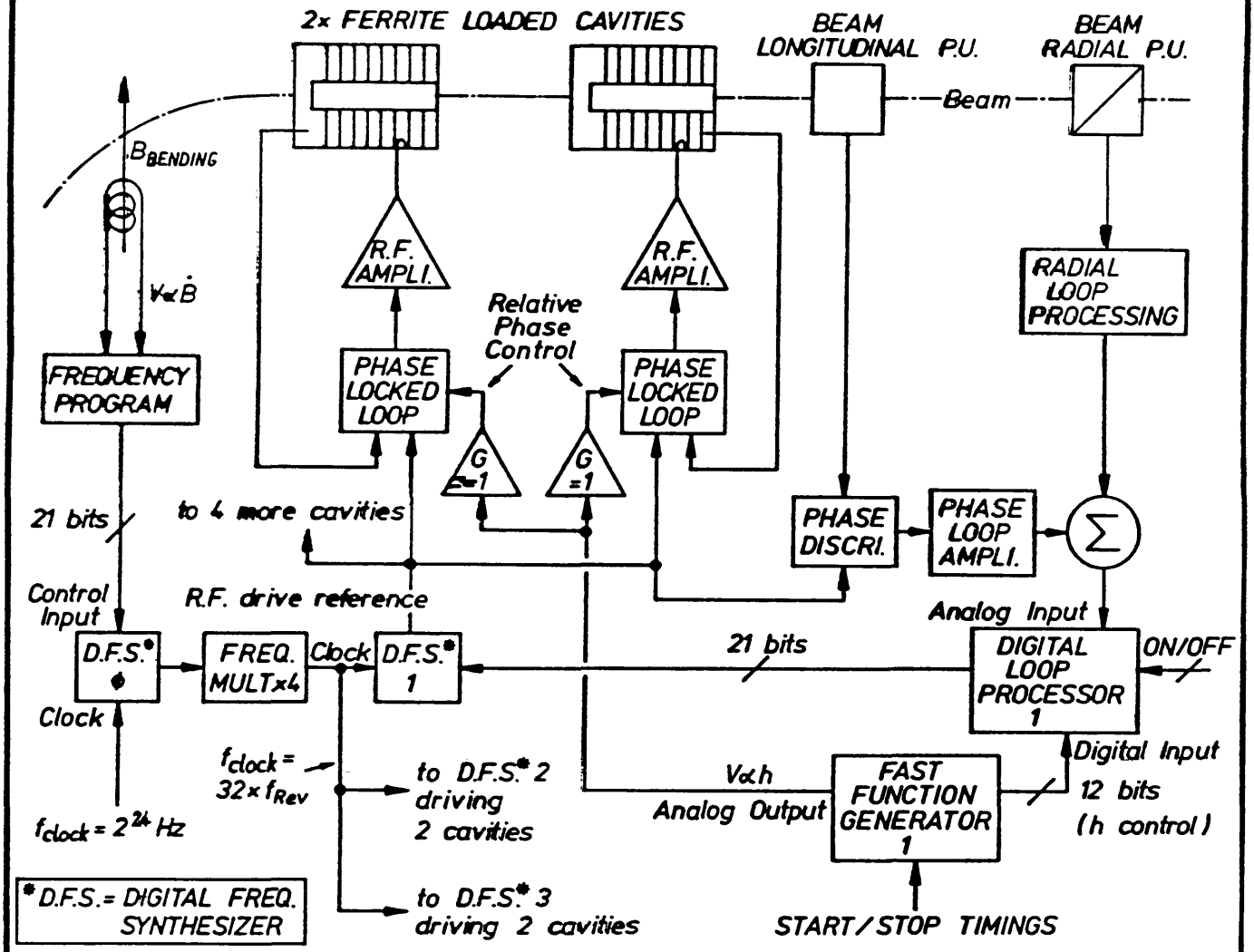


"Batch Compression".


V
(KV)
10
Bunches
BUNCHES PAIR MERGING
5
Bunches
120
80
40
@ H=20
@ H=10
Time
1
2
3
4
5
Dp/p
Phase

SELECTED CONTROL PARAMETERS FOR THE 8 GeV "BATCH COMPRESSION" PROCESS.





QUANT.	DESCRIPTION	POS.	MATIERE	OBSERVATIONS
	ENSEMBLE / ASSEMBLY		S. ENS./S. ASSY.	

Fig. 2: Simplified block diagram of low level R.F.

ECHELLE SCALE

	NOM	DATE
DESSINE	Roemer	23.2.87
CONTROLE		
VU		

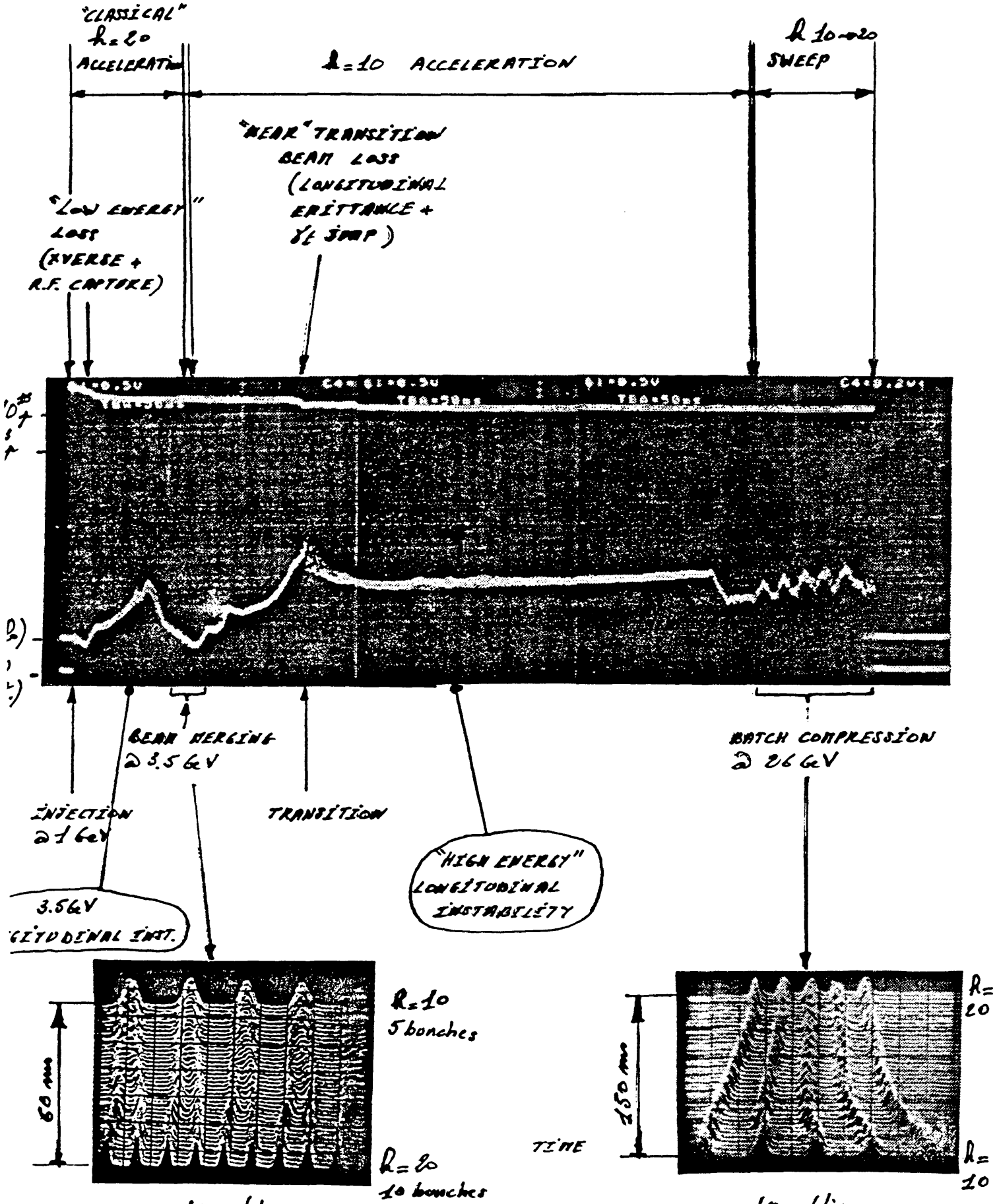
REMPLACE

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
GENEVE

INDICE

DESSIN, RUGOSITE, TOLERANCES SELON NORMES ISO
DRAWINGS, RUGOSITY, TOLERANCES ACCORDING TO ISO STANDARDS

TYPICAL BEAM SIGNALS DURING A FULL CYCLE.



LOW INTENSITY OPERATION ($< 2.10^{12}$ ppp):

- Many iterations to come to a satisfactory lay-out giving reliable results.

  Burning in was done during the many machine developments.

- Adjustment time was very long, due to the large number of control parameters (amplitude, phase, timing, ...).
- Synchronization before ejection was difficult and implied modifying the sequence of events.

HIGH INTENSITY OPERATION (up to 1.55×10^{13} ppp).

- Short circuiting unused cavities is mandatory.

  ($\Rightarrow$ hard work! $\nu 3.10^6$ operations in 6 weeks)

- Complementary feedbacks had to be implemented:
  - Heuward damping (on φ_s below transition, on $\hat{V}_{RF}$ above).
  - h=1 beam phase loop against coherent dipolar bunch-phase oscillations.
- A few phase perturbations were necessary to handle the transient cavity beam loading.

BUNCH LENGTH COMPRESSION

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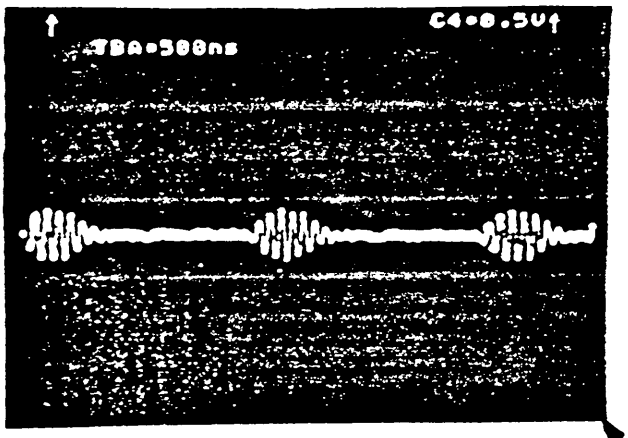
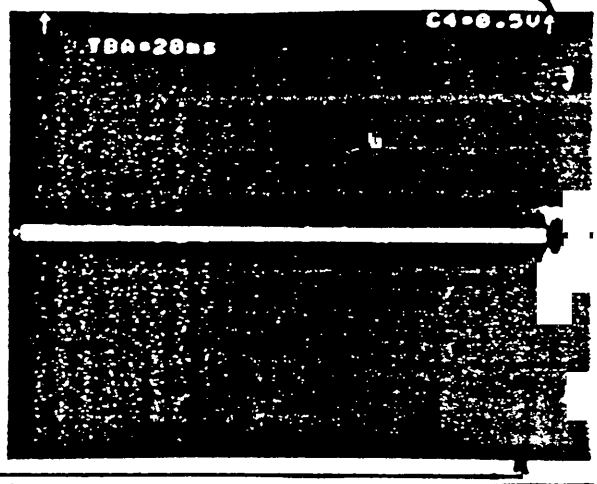
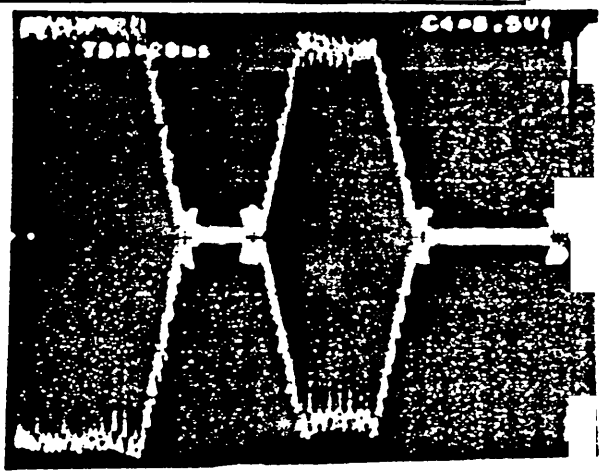


C51



CLOSE UP VIEW OF BEAM INDUCED VOLTAGE ON A NON-SHORT CIRCUITED CAVITY



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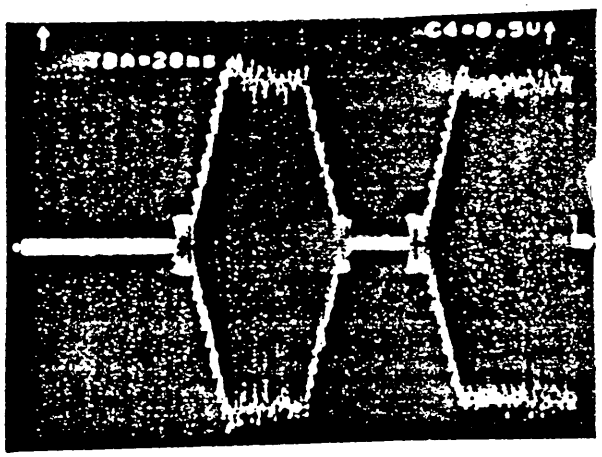
VOLTAGE ON THE CAVITY GAPS DURING THE 26GeV PROCESS.

$I_p = 1.42 \times 10^{13}$ ppp.



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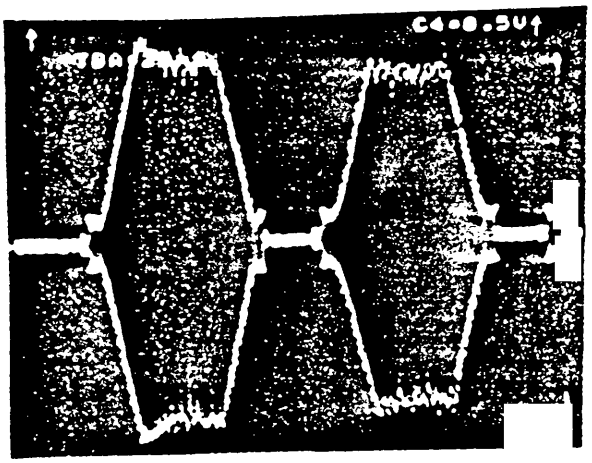
Note: - gap short circuits are pulsed.

- Hereward damping modulates the R.F. envelope.



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BEAM CHARACTERISTICS.

PRESENT PERFORMANCE.

+ - 1.5×10^{13} ppp sent on target with $\sim 2.10^{12}$ ppp lost between P.S.B. output and P.S. extraction.

- - Bunch length : $\sim$ 30 ns

-- - "Ghost" bunches : $\sim 1.5 \times 10^{12}$ ppp.

Overall performance: $\sim$ 10% improvement of the stacking rate compared to the other beam (40% expected).

PROBLEMS.

- Longitudinal beam instability above transition energy, asking for enormous longitudinal emittances. ($\varepsilon_l \simeq 2$ e.V.s for 2.10^{12} ppb).
  ⇒ long bunches ⇒ poor bunch rotation efficiency in the A.C..
  ⇒ $\sim$ full buckets during manipulations ⇒ diffusion of particles outside the central buckets.

- Strong periodic transient beam loading generating large bunch shape oscillations ⇒ filamentation ...

DIRECTIONS OF WORK.

① Fight against periodic transient beam loading in the cavities: ⇒ • Improvement of the gap relays control, to reduce dead time, while preserving reliability.

• Development of a "One turn delay feedback" around each cavity.

② Against longitudinal coupled bunch instabilities:

⇒ • Search for offending impedances.

• Damping system around $h = 9, 8, 7$ above transition energy.

③ Operational improvements:

⇒ • Improved "Horizontal damping".

• Better synchronization logic.

• P.C. controlled monitoring.

• Control parameters reorganization. (which will allow using "AA" cycles).

④ Machine study and office thinking!

PREVISIONS.

Best case: - Intensity increase (present level dictated by P.S.B. beam quality + P.S. losses): $\sim 10\%$.

- Smaller bunch emittances giving a better yield and an improved bunch rotation efficiency.

?...

⇒ Need for: - machine development time.

- machine specialists time and engineering support.

FIRST IDEAS ABOUT A "ONE-TURN DELAY FEEDBACK" ON THE P.S. FERRITE CAVITIES

1989 Aims :

① Proof of principle :- hardwarewise.
- beamwise.

② Get some benefits during the $p/\bar{p}$ run.

⟹ Implementation of a limited capability system.

1989 Hardware specifications.

① Fixed energy system. (26 GeV) ⟹ No need for variable delay and variable term of the comb filter

⟹ but need for tunable notch filter running, to be able to cover all the "Batch compression" process.

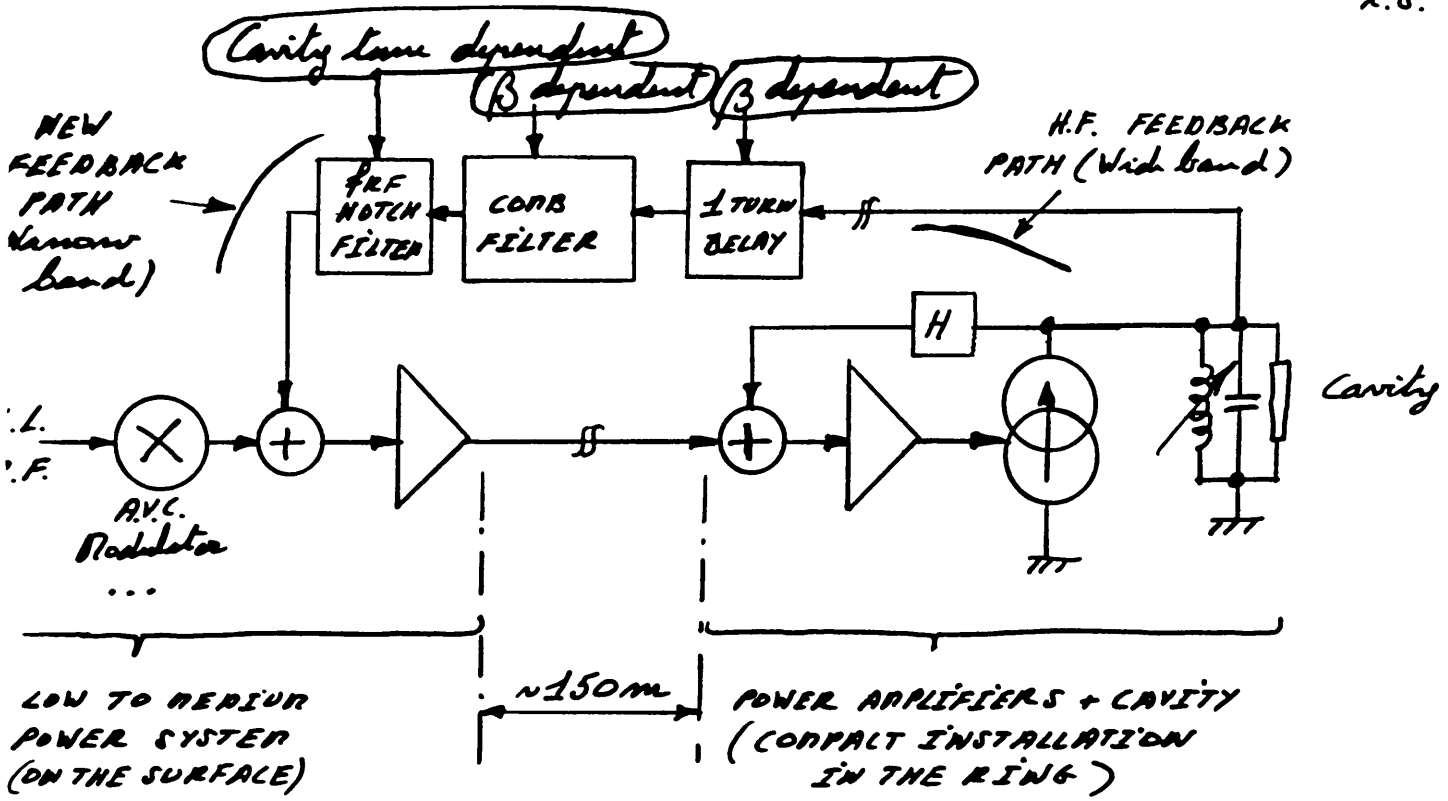
② Analog design providing ≥ 12 dB impedance reduction on the first ± 3 revolution frequency sidebands around the cavity tune.

Design options adopted.

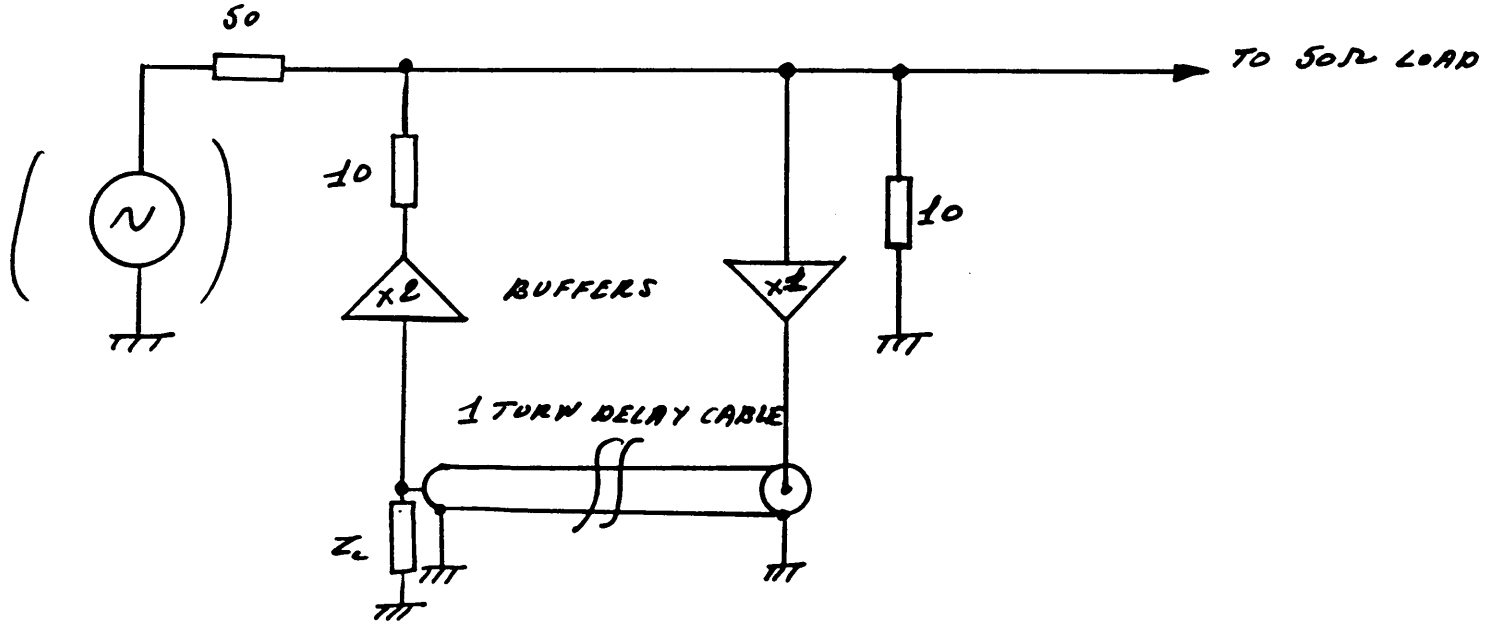
① Fully analog design.

② Wide band without mixing (no frequency translation).

③ Reuse of maximum part of old feedforward compensation (Controls, cabling, ...)

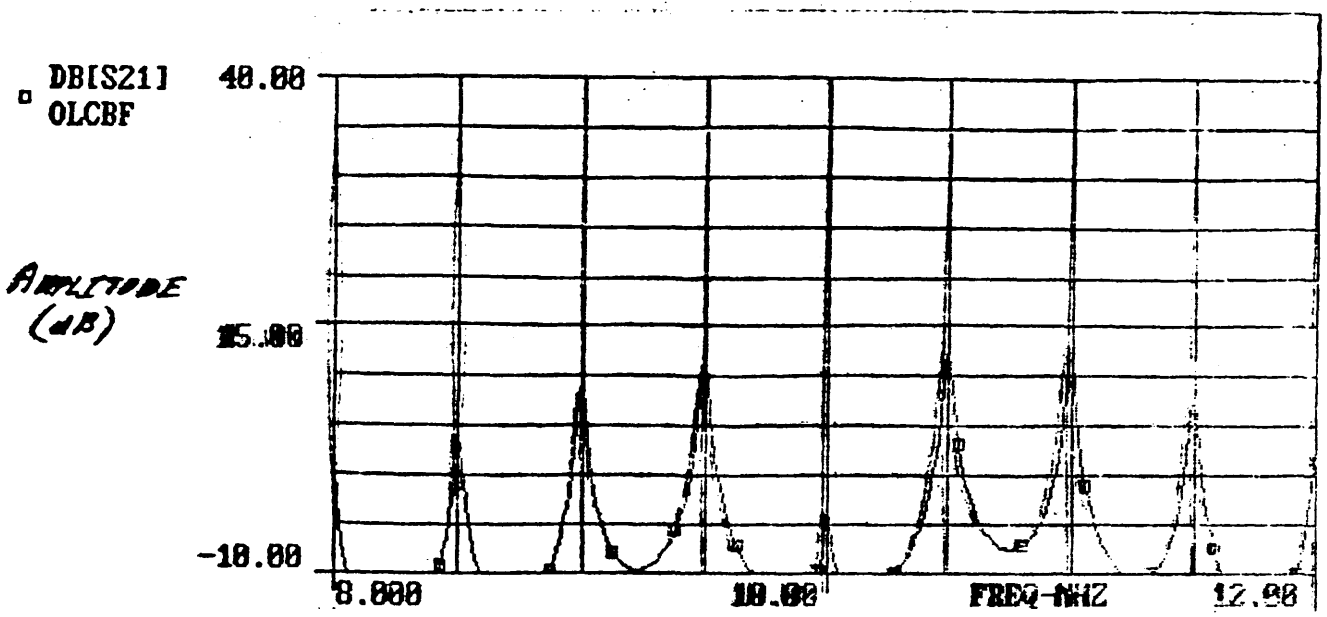


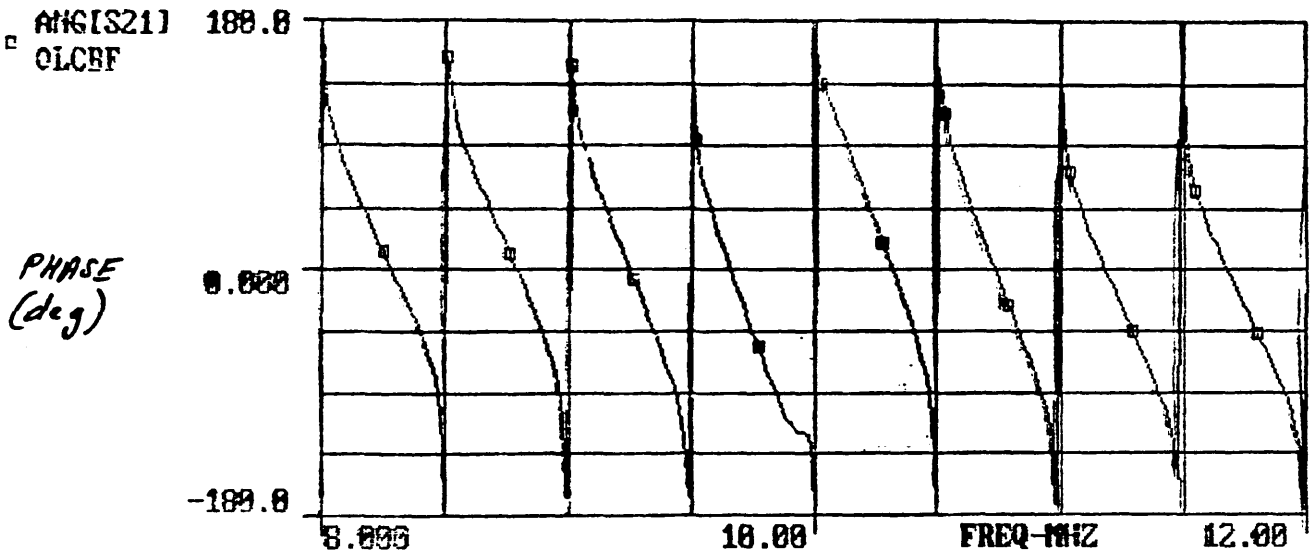
OVERALL IMPLEMENTATION



"EASY-MINDED" IMPLEMENTATION OF AN ANALOG RECURSIVE FILTER.

COMB FILTER OPEN LOOP XFER FUNCTION.





CLOSED LOOP CAVITY IMPEDANCE