

# BUNCH FEEDBACK SYSTEMS

&

# RELATED SYSTEMS

KEKB Accelerator Review

9 March 1999

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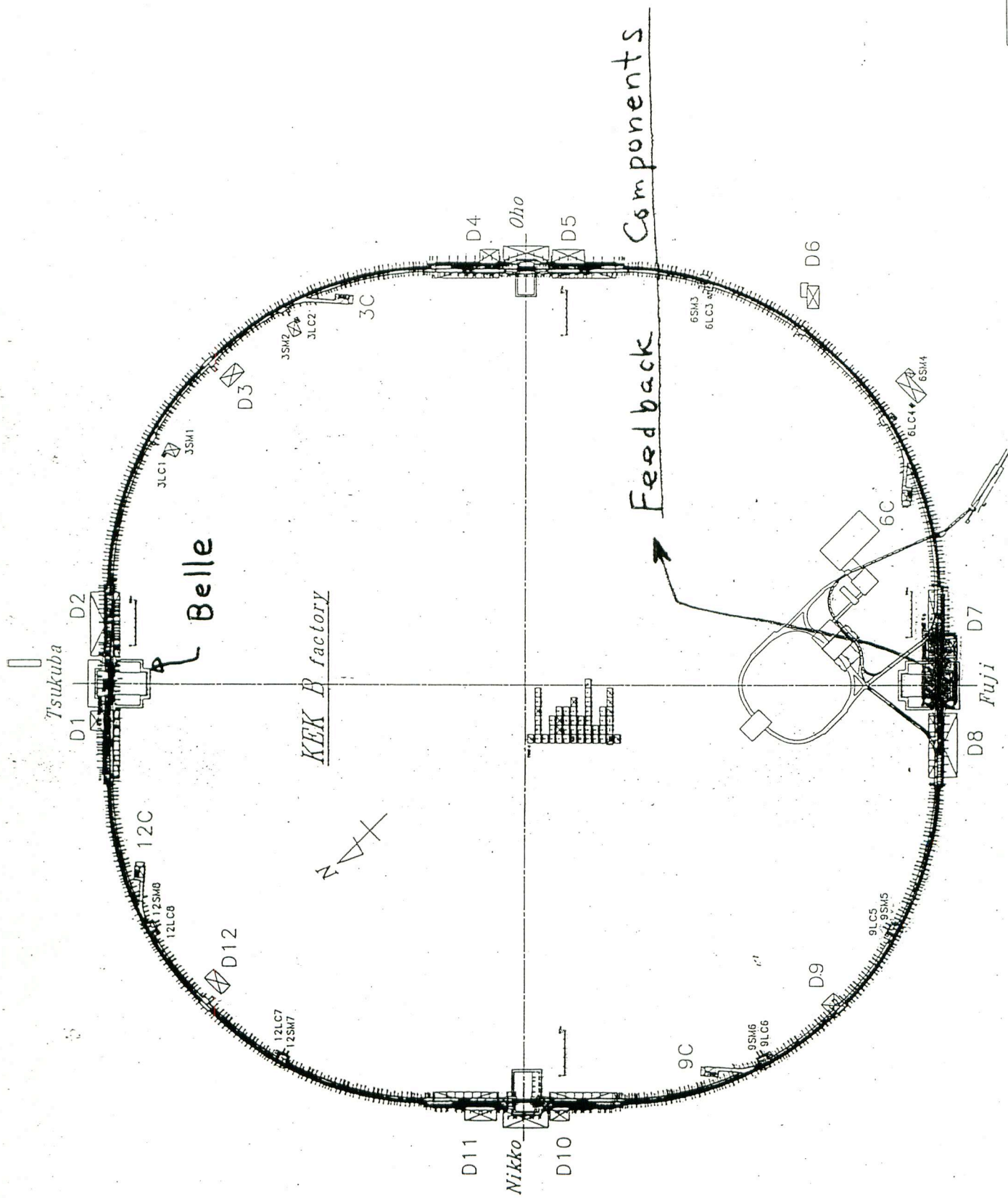


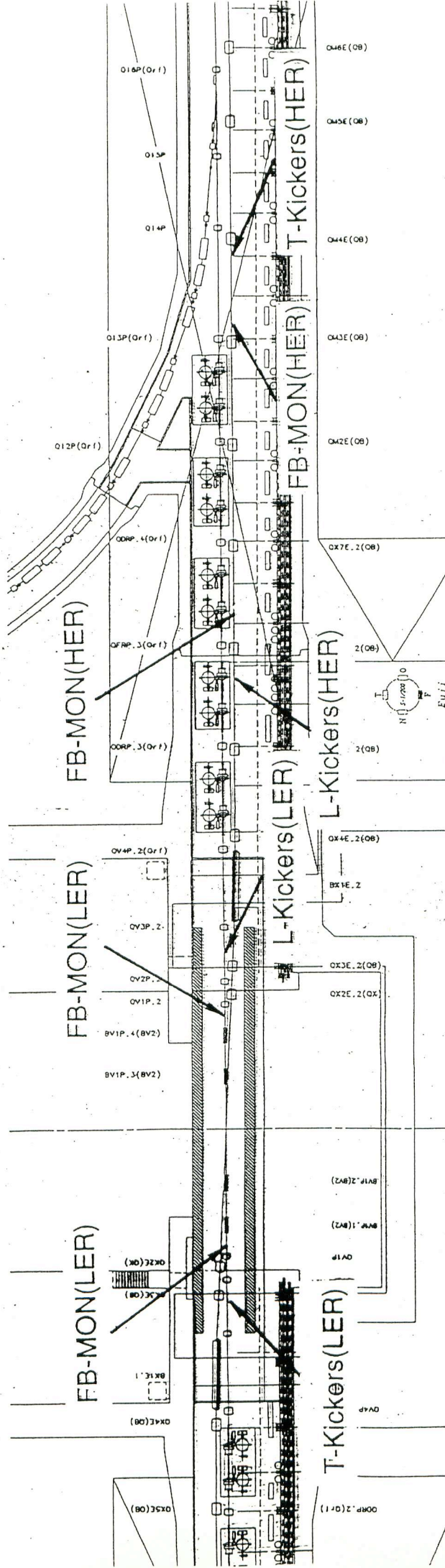
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1. Transverse feedback systems
2. Tune measurement system
3. Bunch current monitor
4. Plans in near future

## Feedback-Related Machine Parameters

RF frequency	: 509 MHz
revolution frequency	: ~100kHz ( $h=5120$ )
# of bunches	: ~ 5000
minimum bunch spacing	: ~2ns ( $f_{\text{bunch}} \sim 500\text{MHz}$ )
betatron frequency	: 5kHz~45kHz
synchrotron frequency	: ~1kHz
radi. damp. time (long)	: 23ms
bunch current	0.5mA/0.2mA (LER/HER)





beam lines B3  
 low level + PA B4



## Transverse Feedback Systems

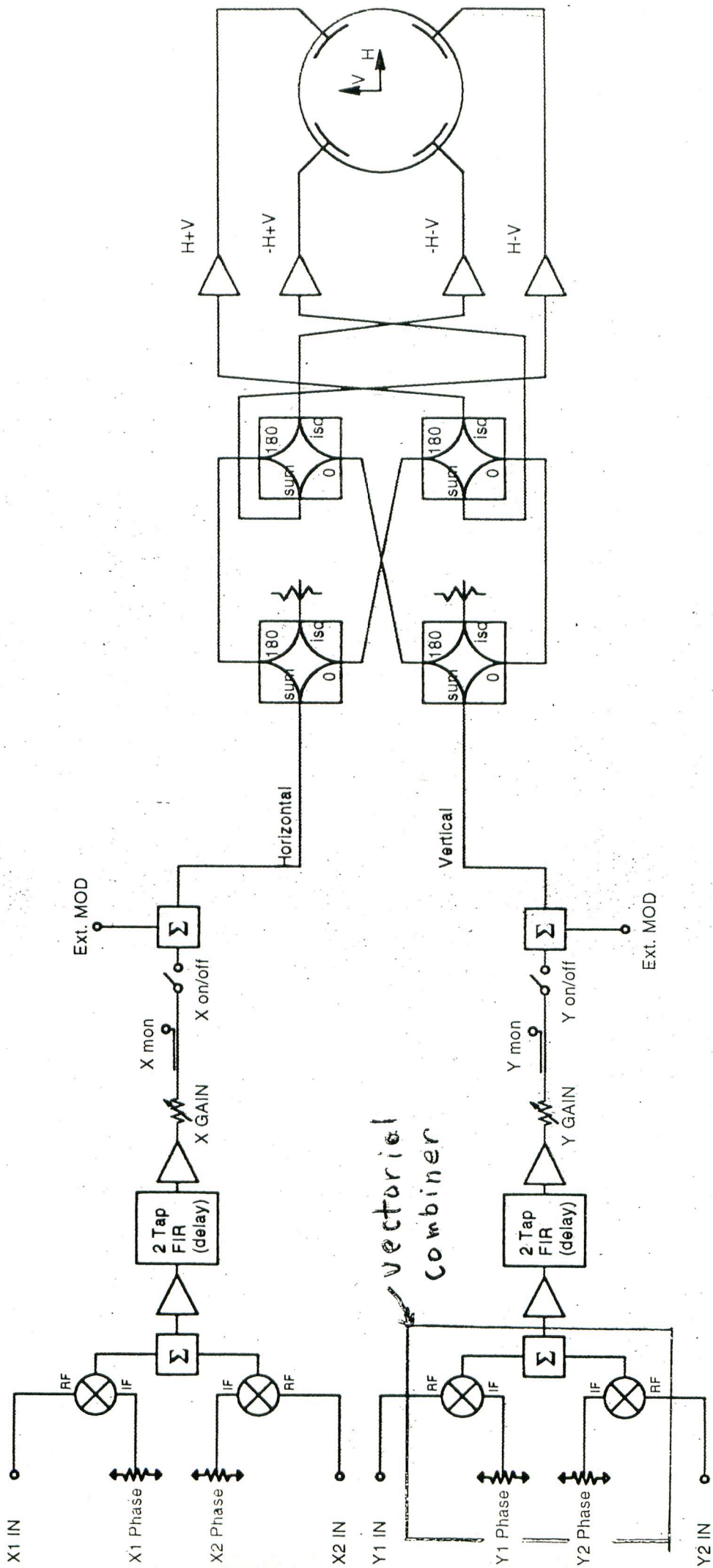
**pickup:** button (two points)

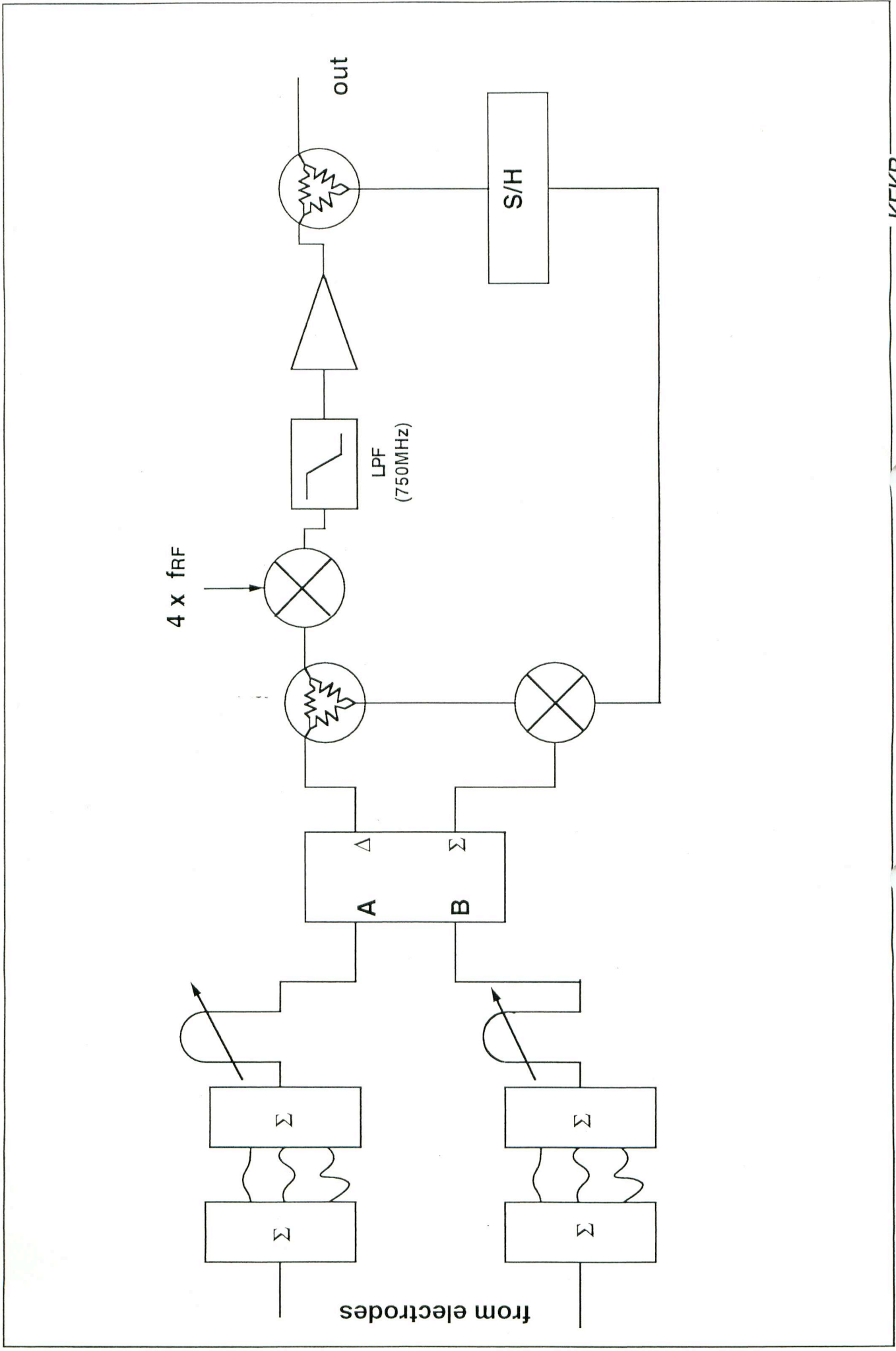
**detector etc:** analog FIR filtering  
hardware subtract (+DC canceller)  
vectorial combiner

**signal process:**  
simple digital delay or 2-tap filter

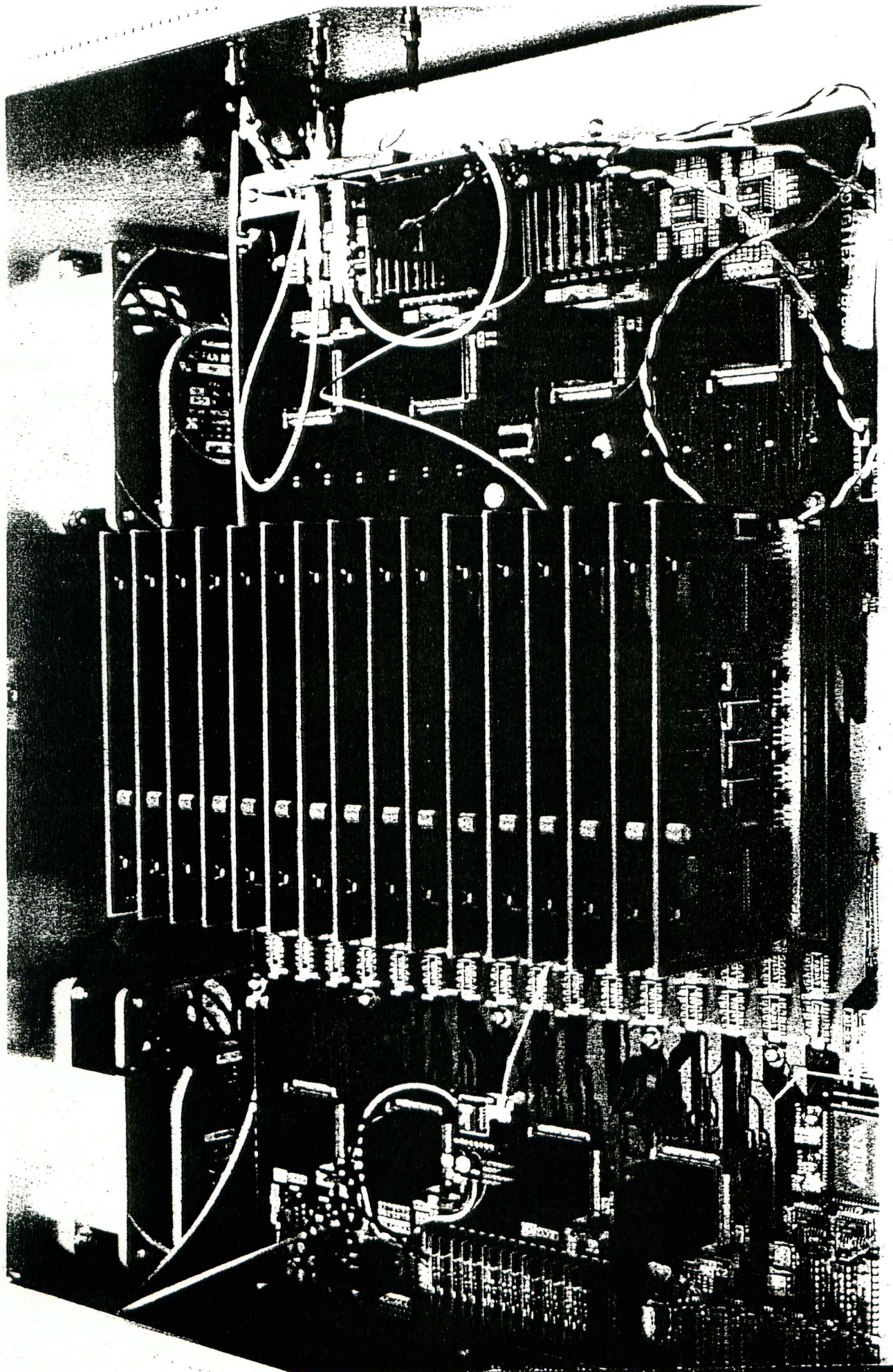
**power ampl.** 250Watts x 4 (wide band)  
250Watts x 4 (lower narrow band)

**kickers** 40 cm x 4 (wide band)  
120 cm x 4 (lower narrow band)









2 Tap FIR Filter

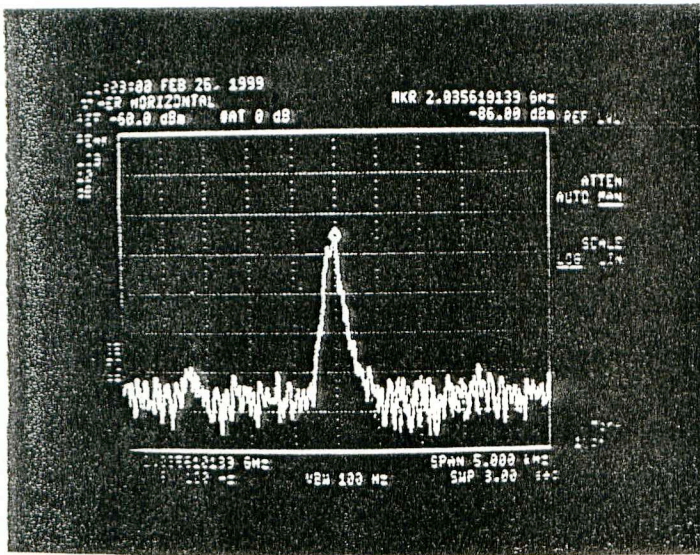


## Effects of the feedbacks

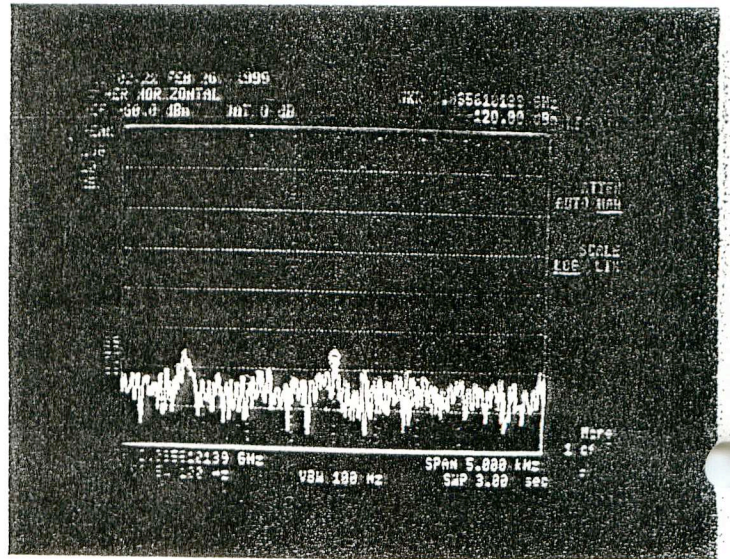
- ◆ Instabilities are observed in HER and LER.
- ◆ They are almost completely suppressed. It was confirmed by observing the signal by a spectrum analyzer, up to 220mA (HER) and 200mA (LER).
- ◆ When the feedback is turned off (LER), the beam current was decreased down to about 60% of the original one.
- ◆ Without the feedback, the stored current was  $\sim 100$  mA. With the feedback the maximum current was increased to 200mA or more.



# HER

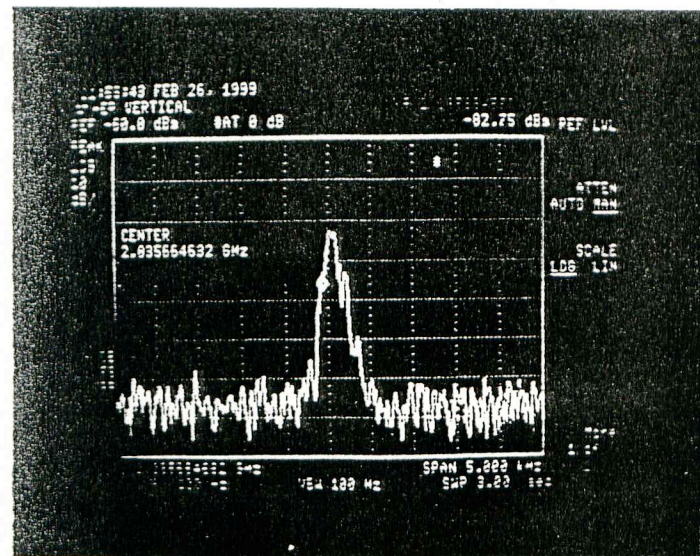


feedback off (-7db)

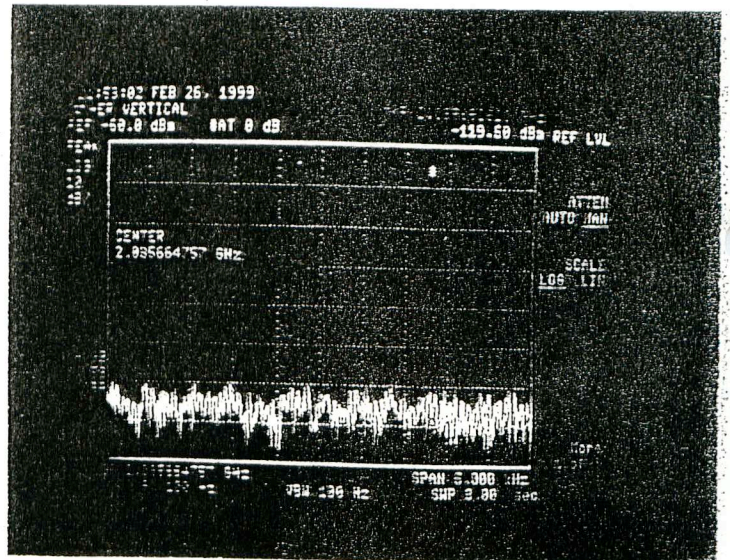


feedback ON

## HORIZONTAL



feedback off (-16db)

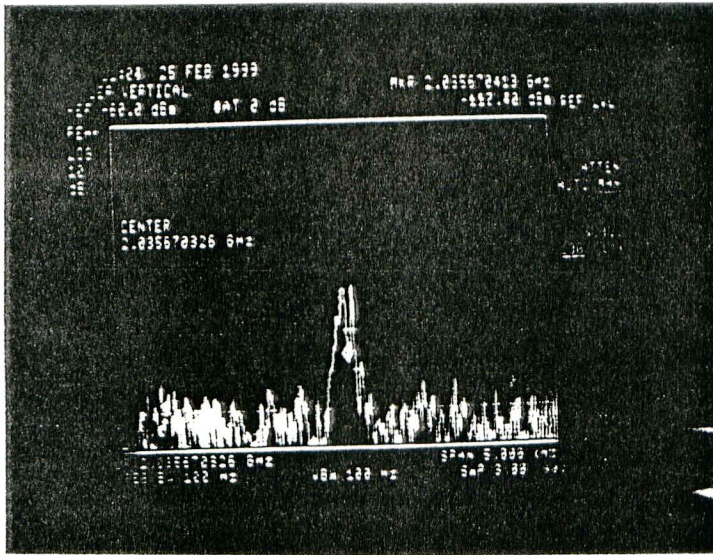


feedback ON

## Vertical

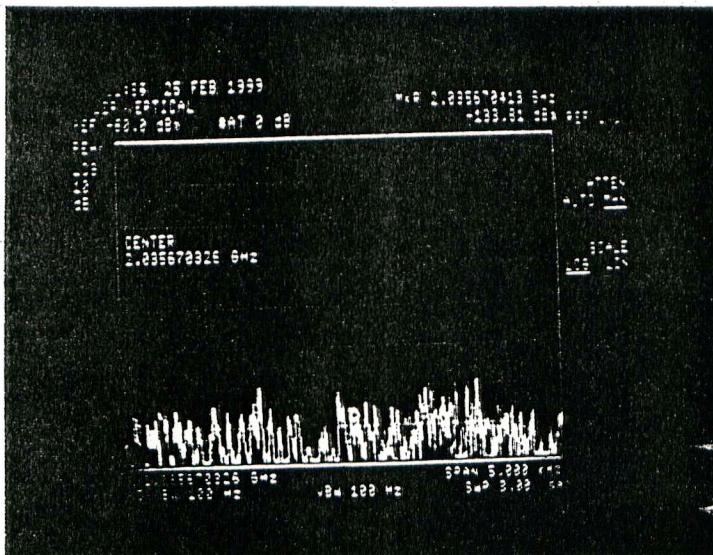


# LER (horizontal)



FB off  
(vertical)

feedback off



FB ON

feedback on

## Rough Estimation of the damping rate

From the following parameters,

- ◆ sensitivity of the monitor
- ◆ gain of the power amplifiers ( $\sim 53\text{db}$ )
- ◆ shunt impedance of the kicker ( $10\text{k}\Omega$ )
- ◆ losses in cables etc.
- ◆ beta function at the monitor and the kicker  
 $(\beta \beta)^{1/2} = 11 \sim 24\text{ m}$

we can roughly estimate the damping time.

The result is

	horizontal	vertical
HER	1.2 ms	2 ms
LER	1.3 ms	1.8ms

The damping rate will be increased by adding pre-amplifiers.



## A problem to be solved

Stationary changes of the beam position should waste the dynamic range of the A-to-D converter(8 bits).

A simple high pass filter is not usable.

---> An effective DC offset-canceller circuit is required.

But, it is now under tuning.

Then, at present, the feedback system can not work continuously without human adjustment.  
(if we require the best performance)

--> Install the DC-offset canceller

--> operate a closed orbit corrector

## Tune Measurements

### ◆ Excitation

exciting betatron oscillation by the feedback kicker(longer type)

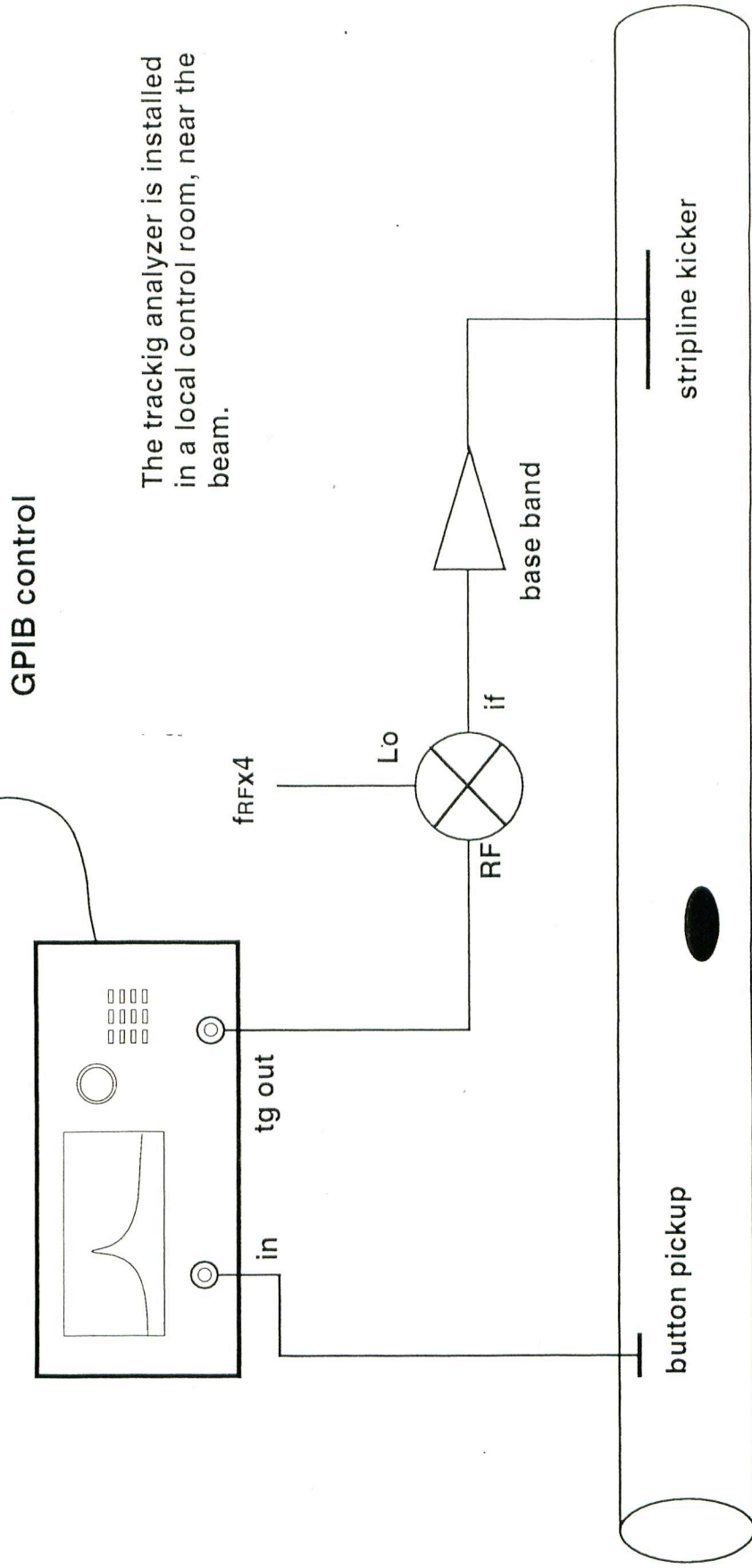
source : a spectrum analyzer (9k-2.9GHz)  
(with a tracking generator)

### ◆ A tune-meter software

- > finds a peak in the spectrum,
- > displays the calculated tune corresponding to the peak on the operator's console.

# tracking analyzer

(center frequency =  $4 \times f_{RF} + f_r$ )



The tracking analyzer is installed in a local control room, near the beam.

# TUNE MEASUREMENT SYSTEM(conceptual)

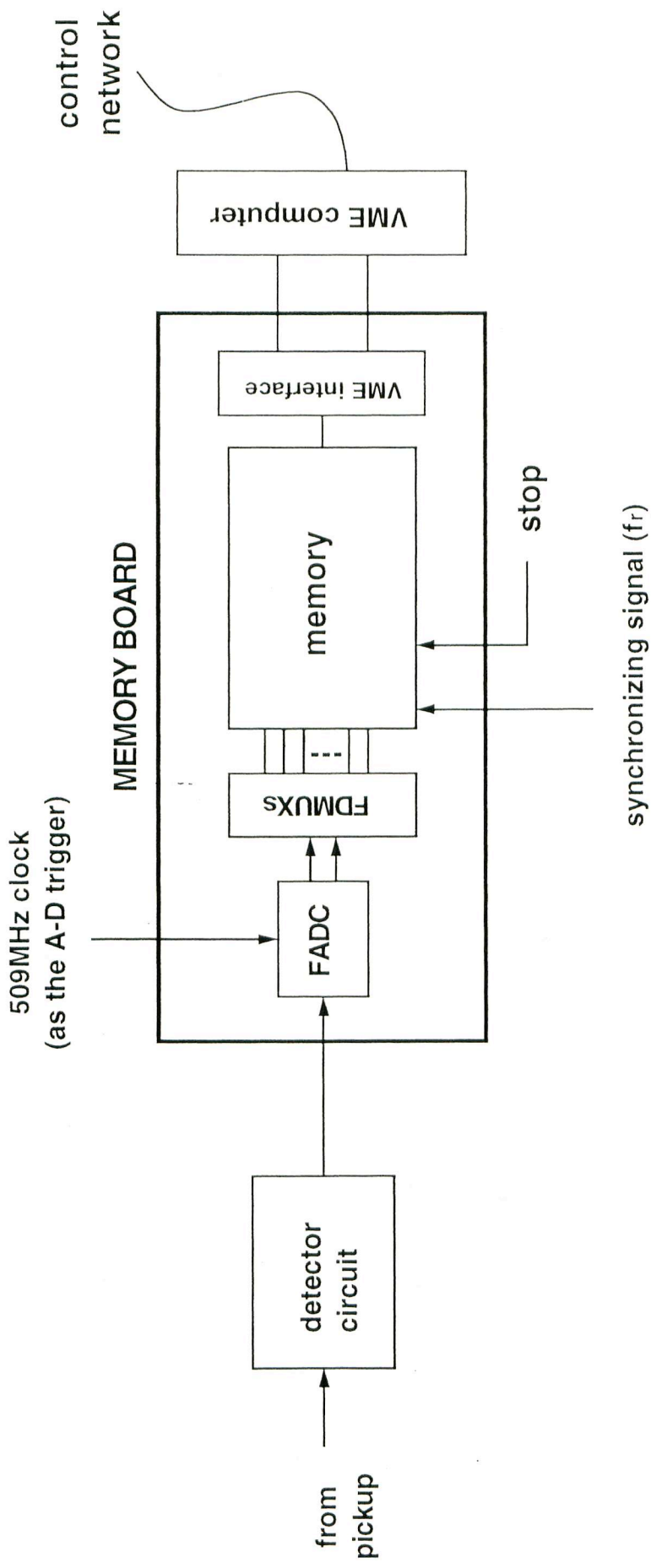
# Bunch Current Monitor System

Bunch to bunch current detection circuit

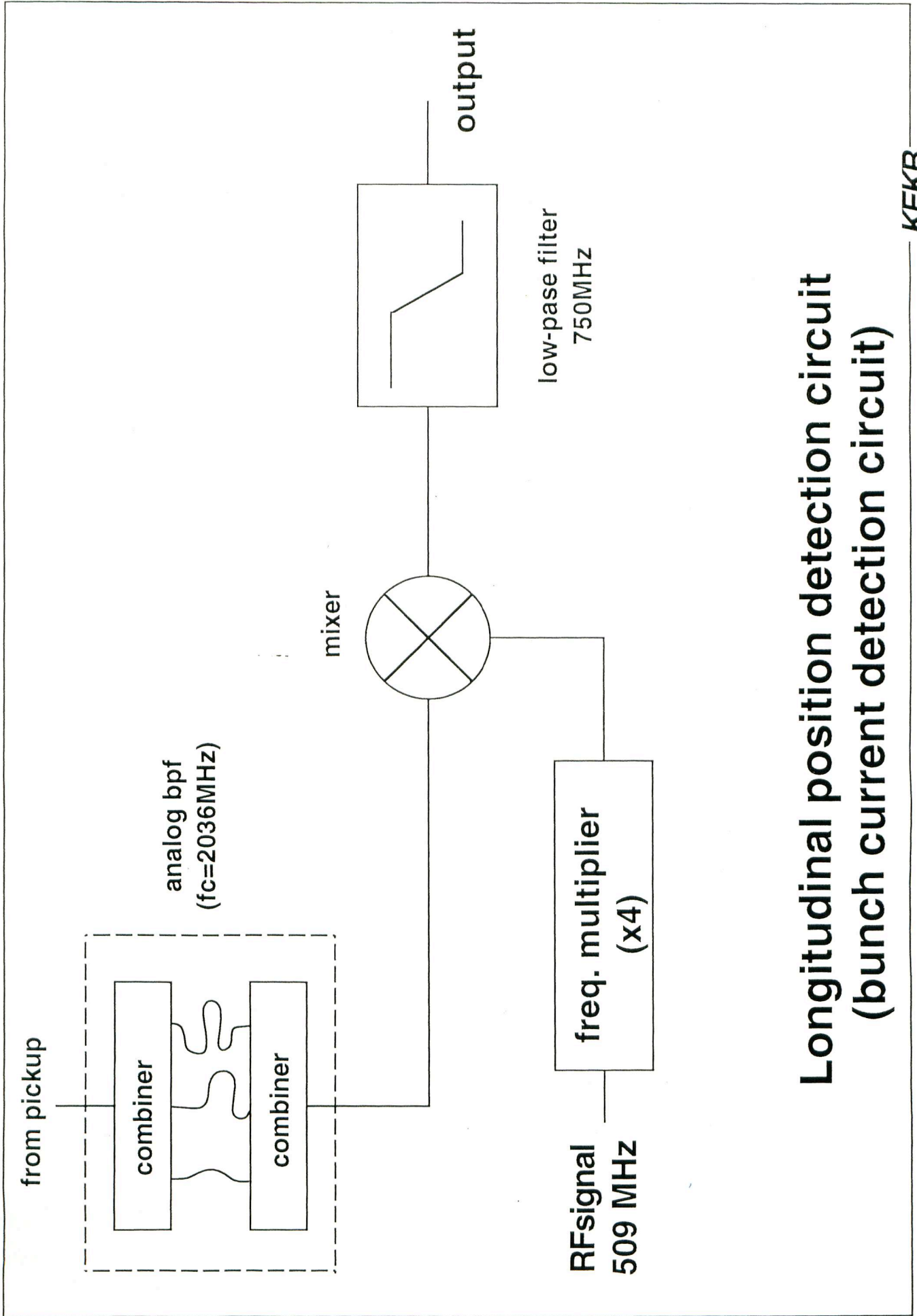
+

the Memory Board  
(specialized to the bunch curr.)





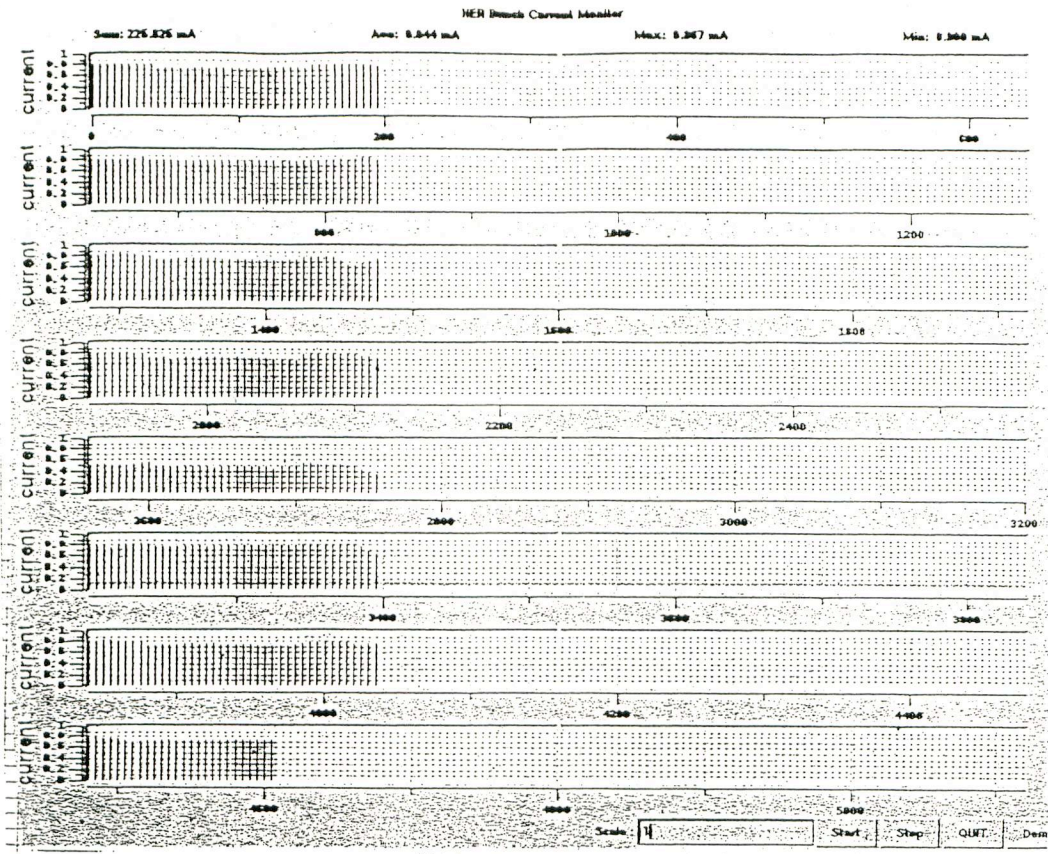
# Bunch Current Monitor System



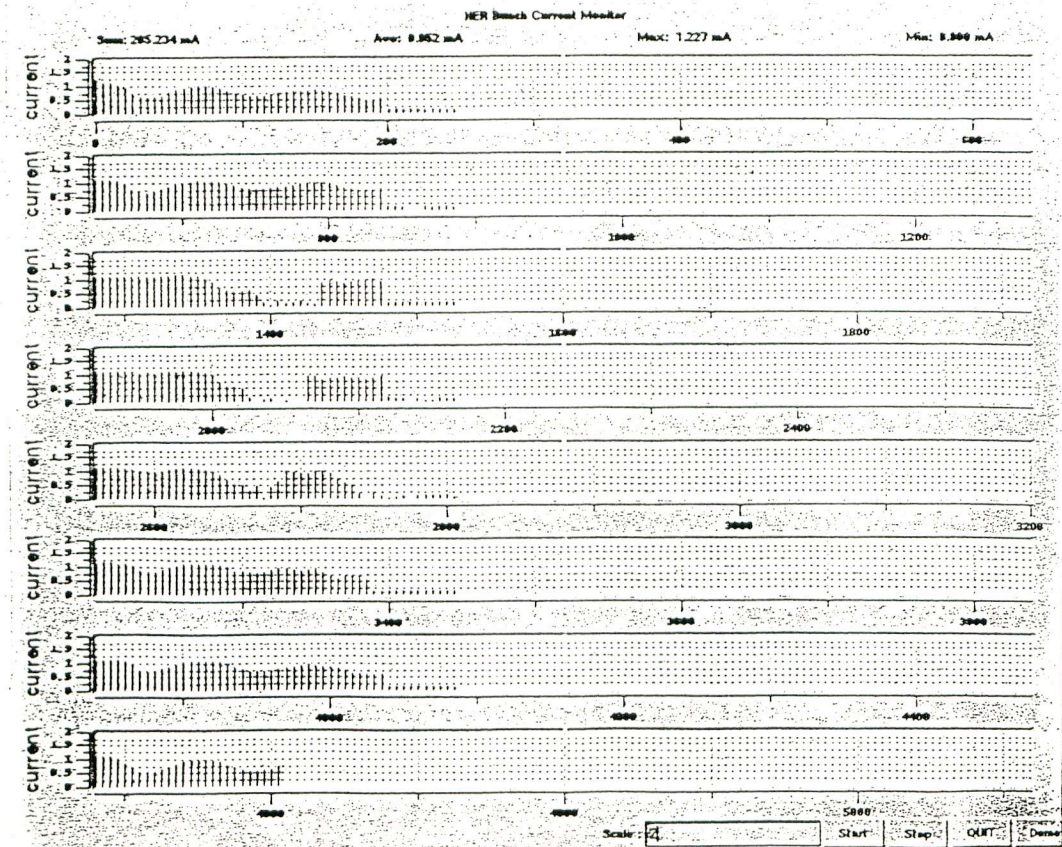
**Longitudinal position detection circuit  
(bunch current detection circuit)**



# Bunch Current Monitor Display



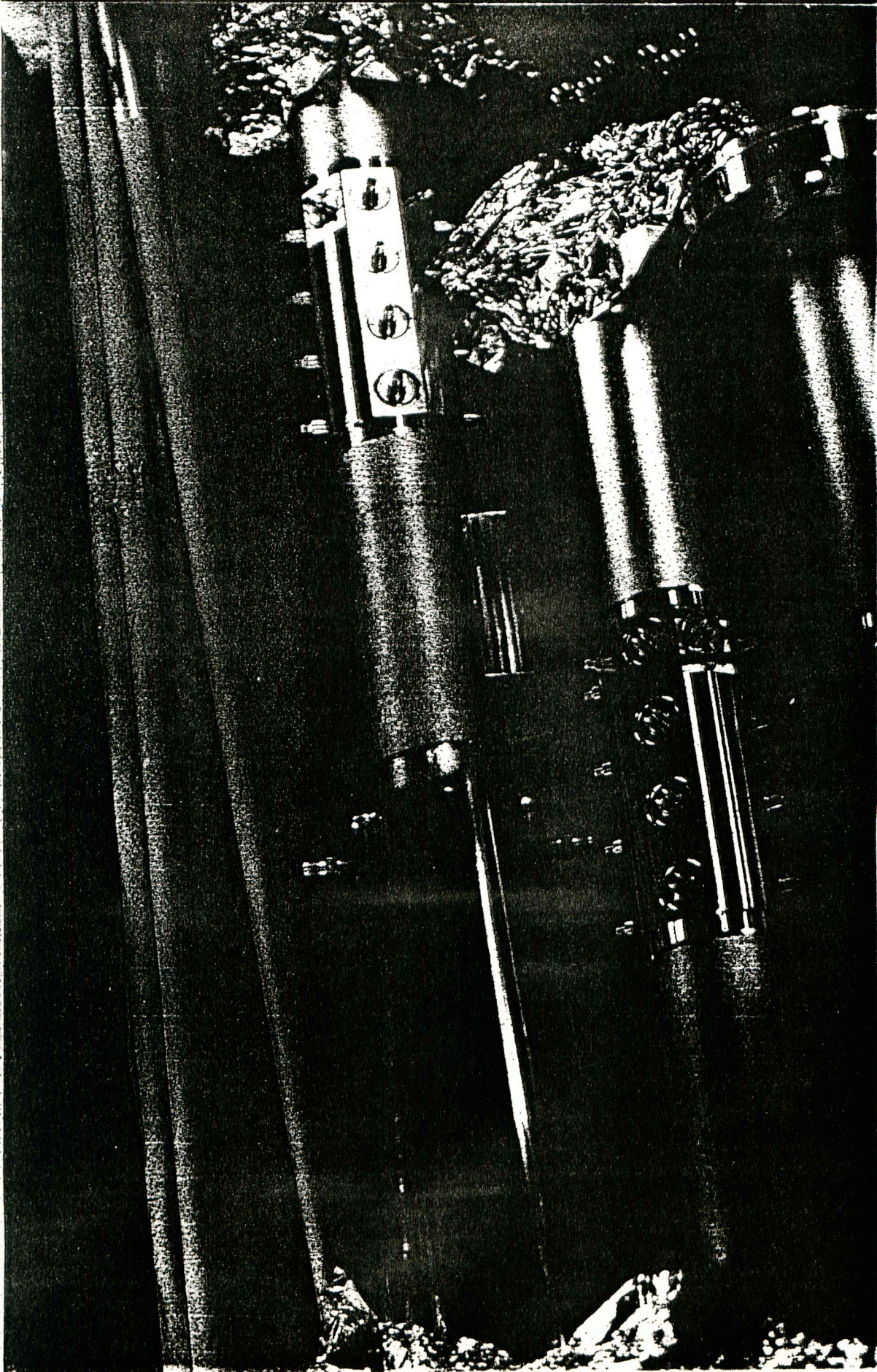
640 b.kts  
per line



## Plans in near future

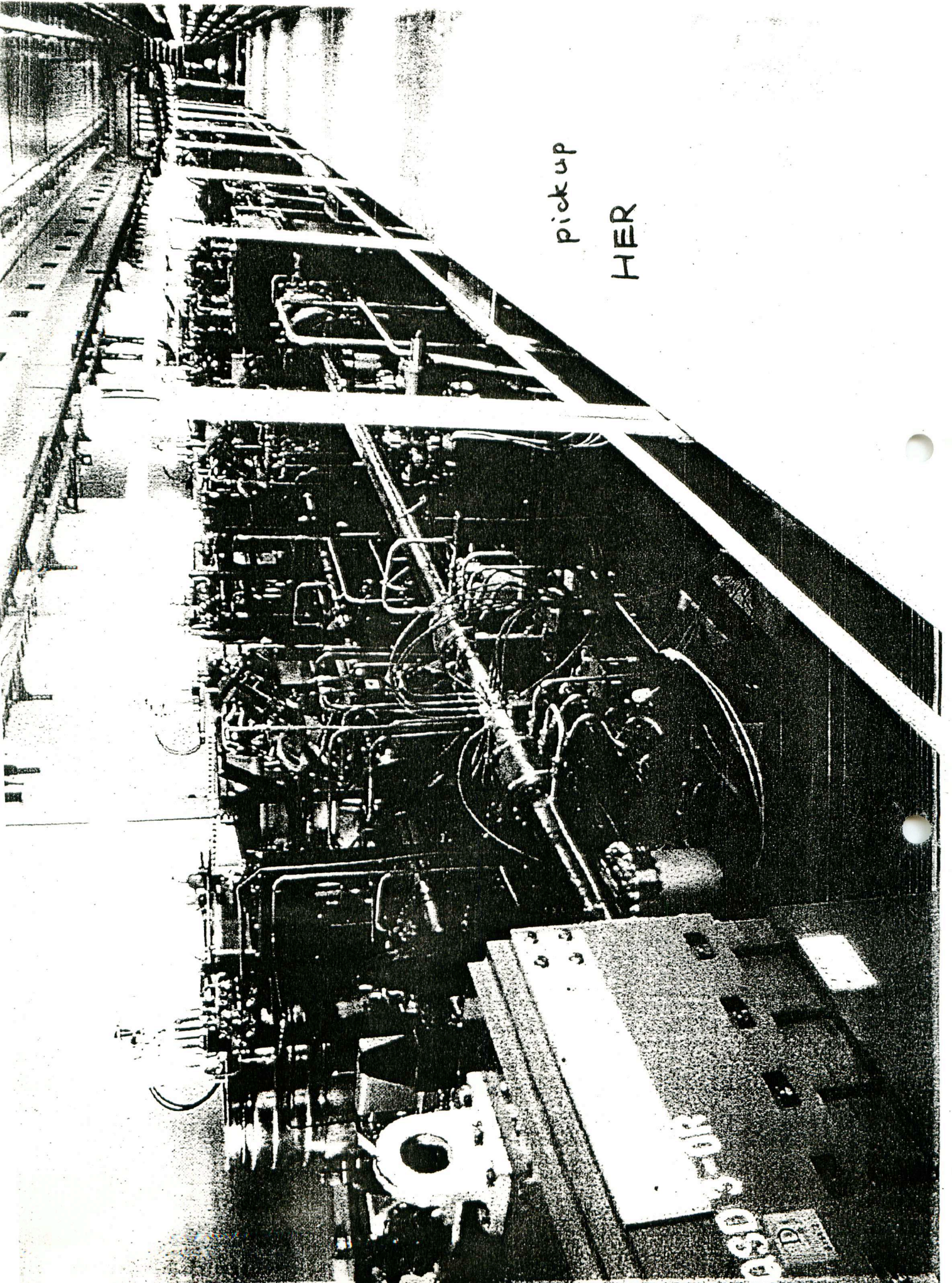
1. Use the low-frequency power amplifiers and the long stripline-kicker for the feedback.
2. Start the operation of the large-size memory board to investigate the bunch motion in time-domain.
3. Study the performance of the longitudinal kicker. (Though we have not found longitudinal motion)





for LER (upper)  
and for HER (lower)





pickup

HER

3-012

QSD

QD



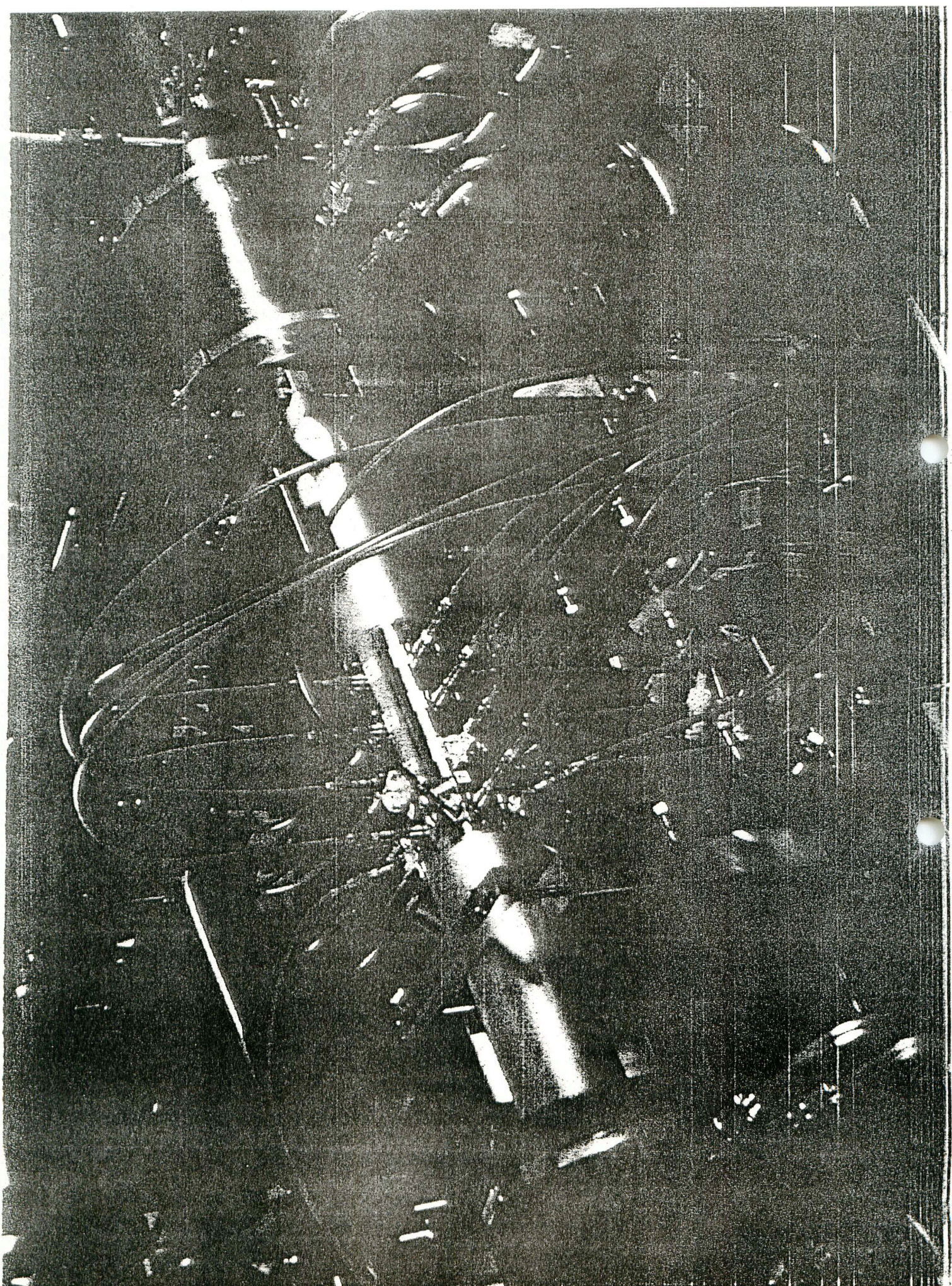
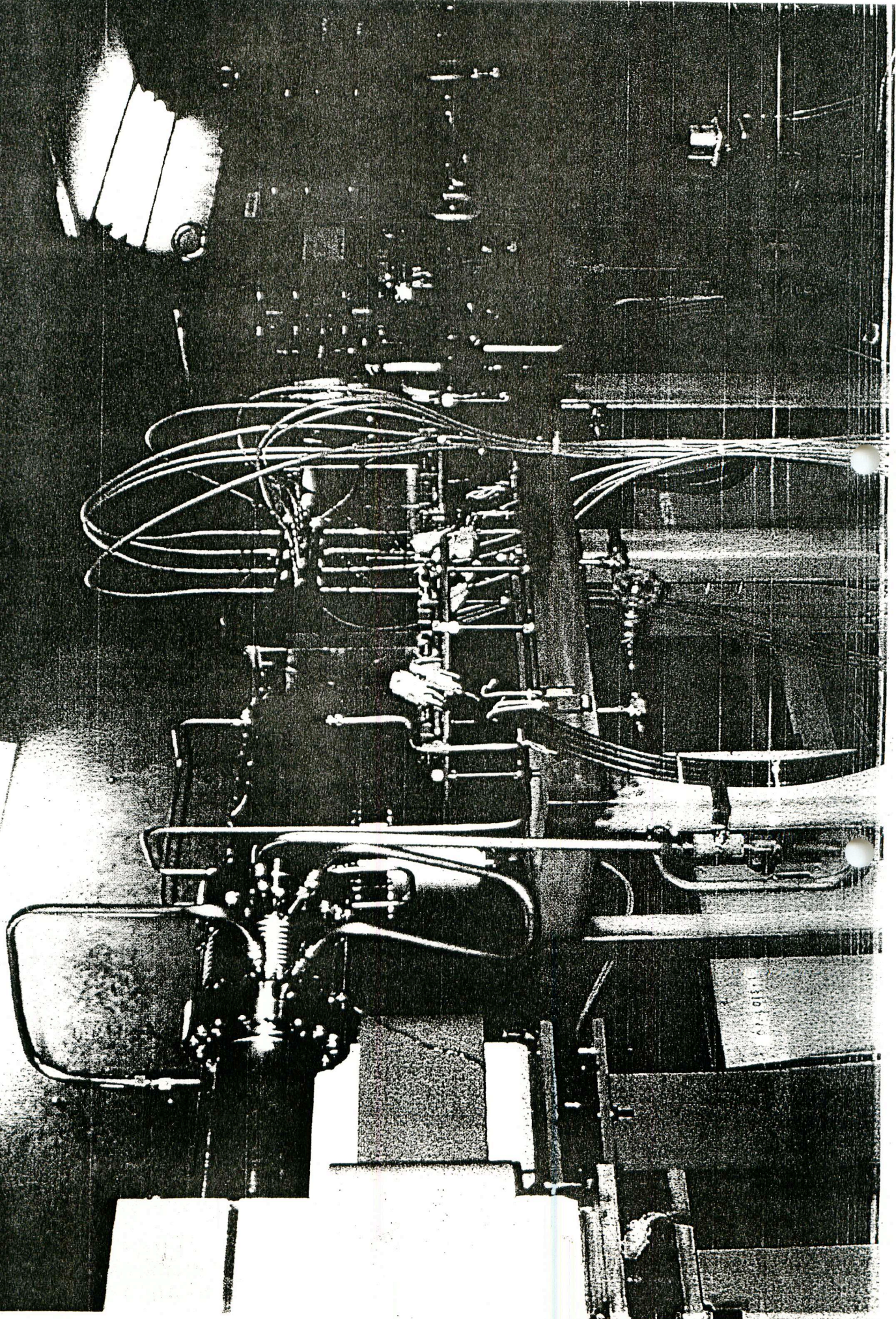


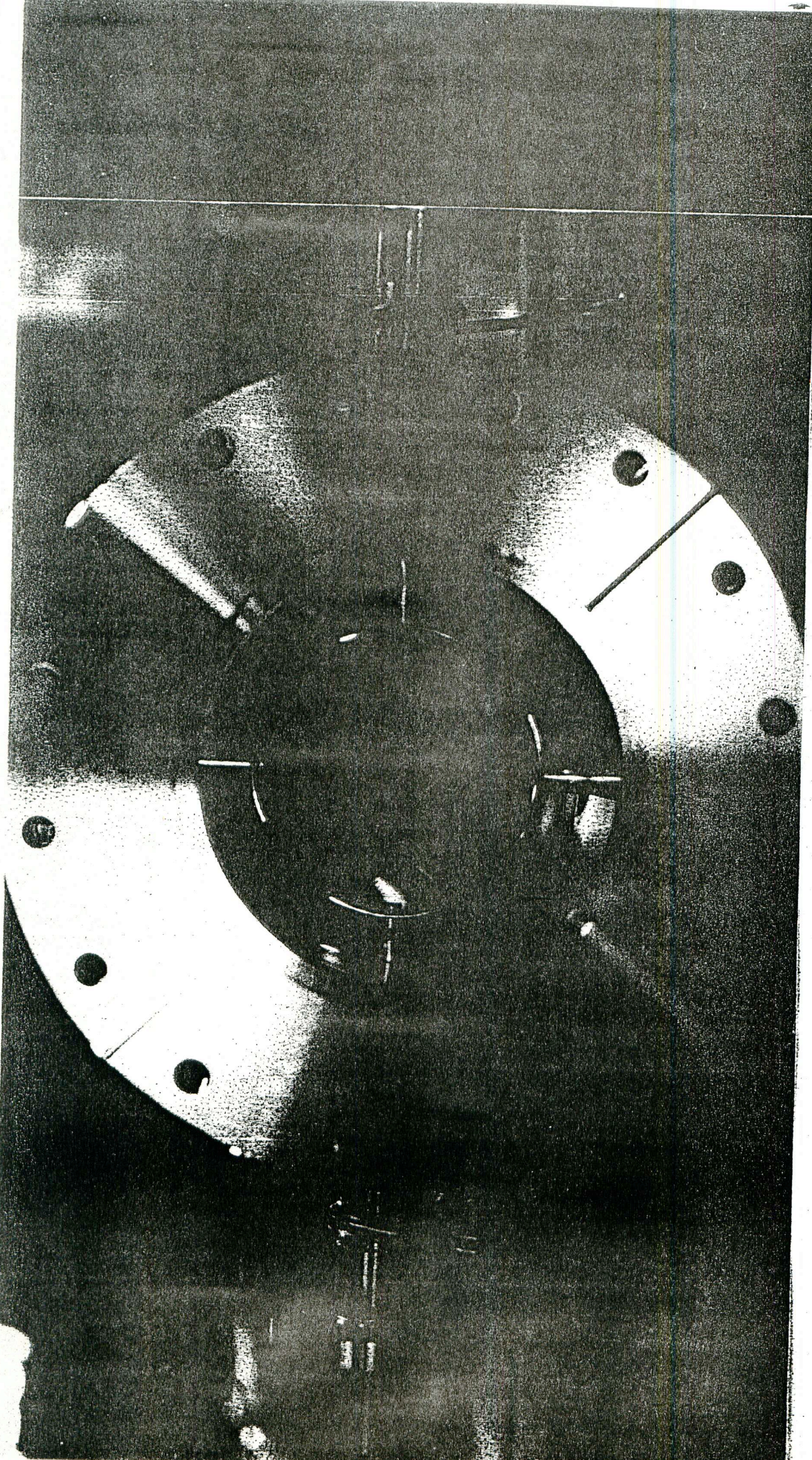
Photo-up (MERS)



Pickup (LER)





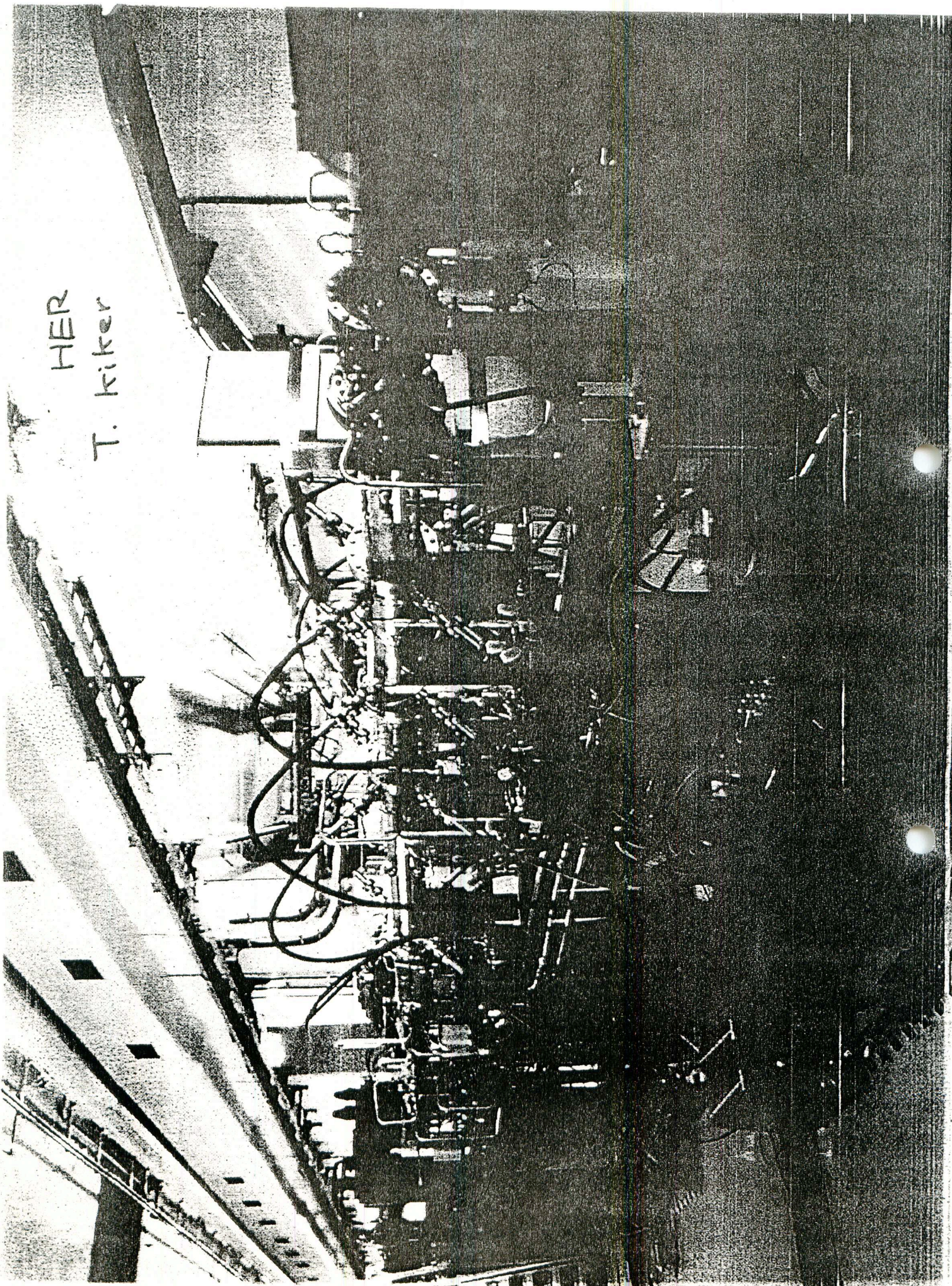


Stripline bicker

short type (40 cm)

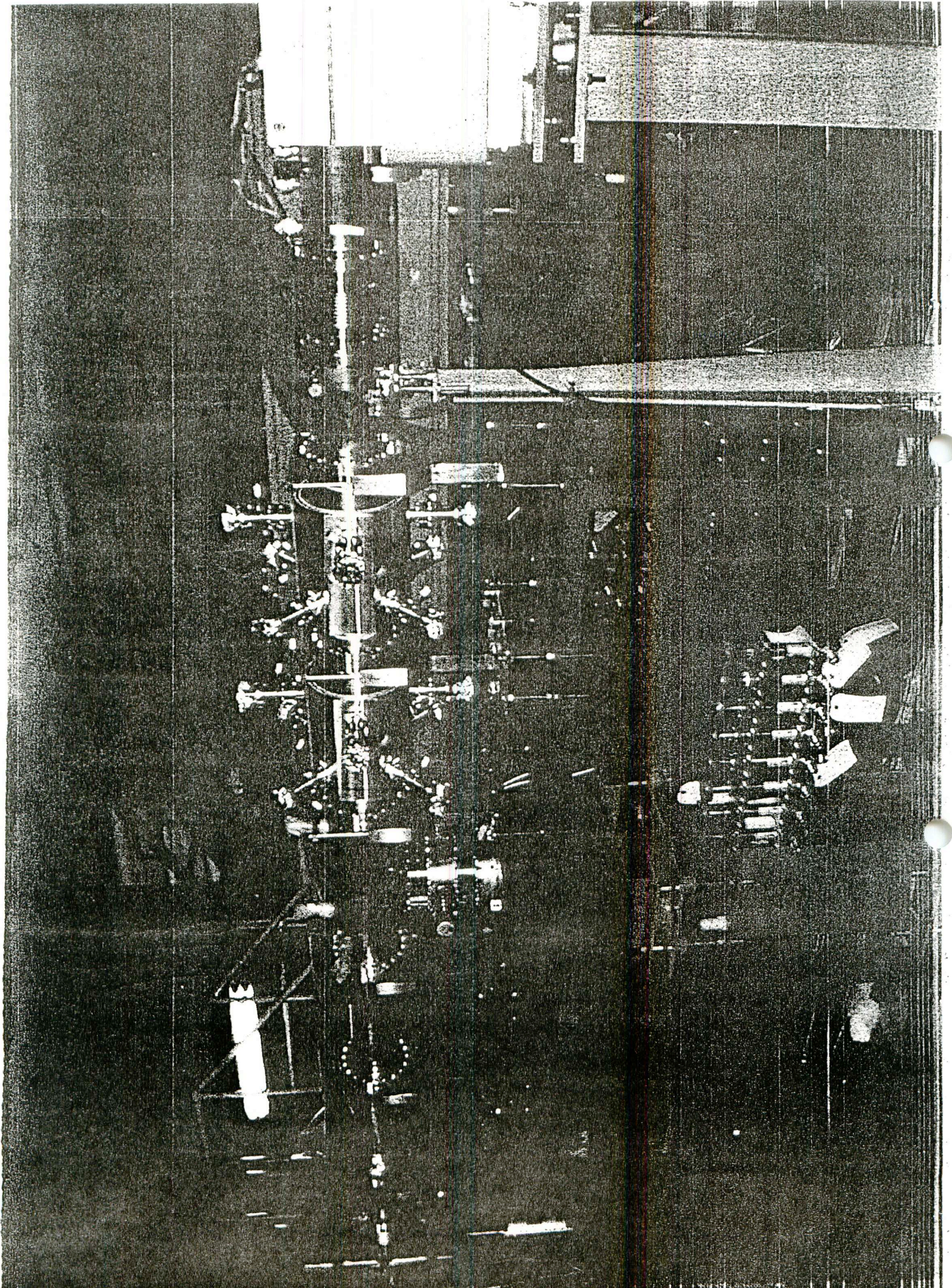


HER  
T. Kiker



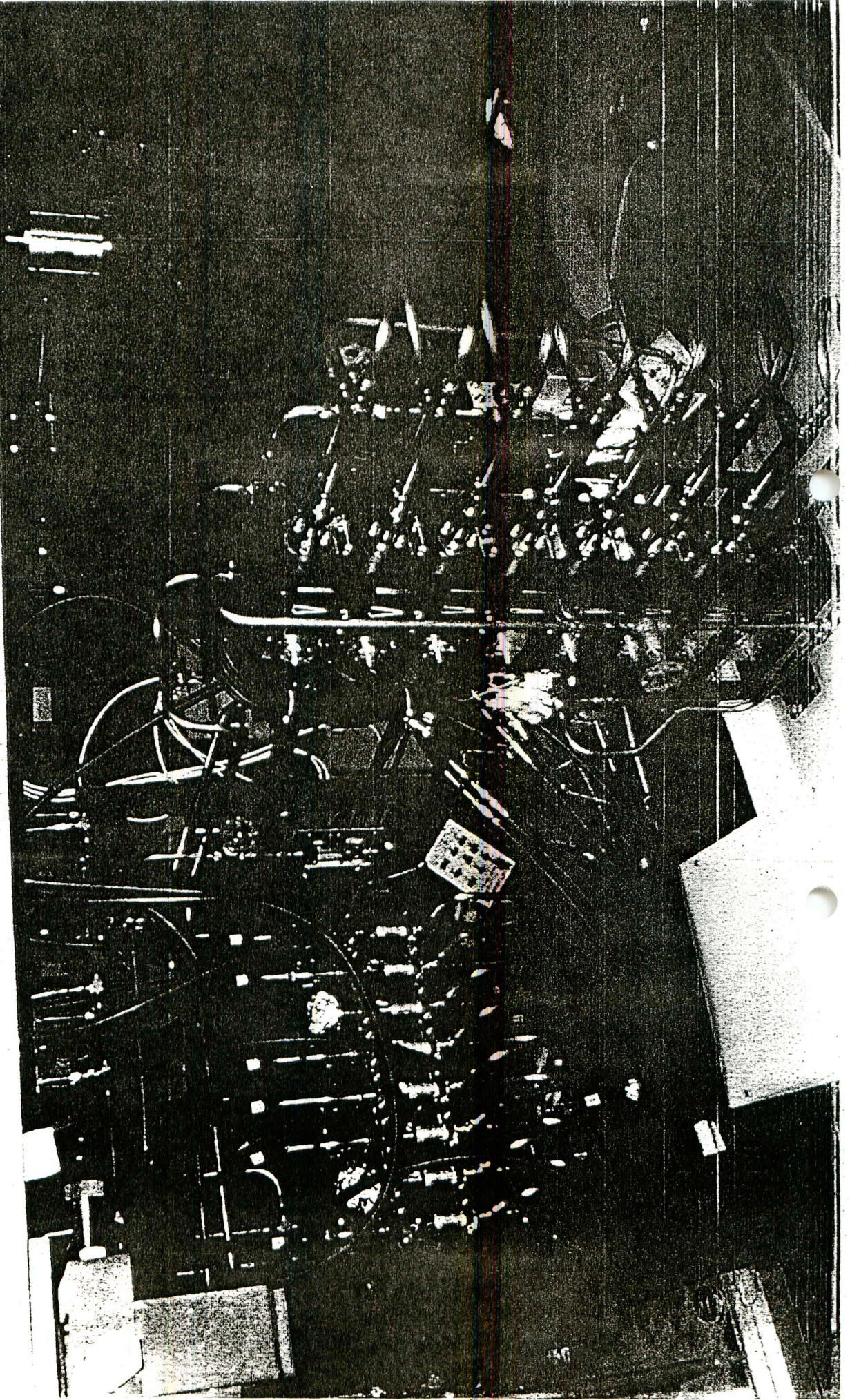


longitudinal kiker (LER)

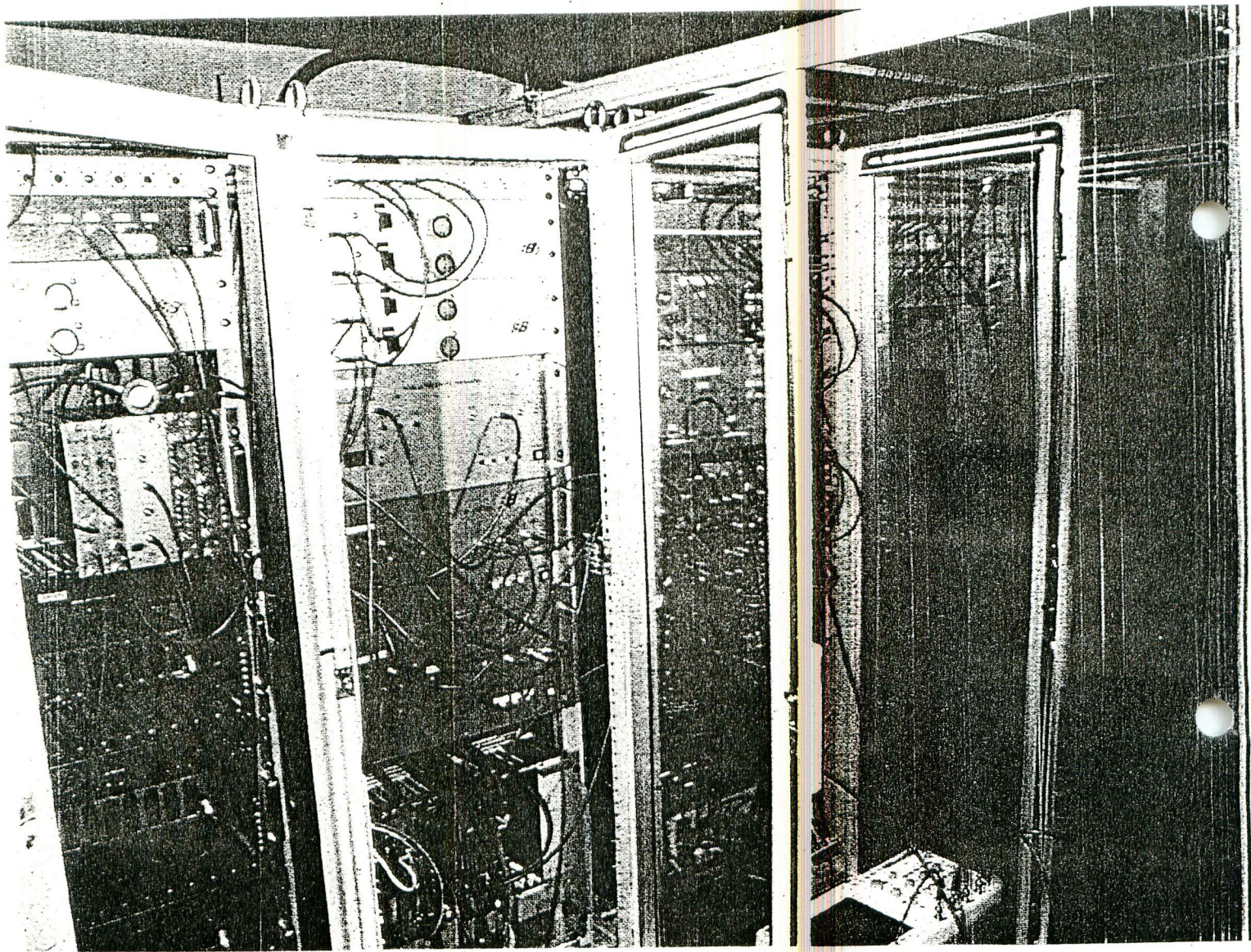




Circulators  
for long. kicker (AFT)

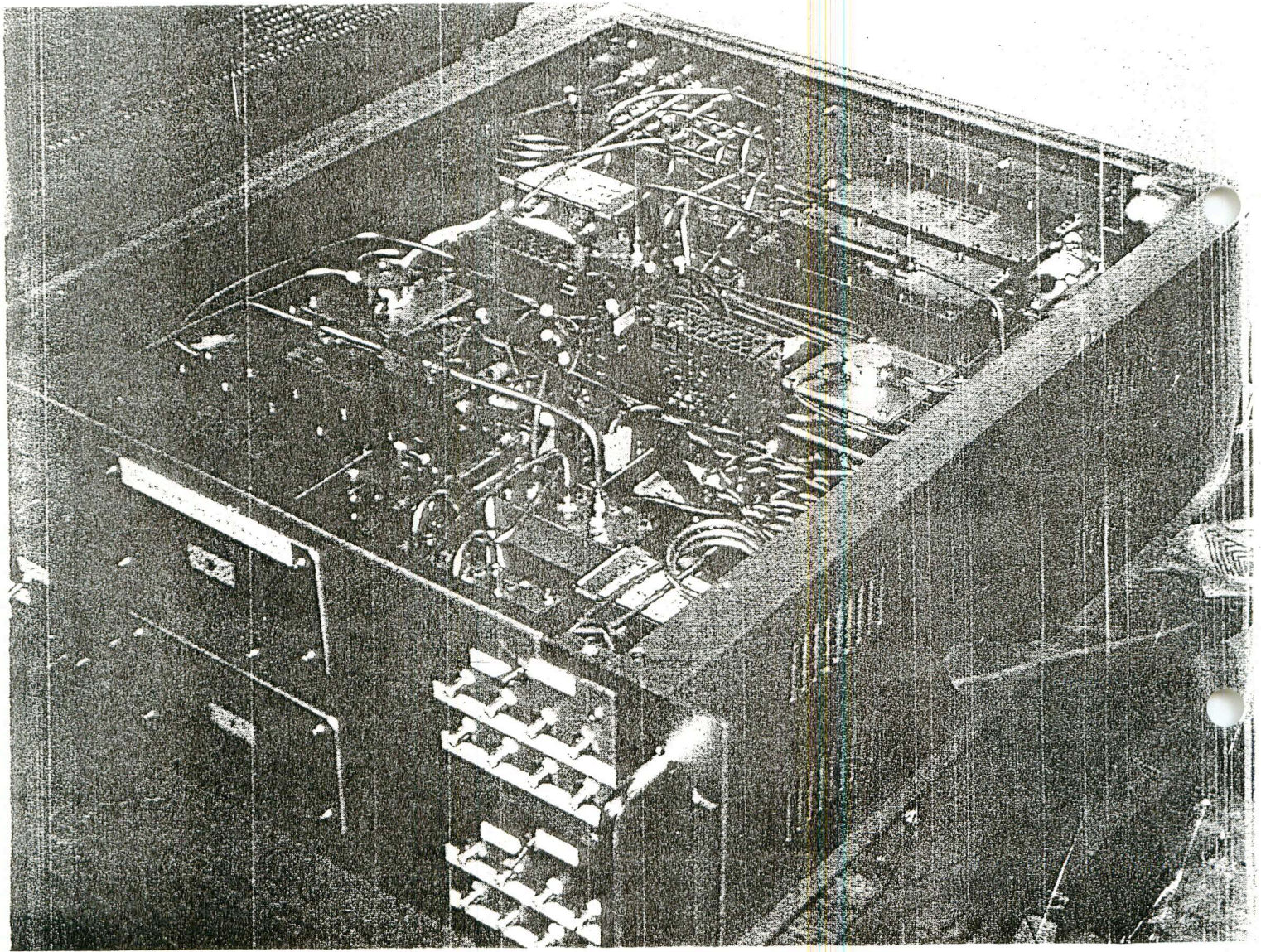






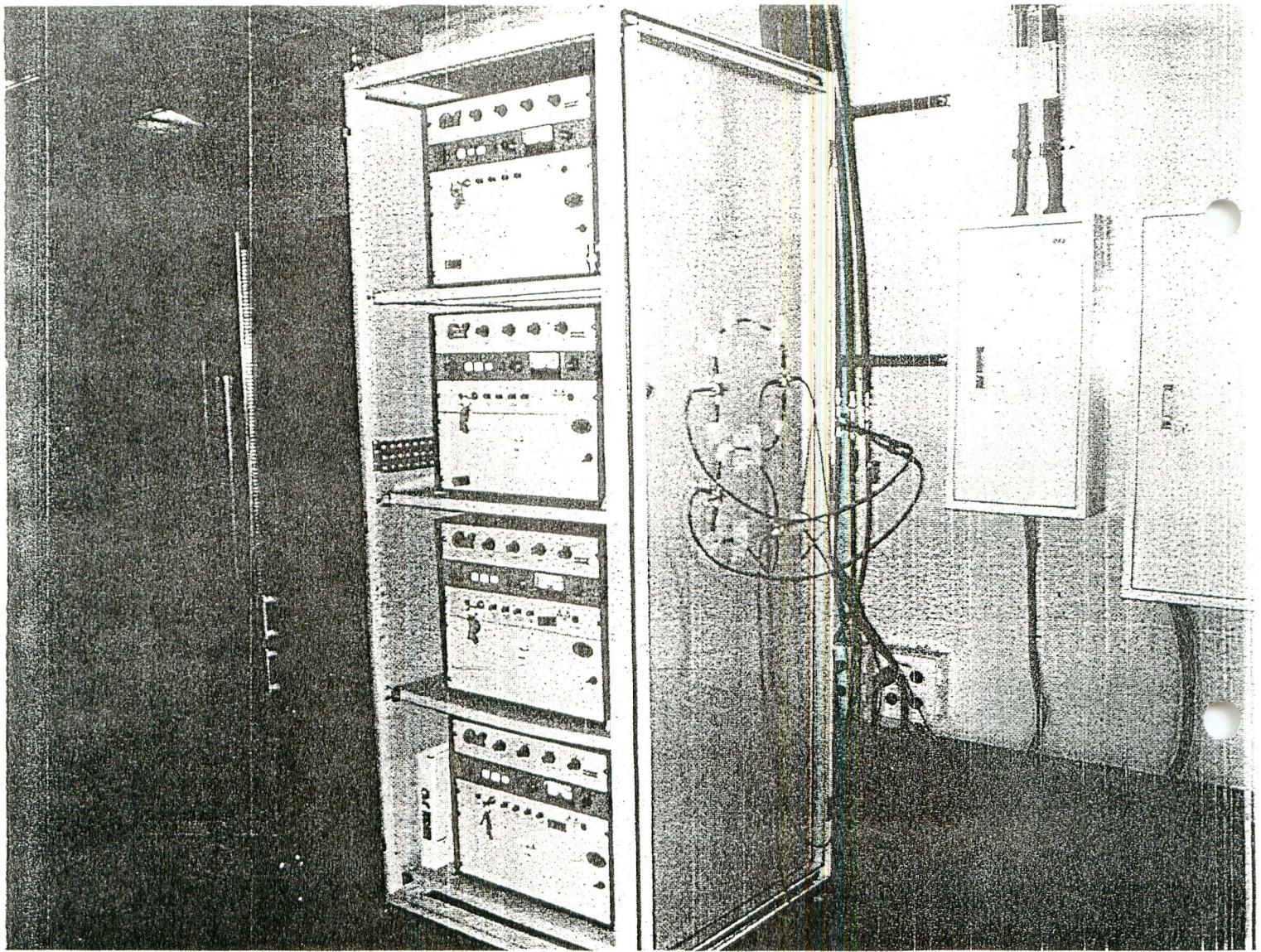
in local control room in Fuji B4





transverse detector circuit

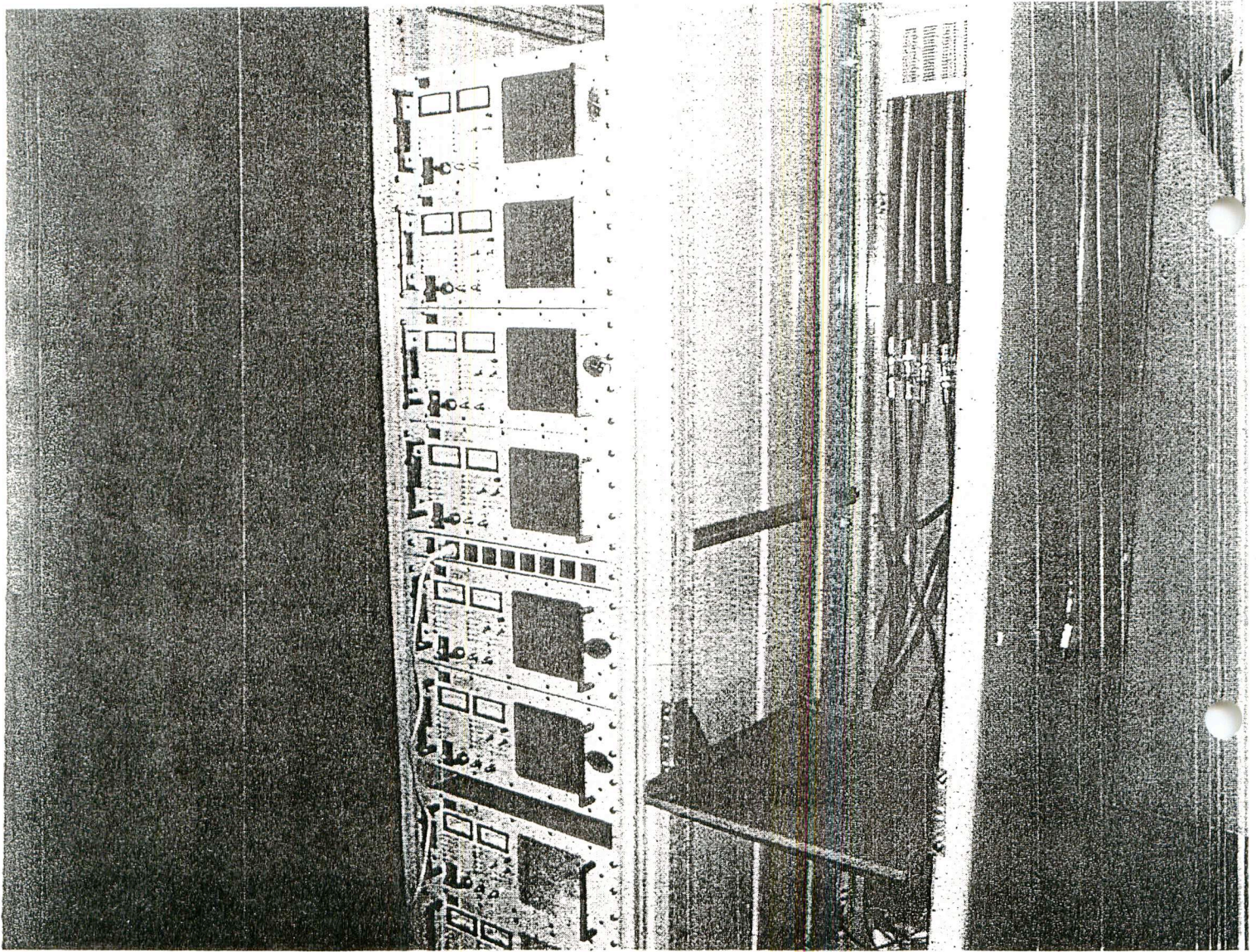




Transverse kiter Amplifiers 250 w / unit

Amplifiers Research





amplifiers  
(longitudinal kicker)

140W/unit  
 $1150 \pm 500$  MHz



## Summary

1. The transverse feedback systems are working very well. They are contributing to increase the stored currents.

However, DC suppress system should be prepared for the maintenance-free continuous operation of the systems.

2. Bunch current monitor systems are working without serious problem.
3. Tune measurement systems are working.