Report on Vacuum System

KEKB Accelerator Review
January 24, 1997

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for
KEKB Vacuum Group

Present status of preparation

LER(except Tsukuba and Injection straight)
now manufacturing, will be completed June 1997

HER(except Tsukuba and Injection straight)
now final check of drawing, will be completed March 1998

Tsukuba, Injection, Other special chamber.
contract May 1997, most part will be completed March 1998

Table 1. Parameters of KEKB Vacuum

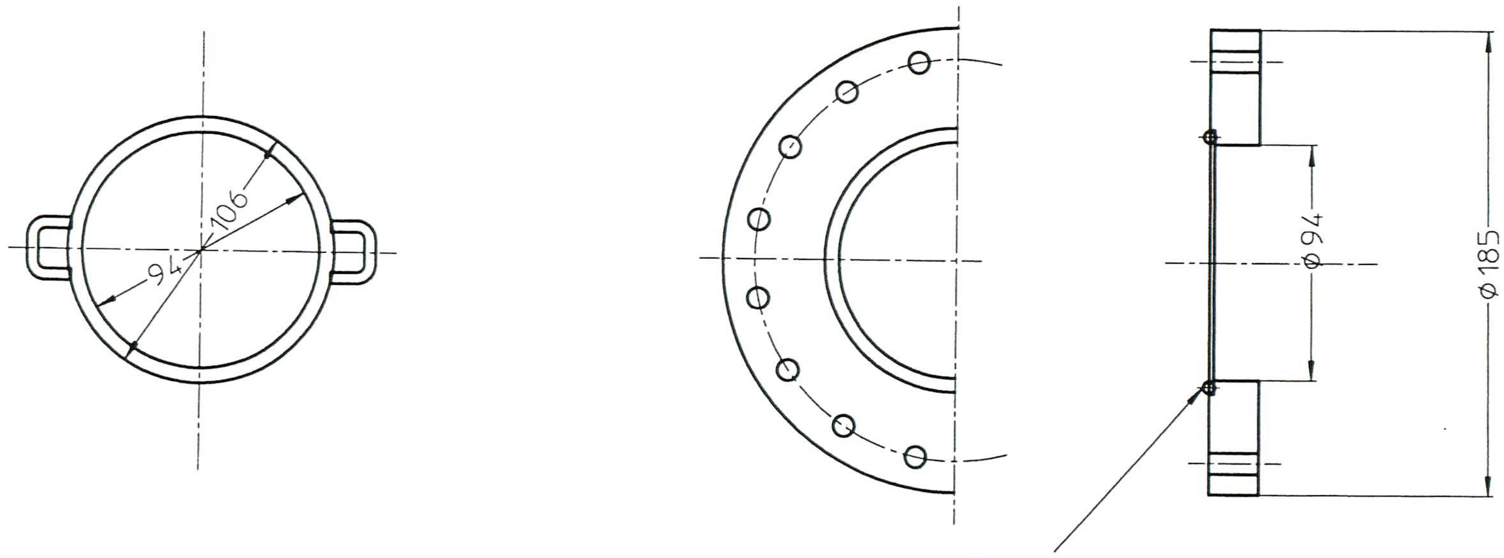
	LER	HER	
Beam energy	3.5	8.0	GeV
Beam current	2.6	1.1	A
Circumference	3016	←	m
Bunch length	4	←	mm
Bending radius	16.31	104.46	m
Total Power of SR	2117 (arc)	3817	kW
Critical Energy of SR	5.84	10.9	keV
Total photon flux of SR	7.35×10^{21}	7.11×10^{21}	photons s^{-1}
Local maximum of the linear power density	14.8 (bend) ~13 (wiggler front) ~10 (wiggler)	5.8 (bend)	kW m^{-1}
Duct material (thickness)	OFC (6)	←	(mm)
Radiation dose on duct surface	$<10^{5}$	$<10^{7}$	rad year^{-1}
Maximum temperature	120 (bend)	not estimated	°C
Maximum strain	-0.15 (bend)	not estimated	%
Surface exposed to SR	wall of beam duct	←	
Average linear photon density	3.3×10^{18}	3.2×10^{18}	photons s^{-1} m^{-1}
Average pressure with beam	$\sim10^{-9}$	←	Torr
Average base pressure	$\sim10^{-10}$	←	Torr
Photo desorption coefficient	10^{-6}	←	molec. photon^{-1}
Static outgassing rate	$<10^{-11}$	←	Torr l s^{-1} cm^{-2}
Linear pumping speed	100 (target)	←	l s^{-1} m^{-1}
Cross section of duct	circle	racetrack	
Conductance of beam duct (1m)	102	52.3	l s^{-1}
Arrange of pump	array of port	integrated+port	
Main pump	NEG cartridge	NEG strip	

LER=Low Energy Ring, HER=High Energy Ring, SR=Synchrotron Radiation. NEG=Non Evaporable Getter (SAES)

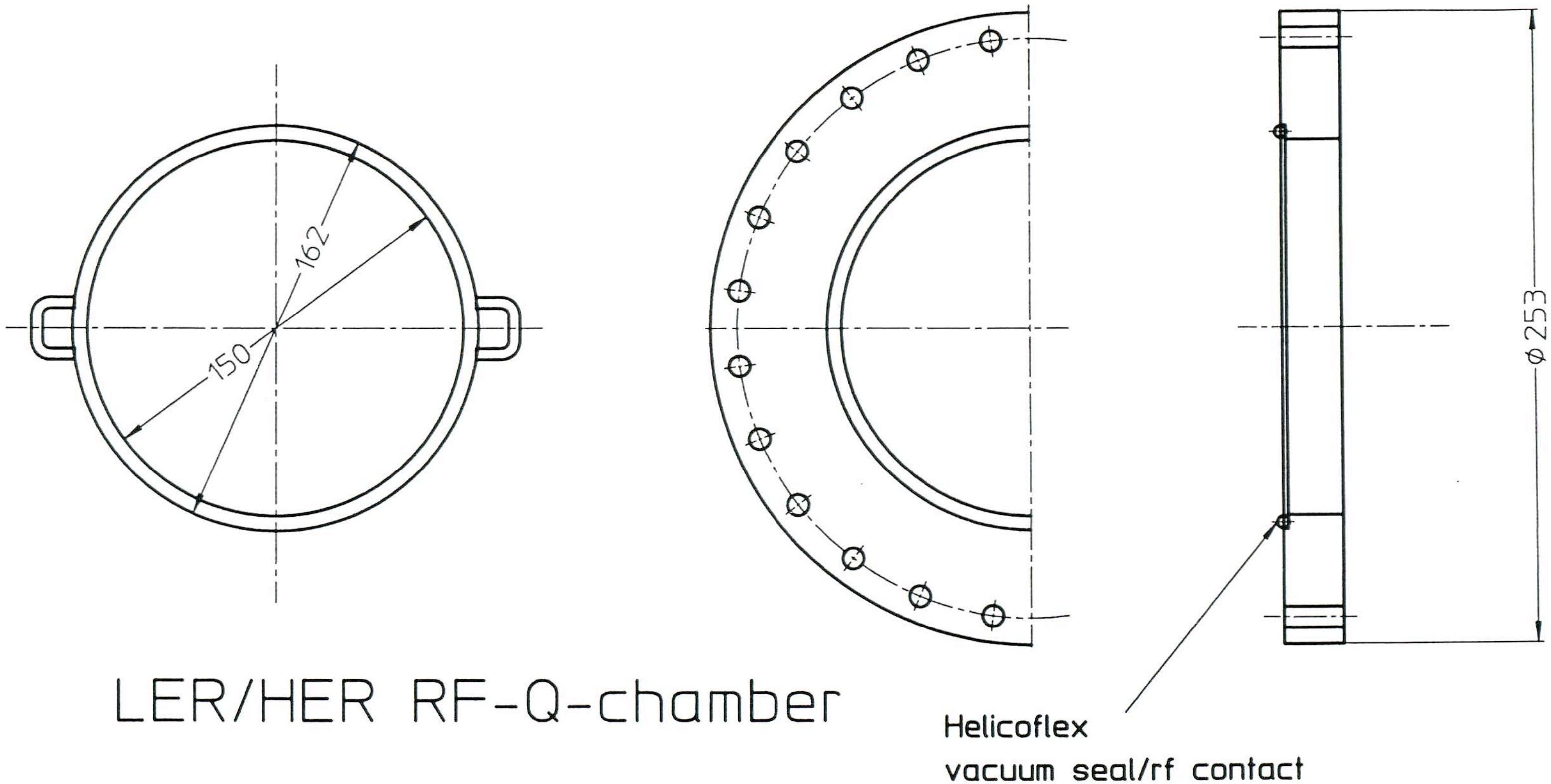
Duct cross section and Flange connection

The cross section of a duct is symmetric in ST,Q, and SX.

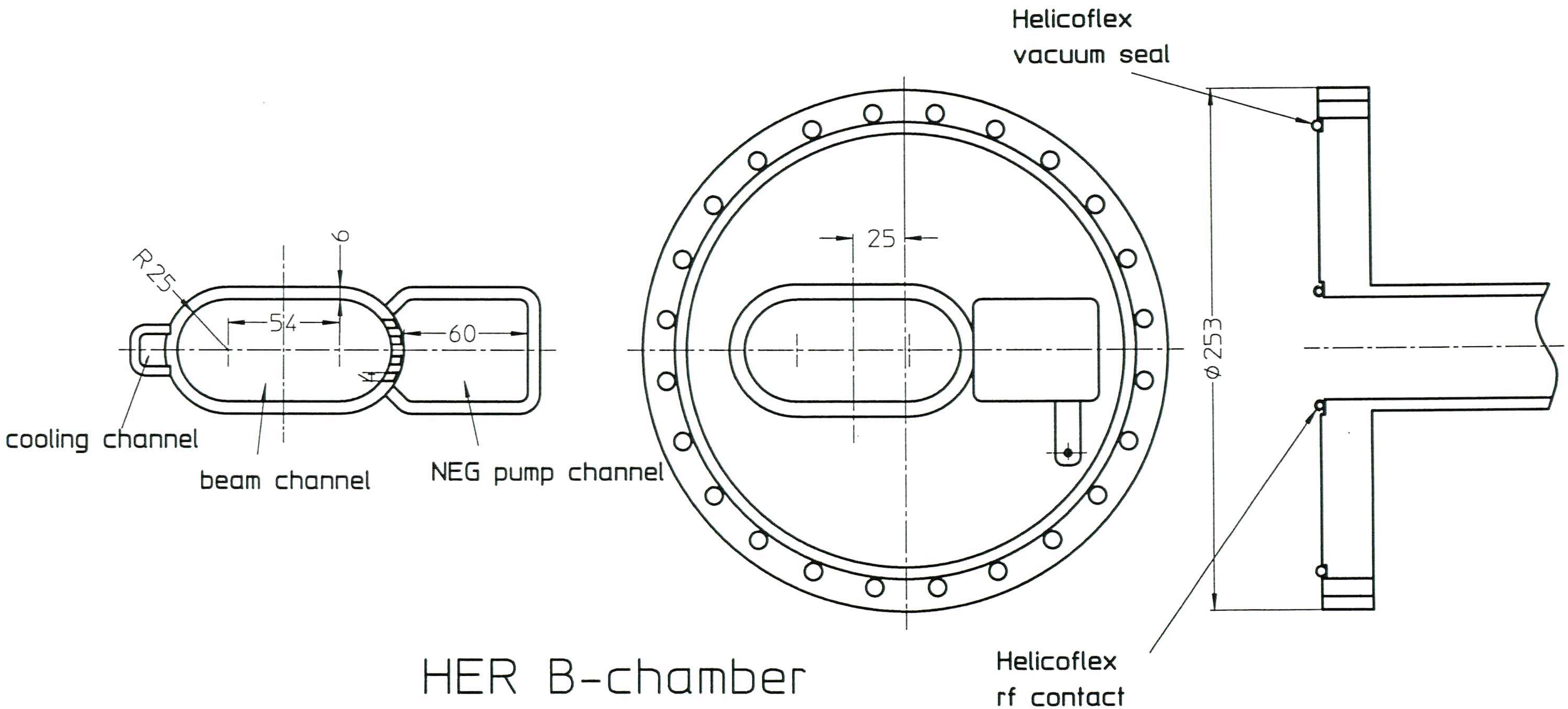
Helicoflex is used for vacuum seal and rf contact.



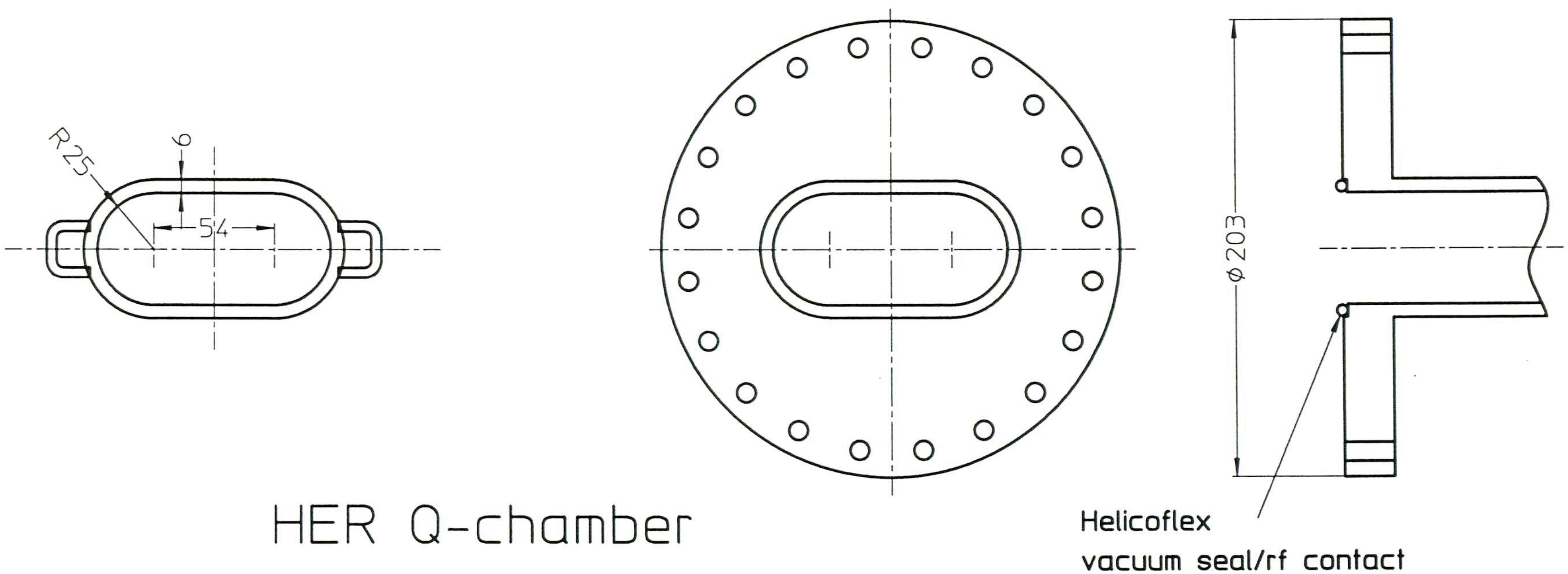
LER chamber



LER/HER RF-Q-chamber



HER B-chamber



HER Q-chamber

Setting Q-chambers

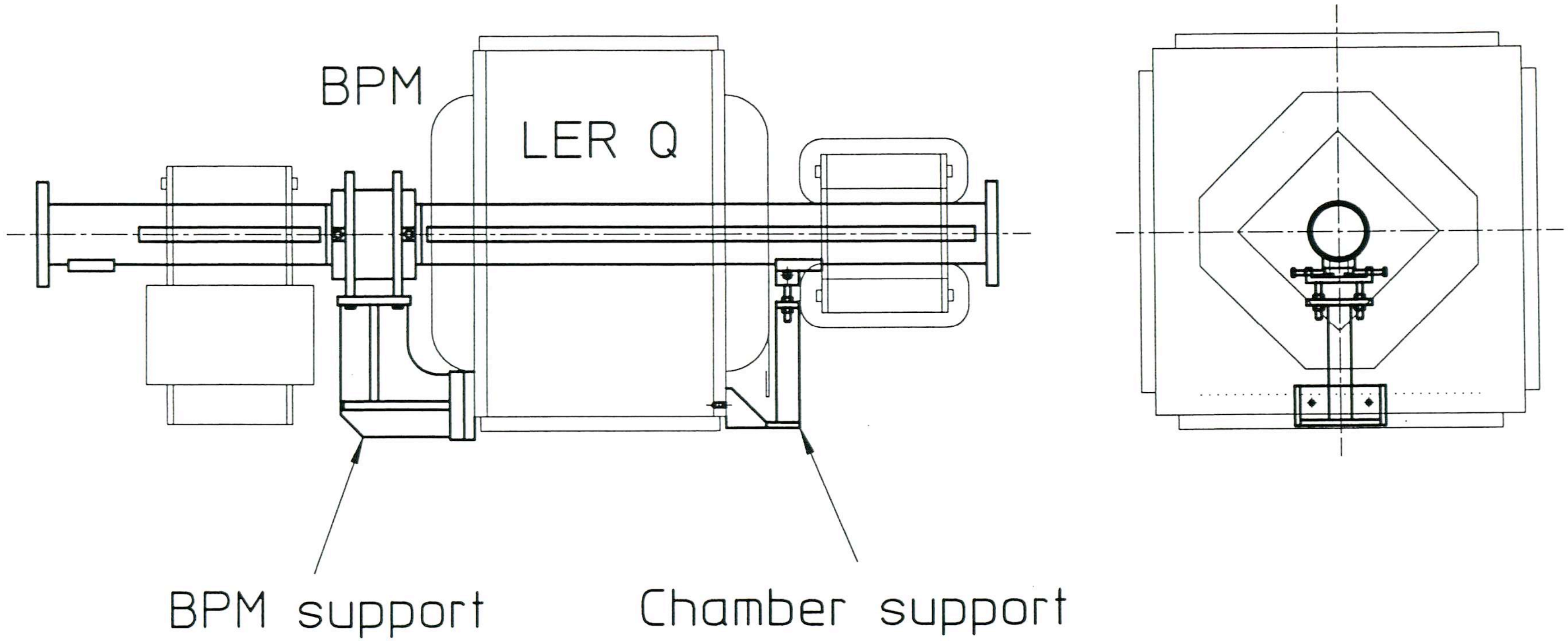
The position of Q-chamber is mainly determined by a BPM support.

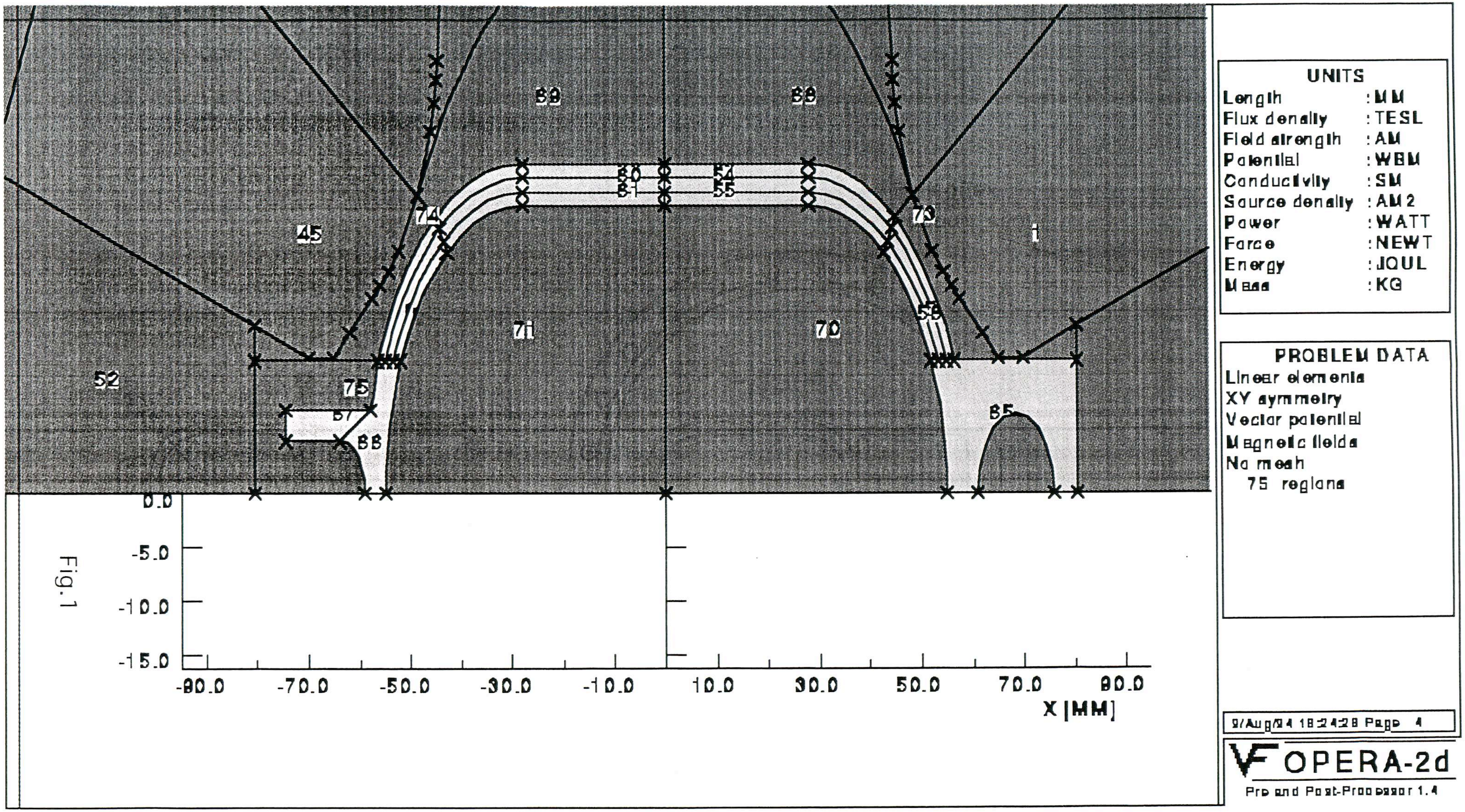
The setting error will be less than ±1mm.

The effect of centering error in beam based alignment.

M. Kikuchi, K. Egawa, H. Hukuma, and M. Tejima, 'Beam based alignment of sextupoles with the modulation method', Proc. of PAC, Dallas, USA, 603(1995).

For a ±1mm horizontal shift of a vacuum chamber, the offset of a measured value is less than ±11.4% that of asymmetry. Or at 0.6Hz modulation, a residual offset is ±6 micron. Can be corrected by changing frequency.


BPM
LER Q
BPM support
Chamber support


UNITS
Length : MM
Flux density : TESL
Field strength : AM
Potential : WBM
Conductivity : SM
Source density : AM2
Power : WATT
Force : NEWT
Energy : JOUL
Mass : KG
PROBLEM DATA
Linear elements
XY symmetry
Vector potential
Magnetic fields
No mesh
75 regions
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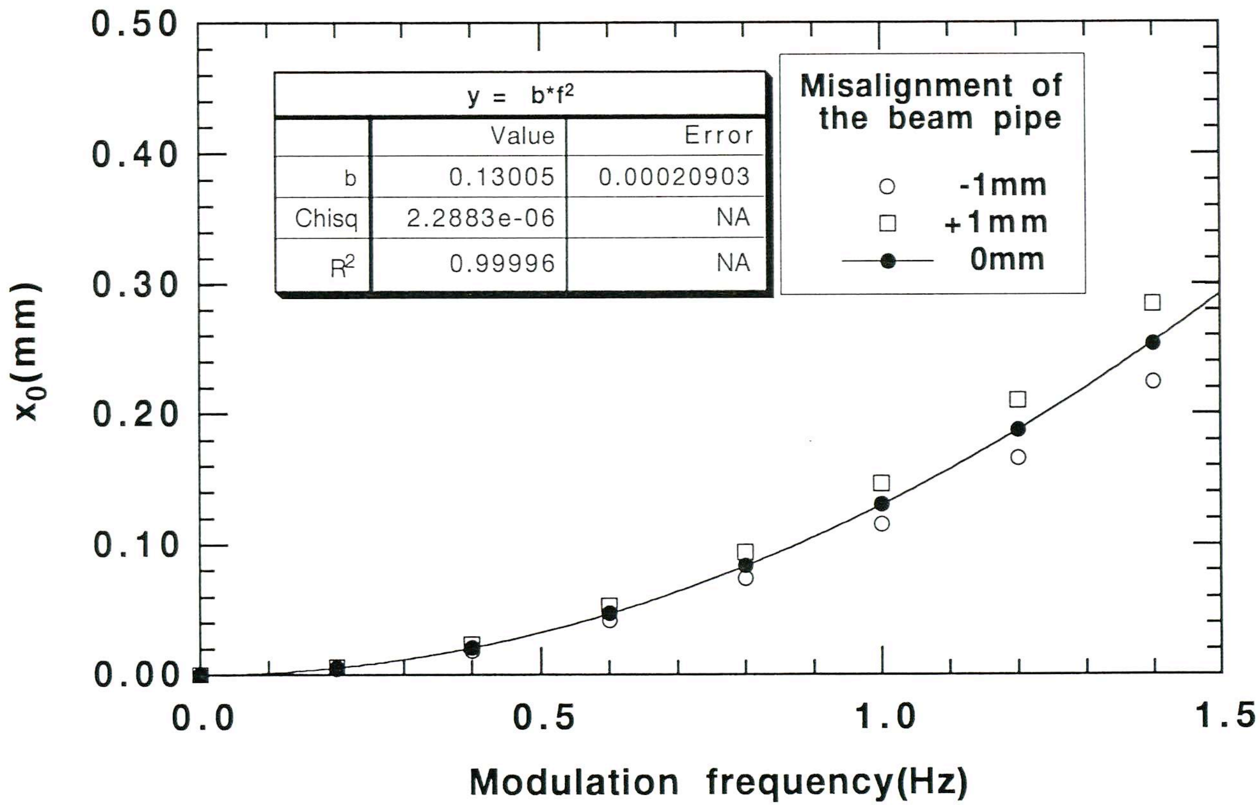
OPERA-2d
Pre and Post-Processor 1.4
X [MM]
-90.0
-70.0
-50.0
-30.0
-10.0
10.0
30.0
50.0
70.0
90.0
0.0
-5.0
-10.0
-15.0
69
69
45
74
73
71
70
52
75
88
65
1

Fig.1


y = b*f²
Value
Error
b
0.13005
0.00020903
Chisq
2.2883e-06
NA
R²
0.99996
NA
Misalignment of the beam pipe
-1mm
+1mm
0mm
0.50
0.40
0.30
0.20
0.10
0.00
0.0
0.5
1.0
1.5
x0(mm)
Modulation frequency(Hz)

Pumping concept

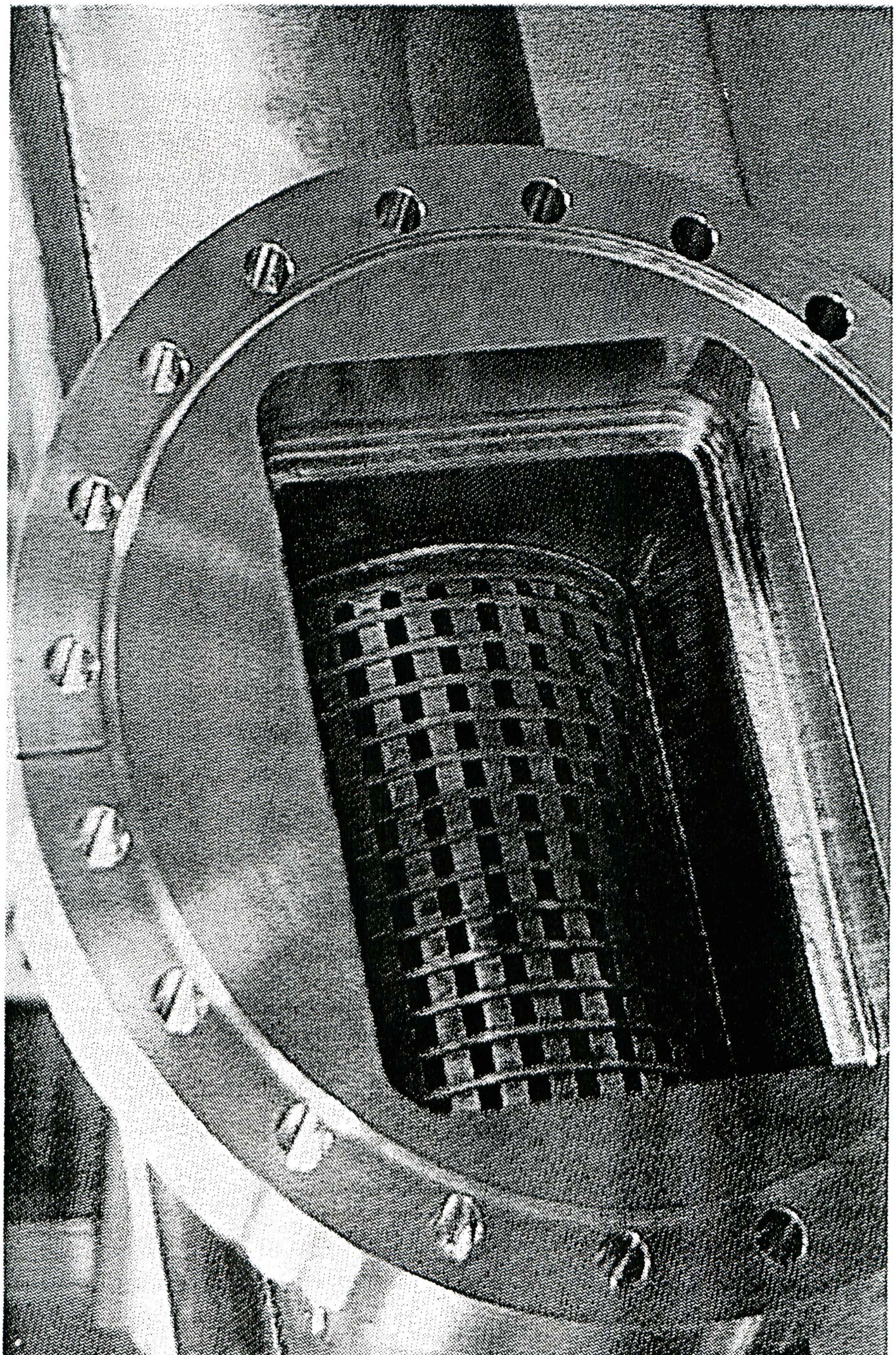
Roughing port: every 40m, sputter ion pump: every 10m, and
LER: NEG cartridge port: every 1m
HER: NEG strip in a bend +NEG cartridge port: every 1m.

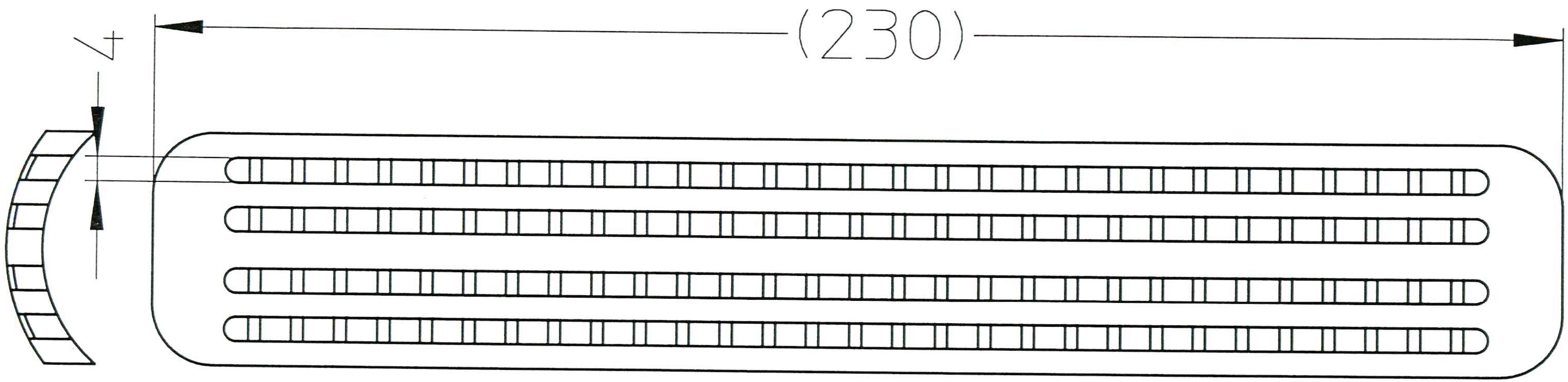
Use grid, not slot.

Calculated pumping speed for an actual layout is about 60 $ls^{-1}m^{-1}$.
(Design aim is 100 $ls^{-1}m^{-1}$)

NEG's are conditioned after 0.1 Torr lm^{-1} absorption.

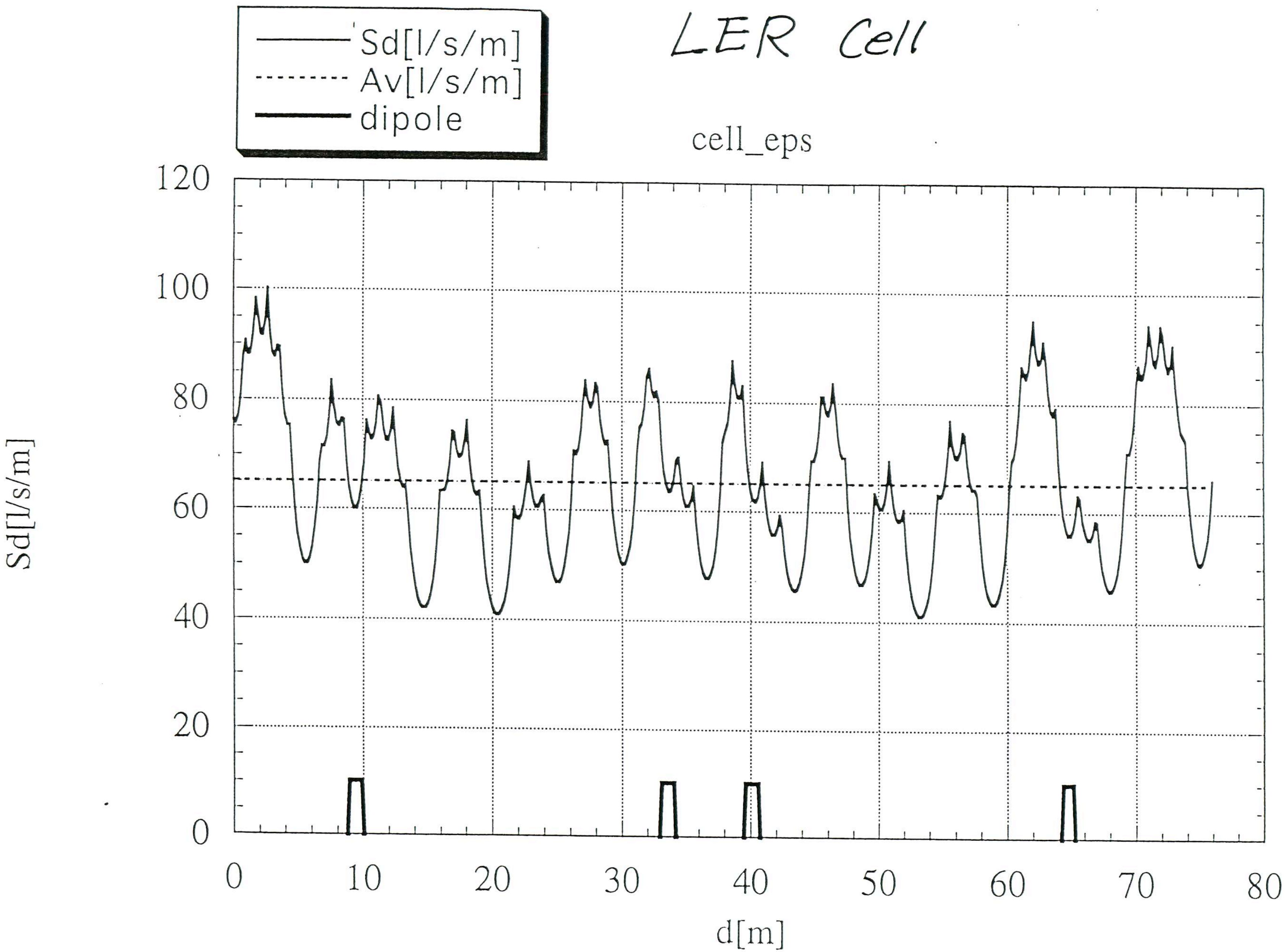
(The first conditioning is after 0.25 Ah for LER, 0.5 Ah for HER)



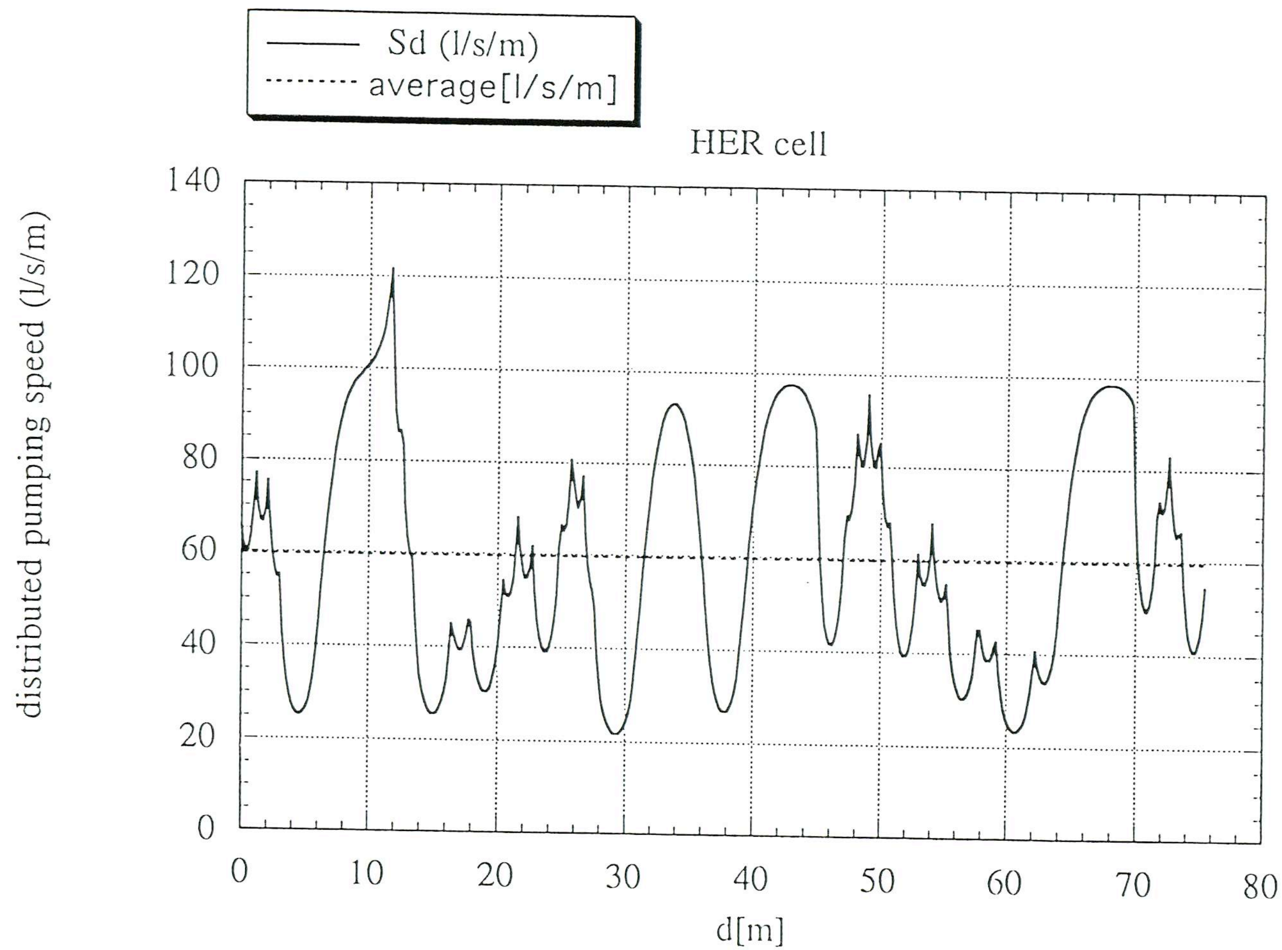


x20 for HER B-chamber

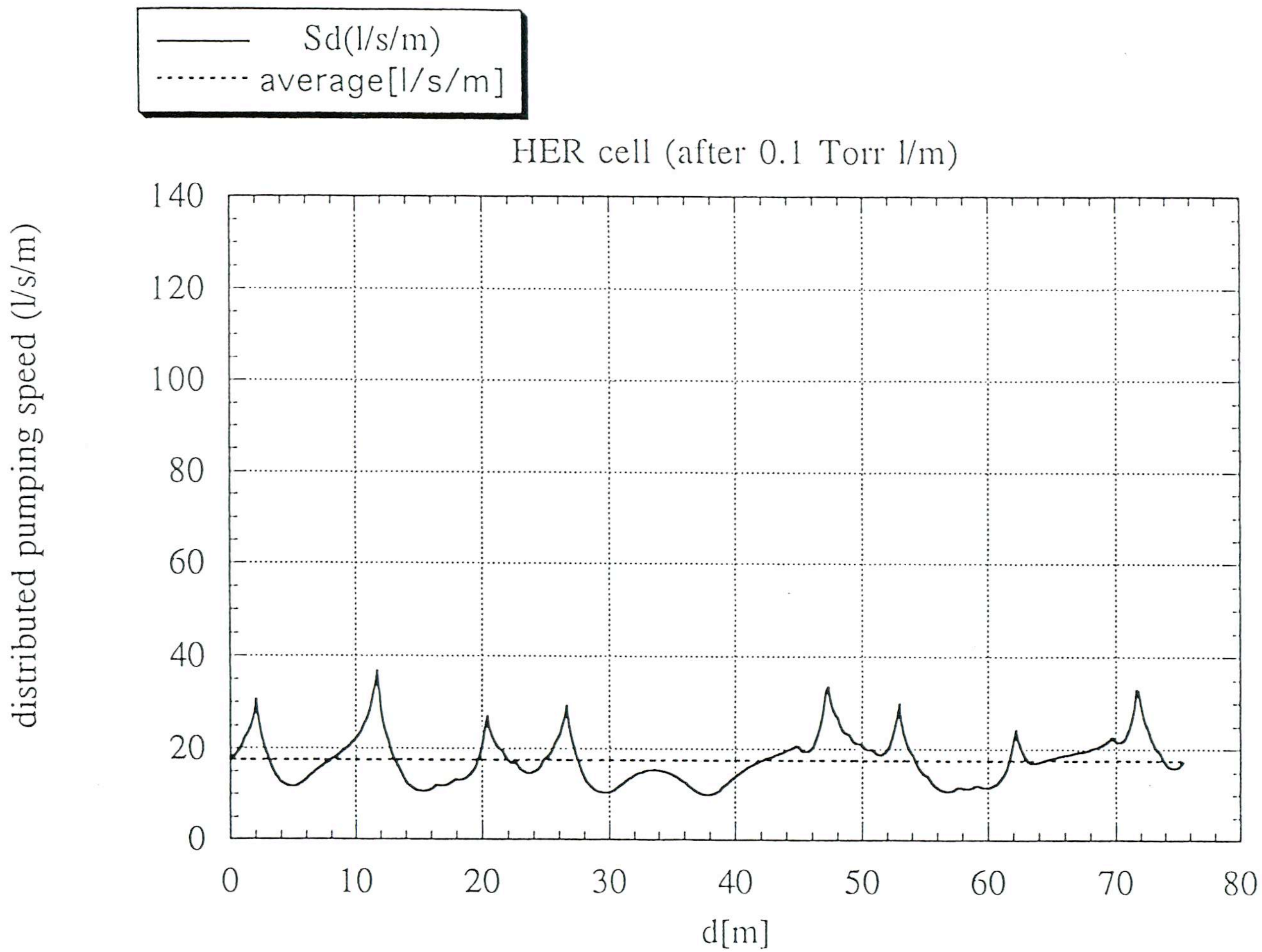
LER Cell



Sd[l/s/m]
Av[l/s/m]
dipole
cell_eps
120
100
80
60
40
20
0
10
20
30
40
50
60
70
80
Sd[l/s/m]
d[m]



Sd (l/s/m)
average[l/s/m]
HER cell
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
d[m]
distributed pumping speed (l/s/m)


Sd(l/s/m)
average[l/s/m]
HER cell (after 0.1 Torr l/m)
distributed pumping speed (l/s/m)
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
d[m]

Cleaning

Two problems in fabrication of LER chambers (in US, Due to insufficient communication).

1. Citranox cleaning for an extruded surface.

Though this is useful for a once cleaned surface. Effectiveness for an extruded surface is doubtful because Citranox removes only little amount of a surface, about ~10 A which is 1/1000 of the specification (1 μm)

2. Inside welding of flanges.

It is adopted to prevent virtual leak due to voids in the bottom of a welded zone. But work to remove sputtered and evaporated copper have a risk of scratches on a sealing surface.

First step measure for the rest of LER chambers.

1. Acid cleaning (in Japan) for a duct pipe.

2. Use of masks

In parallel, PID experiment will be done at NSLS (collaboration with C.L.Foerster) to check,

a) the effect of Citranox cleaning on an extruded surface,
b) that a photon desorption coefficient of 10^{-6} is attainable by an acid cleaned chamber.

Second step for HER chambers

1. Use Ciranox only for parts (grid, pump port etc).

2. Outside welding

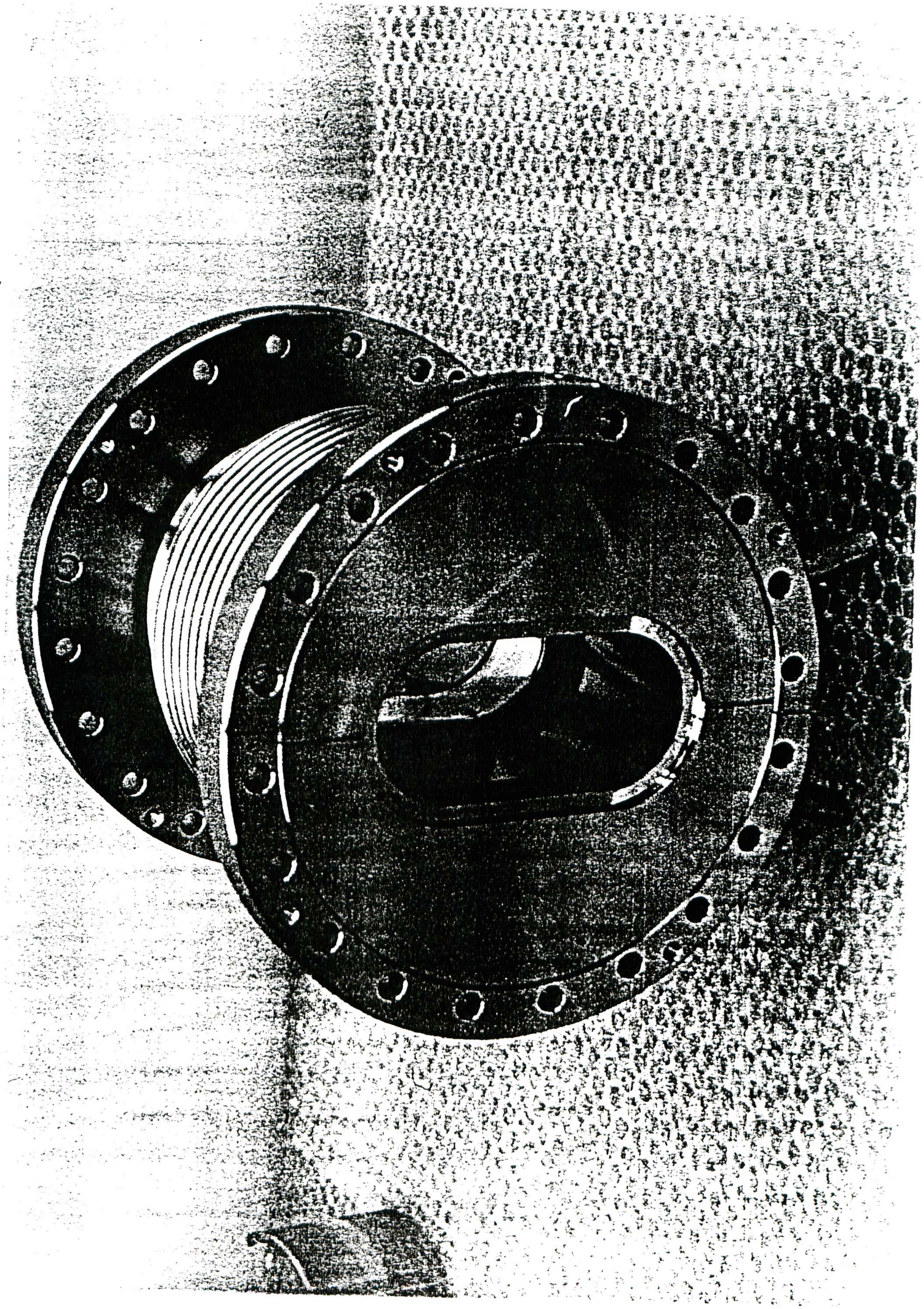
Bellows

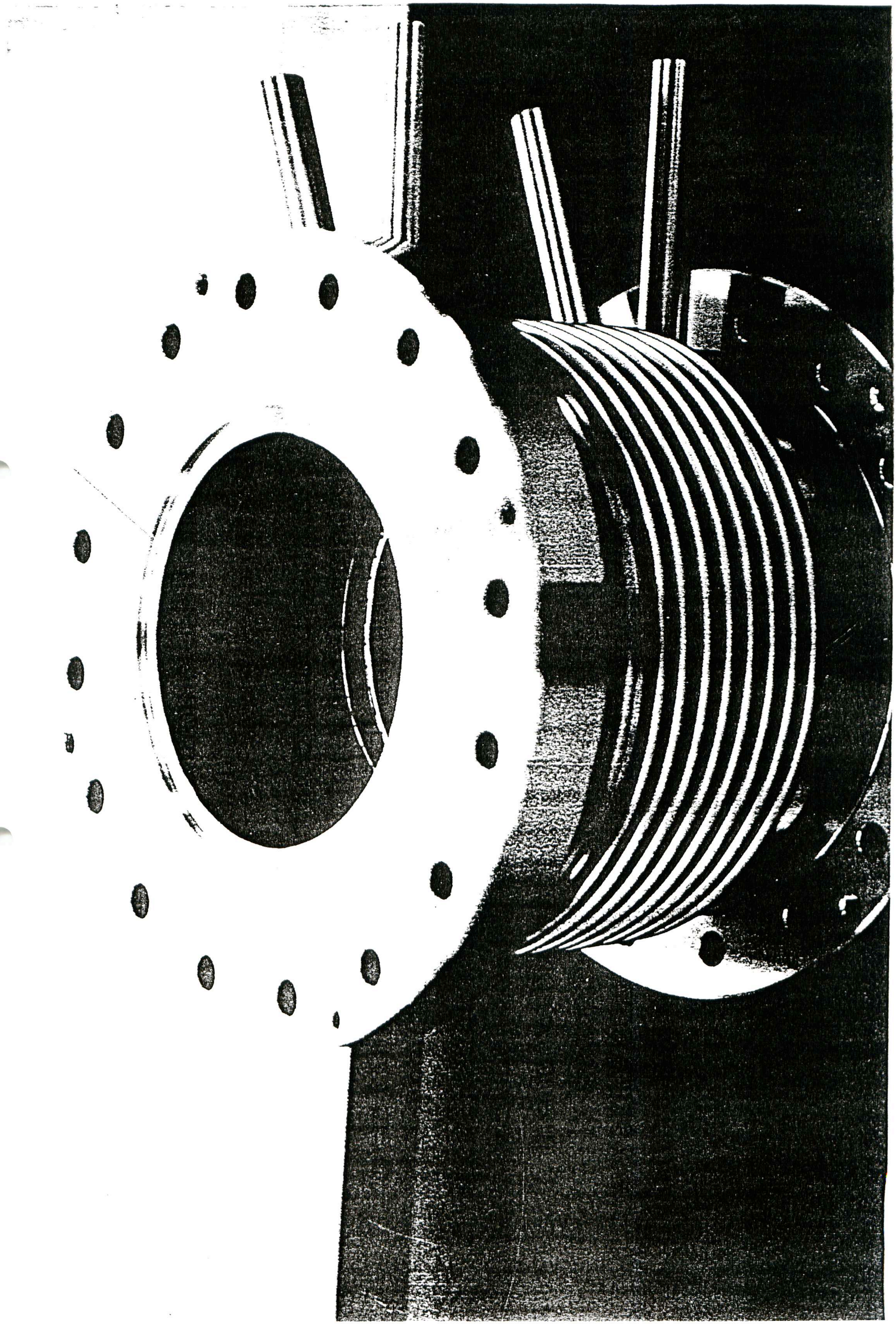
Y. Suetsugu, K. Ohshima, and K. Kanazawa
'Design studies on a vacuum bellows assembly with radio frequency shield for the KEK B factory', Rev. Sci. Instrum. **67** 2796(1996).

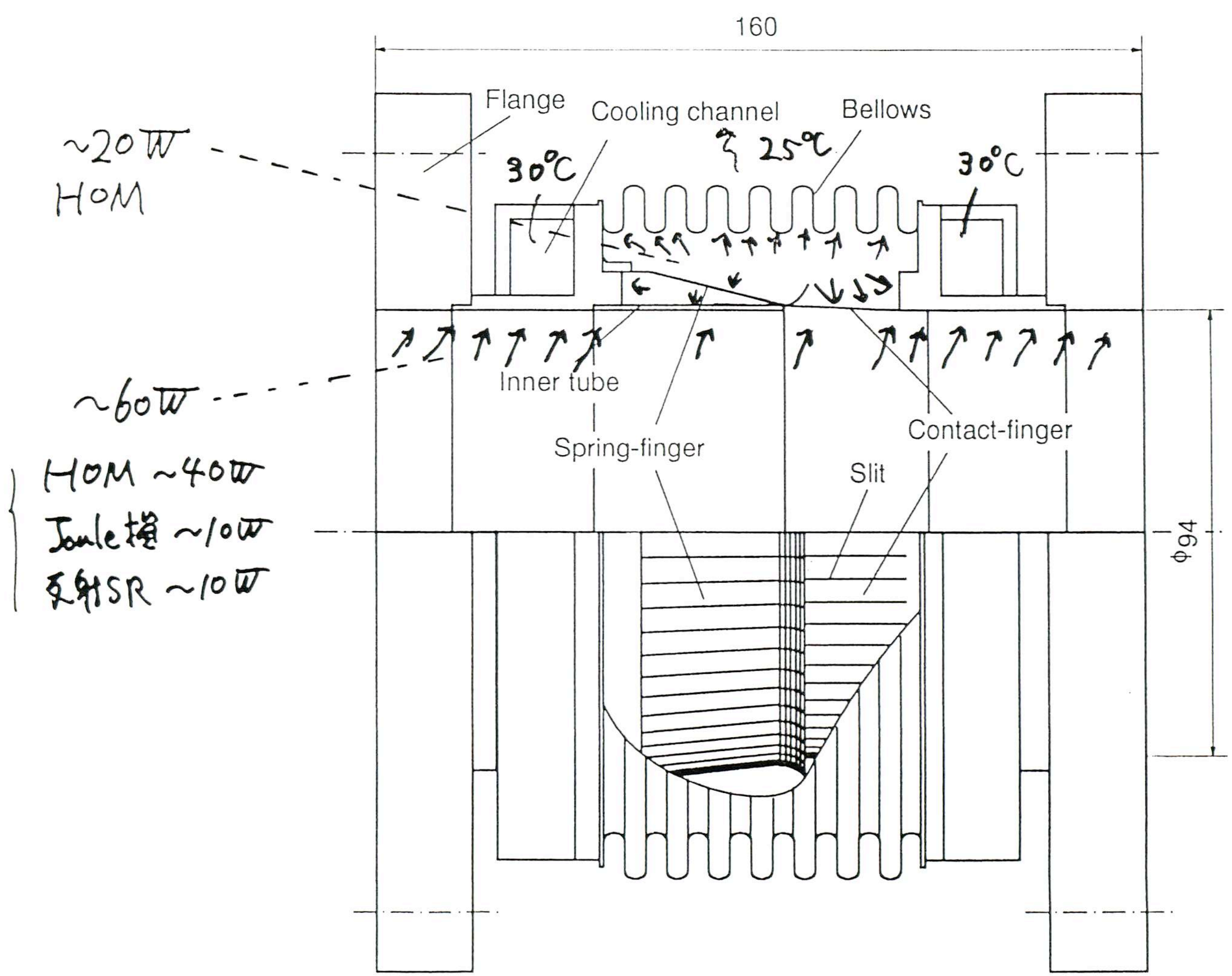
High power test for the rf contact.

Measurement of the coupling coefficient β of the rf shield for a basic TM mode.

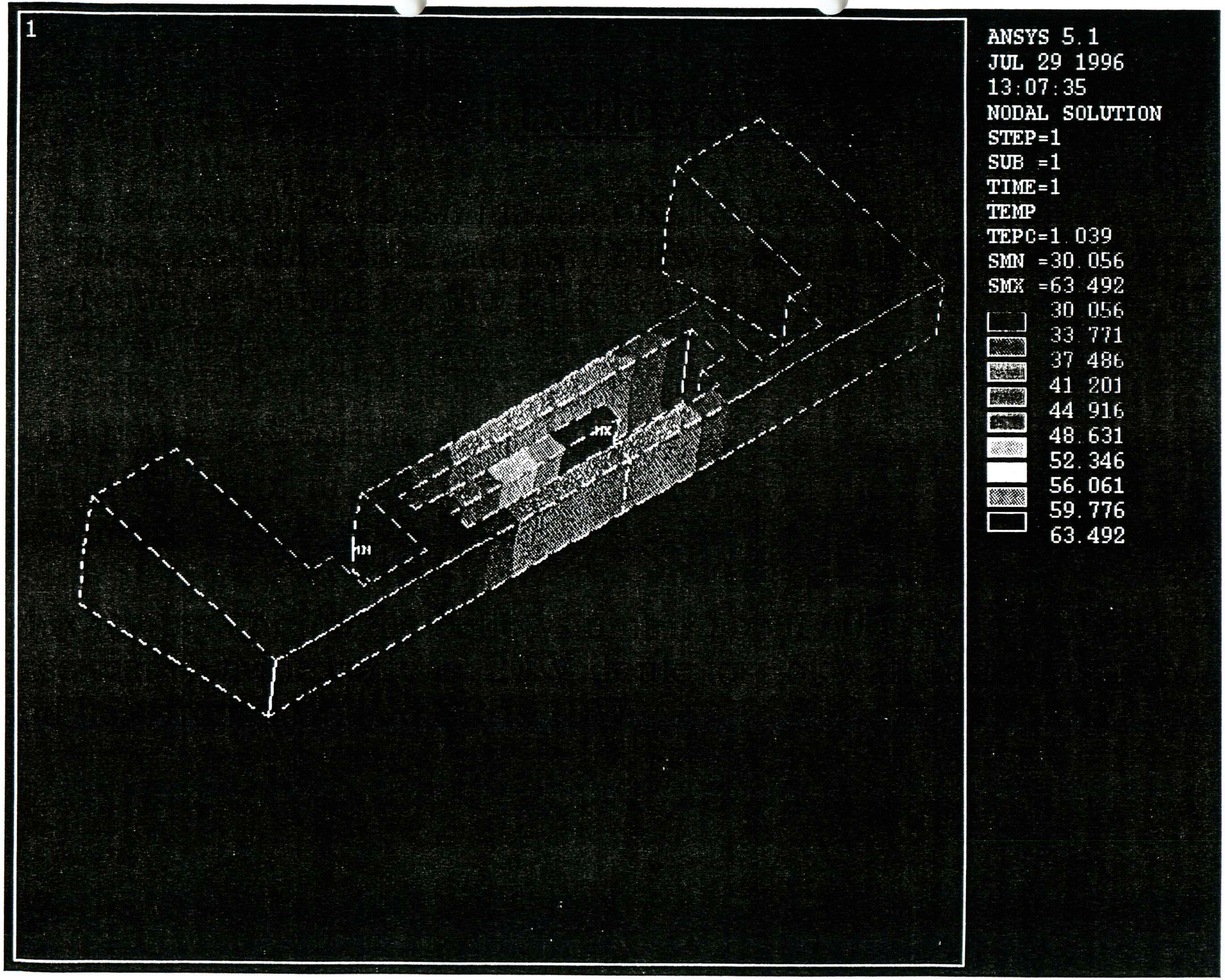
Max temperature in the bellows unit is about 60°C for a probable case that HOM leakage is 20W, Joule loss of wall current is 10W and heat from scattered SR is 10W.







Structure of bellows assembly for KEKB


1
ANSYS 5.1
JUL 29 1996
13:07:35
NODAL SOLUTION
STEP=1
SUB =1
TIME=1
TEMP
TEPC=1.039
SMN =30.056
SMX =63.492
30.056
33.771
37.486
41.201
44.916
48.631
52.346
56.061
59.776
63.492
MX
MN

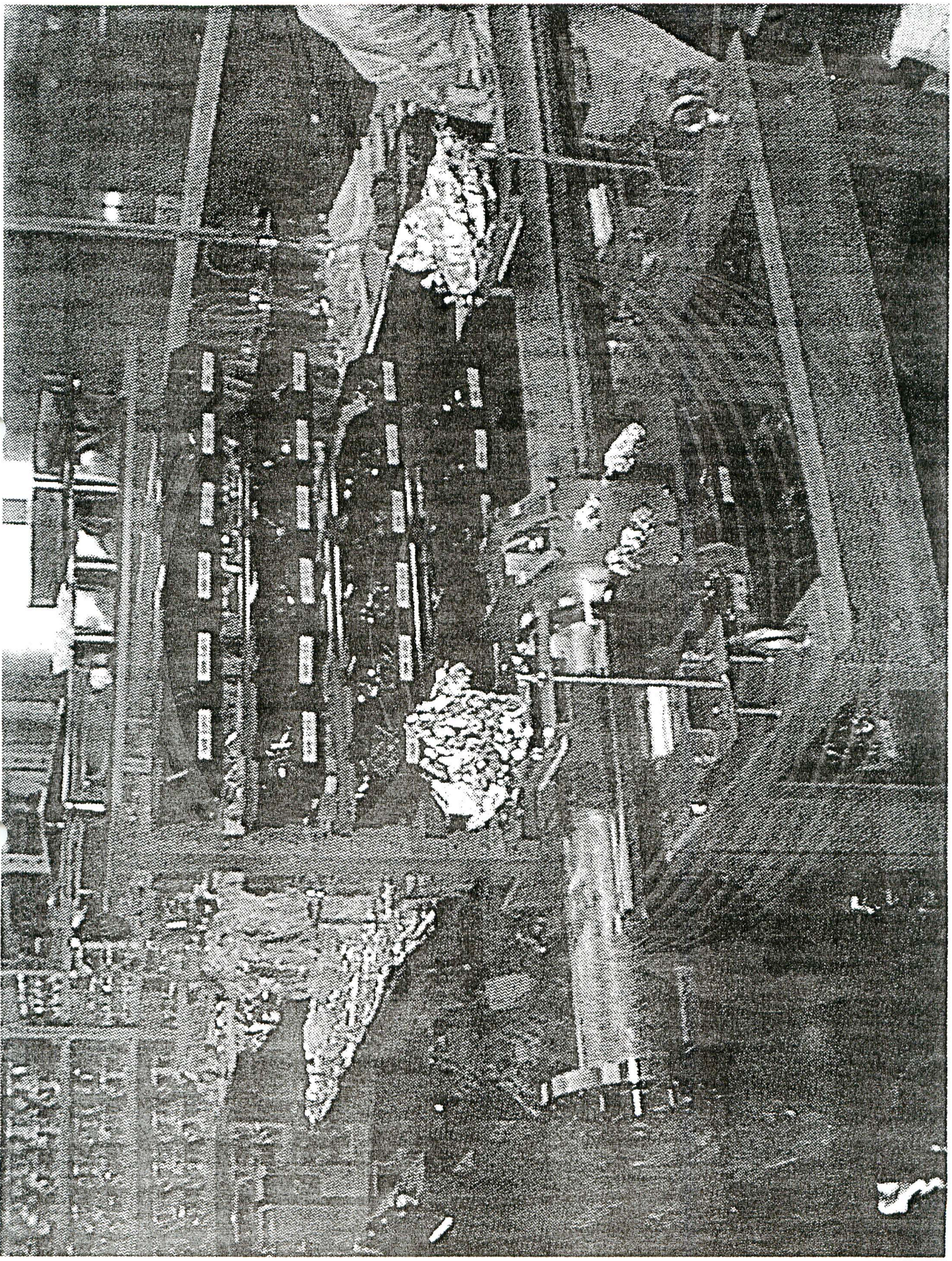
Receiving work

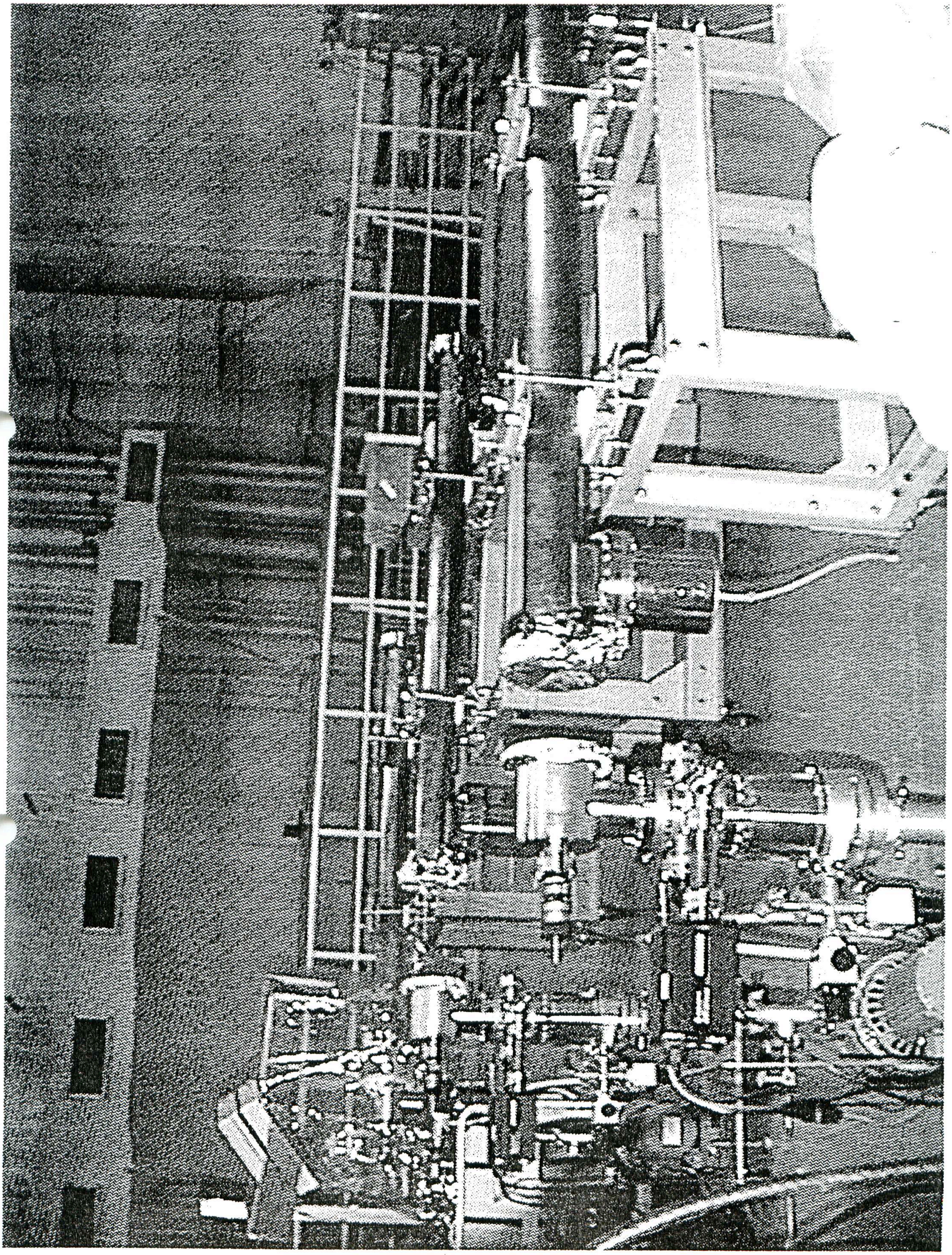
9/30/96-1/21/97

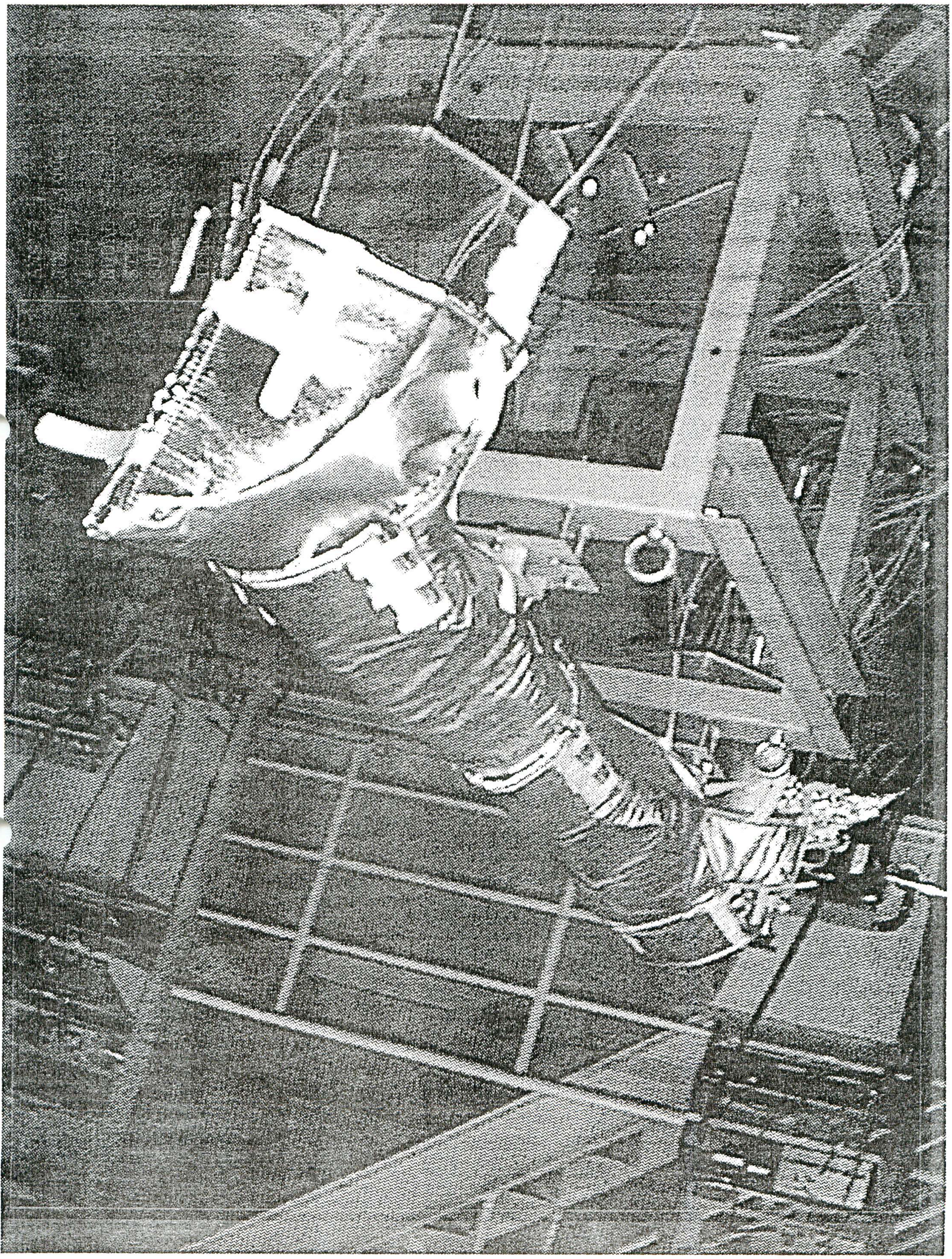
LER S-chamber; received: 38
  baked and waiting N_2 purge: 5
  N_2 purged: 5
LER Q-chamber; received: 30
  baked and waiting N_2 purge: 6
(Plan: total received: 80)

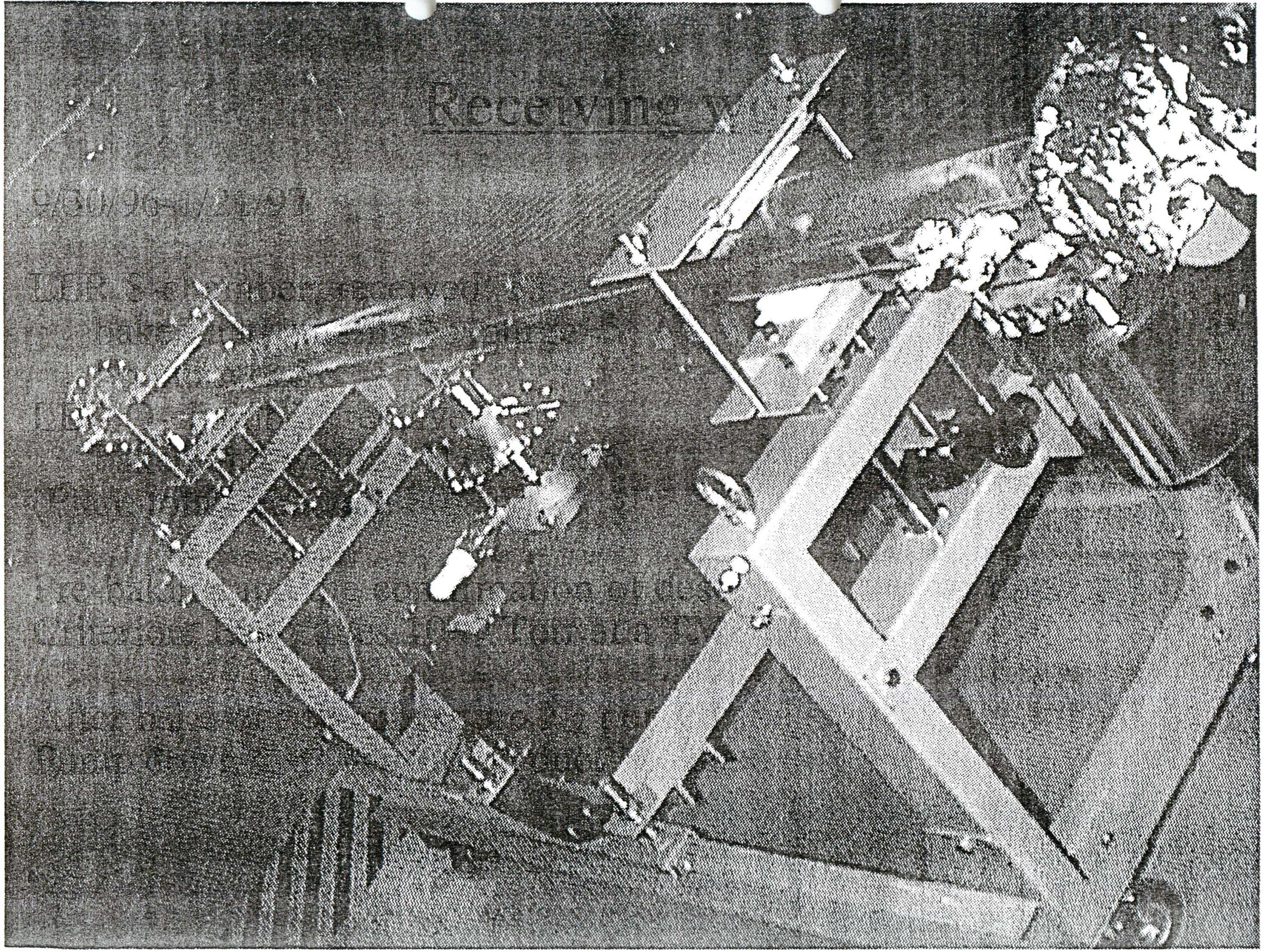
Pre-baking and the confirmation of desorption rate are done at KEK.
Criterion: Few times 10^{-10} Torr at a TMP head.

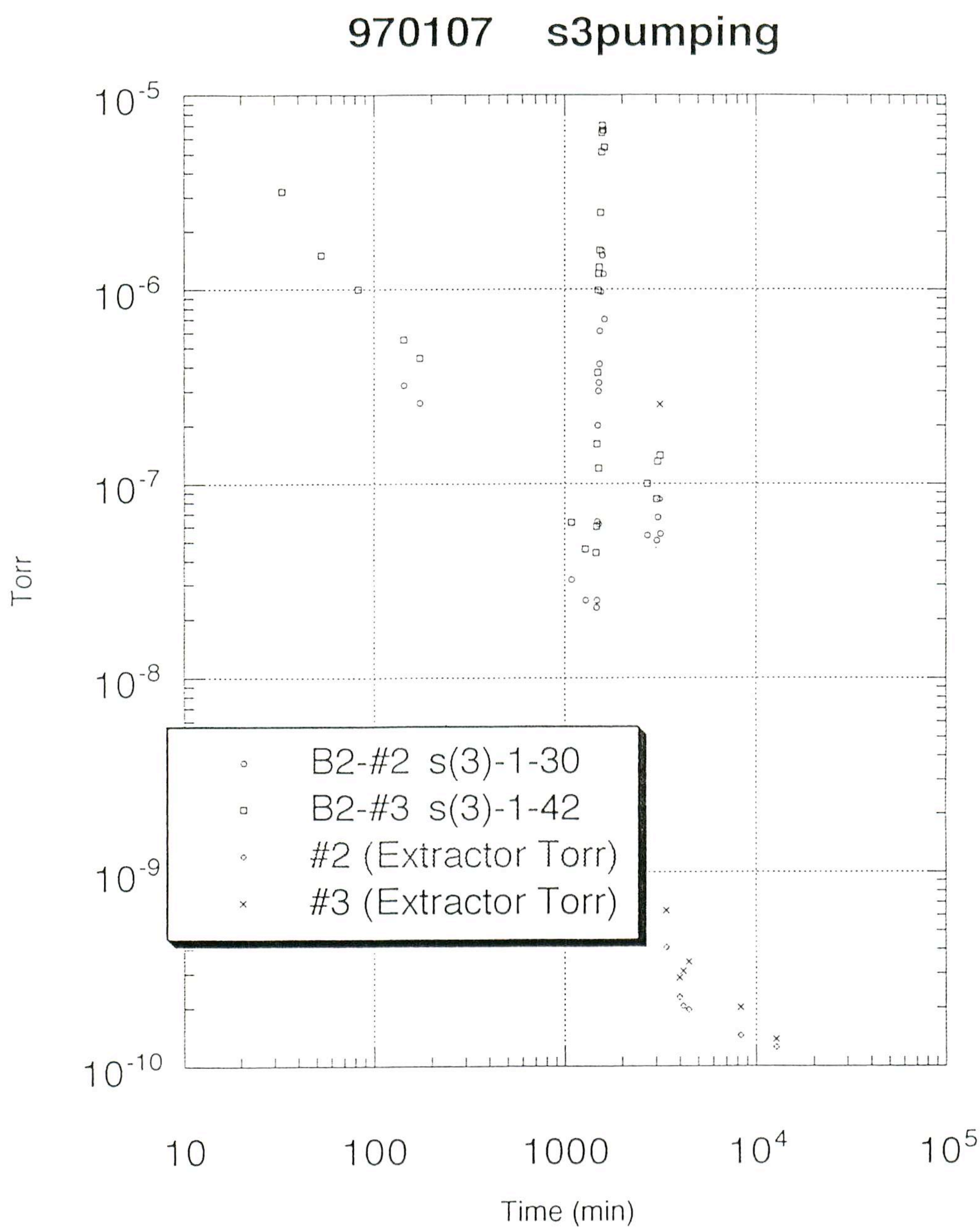
After bake-out chambers are N_2 purged and stored in the tunnel.
Pump down test for a stored duct is planed



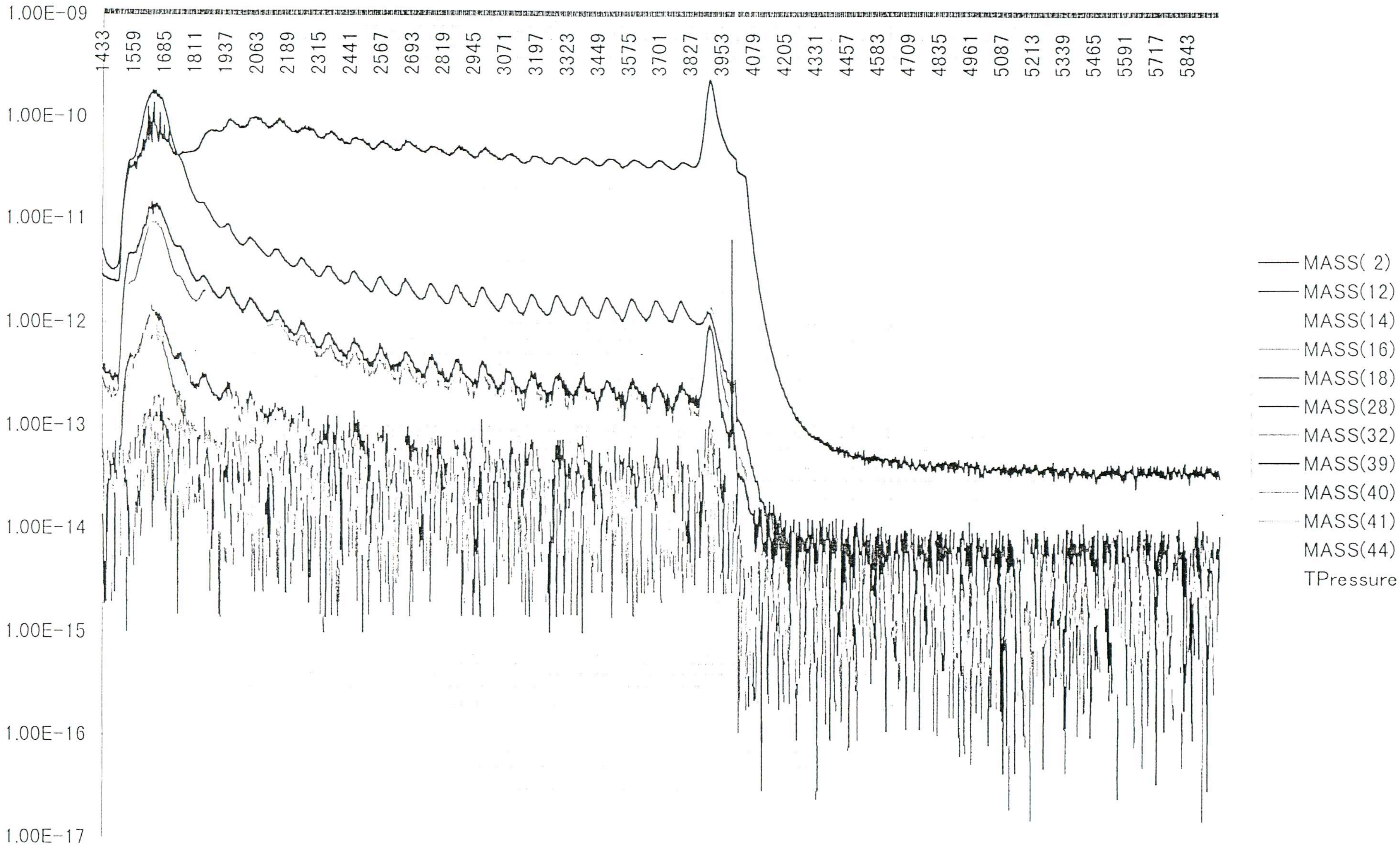





Receiving


970107 s3pumping
Torr
Time (min)
B2-#2 s(3)-1-30
B2-#3 s(3)-1-42
#2 (Extractor Torr)
#3 (Extractor Torr)
10^-5
10^-6
10^-7
10^-8
10^-9
10^-10
10
100
1000
10^4
10^5

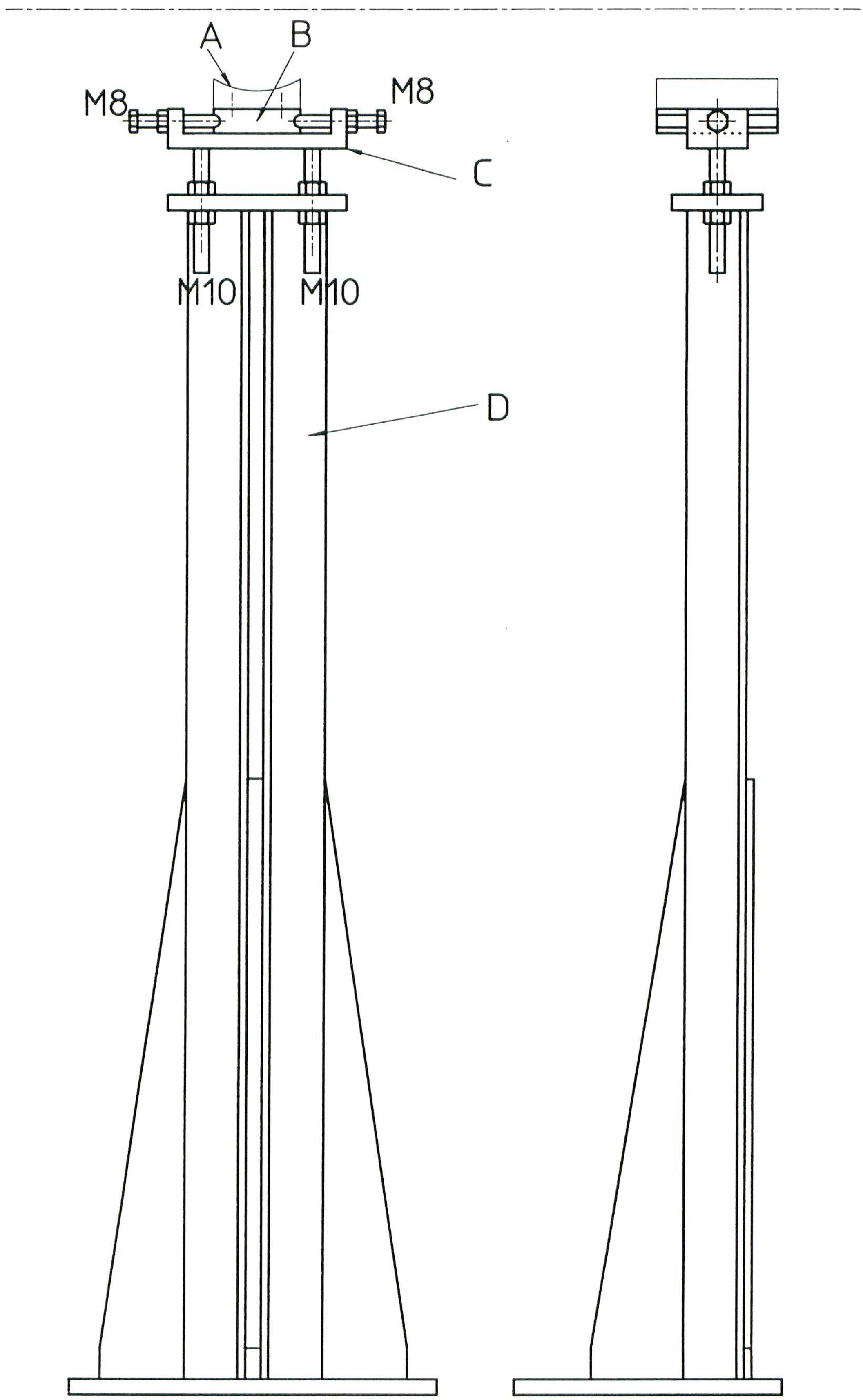
0107-2BK グラフ 1

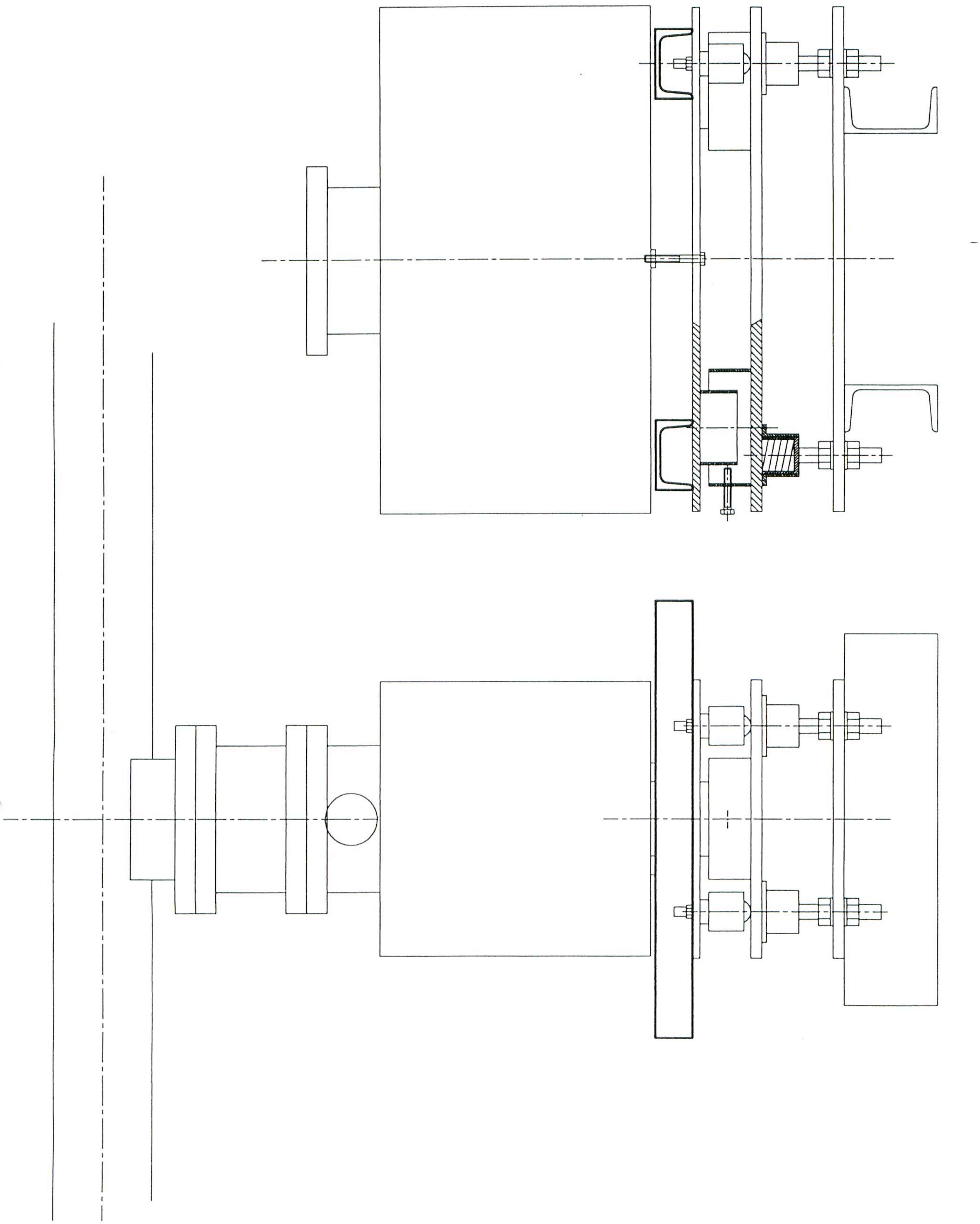


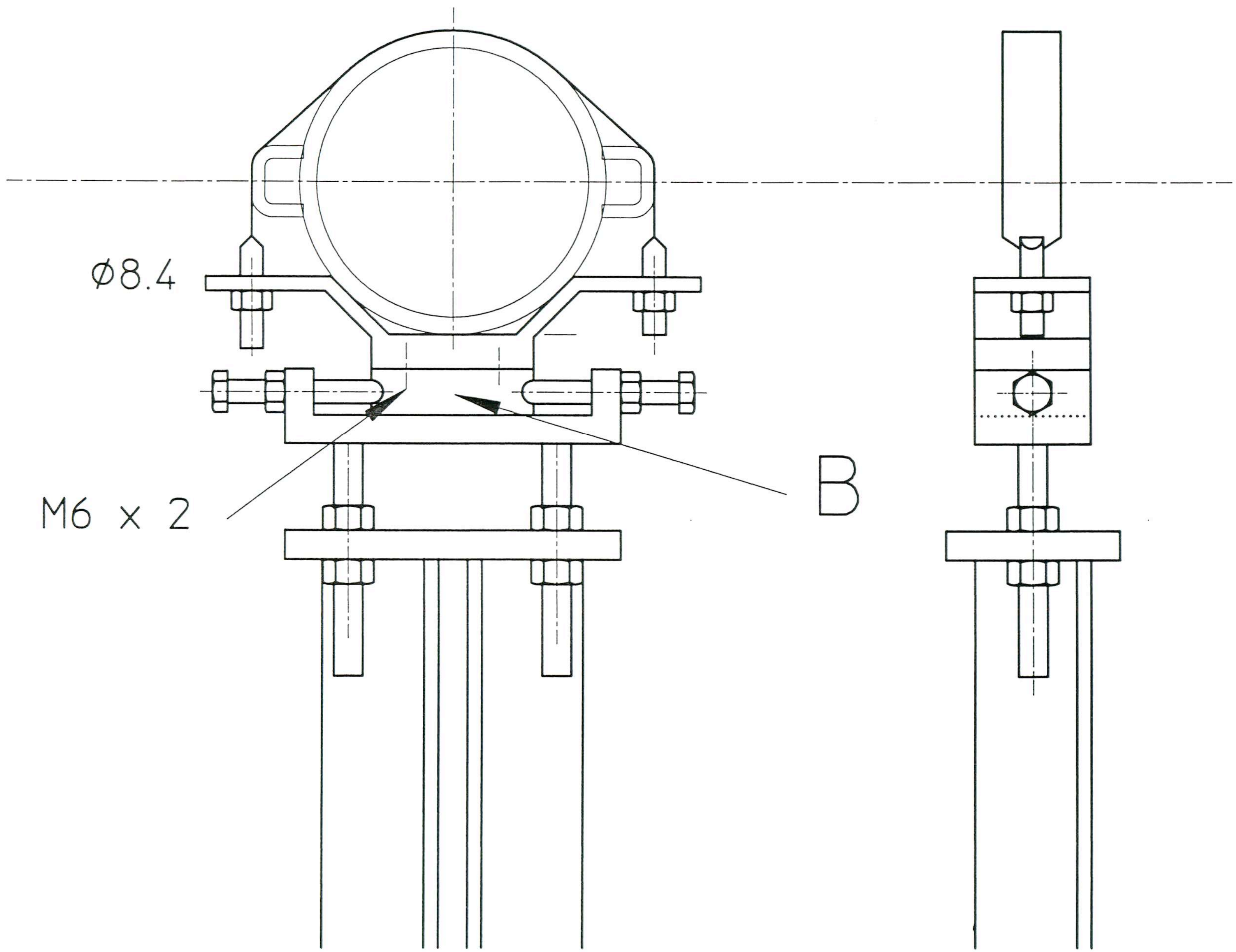
Preparation for installation

A longitudinal slide support, a fixed support, and an ion pump support, for LER S-chambers and B-chambers, and a support for LER Q-chambers are designed and contracted.

Support at a bending magnet for B-chamber, Wiggler chamber must be optimized


A
B
M8
M8
C
M10
M10
D




Ø8.4
M6 x 2
B

Heat and material

Slow fatigue test at elevated temperature is performed.
(Y. Nagai, Hitachi Cable)

A fatigue test is done for Class 1 OFC (both 1/2H and annealed) at 100, 150, 200°C, up to 10^4 cycles.

0~0.5% strain,
one cycle = 90 sec.

Result : no sign of fatigue.

Vacuum Monitoring

Pressure:
every 10m by CCG.

Temperature:

All bellows.
All GV's.
Some NEG port.
Cooling water at high heat load.

Vacuum check with Vacuum switch and CCG.