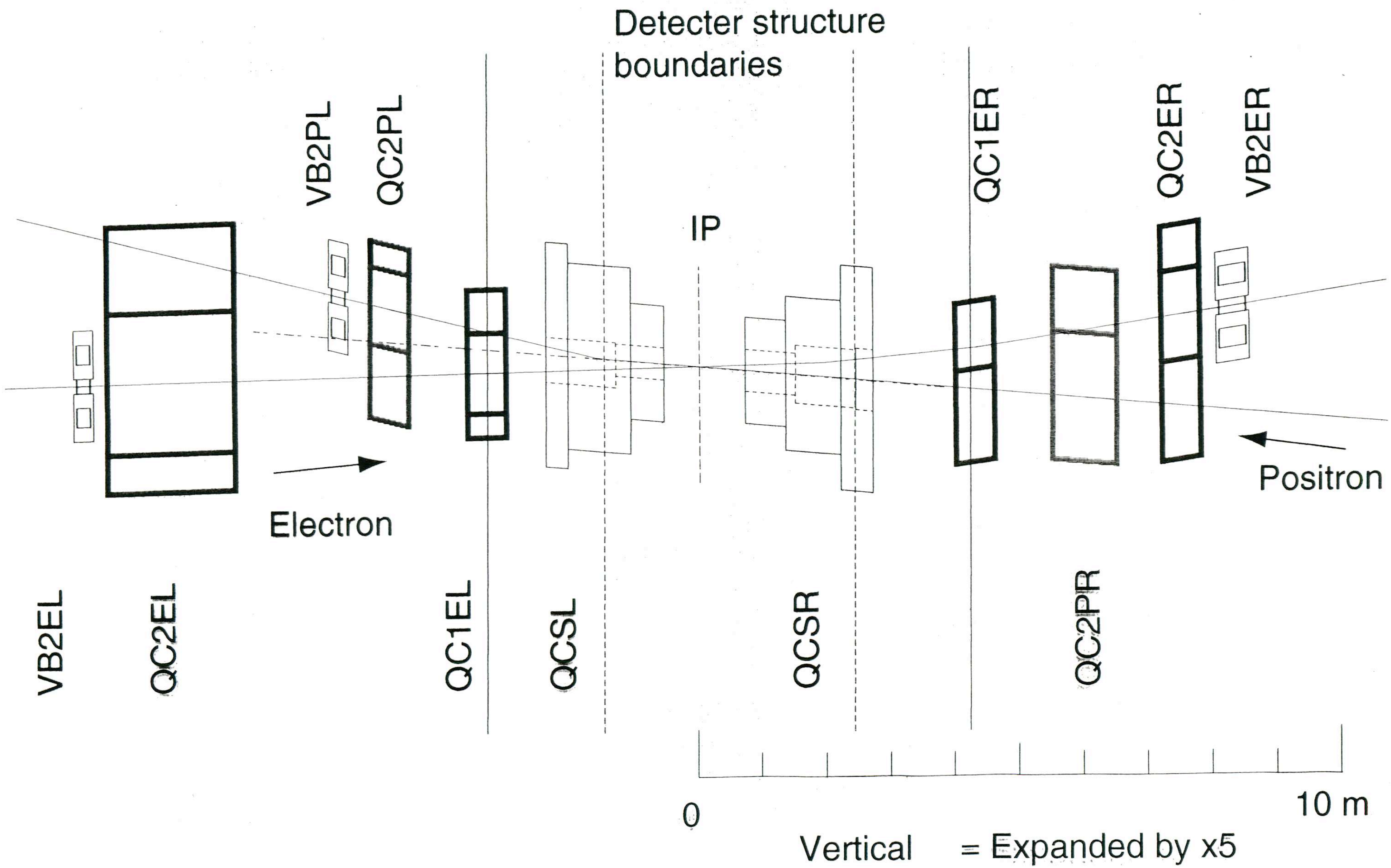
Special Magnets for the Interaction Region

KEKB Accelerator Review (1/23/97)

Nobu Toge (KEK, Accelerator Department)

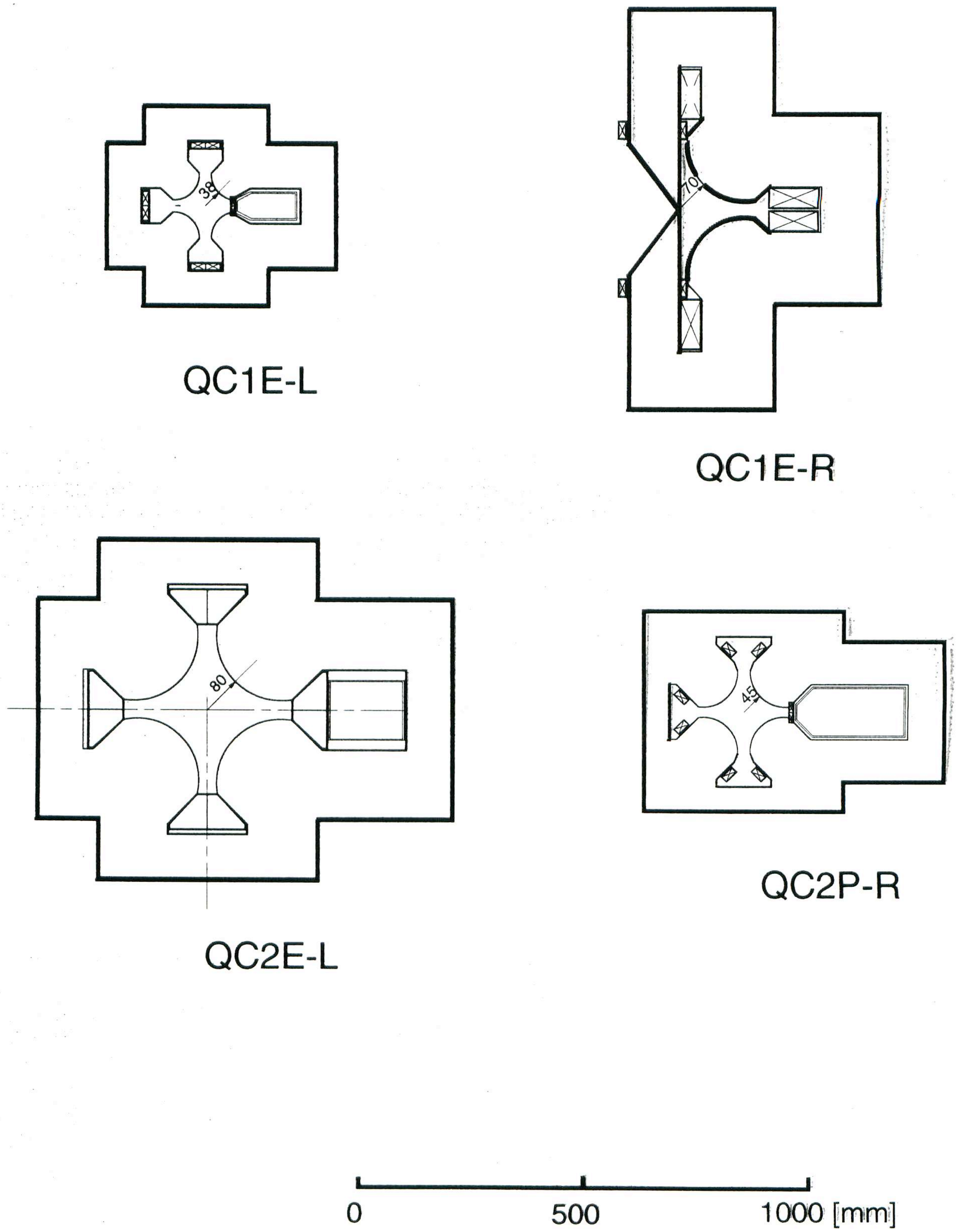
for

H. Nakayama and K.Satoh



Detecter structure
boundaries
VB2PL
QC2PL
QC1ER
QC2ER
VB2ER
IP
Electron
Positron
VB2EL
QC2EL
QC1EL
QCSL
QCSR
QC2PR
0
10 m
Vertical = Expanded by x5

Example Cross Section of IR Special Quadrupole Magnets



■ We have six special magnets (normal-conducting) near the IP, where electrons and positrons are going through the same iron core.

■

	Aperture mm	Length mm	Field T/m	Weight t
Electron Vert Foc.				
QC1LE	76 ϕ	600	< 14	0.6
QC1RE	140 ϕ	600	< 12	1.4
Electron Horiz. Foc.				
QC2LE	120 ϕ	2000	< 3	4.2
QC2RE	120 ϕ	600	< 11	1.3
Positron Horiz. Foc.				
QC2LP	90 ϕ	600	< 7	0.8
QC2RP	80 ϕ	1000	< 3.5	1.2

■ Calculations of mag fields with realistic coil specifications and magnet sizes are completing; including optimization of the pole pieces + shimming.

■ A prototype of QC1LE (the most technically challenging one) and possibly QC1RE will be built this summer (97), with full LCW cooling, excitation tests and field measurements.

Status of the Design of QC1LE

1. The most challenging, because of the very small separation between the designated aperture of electrons and positrons. This is a "septum magnet".

2. 4-piece iron core will be made of Shin-Nittetsu N-SMIP-1 (better than JIS S10C).

3. 4 main coils, consisting of 3 turns each.

4. Coils are made of 6 mm x 8 mm hollow conductor (4 mm ϕ hole for LCW). Current density J ~ 87 A /mm2 $\Rightarrow$ ~ 3100 A / coil

5. Each coil turn has its own LCW flow circuit $\Rightarrow$ 12 circuits in total.

6. Six (6) trim winding coils; 2 for Left-Right symmetry, 4 for individual poles.

7. This magnet (and all the other five special magnets) can be split into top and bottom halves to allow smooth installation of vacuum chambers and other components.

8. Calculated fields, with optimized pole piece shapes, show excellent characterists for both electrona and positron aperture regions.

9. Fabrication quality (of pole pieces and coil positions) vs. Field quality, and remedies to be made by trim winding coils: This issue will be expermentally studied this summer.

Graph 1-1.

Test Results

Chemical Composition (Ladle Analysis. wt.%)

Grade	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	T.Al	T.N
N-SMIP-1	0.002	0.004	0.06	0.004	0.002	0.01	0.027	0.016	0.001	0.018	0.0040
AISI 1006	0.062	0.031	0.33	0.012	0.006	0.01	0.018	0.024	0.001	0.014	0.0058
JIS S10C	0.12	0.25	0.41	0.006	0.003	0.01	0.021	0.019	0.001	0.022	0.0058

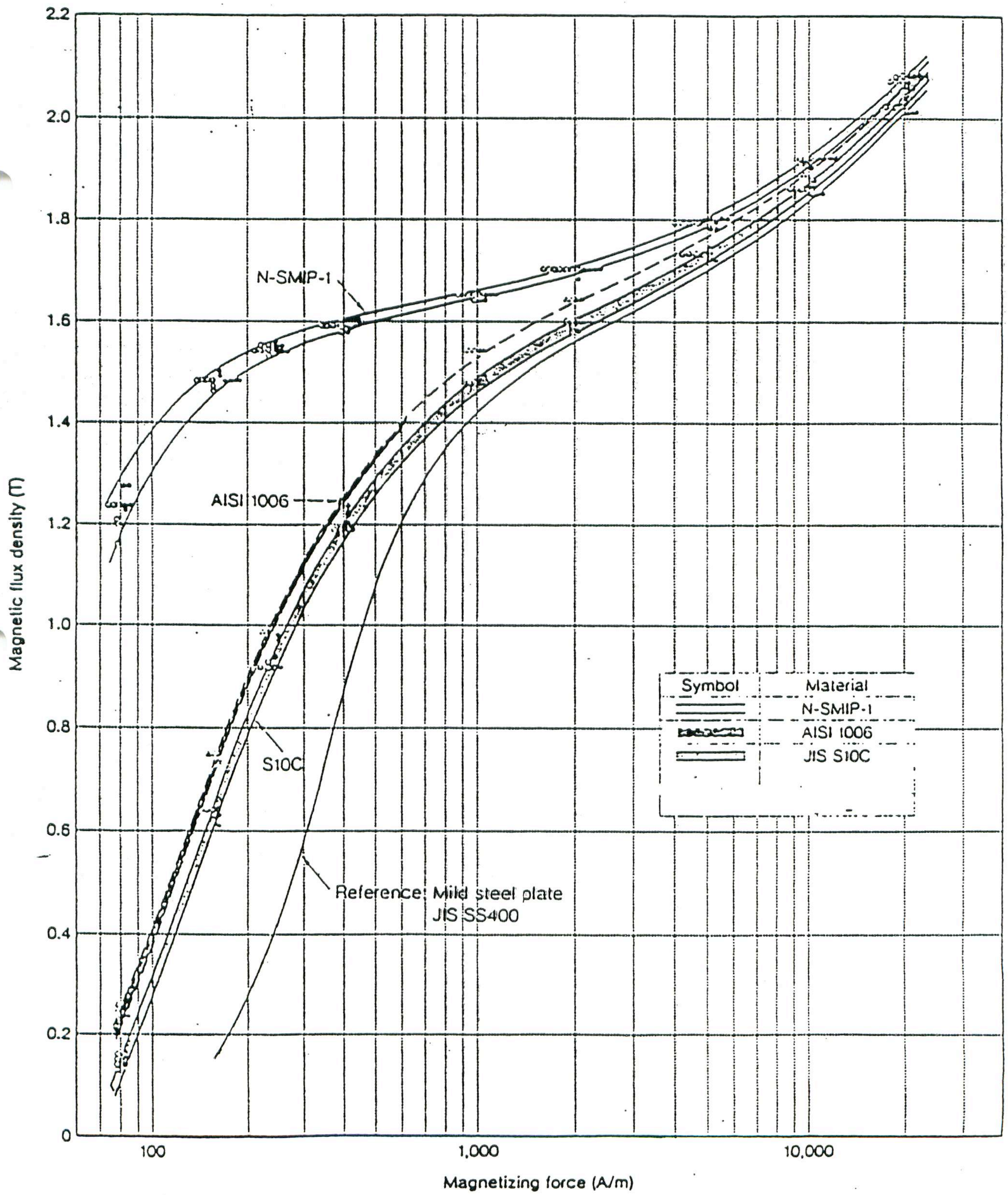


Table 2. Test results

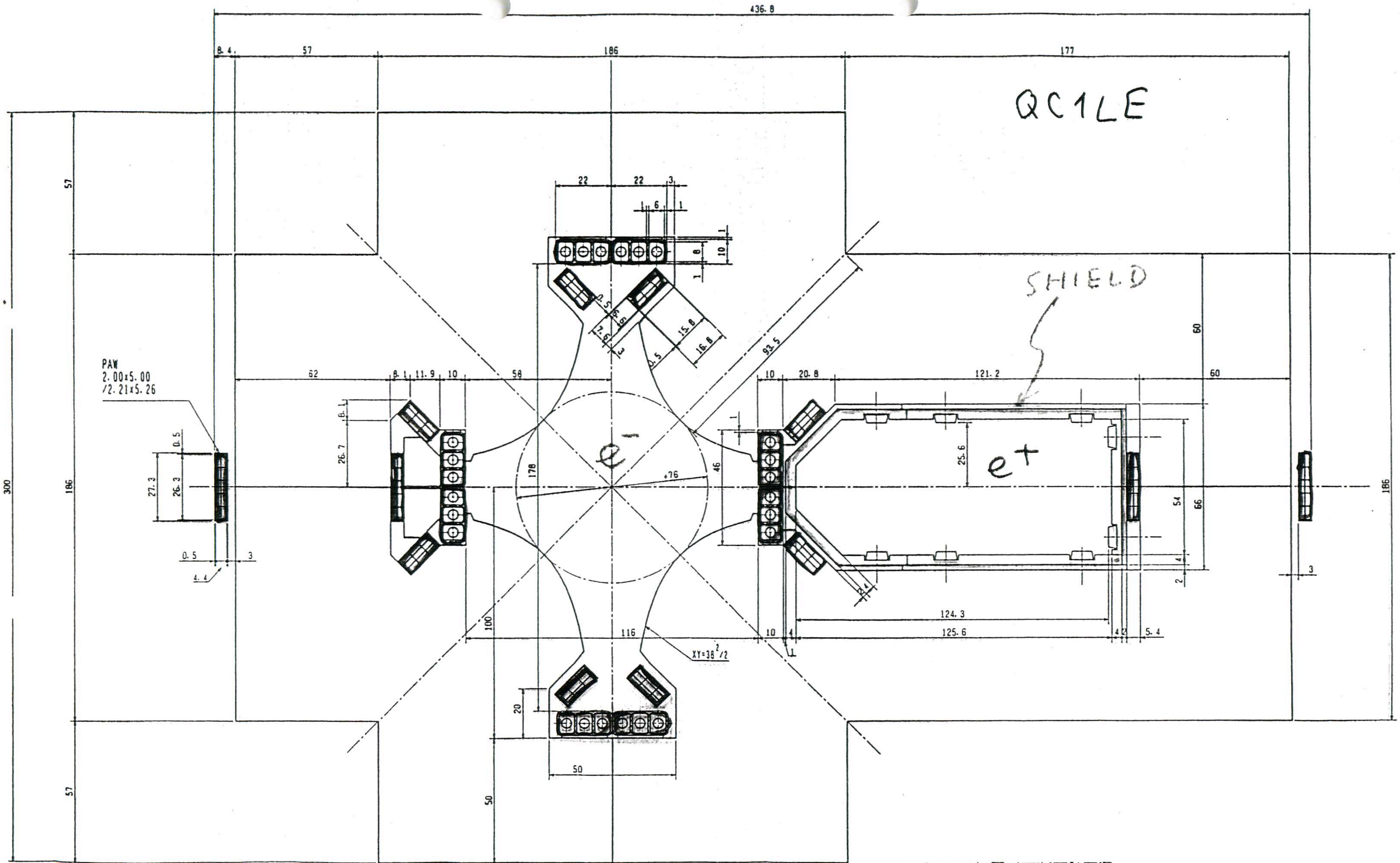
Properties of Electrical Steel Plates

May, 1996
NIPPON STEEL CORPORATION
NAGOYA WORKS

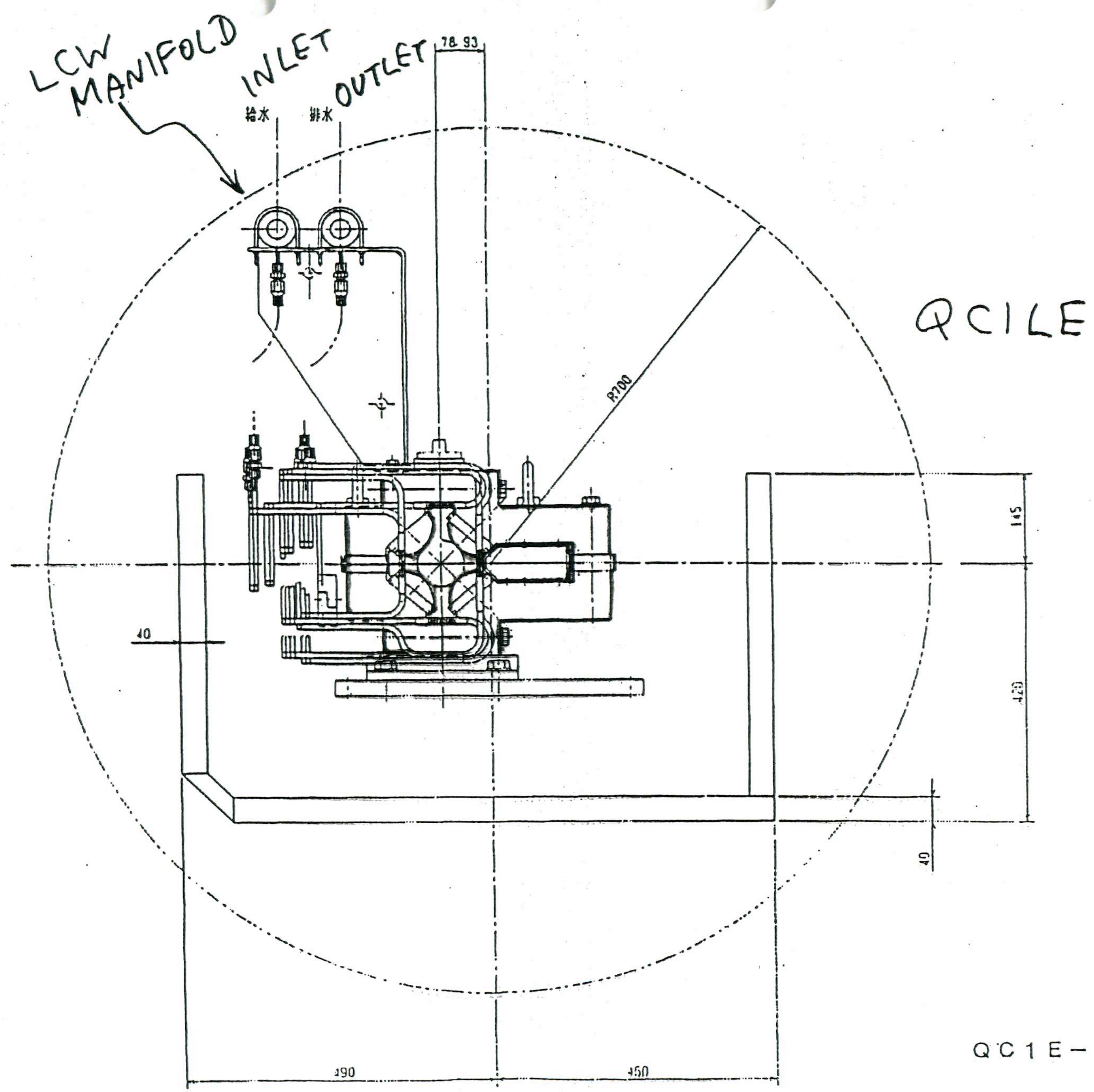
Classification		Plate Thickness (mm)	Chemical analysis (wt.%) C	Si	Mn	P	S	Heat treatment of Plate	* Magnetic properties: Magnetic flux density (T) 80 A/m	160	240	400	2000	10000	30000	**Hc (1.5T) A/m	Tensile properties YP (kgf/mm²)	TS (kgf/mm²)	El (%)	B-H
Specification AISI-1006		—	≦ 0.08	—	0.25 ~ 0.40	≦ 0.04	≦ 0.05	—	—	—	—	—	—	—	—	—	—	—	—	—
JIS SUMP-1		—	—	—	—	—	—	—	≧ 0.5	≧ 1.0	≧ 1.2	≧ 1.35	≧ 1.55	—	—	≦ 79.1	—	HRB 45~75	—	—
A	JIS-S10C	47 ~ 250	0.09 ~ 0.12	0.22 ~ 0.25	0.36 ~ 0.53	0.006 ~ 0.017	0.003 ~ 0.009	Norma	0.11 ~ 0.15	0.51 ~ 0.64	0.90 ~ 0.99	1.17 ~ 1.26	1.60 ~ 1.63	1.85 ~ 1.87	—	145 ~ 159	21 ~ 32	36 ~ 41	40 ~ 46	①
B	AISI-1006	252	0.06	0.03	0.33	0.012	0.006	Norma	0.24 ~ 0.28	0.73 ~ 0.75	0.97 ~ 0.99	1.32 ~ 1.34	1.64 ~	1.88 ~ 1.89	2.16 ~ 2.17	91 ~ 98	23	32	47	②
C	N-SMIP-1	30 ~ 180	0.002 ~ 0.008	0.002 ~ 0.013	0.05 ~ 0.10	0.005 ~ 0.013	0.001 ~ 0.003	Norma	0.72 ~ 1.25	1.25 ~ 1.47	1.41 ~ 1.53	1.53 ~ 1.60	1.68 ~ 1.70	1.90 ~ 1.92	2.17 ~ 2.18	37 ~ 70	15 ~ 18	25 ~ 30	54 ~ 60	③

* Test specimen was stress-relieving annealed (at 750℃ for 2 hours) after machined to ring-shaped.

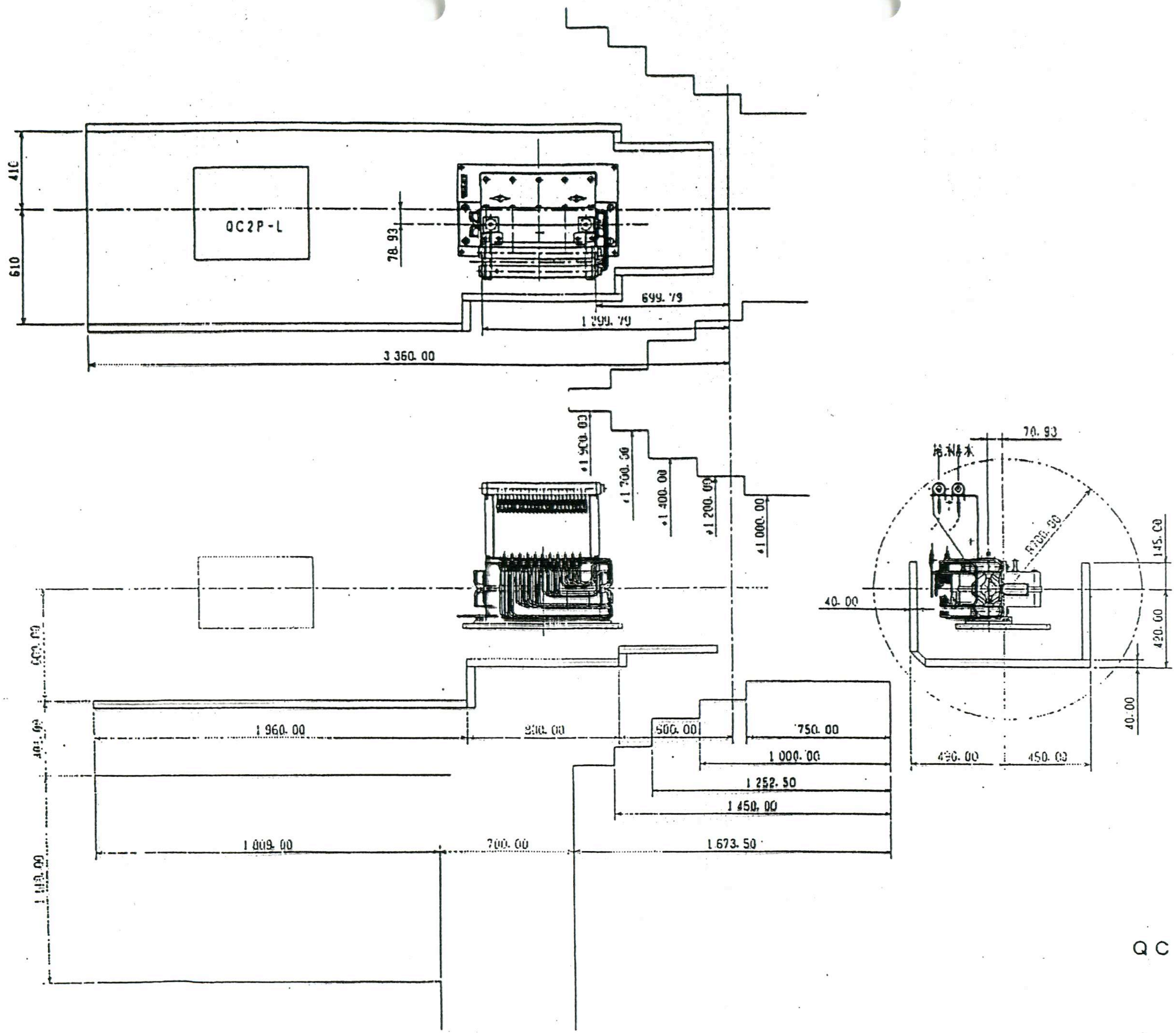
** Coercive force (A/m) at magnetic flux density of 1.5T



セプタム四極電磁石断面計画図

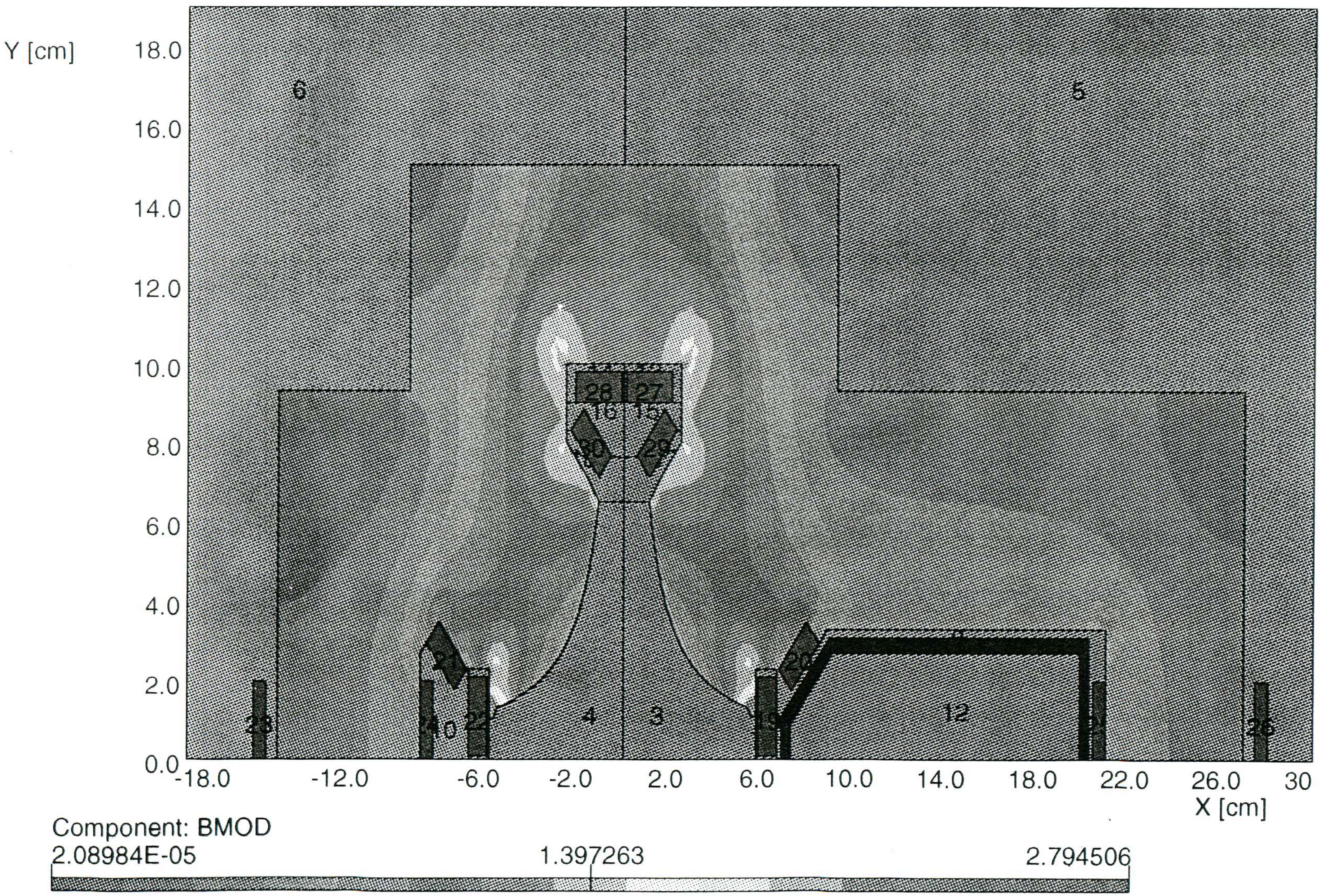


QC1E－L配置正面図(詳細)



410
610
QC2P-L
78.93
699.79
1 299.79
3 360.00
φ1 900.00
φ1 700.00
φ1 400.00
φ1 200.00
φ1 000.00
70.93
R700.00
145.00
420.00
40.00
490.00
450.00
1 960.00
500.00
750.00
1 000.00
1 252.50
1 450.00
1 009.00
700.00
1 673.50

QC1E－L配置計画図



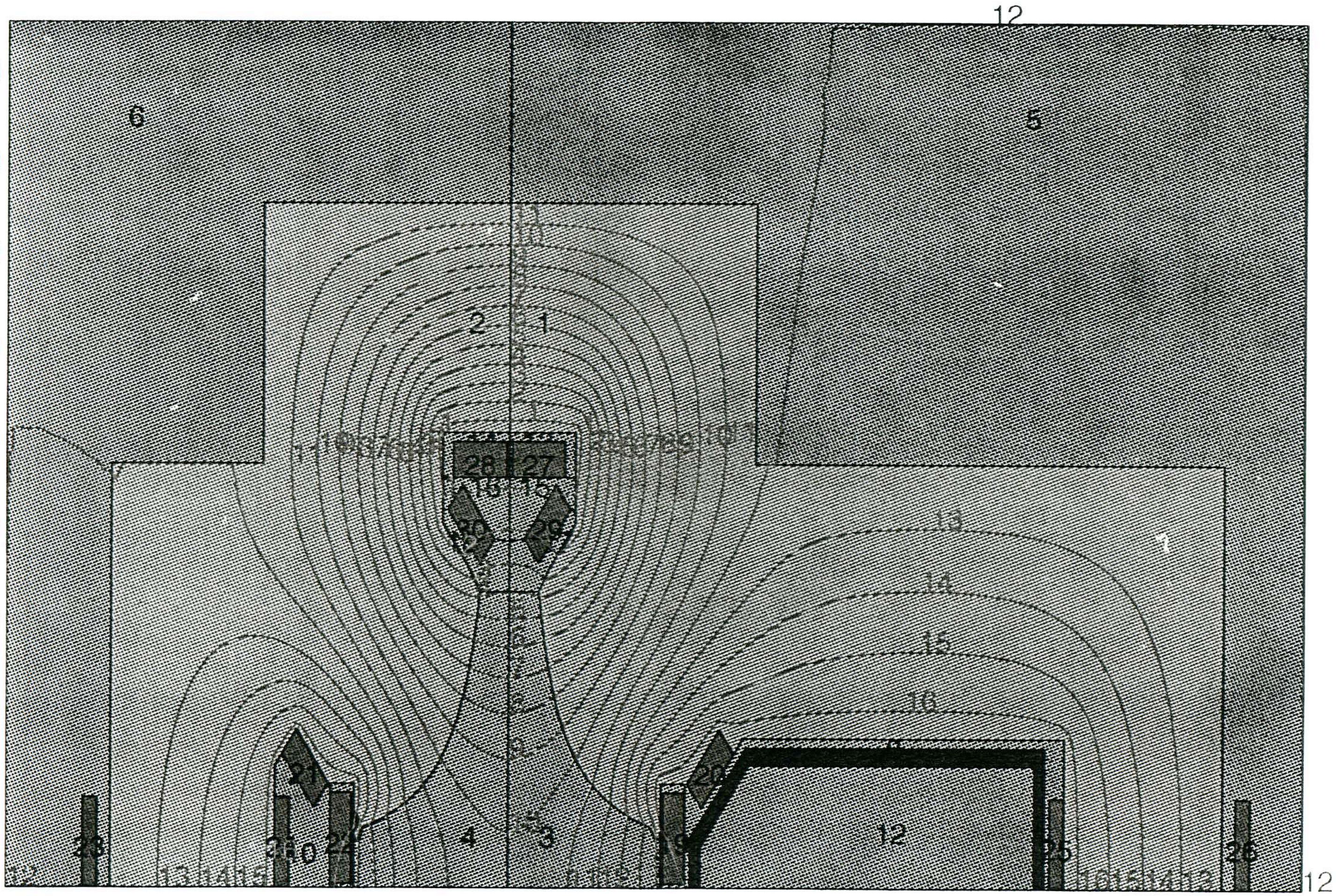
UNITS

Length	: cm
Flux density	: T
Field strength	: A m⁻¹
Potential	: Wb m⁻¹
Conductivity	: S cm⁻¹
Source density	: A cm⁻²
Power	: W
Force	: N
Energy	: J
Mass	: kg

PROBLEM DATA
mitsu_qc1el-30-7.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
9492 elements
19167 nodes
30 regions

14/Jan/97 13:54:38 Page 5

OPERA-2d
Pre and Post-Processor 1.6



Component: POT
Minimum: -0.055, Maximum: 0.02, Interval: 0.005

UNITS

Length : cm
Flux density : T
Field strength : $A\ m^{-1}$
Potential : $Wb\ m^{-1}$
Conductivity : $S\ cm^{-1}$
Source density : $A\ cm^{-2}$
Power : W
Force : N
Energy : J
Mass : kg

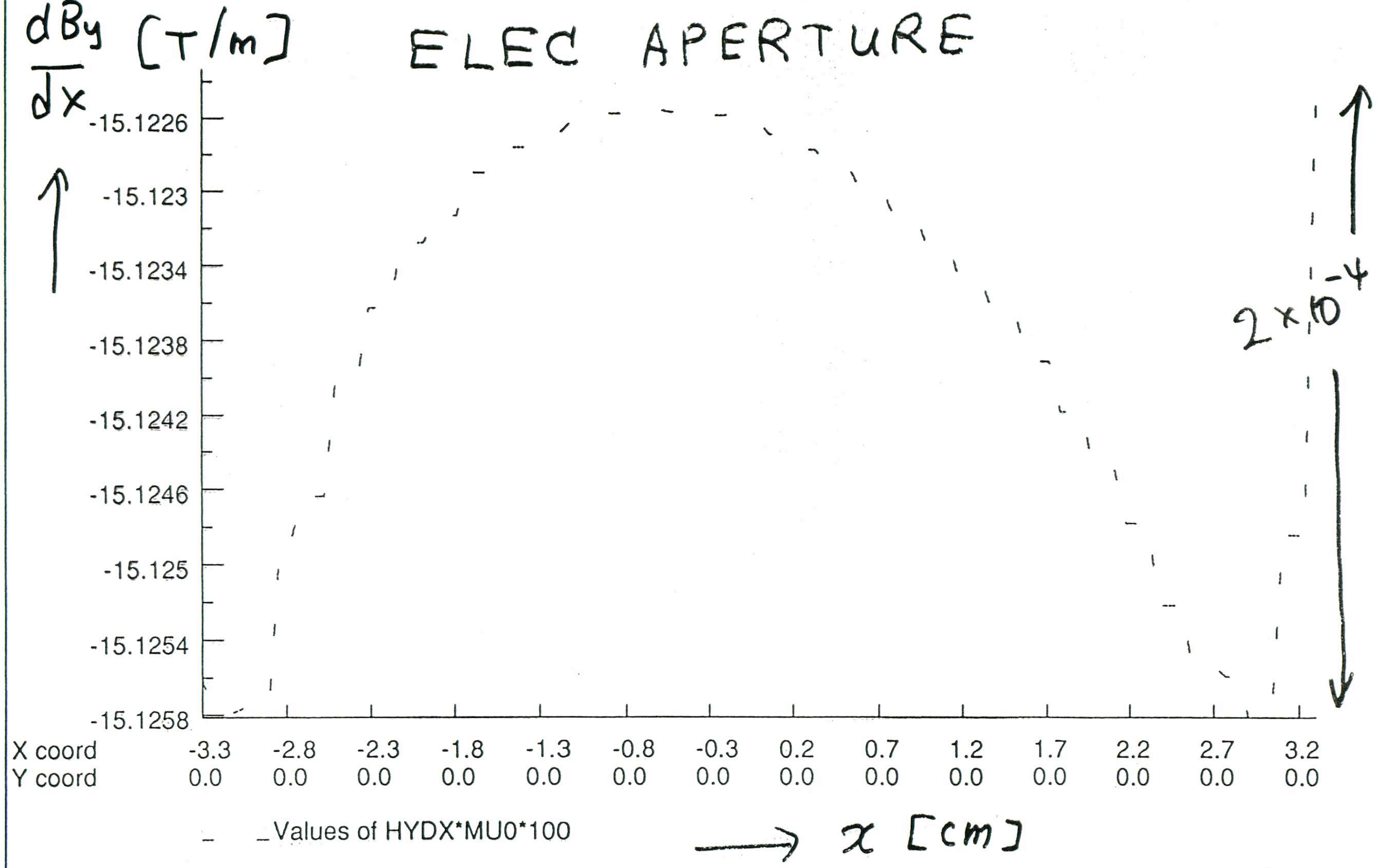
PROBLEM DATA

mitsu_qc1el-30-7.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
9492 elements
19167 nodes
30 regions

14/Jan/97 13:53:14 Page 4

OPERA-2d
Pre and Post-Processor 1.6

QCILE



UNITS

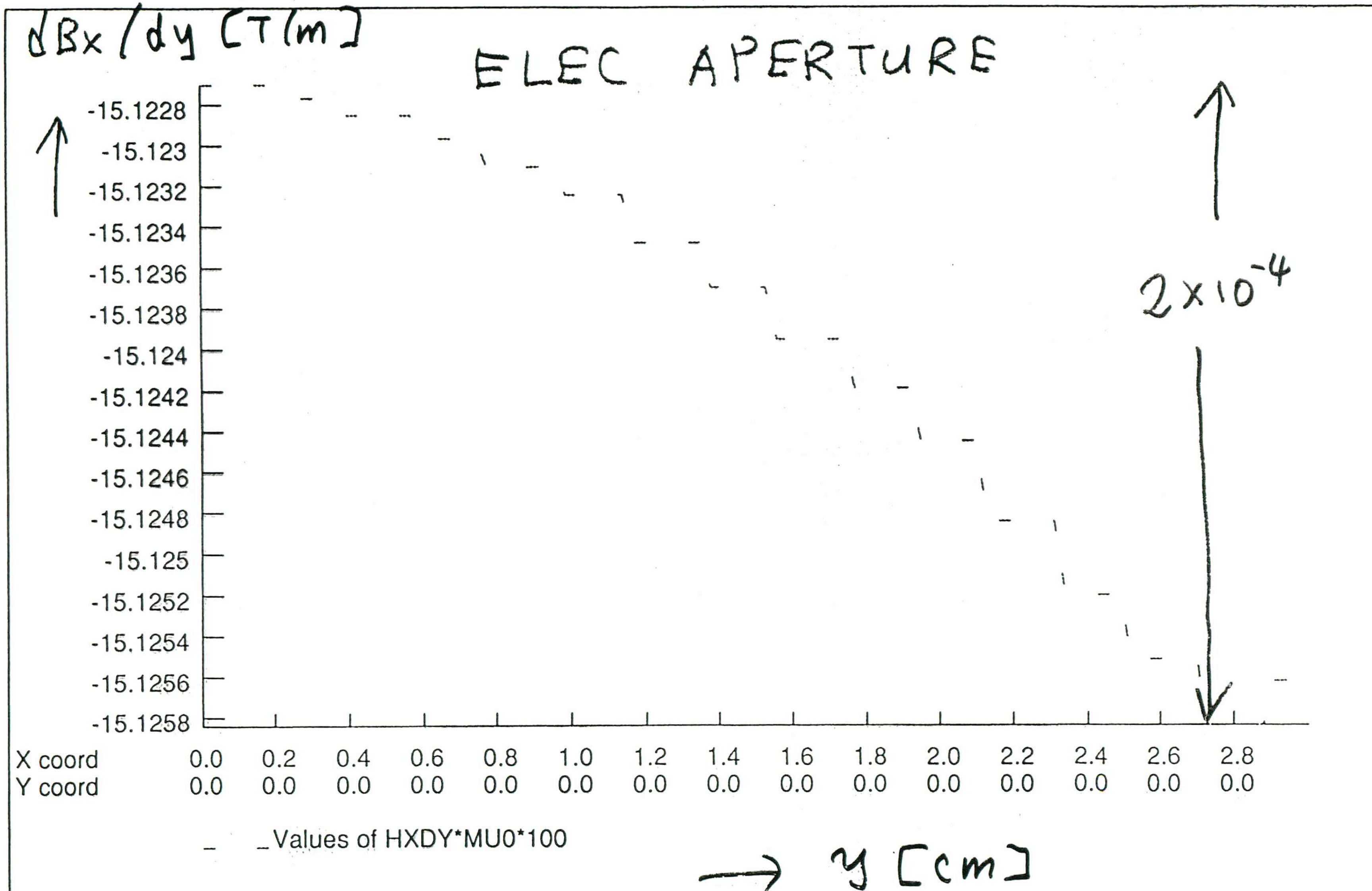
Length	: cm
Flux density	: T
Field strength	: $A\ m^{-1}$
Potential	: $Wb\ m^{-1}$
Conductivity	: $S\ cm^{-1}$
Source density	: $A\ cm^{-2}$
Power	: W
Force	: N
Energy	: J
Mass	: kg

PROBLEM DATA
mitsu_qc1el-30-7.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
9492 elements
19167 nodes
30 regions

16/Dec/96 14:52:51 Page 7

OPERA-2d
Pre and Post-Processor 1.6

QC1LE



UNITS

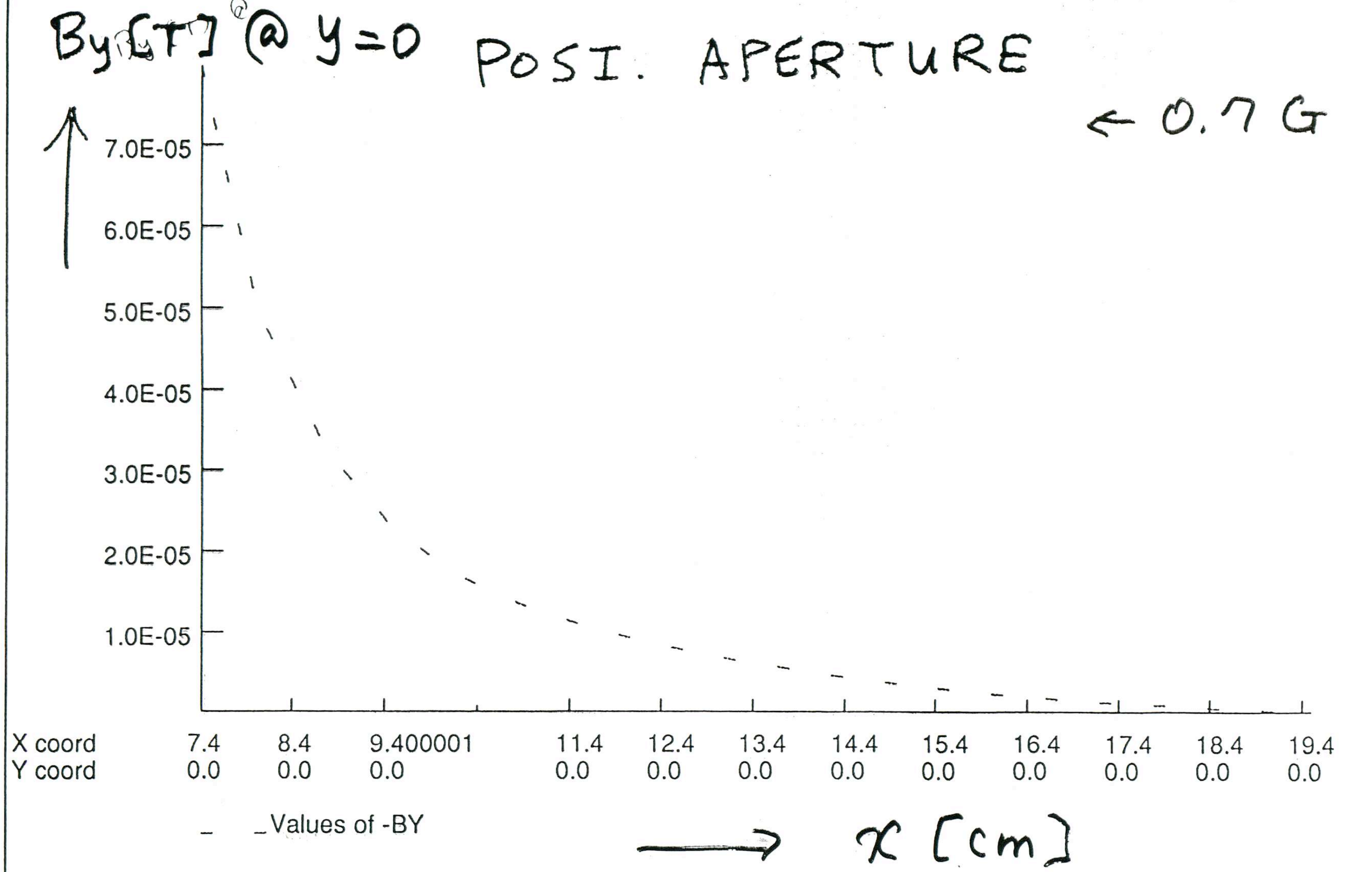
Length	:cm
Flux density	:T
Field strength	:A m^{-1}
Potential	:Wb m^{-1}
Conductivity	:S cm^{-1}
Source density	:A cm^{-2}
Power	:W
Force	:N
Energy	:J
Mass	:kg

PROBLEM DATA
mitsu_qc1el-30-7.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
9492 elements
19167 nodes
30 regions

16/Dec/96 14:53:32 Page 8

VF OPERA-2d
Pre and Post-Processor 1.6

QC1LE



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Flux density	: T
Field strength	: $A\ m^{-1}$
Potential	: $Wb\ m^{-1}$
Conductivity	: $S\ cm^{-1}$
Source density	: $A\ cm^{-2}$
Power	: W
Force	: N
Energy	: J
Mass	: kg

PROBLEM DATA
mitsu_qc1el-30-7.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
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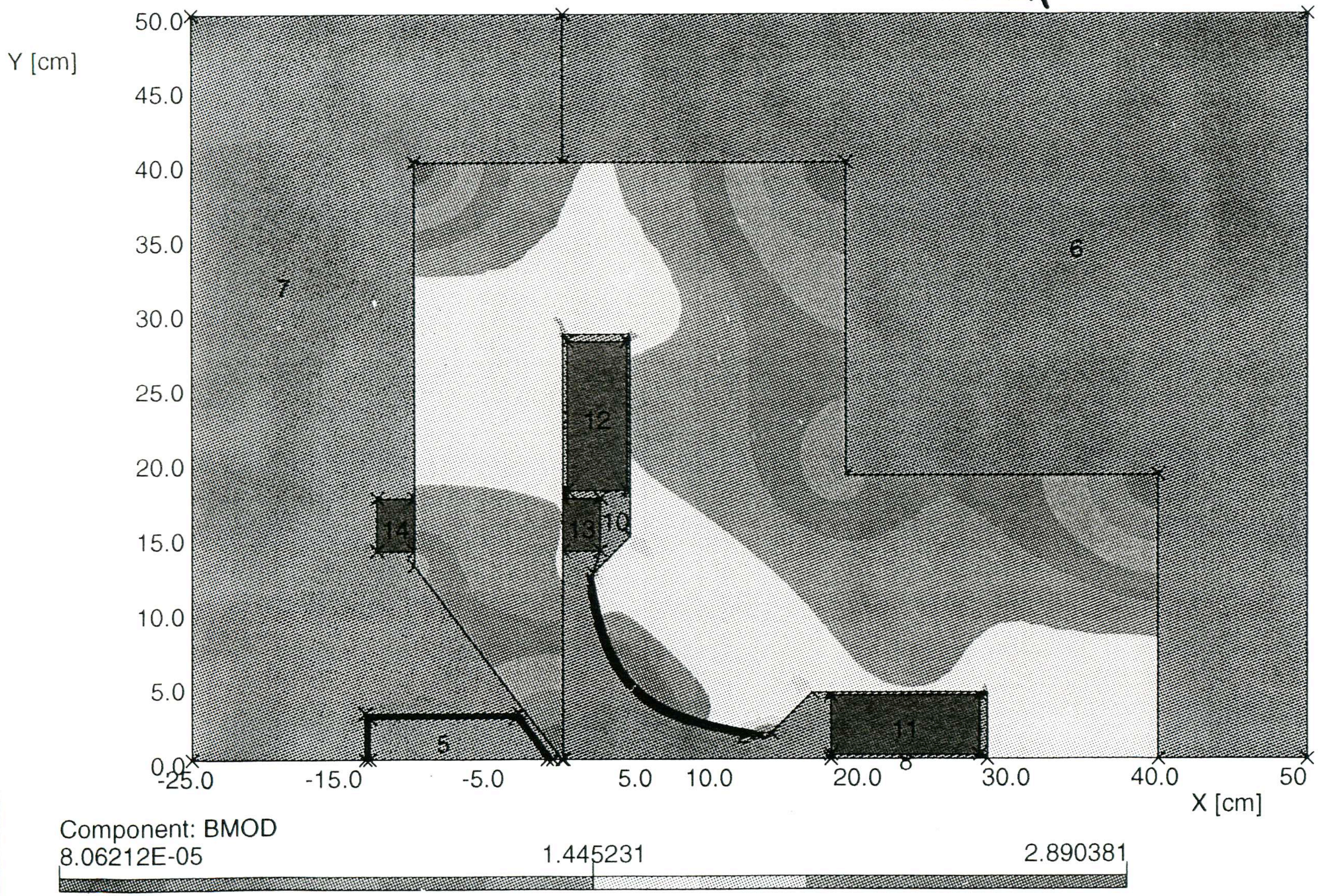
19167 nodes
30 regions

17/Jan/97 15:34:58 Page 6

OPERA-2d
Pre and Post-Processor 1.6

QC1ER



UNITS

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Flux density	: T
Field strength	: A m^{-1}
Potential	: Wb m^{-1}
Conductivity	: S m^{-1}
Source density	: A cm^{-2}
Power	: W
Force	: N
Energy	: J
Mass	: kg

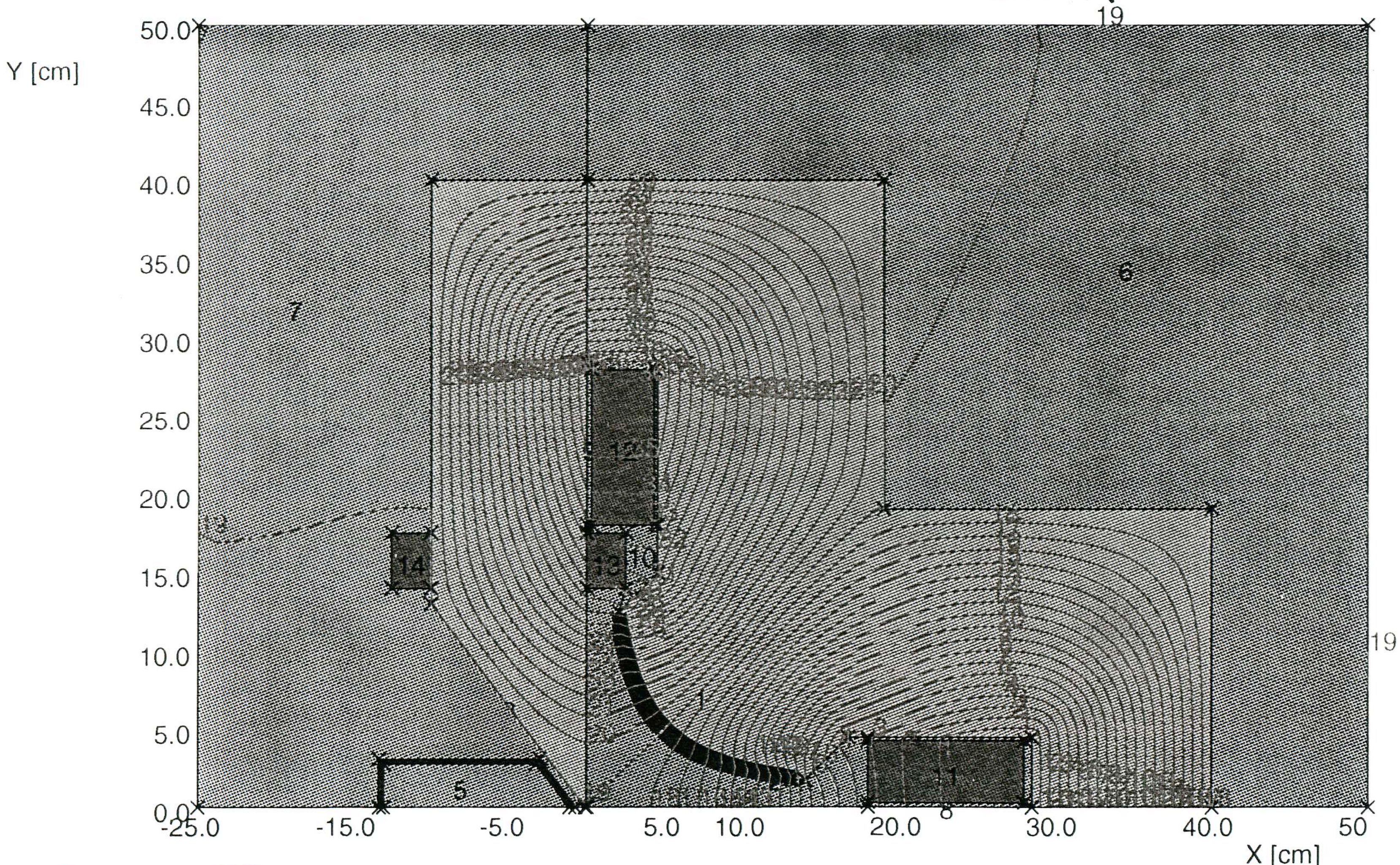
PROBLEM DATA

mitsu_qc1er-6-3.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
14237 elements
28694 nodes
14 regions

16/Dec/96 14:32:36 Page 3

OPERA-2d
Pre and Post-Processor 1.6

QC1ER



Component: POT
Minimum: -0.18, Maximum: 0.17, Interval: 0.01

UNITS

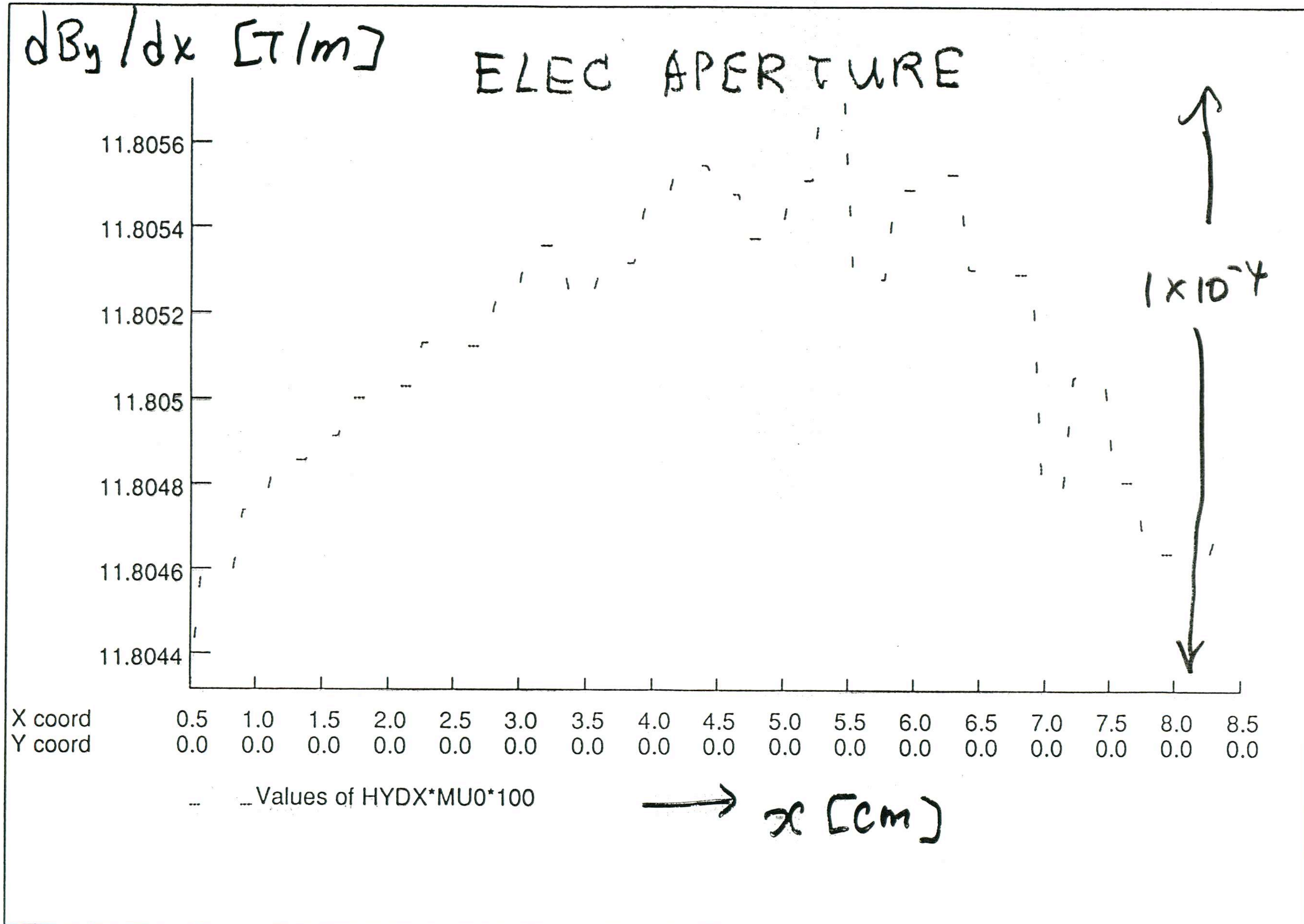
Length	: cm
Flux density	: T
Field strength	: A m⁻¹
Potential	: Wb m⁻¹
Conductivity	: S m⁻¹
Source density	: A cm⁻²
Power	: W
Force	: N
Energy	: J
Mass	: kg

PROBLEM DATA
mitsu_qc1er-6-3.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
14237 elements
28694 nodes
14 regions

16/Dec/96 14:38:00 Page 5

OPERA-2d
Pre and Post-Processor 1.6

QC1RE



UNITS

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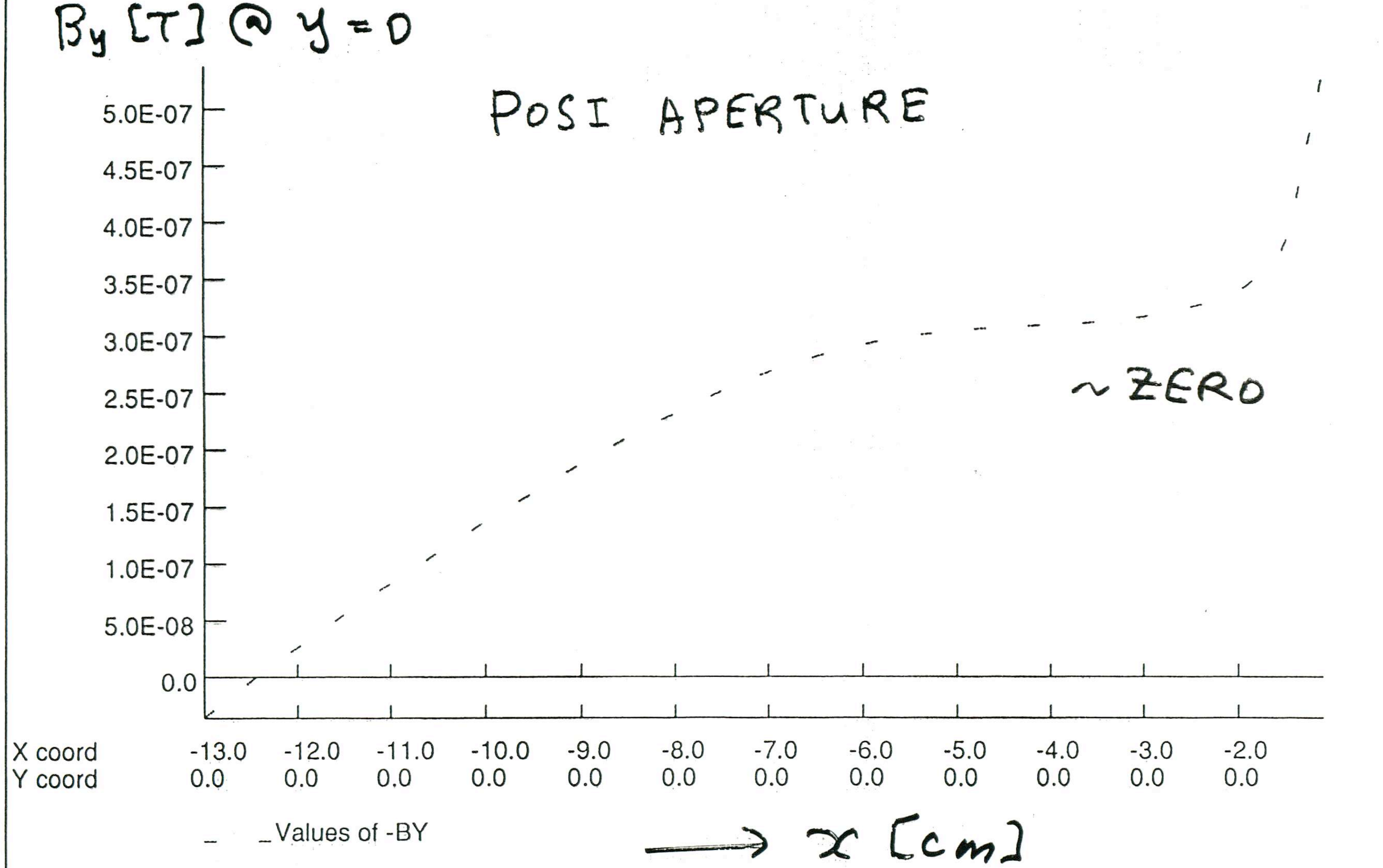
Flux density	: T
Field strength	: A m^{-1}
Potential	: Wb m^{-1}
Conductivity	: S m^{-1}
Source density	: A cm^{-2}
Power	: W
Force	: N
Energy	: J
Mass	: kg

PROBLEM DATA
mitsu_qc1er-6-3.st
Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
14237 elements
28694 nodes
14 regions

16/Dec/96 14:39:42 Page 6

VF OPERA-2d
Pre and Post-Processor 1.6

QC1RE



UNITS

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Flux density	: T
Field strength	: A m^{-1}
Potential	: Wb m^{-1}
Conductivity	: S m^{-1}
Source density	: A cm^{-2}
Power	: W
Force	: N
Energy	: J
Mass	: kg

PROBLEM DATA
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Quadratic elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Scale factor = 1.0
14237 elements
28694 nodes
14 regions

17/Jan/97 13:03:21 Page 9

OPERA-2d
Pre and Post-Processor 1.6

QC1/2 Magnet Support with Active Movers

- QCS - QC1 - QC2 are held by a moveable-table + support structure. The table has "a single set adjustment" for its x / y / roll / yaw / pitch adjustment.

  So with this method, all these magnets move together.

- Besides above, QCS will have trim dipole windings to shift its center (effectively ~ by +/– 2 mm)

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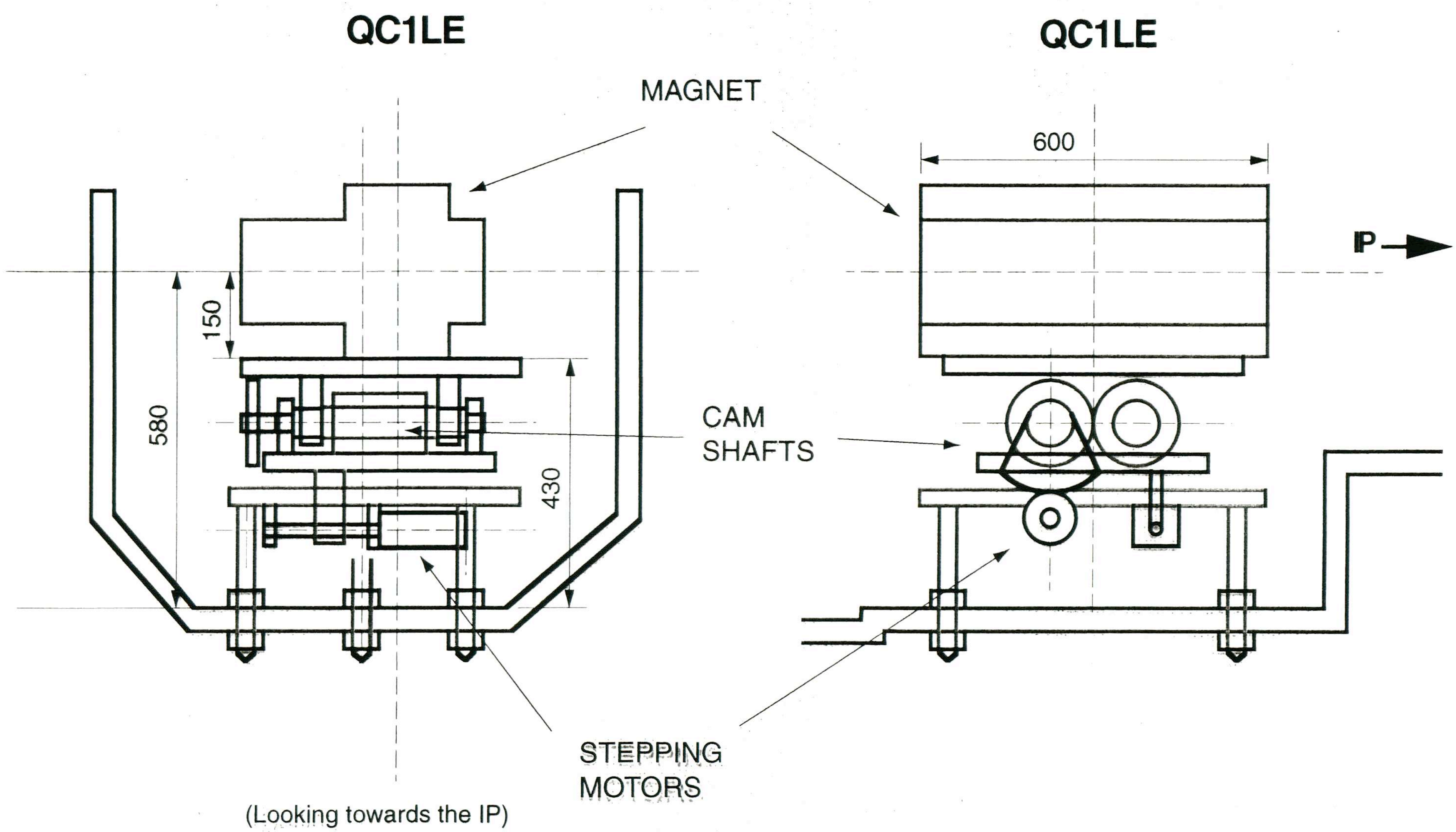
- QC1 and QC2 magnets (six of them in total) will have individual active magnet movers, with two degrees of freedom, horiz and vert.
- Will use cam-shaft mechanism driven by stepping motors.
- Engineering design is in progress.
- +/– 2 mm stroke
- Setting accuracy < 10 μm
- Implement these within the QCS - QC1 / 2 support structure
- No active movers for roll adjustment. Will need to do it by hand.



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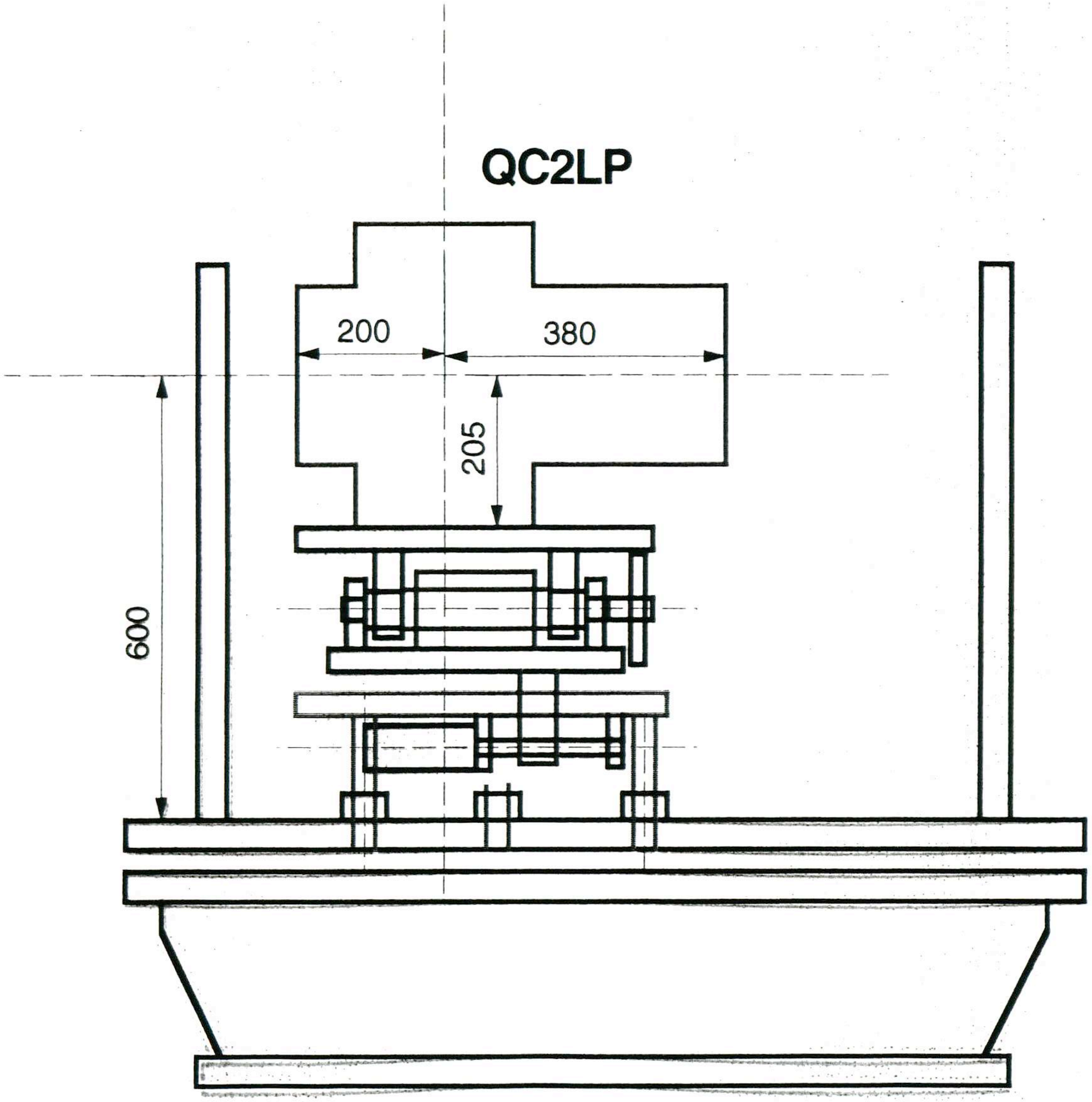
Jan. 17, 1997 K.S.



Looking towards the IP

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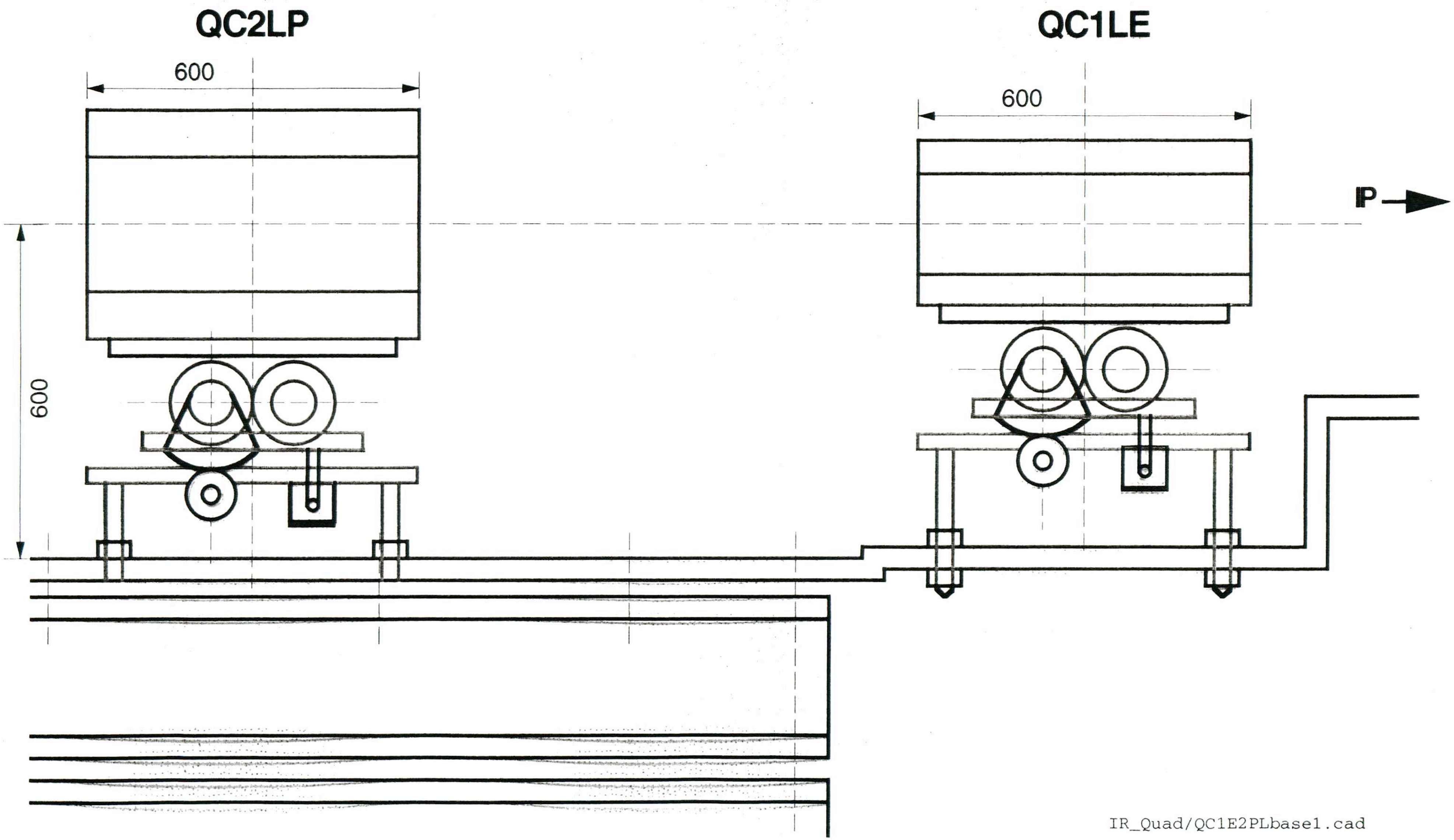
Jan. 17, 1997 K.S.



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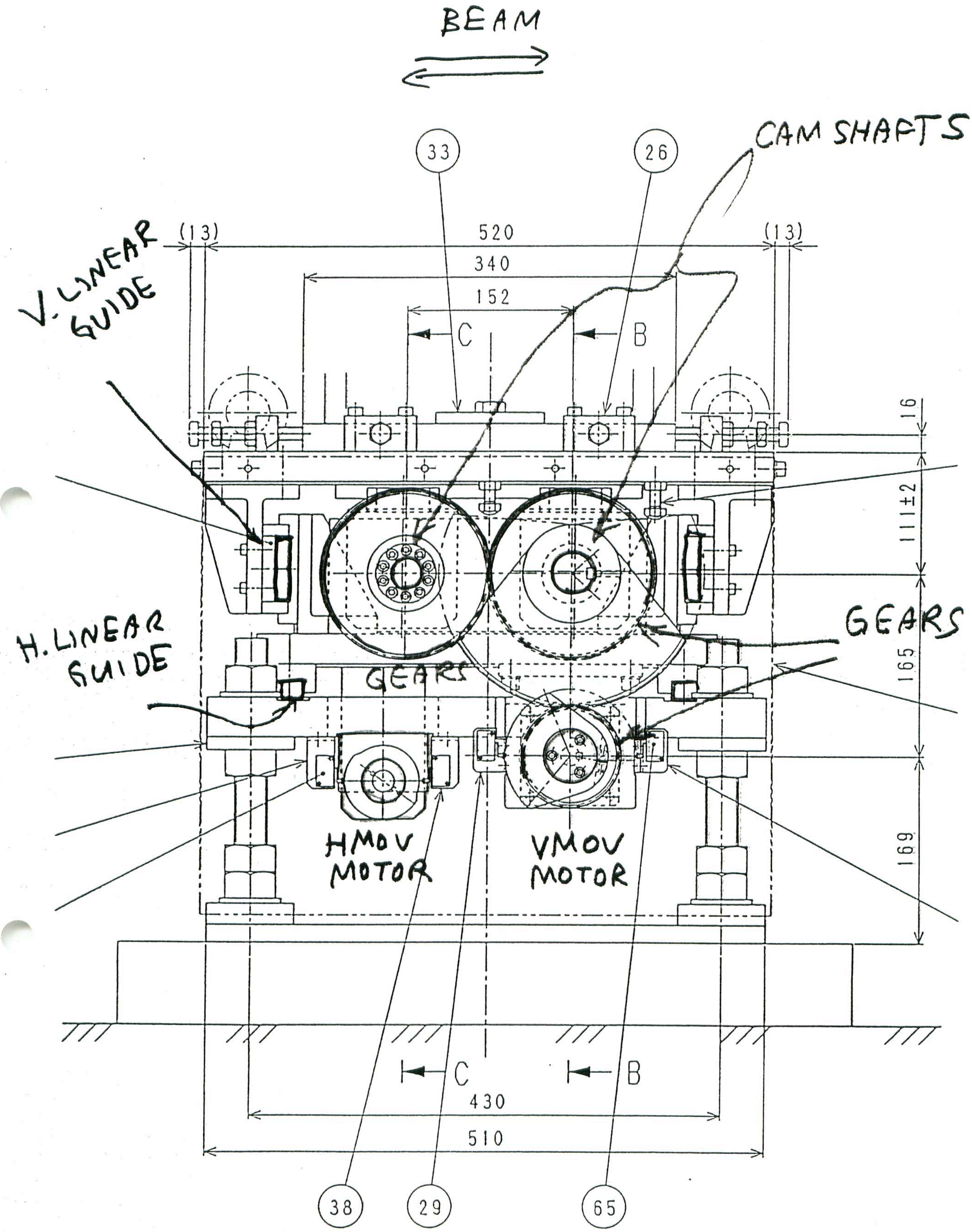
Jan. 17, 1997 K.S.



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V. LINEAR GUIDE
H. LINEAR GUIDE
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HMOV MOTOR
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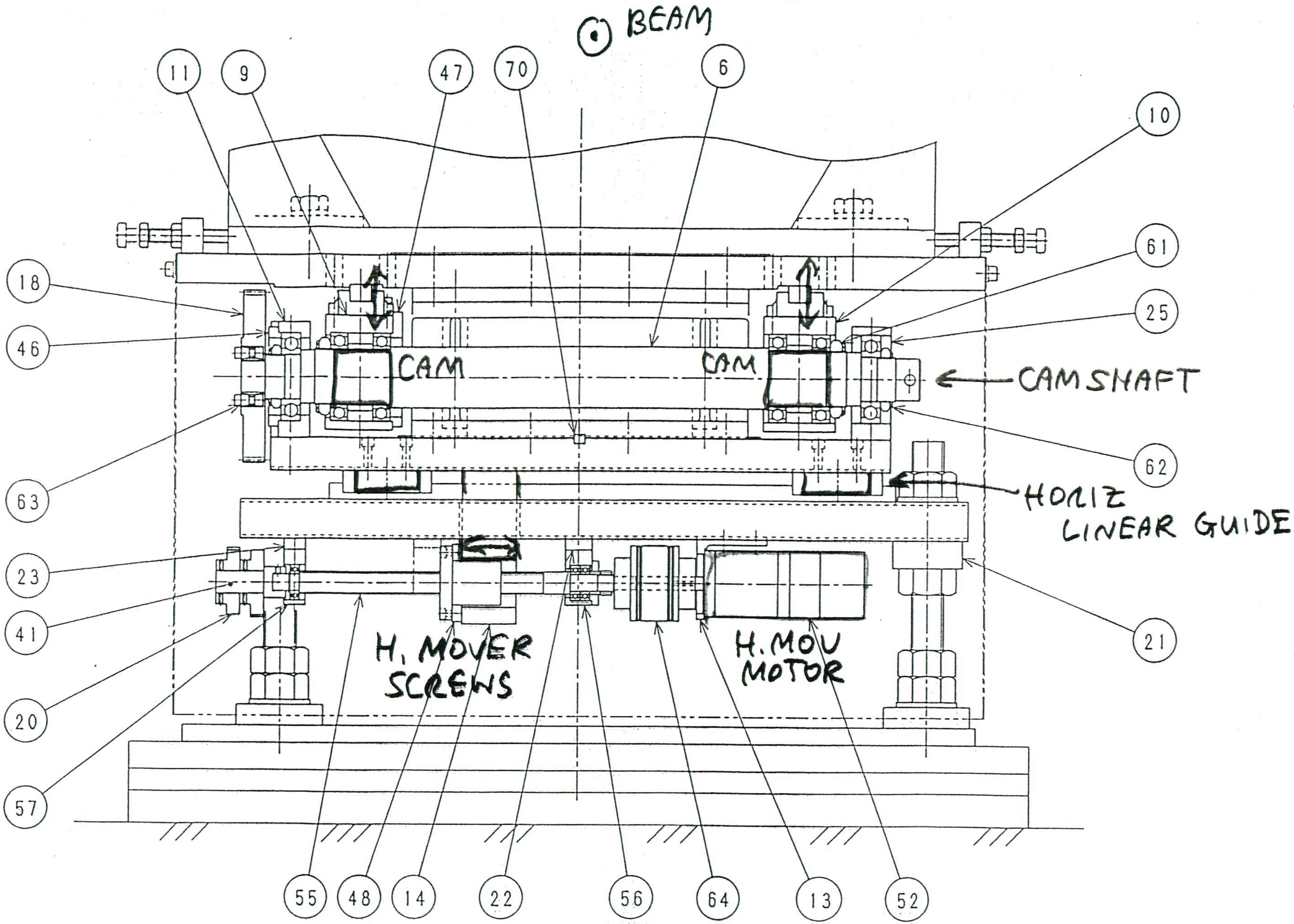
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