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To Honda

Magneticfield Technology

Unit-1

Reported by SST

Jul-99

Electromagnetic interference (EMI)

Semiconductor circuit has progressively been integrated to higher level and function and now the age of mass production of 256 M DRAM has been ushered in with an experimental model of 1 G DRAM introduced.

The technique of higher integration of circuits is supported by instruments of applied electron beam. The electron beam lithograph is indispensable in the mass and test production of masks and devices. The electron microscope is widely used for evaluation of wafer process as well as defects and also for measuring length.

Equipment of applied electron beam plays an indispensable role in minute fabrication and checking. However, as the electron beam is liable to be deflected by magnetic field, it has a weak point of being disturbed by environmental magnetic interference. In the factory there are inevitably found many items of equipment furnished with magnets and large power source. Because of terrestrial magnetism, movement of magnetic bodies such as trucks and rolling stock causes fluctuant deflection in the magnetic field. Our magnetic environments are getting yearly worse with increasing cases where satisfactory performance of equipment is much deterred.

Fluctuant magnetic fields and allowance given for items of equipment are summarized below:

(1) Intensity of magnetic field (magnetic flux density)

Following figure shows magnetic fields and their flux density:

Bio-magnetic field Interplanet magnetic field Magnetically shielded vessel

Stratosphere magnetic field Flux gate magnetometer Terrestrial magnetic field

Proton magnetometer Light pumping magnetometer Air core solenoid

Super conducting magnet Permanent magnet Hole element magnetometer

Strong magnetic resonance magnetometer Normal magnetic resonance magnetometer

(2) Magnetic field fluctuation

Fluctuant magnetic fields may be roughly divided into following four categories:

1. Fluctuation of terrestrial magnetic field caused by movement of magnetic objects such as rolling stock, trucks, movement stages within equipment, fluctuation of electric current in DC line such as trolley line of cars.
2. Fluctuation of DC electric current such as trolley line of cars.
3. Leakage of magnetic field from AC electric line of commercial frequencies.
4. Electric furnace, magnet consuming a great amount of current such as ion injector, etcher, etc.

Their magnetic flux densities are:

1. In case of a magnetic object moving in the terrestrial magnetic field, such as a motor

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Jul-99

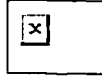
FFT analyzer(portable)	Ono Sokki	CF-350Z
data recorder	TEAC	CF-250
data recorder	TEAC	RD-130TE
data recorder	SONY	RD-135T
		PC-208A
Noise and Sound Pressure Level per JIS-A-1417		
sound level meter	Rion	NA-27
sound level meter	Rion	NA-60
octave unit	Rion	NX-01
noise generater	Rion	SF-05
FFT analyzer	Ono Sokki	CF-350B
FFT analyzer	Ono Sokki	CF-350Z
FFT analyzer(portable)	Ono Sokki	CF-250

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Mesuring Equipment and Applications

equipment	manufacturer	model
Magnetic Field Measurement :		
gaussmeter	MTI	HM-310N
gaussmeter	Bartington Instruments	Mag-03SCU
probe	Bartington Instruments	Mag-03IE
Electromagnetic Field Intensity & Shielding Effeciveness per MIL-STD-285		
spectrum analyzer	Hewlett Packard	8591A
antenna	EMCO	3305
antenna	EMCO	6505
antenna	EMCO	3108
antenna	EMCO	3146
Vibration		
charge amplifier	B & K	TYPE2635
accelerometer	B & K	TYPE4378
vibration processor	Shindo Giken	UPS-S1
vibration processor	Shindo Giken	UPS-S2
vibration processor	Tokkyokiki	MG-102S/OSP-06
FFT analyzer	Ono Sokki	CF-350B
FFT analyzer	Ono Sokki	CF-2507

by trial and error.



As it is difficult to find the cause of defect, implementation of counter measures is either delayed or the matter is left unsolved if the frequency of trouble occurrence lessens. This further leads to less product yield (product management), decreasing production efficiency and increasing production cost. In short, as it takes time to determine the cause of the problem, a counter-measure cannot help but be a make-shift.

Survey and Counter-Measure

In order to look into the cause of the troubles it is necessary to survey precisely environments surrounding the equipment.

In case of pre-installation, it is necessary to survey environments of the equipment to be installed to see if

installation conditions are satisfied.

Advance Survey of Environments prior to Delivery of Equipment

To secure environmental conditions that allow the normal operation of the equipment it is prerequisite to survey the environments to obtain precise environmental conditions that permit the normal operation.

In case that the conditions are not satisfactory, it is necessary to propose useful counter measures so that satisfactory environments may be secured.

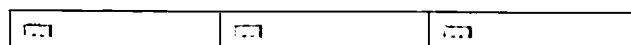
Environmental changes occurring following delivery and installation

Even though necessary environment survey is made to confirm that every condition is satisfactory, it happens that surrounding conditions are constantly changing as a result of a new installation of equipment or a change in the layout. In such a case it is worthwhile to reinvestigate the changes accurately for further analysis and determine promptly to take remedial steps.

EMC Inc. have been closely working with equipment manufacturers and semiconductor manufacturers to conduct environmental surveys in their facilities.

We are ready to cooperate with you on request to check your environments.

This is the only way to build up precious knowhow.



Ultra high tension power line of the electric company and high tension power line in the factory compound.

- Line noises

Inverter lines, high frequency hearth, high frequency generator, discharge equipment.

DISCUSSION

Following two points are of utmost importance as measures for satisfactory operation of each item of equipment.

Environmental conditions to secure accuracy in each item of equipment → Prevent deviation from accuracy

Straighten out the building, air-conditioning system (environment of equipment system) to satisfy the conditions of equipment layout.

Environmental conditions to secure the normal operation during the equipment running → Prevent abnormal operation of equipment.

Try to protect against any interference by equipment installed subsequent to the previously installed equipment.

Secure a steady supply of clean power, water and air.

Only when all these conditions are satisfied, you get the equipment running continually and steadily. For this it is essential at the time of initial structure designing, prior to the delivery of equipment into the factory, and even while the equipment is already in operation that discussions and studies for counter-measures be made.

At the time of structural designing

Faulty Precision

- Designing Stage Structure design, study of anti-vibration while in furnishing designing, study of equipment lay-out.
- Construction Stage Execution of antivibration system, magnetically sealed chambers, etc.
- Post Construction Stage Individual check and study of each item of equipment

Faults in Operation

While equipment is running

- Faulty operation factors as above caused by environmental changes following equipment installation (such as in magnetic field, vibration, line noise, acoustic noise, etc.) and their counter-measures.

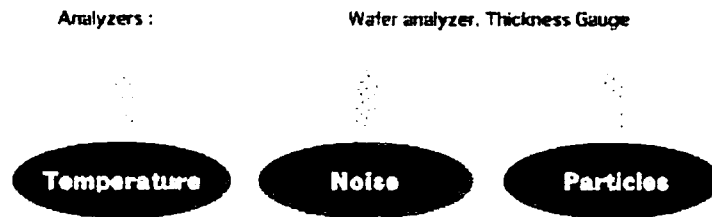
Prevent defective material qualities.

Counter-measures to prevent defective operation of equipment.

Current Status of Counter Measures against Troubles

Under this category comes the emergence of problems resulting from irregular operation of equipment and generation of defects in end products.

Irregularities are only found at the final product inspection, and it is extremely complicated to determine the cause of the defect, leading inevitably to haphazard solution



Exterior factors causing environmental problems

Mentioned below are factors causing imperfect operation of high precision equipment leading to defective finished goods.

• Vibration & Noise

Constant minute vibration of the ground, traffic vibration, air-conditioning equipment vibration and noise in the building, acoustic noise, vibration and noises by machine tools and processing machines.

• Magnetic Field

1. Direct Current

<Ground Magnetism>

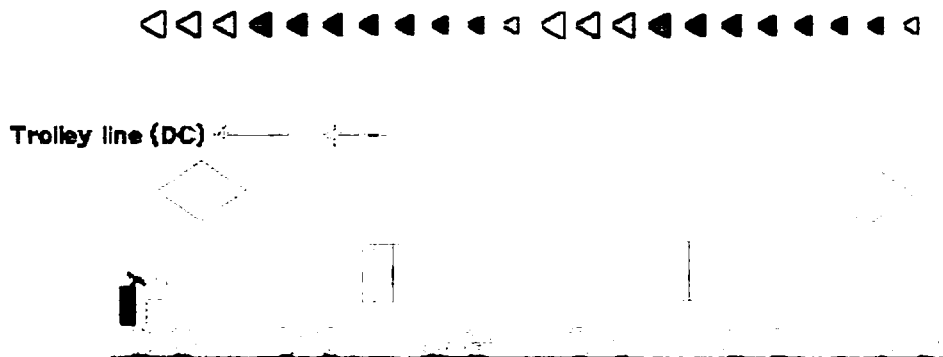
Movement of surrounding stages (steppers, inspecting equipment, etc.), magnetic bodies (elevators, rolling stocks, trolleys, etc.)

<Direct Current Power Source>

Equipment with direct current power source, magnet (electromagnet, permanent magnet) inside.

<Railway Trolley Line>

Trolley line (DC) of JR & private railways

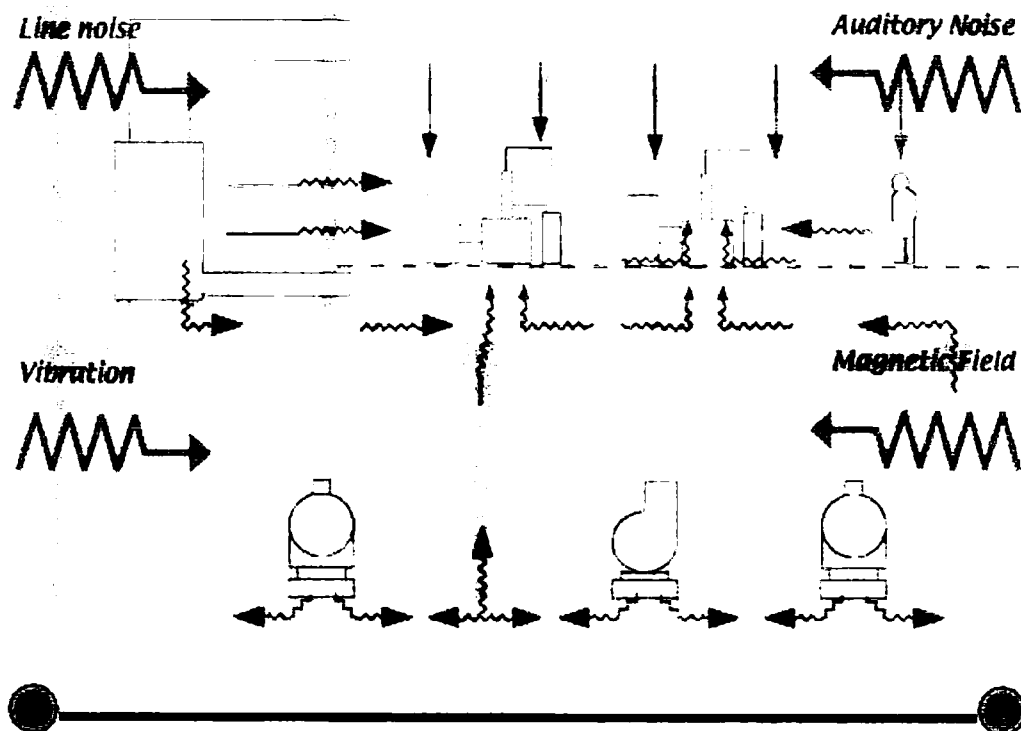


2. AC Magnetic Field

<Equipment power source>

Electric power lines in the vicinity of equipment including air-conditioning units.

<Power Lines>



- Equipment that generates vibration and magnetic field fluctuation while in operation
(example: ion implant, etcher, sputter, etc.)
- Equipment that generates vibration and is susceptible to the self generated vibration
(example: stepper, prober, etc.)
- Equipment susceptible to environments
(example: electro-magnifier, EB lithograph, laser lithogrtaph, wafer inspection unit, process evaluation unit, etc.)

CURRENT STATUS OF ENVIRONMENTAL CONDITIONS

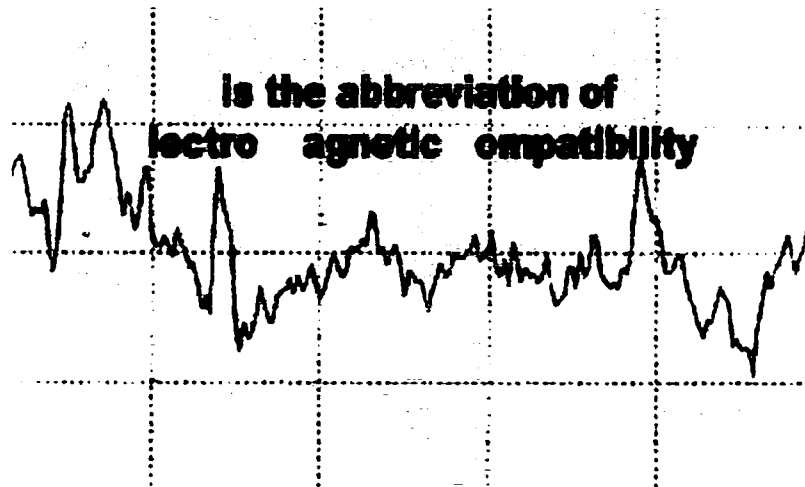
The extent of precision required for manufacturing and inspection of LSI is less than 1 micron meter, i.e., in the order of 0.1 micron meter. To attain to such a degree pf precision highly strict conditions must be met with. Prior to the building construction, the interior environments including the structural form, temperature, cleanliness of air and vibration must be studied. Though structure, air-conditioning system, floor vibration and power lines, etc. are well studies beforehand, the speed of equipment development is often so fast that the interior conditions of the building happens to lag behind, resulting in the insufficient realization of precision function. Therefore, items of equipment delivered into the building are often laid out in quite a haphazard manner. Such instances are as follows.



Inspection and Manufacturing of High Performance Semi-Conductors

Inspection equipment : SEM, Defect Inspection Unit, IC Tester
Process Evaluating Unit.

Manufacturing, Processing Units : EB lithograph, Stepper, Sputter,
Ion Implant, Laser Marker, Mounter.



The play on the stage is, so to speak, the ceaseless progress in increasingly large scale of semiconductor integration. It's our pride to participate in this great drama by furnishing technological properties on this stage.

We are always ready to cooperate with owners and solve problems arising in precision facilities where precision faults or system malfunction may be encountered due to deficient quality.

It's quite normal that in the immediate vicinities of your facilities there often full of magnetic noises detrimental to the normal performance of your equipment.

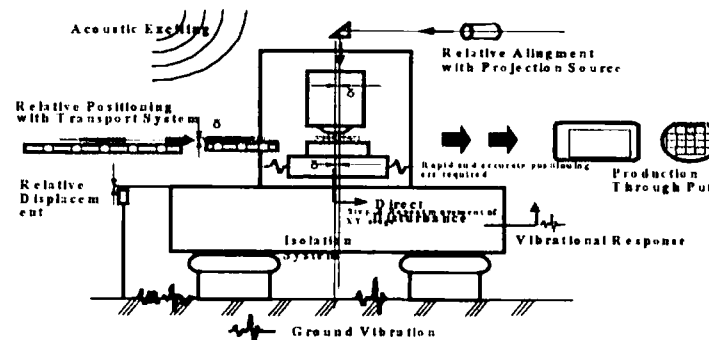
EMC Inc. is ready to perform an environmental survey of your installation and offer counter measures to eliminate the noise problems.

Please don't hesitate to contact EMC Inc., your best trouble shooter.

Let us consider a few examples of hazardous noises existing around your installation, disrupting the normal operation of precision function with semiconductor plant for an example.



◆ Micro-vibration Monitor MVM-06X



It can monitor volume of input disturbance as 'estimated weight' by adding certain weight in accordance with allowable vibration performance for the precision apparatus.

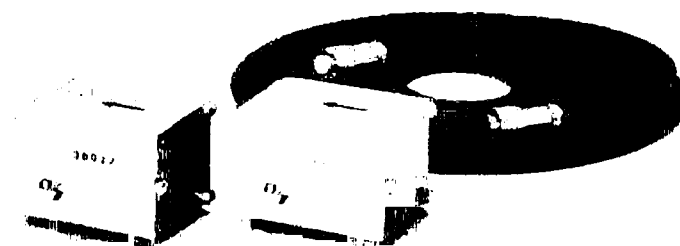
It can also extract through monitor for the disturbance vibration which exceeds allowable value established.

◆ Microvibration Generator System

- Creating of microvibration less than 0.1Gal without wave distortion
- Creating of target wave from floor vibration
- Confirming of microvibration sensitivity for the precision apparatus

◆ Micro Accelerometer MG-102S

Specifications : Dimension : 40 x 50 x 50mm
 Maximum Input : $\pm 3 \text{ G}$
 Sensitivity : 3V/G
 Resolution : $5 \times 10^{-6} \text{ G}$
 Frequency Range : DC $\sim 400 \text{ Hz}$
 Zero-point Unbalance : 0.02G
 Cross-talk : 1/1000
 Power : 15V, 18mA
 Weight : 160g



◆ Options

◆ Micro-Vibration Measuring Instrument MMI-06X

Main Features :

- No of measuring channels : 6ch
- Output change for acceleration, velocity displacement
- 4 step switches for low pass filter

◆ Micro-Vibrometer OSP-06

Specifications : Frequency Range : Acce ---- 0.1 ~ 400Hz

Vel ---- 0.3 ~ 100Hz

Disp ---- 0.3 ~ 100Hz

Measuring Range : 40, 50, 60, 70, 80, 90, 100, 110, 120dB

Acce 60dB = 1Gal/V

Vel 60dB = 1mm/s/V

Disp 60dB = 0.1mm/V

Signal Output : $\pm 10V/\max$

Low-pass Filter : 50, 100, 200, 400Hz

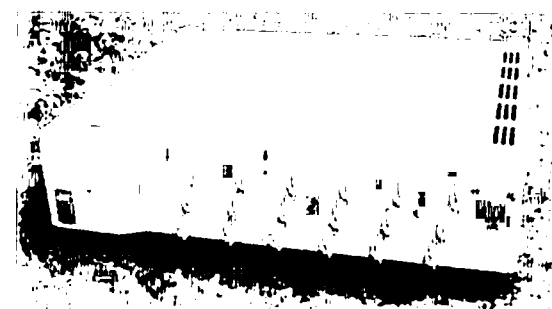
Weight : 4.5Kgs

Dimension : 335 x 275 x 60mm

Power Supply : AC Supply

85 ~ 265V.AC (47~440Hz)

110 ~ 240VDC



◆ Applications

- Stepper
- EB
- Laser Trimmers
- Crystal Growing Puller
- Furnace
- Mask Aligner
- Defective Inspection Machines :
 - Mask Inspection Machines
 - Mask/Wafer Repair Machine
 - Scanning Electron Microscope
 - Transmission Electron Microscope
 - Focus Ion Beam Machine
 - Atomic Force Microscope
 - Scanning Tunneling Microscope
- Other Precision Instruments

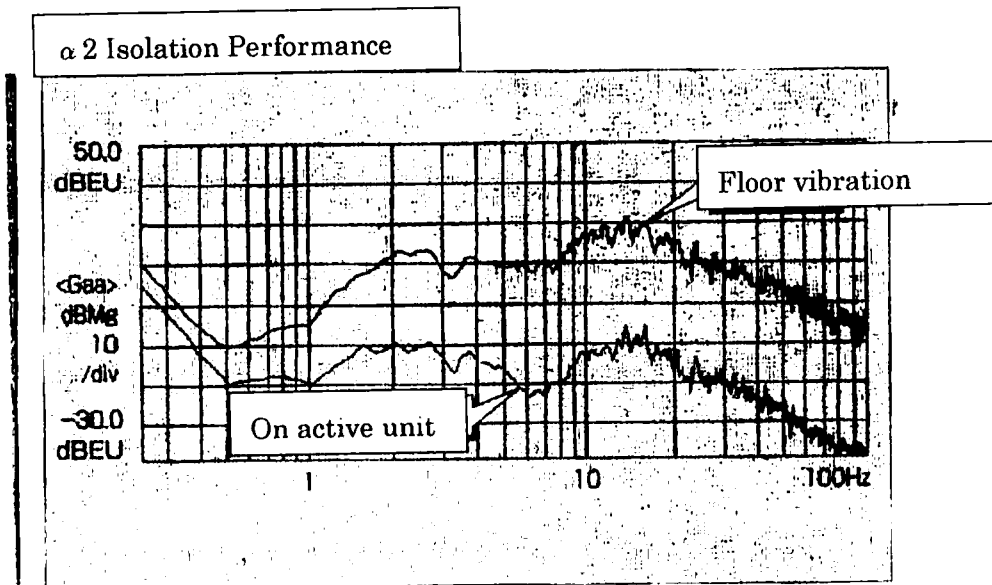
◆ α 2 Sister Series

Hybrid Active Actuator Unit α P and α L

Actuator	α P	α L
Vertical direction	Pneumatic	Pneumatic
Horizontal direction	Piezo	Liner



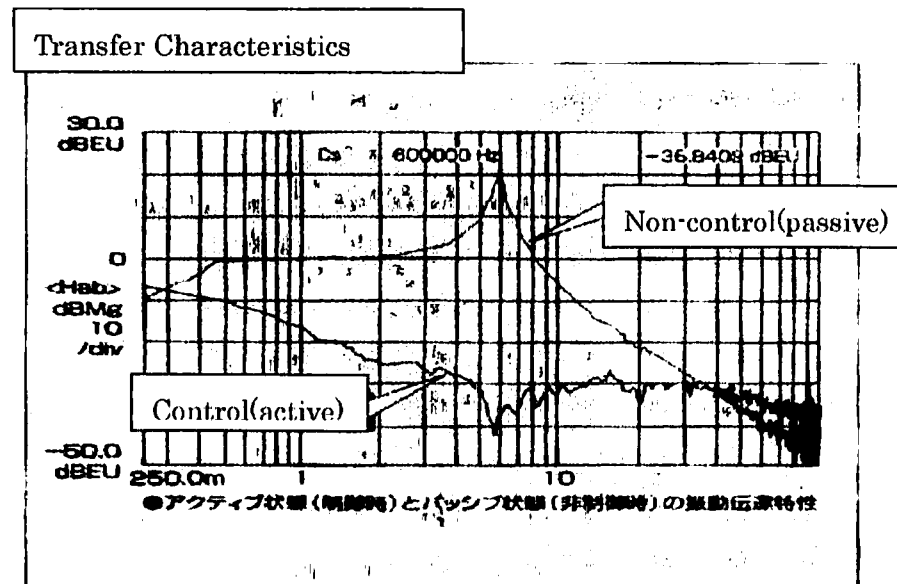
◆ Isolation Performance



◆ Specifications

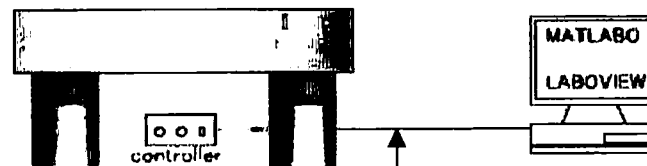
Model	α 2-100	α 2-140	α 2-200	α 2-400	α 2-600
Payload Weight (1 set/4 units)	~800kgs	~1600kgs	~3300kgs	~6000kgs	~8800kgs
Dimension/unit	215x180x170	215x180x170	328x306x170	339x316x200	339x316x230
Weight/unit	8kgs	14kgs	22kgs	28kgs	33kgs
Controller Dimension	184x250x82(mm)				

◆ Transfer Characteristics



◆ Smart

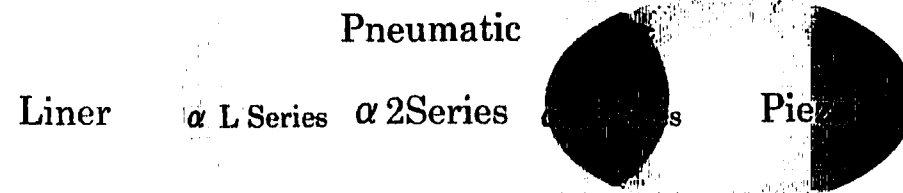
- Easy digitalization and best solution for several control theory and technology such kind of Double Active Model Matching · H^∞
- Back-up of vibration analysis through real-time connecting with the control data and MATLAB · LABVIEW



Double Active Model Matching · H^∞

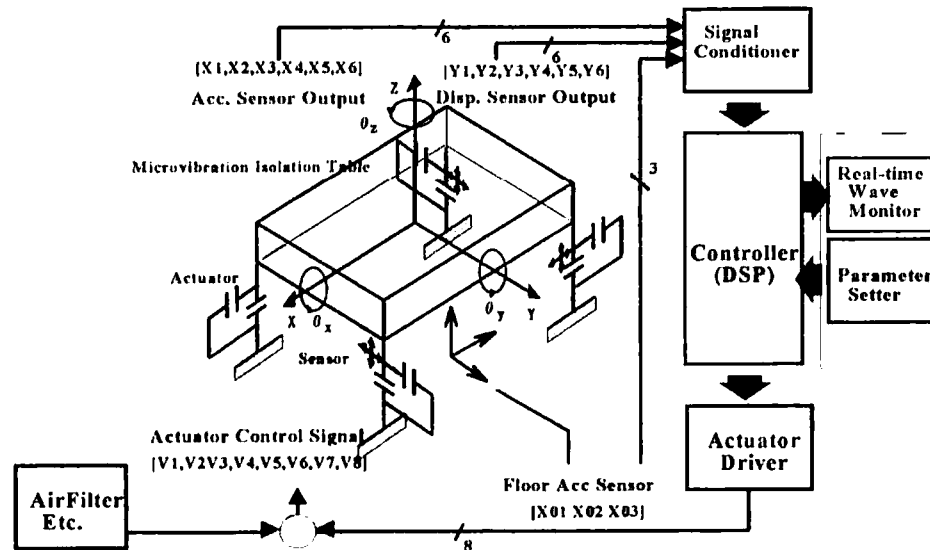
◆ Satisfy

- Offering of up-dated actuator technology (αP , αL) suitable for any kind applications
- Offering of the most advanced processing tool and platform for the micro vibration control technology such as micro vibration generator, micro vibration monitoring system and measuring system.



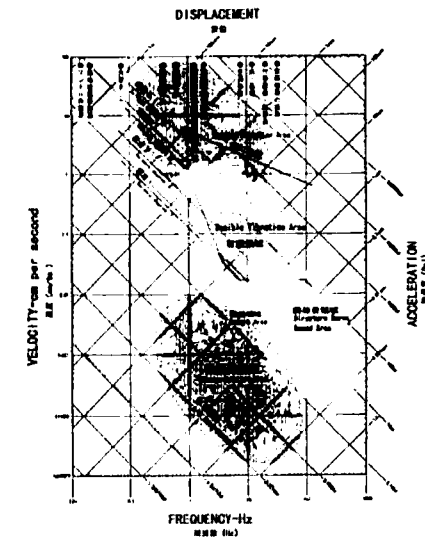
◆ Skillful

- Corresponding to coordinate transformation and frequency shape
- Mode separation of coordinate transformation
- Easy correspondence and best solution against any kind of control object and disturbance through certain digital frequency shape



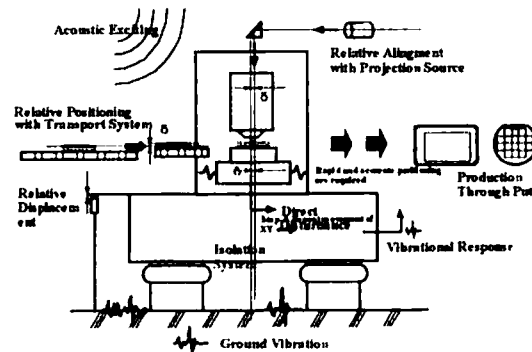
◆ Still

- No transmission from floor vibration and low acceleration
- Creation of environment for ultra-micro vibration
- Offering of cost reduction providing with stand-alone system of the fundamental environment indispensable for the ultra precise process



◆ Steady

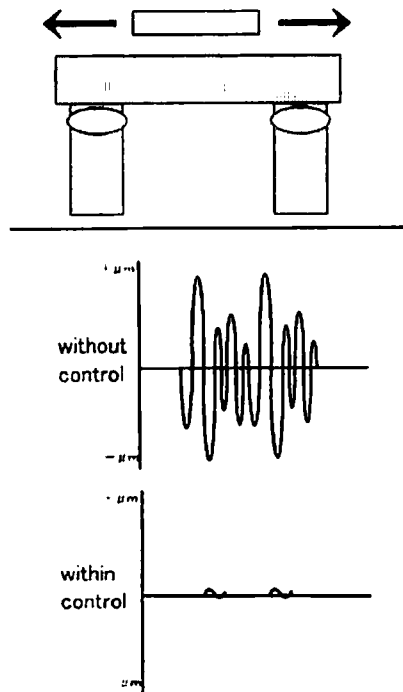
- Maintaining of posture and position, and low compliance
- Immediate response against movement of center for the apparatus
- Maintaining of relative coordinate is key issue for the line system of next generation



Philosophy of $\alpha 2$ consists of six 'S' :

◆ Speedy

- No excess vibration and smaller primal movement
- Absorption of the dynamics to the stage immediately
- Cancellation by control technology for trade-off of the throughput and precisely



<Solution of Vibration Issue for High Sensitive Apparatus>

The world's most advanced isolation and vibration control system ----- α 2

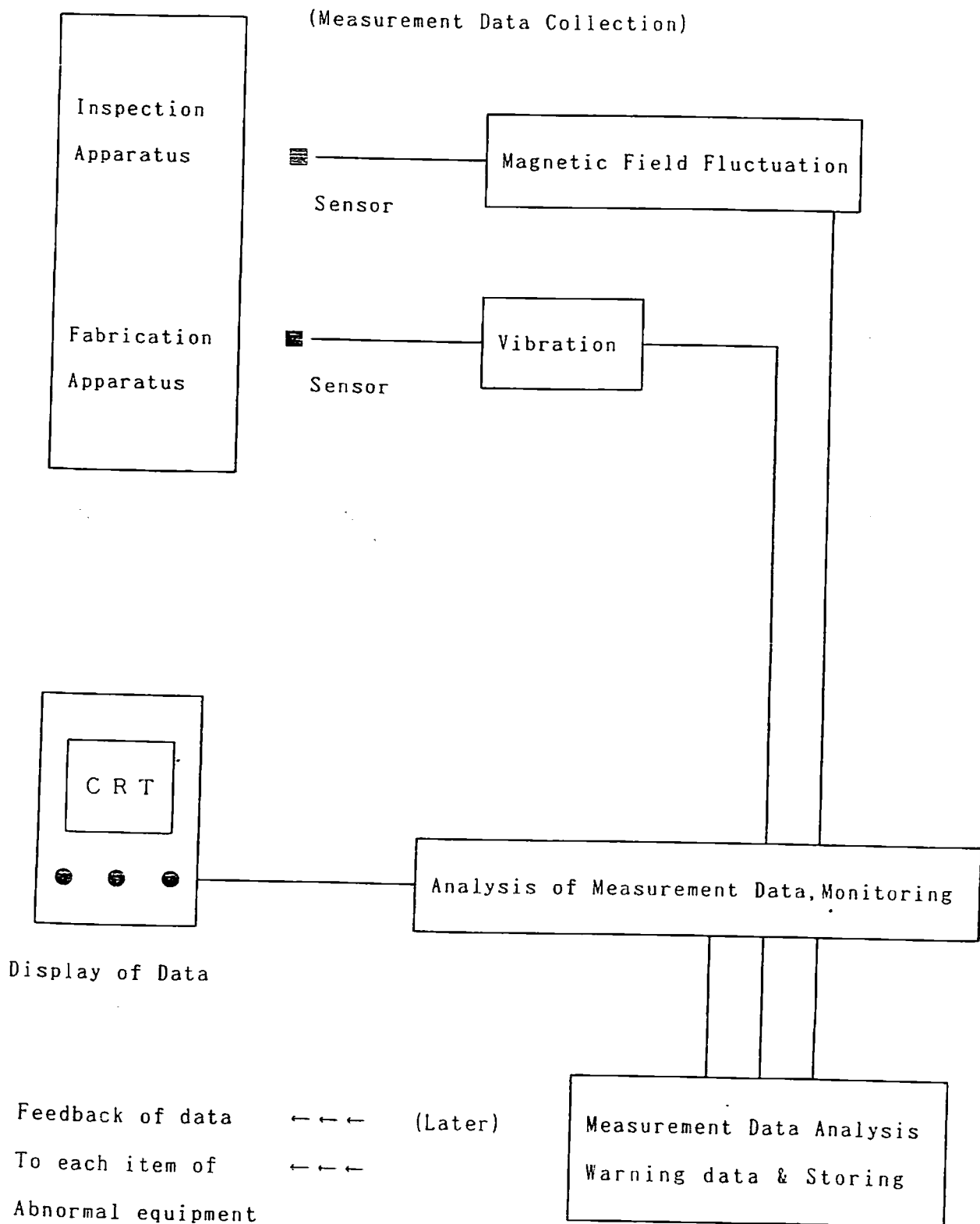
α Series has Pneumatic Active Control with input-output function of 2 axes in compact

α Series makes positioning control and vibration control simultaneously



ENVIRONMENT MONITORIN SYSTEM

○ System Block Diagram



SPECIFICATIONS OF APPARATUS AND SYSTEM

1. Precision Vibration Measuring Instrument

Measuring Range	Acceleration	0.1-400 Hz
	Velocity	0.1-400 Hz
	Displacement	0.1-400 Hz
Channels		6 ch
Weight		4.5 kg
Electric power		100V 3A

2. Gauss Meter

Range	AC, DC (0-1kHz)
Channels	3ch
Weight	11kg
Electric Power	110V 1A

3. PC	DELL Optiplex GXI 350M/512K Pentium ii
Monitor	15" Color
HDD	10GB

Circular marks on display are red for better than judging level, yellow for 80%, and green for less than 80%.

It is possible to change the mode of wave form (or wave form plus spectrogram).

2) Spectrogram (Wave form plus spectram) See attached sheets 2 to 4.

3) Recording

Measurement data are analytically judged and when the data exceeds the judgement point, they are stored. The data should be able to be exhibited in a list according to the time and date and channel. See attached sheet 5.

4) Available balance of disc

When the available balance becomes less than 1GB due to many abnormal data files, a warning signal is given as: "Available balance is x x x x Mbyte. Immediately contact, EMC Inc. attention: Mr. Inoue. Tel. 042-326-1846"

5) Reproduction

Recorded data may be reproduced, displayed and processed. See attached sheets 1-3 : Examples of out put displays.

6) Print

Data display can be printed with a printer.

3. Judging conditions

3-1 (magnetic field)

Establish conditions judging whether or not to memorize the wave form of the magnetic field signals.

In case of AC magnetic field

Judging value . Variation of amplitude at preceding 0.4 second.

When the variation exceeds amplitude of variation at preceding 0.4 second proceed to record AC ,XYZ 3 signal data further preceding 0.4 second (1024 points)

3-2 (vibration)

Establish conditions of determination whether to memorize the vibration signal wave form.

Judging value Power spectram value resulting form analysis by FFT(dB)

If the spectram value given by FFT analysis exceeds the judging value, proceed to record the data of 3 XYZ vibration signals during 60 seconds before and 56 seconds after.

4. Measurements

Perform measurements based on conditions determined in section 3.

Continue monitoring until the end of operation. Measurement of 3 diffierent kinds of signals (measurement,processing,recording of judgement and dispaly) simultaneously start.

- DC magnetic field signal
- AC magnetic field signal
- Vibration signal

1) Main monitor

Put the main monitor display on.

Summary of automatic monitoring and analytical system of magnetic field and vibration.

1. This system performs a continuous survey of environment by monitoring the magnetic fluctuation of magnetic field (AC, DC) detrimental to the normal operation of equipment, and also executes an analysis of the data. The system consists of PC, A/D board magnetic field surveying unit with sensor and amplifier. The function is controlled by program for measurement and control stored in the software.

Surveying conditions are set according to instructions on display. Measurements may be conducted according to 6 channels of magnetic signals (AC magnetic field XYZ axes & 2 vibration XYZ axes) for monitoring the data.

The data surveyed and processed are then compared with prescribed allowable values. The data exceeding the allowance are recorded as wrong data together with measurement conditions. The recorded data can be reproduced for exhibit and processing.

2. Functions

The system measures and process magnetic and vibration signals monitoring. Simultaneous with the signals monitoring, the data obtained is analysed, and in the event of the values thus obtained exceeds the pre-set value, wave forms before and after the preset value are stored in the record.

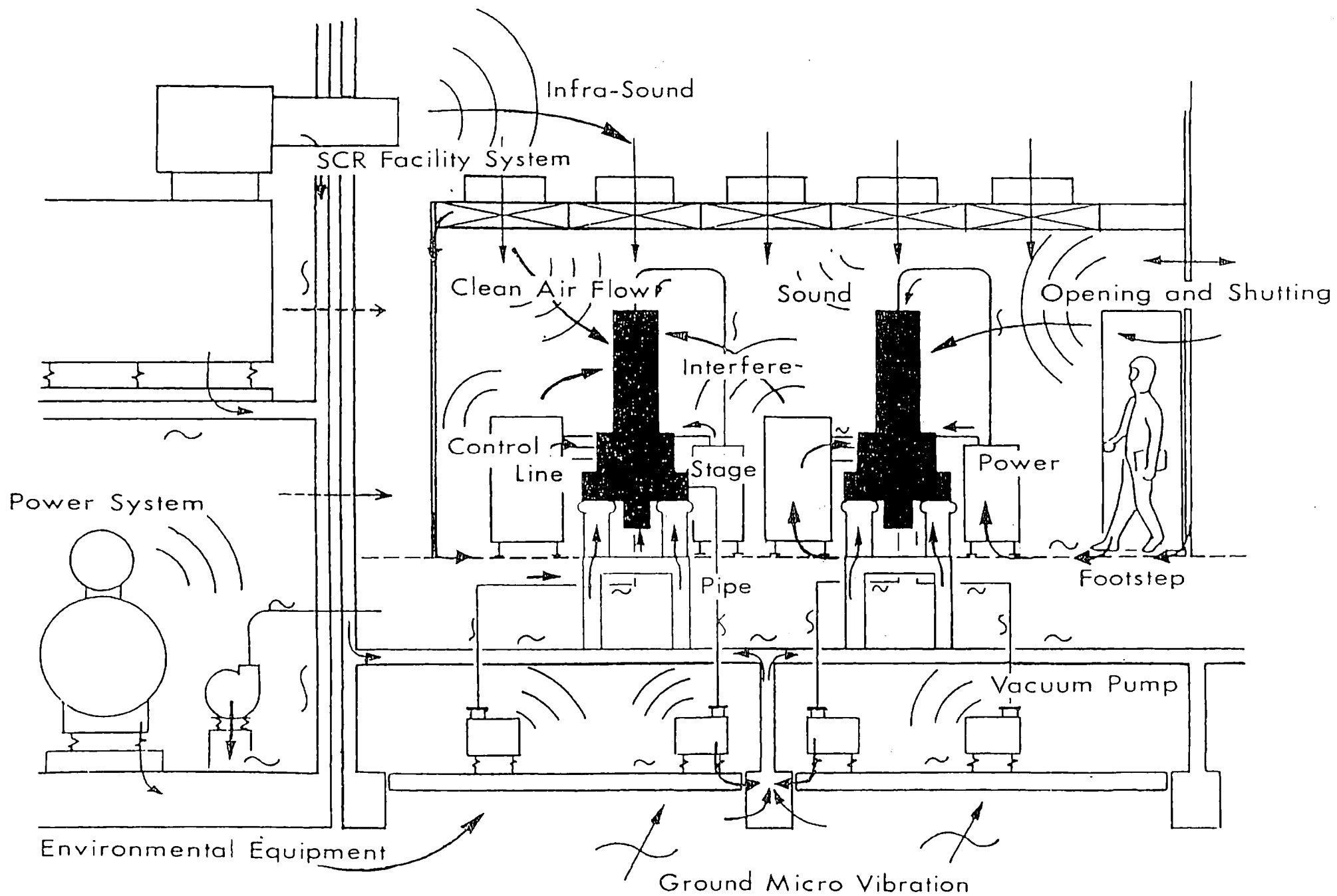
2-1 Input condition

2-1-1 (magnetic field)

Unit:	mGauss fixed	20 Hz
Sampling:	DC magnetic field	20 Hz
	AC magnetic field	2.56 kHz

2-1-2 (vibration)

Unit:	dB fixed (60 dB equal to 1gal)
Sampling:	256 Hz
	Thinned out after digitally filtered at 100 Hz



Measuring Equipment and Applications

1. Magnetic Field Measurement (Hall effect):

<u>equipment</u>	<u>manufacturer</u>	<u>model</u>
gaussmeter	F.W.Bell	640
probe	F.W.Bell	STB4-1802
probe	F.W.Bell	HTB4-0608
probe	F.W.Bell	MOW4-2506
gaussmeter	MTI	HM-310

2. Electromagnetic Field Intensity & Shielding Effectiveness per MIL-STD-285:

<u>equipment</u>	<u>manufacturer</u>	<u>model</u>
spectrum analyzer	Hewlett Packard	8591A
frequency synthesizer	Hewlett Packard	8656B
receiver	Kyoritsu Denshi Kogyo	KNM-402C
antenna	EMCO	3305
antenna	EMCO	6505
antenna	EMCO	3108
antenna	EMCO	3146
antenna	Kyoritsu Denshi Kogyo	KBA-402

3. Vibration:

<u>equipment</u>	<u>manufacturer</u>	<u>model</u>
vibration analyzer	B & K	2635
accelerometer	B & K	4378
vibration analyzer	Shindo Giken	UPS-S1
vibration analyzer	Shindo Giken	UPS-S2
FFT analyzer	Ono Sokki	CF-350B
FFT analyzer	Ono Sokki	CF-250
data recorder	TEAC	RD-135T

4. Noise and Sound Pressure Level per JIS-A-1417:

<u>equipment</u>	<u>manufacturer</u>	<u>model</u>
noise meter	Rion	NA20
noise meter	Rion	NA60
octave unit	Rion	NX01
noise signal generator	Rion	SF05
FFT analyzer	Ono Sokki	CF-350B

A BRIEF SKETCH OF THE COMPANY

Name of company: EMC, Inc.

Location: Head Office:
1-2-14 Minamisemba Chuo-ku
Osaka, Japan

Tokyo Office;
3-10-22 Homchou, Kokubunji
Tokyo, Japan

Board of directors: Hideyuki Yamanaka, managing director

Date founded: March 1972
Date incorporated: July 1986

Capitalized at: ¥10,000,000

Bank accounts maintained at: Tokyo-Mitsubishi Bank, Ltd. Semba Branch
Sanwa Bank, Ltd. Kokubunji Branch

Construction work licence: Osaka prefectural permit No. 73447, Gen-6

Business line: Measuring of electromagnetic waves, magnetic field and auditory noise.

Measuring of vibration.

Consultant of preventive measures of noises and related information service.

Design and construction of anechoic chambers, shielded rooms and magnetic shielded rooms.

Sales of EM absorbent wedges and shield materials.

Sales of active EMI cancellation system.
(Integrated Dynamics Engineering Inc.)

2. To enclose the shielded volume with high permeability metal is the basic rule. Openings must be furnished with doors or lids. Openings for wires and plumbing must be sleeved. As doors are made of magnetic shielding material they must be kept closed while the room is in operation.

3. Problematic frequencies of magnetic shielding are lower than 1kHz and electrically conductive materials are all ineffective. Therefore, magnetic material must be resorted to. In case of electron beam lithograph Permalloy is to be used.

4. It is very effective to limit the enclosed volume to be as small as feasible and it costs less. It is common that the important part of equipment only be placed within the enclosure, leaving controlling parts outside.

5. Magnetic shielding materials tend easily to collect magnetic flux and for this reason magnetic flux coming from internally placed equipment tends to be collected to shielding material, affecting the correct performance of the equipment and it is necessary to determine the configuration of the enclosure so that the position of magnet, etc. be sufficiently off the shielding material.

From the foregoing, it can be said:

1. Highly expensive.
2. Enclosure tends to hinder the easy operation of equipment.

This again leads to the importance of pre-planning to secure good magnetic environment.

It is also noted that recently active EMI cancellation system made up of Helmholtz coils is being introduced. The coils produce magnetic field opposite to magnetic disturbances. This system controls magnetic disturbances effectively and may become widely used in the near future. The application of this system has already been made to electron microscopes, but it will take some more time to verify the stability before becoming popularly used in a factory.

In short, it is of primary importance to study carefully magnetic field intensity, surroundings, budget, etc. before selecting which measures to be employed.

car, etc. 10-20mG magnetic field fluctuation is observed even at a distance of 5 meters.

2. Fluctuation in cities is mostly due to the trolley line. In the vicinity of a railway the intensity often exceeds 1G. In such a case images on computer display are disturbed and colors blurred. Even at a distance of 1 km, 1 - 2mG fluctuation is experienced.

3. AC magnetic field of 50/60Hz. leaks from a power line system in a factory compound. It is a common practice for two-way wires in which current flows to and fro to be bundled and twisted circuit by circuit to cancel mutual magnetic disturbances, keeping the leakage of magnetic field at a minimum. It is commonly assumed that there exists AC magnetic field of 1 to 3mG in a clean room even though there is no equipment installed in the neighborhood.

4. In case of ion injection, though fluctuant magnetic field intensity varies depending on individual equipment, fluctuation of 3 to 5mG is observed.

(3) Allowance of fluctuating magnetic field for electron beam lithography

Deflection of ion beam caused by fluctuating magnetic field directly affects accuracy of imaging. Currently, fluctuation less than 1-2mG is accepted as satisfactory, but the allowance is expected to become more rigidly specified in future. Especially, care should be exercised in case of mask production, as it takes longer time for lithographic operation.

In case of electron microscope, allowance given is generally less than 2 to 3mG, though it depends on magnification, accelerating voltage, etc.

To cope with these disturbances "magnetic shielding technics" plays an indispensable role.

(4) Magnetic shielding measures

It is a common practice to enclose the volume of space with metal sheet of high permeability. External magnetic flux flows toward along material having lower magnetic resistance but high specific permeability. Followings are magnetic shielding materials:

1. Soft (pure) iron
2. Silicon steel
3. Permalloy

The listed materials are commonly utilized. As the optimal magnetic characteristics must correspond to the peak of surrounding magnetic field, for the shielding of intense magnetic field, say in excess of 10G, magnetic soft iron or silicon steel is employed. Whereas, for weak magnetic surroundings Permalloy is the best.

The shielding measure for electron beam lithograph calls for the order of several milliGauss and so Permalloy best suited for low intensity field is most effective.

Basic ideas of magnetic shielding are briefly summarized as follows:

1. Permalloy comprises 70% nickel and is very expensive. It costs several tens of millions yen to enclose a small volume. Since magnetic force diminished in inverse ratio to the square of distance, at the location twice the distance magnetic force is attenuated to a quarter. Therefore, it pays to consider the arrangement of items of equipment at pre-planning stage so that equipment that emits fluctuant magnetic field may not be placed in proximity to electron beam lithograph.