bench is moved, and the standard illumination is found from the value at each point and the light intensity of the standard lamp. The same equipment and instruments as used for light intensity calibration are used.

3. Distribution temperature test

The distribution temperatures of test piece lamps are calibrated by means of comparison using the distribution temperature standard lamps.

The standard lamp and test piece lamp are placed on the photometer bench, their lights are received by a B/R light receiver, and the current at which the test piece lamp yields the same value as the standard lamp is found.

4. Total flux test using light receiver

The total flux of an incandescent lamp or distribution lamp is calibrated based on the total flux of the standard lamp. The standard lamp and test piece incandescent lamp or distribution lamp are placed in a 2.5 meter integrating sphere, and the total flux is determined through comparison.

5. Total flux test by spectrophotometry

Relative spectrophotometric distribution of a test piece lamp is measured using a spectroradiometer to find the total flux, chromaticity, and relative color temperature based on the total flux of the standard lamp at any intended distribution temperature.

6. Spectral irradiance measurement

Spectral irradiance of a light source is measured using a spectroradiometer based on a spectral irradiance standard lamp calibrated in the wavelength range from 250 nm to 2500 nm.

7. Spectral radiance measurement

Spectral radiance of a light source is measured using a spectroradiometer based on a spectral radiance standard lamp calibrated in the wavelength range from 250 nm to 2500 nm.

8. Spectral responsibility measurement

Spectral responsibility of a light receiver is calibrated based on the standard light receiver with calibrated spectral responsibility.

Fig. 7-34 shows the acoustic traceability system. Table 7-19 shows a list of equipment and instruments.

2) Laboratory conditions

This laboratory requires a space of three modules, since it uses large-sized equipment. Other conditions are as shown below.

1. The floor must be made of rigid concrete and its surface must be treated with black powder. A rigid floor free from aged deterioration is needed to install the photometric bench, integrating sphere, spectroradiometer, and laser equipment (on a vibration-proof level block).

2. The room must have no windows to prevent stray light from entering from outside.

3. The floor, ceiling, walls, etc., must be made of material of little reflection. (In general, they must be coated with black mat paint.)

4. An entrance room must be provided to eliminate thermal influences caused when personnel go in and out. It must be so designed that it may be used as a lamp aging room.

5. The temperature and humidity must be controlled to 23°C ±1°C and 55% ±10%, respectively.

   The luminous output of a fluorescent lamp remarkably differs with the ambient temperature. The responsibility of photoelectric detectors (such as the photodiode, photoelectric tube and photoelectric multiplying tube) also depends on the temperature. Thus, the set wavelength of the spectroscope is influenced by the temperature. In addition, the reflectance of the barium sulfate coated on the internal surface of the integrating sphere and a glass filter is influenced by the humidity. Accordingly, strict air conditioning is necessary.

6. Conditioned air must be blown out from the ceiling as evenly as possible. Air inlets must be provided in the lower part of the four walls. The air amount must be suppressed for even temperature distribution.

7. Separate power supply lines must be provided for the measurement and general use. They must not be brought close to each other. The power supply for the measuring instruments must have an insulating transformer on the distribution board to eliminate disturbing noises.

8. An exclusive grounding line must be provided for the measuring instruments. Its grounding resistance must desirably be 1 ohm or less.

9. Cooling water facilities must be provided. The lamp houses and light receivers must have exclusive sinks for cooling water with more than two cocks.

10. The walls have low reflectance. Thus, the interior lighting must be three times as bright as the normal interior lighting.

11. The ceiling height must be 4 meters at least, since an integrating sphere of 2.5 meters in diameter is placed in the room.

3) Layout plan in laboratory

Fig. 7-35 shows the layout plan of the photometry laboratory.

4) Staffing plan

Research and development of the photometry standards are conducted by three full-time technical staffs at starting of NML. They may be able to do works sufficiently for the time being. The employment plan shown below assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	3	3	3	3	3	3	3
Assistant R/O	1	1	1	1	1	1	1
Technician	0	0	0	0	0	0	0
Total	4	4	4	4	4	4	4

5) Education and training plan

This is an unaccustomed field of research. Thus, the technical staffs should be educated and trained in an overseas metrology organization.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 100 million yen.

F11. Magnetic

1) Facilities and equipment plan

There are restricted industrial needs in magnetic standard research. The plan is intended to establish a system to fulfill the industrial needs at present. It is difficult to establish a satisfactory calibration system with equipment and instruments obtainable on the market. We propose an example of a calibration system. Figs. 7-36 and 7-37 show the traceability system. The Bureau International des Poids et Measures BIPM (International Bureau of Weights and Measures) determines the standard values of magnetic based on the physical constant γp (magnetogyric ratio of hydrogen atomic nucleus) measured by the metrology organizations in many countries. The magnetic standards are derived from these values through resonance frequency measurement by means of nuclear magnetic resonance absorption (NMR).

The calibration system for each item shown below should be established to fulfill the industrial needs.

1. Calibration of Gauss meters

   Gauss meters are compared according to ranges with an NMR magnetic field measuring equipment, electromagnets (30 mT to 2 T), Helmholtz coils (30 mT or less), etc. In addition to the above-shown equipment and instruments, a frequency counter, DMM, shunt, electromagnets, and coil drive power supply are required for the calibration system.

2. Calibration of standard magnet

   In general, the standard magnet is used for sensitivity adjustment of a Gauss meter and auxiliary calibration of the NMR magnetic field measuring equipment. The standard magnet is calibrated with the NMR magnetic field measuring equipment by the intermediation of a Gauss meter with the differential magnetic field measuring function (reading expansion function) based on the values of the Gauss meter.

The NMR magnetic field measuring equipment, Helmholtz coils, frequency counter, DMM, shunt, electromagnets, Gauss meters for differential magnetic field measurement, and electromagnet and coil drive power supply are required for the calibration system.

3. Calibration of flux meters

A widely used flux meter has an integration circuit consisting of DC amplifier, capacitors and resistors and is designed for time-based integration of excitation voltage produced by magnetic induction. It may be calibrated with the voltage and time standards.

Magnetic flux of 1 Wb represents a time integration value (1 V.s) of single sweep rectangular voltage waveform of 1 volt, 1 second. For calibration, a flux meter calibration equipment or fixed phase mutual inducer is used.

4. Calibration of search coils

Search coils used as a detectors of flux meters are calibrated by deciding the coil constants with a flux meter with calibrated flux density, which is measured with the NMR magnetic field measuring equipment.

The NMR magnetic field measuring equipment, flux meter calibrating equipment, digital flux meters, electromagnets, etc. are required for the calibration system.

Table 7-20 shows a list of equipment and instruments.

2) Laboratory conditions

This laboratory requires a space of two modules. In addition to the conditions shown in 2), F1 above, the following should be taken into consideration.

1. The magnetic field axis of the Helmholtz coil should be adjusted to the east and west direction of the magnetic field of the earth in order to eliminate the influences of the earth magnetism.

2. Easily affected measuring instruments should be installed in a magnetically shielded chamber in order to eliminate the influences of peripheral magnetic objects and floating magnetism.

3) Layout plan in laboratory

Fig. 7-38 shows the layout plan of the photometry laboratory.

4) Staffing plan

Research and development of the magnetic standards are conducted by two full-time technical staffs. As the subject of research extends, two additional technical staffs will be employed. The staffing plan shown below assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	2	3	3	3	3	3	3
Assistant R/O	0	1	1	1	1	1	1
Technician	0	0	0	0	0	0	0
Total	2	4	4	4	4	4	4

5) Education and training plan

This is also an unaccustomed field of research. Thus, the technical staffs should be educated and trained sufficiently.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 20 million yen.

7.2.2 Expansion Plan of National Calibration Laboratory (NCL)

7.2.2.1 Outline of plan

A metrological calibration service organization aims to offer accurate metrological standards to all industrial fields. It should be established and managed as the unified technical infrastructure of the industry. Thus, an organization handling the traceability of metrological standard and upstream parts should desirably be managed by the government. In fact, such organizations are managed by the government in many nations.

The organization called as the National Calibration Laboratory NCL in this report is an engineering organization which takes charge of the core of the traceability system applicable to a wide range of applications. It is a further development of the current SIRIM Measurement Centre and covers a wider range of operations. The NCL should offer a wide range of calibration services and fulfill the engineering needs of the industry in close cooperation with the NML, which maintains and controls the national standards. As an organization, it may be considered as one of the internal sections of the SIRIM like the NML.

The NCLs should be located near Kuala Lumpur, Penang, and Johor Baharu which are advanced industries in Malaysia. In the future, additional NCL will probably be established in Eastern Malaysia, which is not described in this report. In this report, NCLs located near Kuala Lumpur, Penang, Johor Baharu and in the Eastern Malaysia are referred to as NCL-SA, NCL-P, NCL-JB and NCL-EM.

1) Purpose of NCLs

The function and purpose of the NCLs are to offer calibration services for the measuring instruments whose traceability should be certified. At present, qualified auditors in the SIRIM Measurement Centre take part in the assessment works based on the SAMM Laboratory Accreditation System. However, such works are omitted from this report, since this plan covers metrology technologies only.

2) Types of applicable quantities

The NCLs offer calibration services. As described in section 7.2.1 above, the NML is to offer, for the time being, calibration services for the quantities which the SIRIM Measurement Centre does not handle now and the NML will handle newly. The NCLs offer calibration services all over Malaysia. The NCL-SA near Kuala Lumpur, where the SIRIM Measurement Centre is located now, will play a major role. Therefore, the NCL-SA will cover all the quantities which the NML will handle, in principle. As for the fields which the NML will handle newly, the NCL-SA will offer services when calibration needs increases. Table 7-21 shows the measures handled by the NML and NCL.

The quantities which are to be handled by NCL-SA are as follows.

1. Length
2. Mass
3. Volume and flow
4. Force and pressure

5. Temperature
6. Electrical
   DC current
   Resistance
   LC
   AC
   Electric power
   Time and frequency

The NCL-P and NCL-JB will offer calibration services of only the basic quantities in much needs as follows. In the future, they will expand their operations according to the needs. The NCL-EM to be located in the Eastern Malaysia should begin its calibration services of the measures shown below.

1. Length
2. Mass
3. Force and pressure
4. Temperature
5. Electric measures
   DC current
   Resistance
   LC
   AC
   Electric power
   Time and frequency

3) Building plan

We assume that the current SIRIM Measurement Centre is enlarged and renovated for the NCL-SA. The problems of the current building are described in Chapter 4. Our plan assumes that it will be renovated as far as possible. Its points are as shown below.

- Both flanks of the current building must be extended to increase the floor area.
- A storage room of equipment and instruments requested to be calibrated must be provided.
- A space for making test pieces, etc. must be secured.

- Lifts for carrying equipment and instruments requested to be calibrated must be provided.
- Reception work must be done out in one place.

The area of the laboratories of the NCL-SA based on our plan is approx. 1300 m^2. The total floor area is approx. 3000 m^2. Fig. 7-39 shows the layout of the building. Details of the calibration laboratories are described in the following section. Table 7-22 shows the conditions of the laboratories. The current SIRIM Northern Branch Office is planned to be rebuilt into a new building, and accordingly the expansion plan of the NCL-P will be made in relation with it. In principle, the NCL-P will be constructed newly. The NCL-JB must be also built newly. The general requirements of these buildings must refer to the NML conditions described in 7.2.1 above. Table 7-23 shows the conditions of the laboratories.

The area of the laboratories of either the NCL-P or NCL-JB is approx. 450 m^2. Thus, the total floor area of either building will be approx. 1000 m^2.

4) Equipment plan

The NCL-SA will use most equipment and instruments currently used by the SIRIM Measurement Centre. As we researched the industrial needs as a part of this study, the equipment and instruments currently in use will meet most needs. Thus, the facilities and equipment plan of the NCL-SA is fulfilled by making use of the most equipment and instruments currently in use and by purchasing some new equipment and instruments. For the NCL-P and NCL-JB, most equipment and instruments will be purchased newly.

The equipment and instruments to be purchased should be adjusted with consideration of improvement of the calibration abilities of private accredited laboratories.

The following shows the equipment plans of the laboratories and their costs we estimated. (The costs are estimated in yen and shown for reference only.) The NCL-SA requires approx. 248 million yen, and either the NCL-P or NCL-JB requires approx. 170 million yen each, amounting to approx. 588 million yen.

1. Equipment costs of the NCL-SA

Length calibration laboratory	Diverting equipment currently in use
Mass calibration laboratory	Approx. 10 million yen
Volume and flow calibration laboratory	Approx. 8 million yen
Force and pressure calibration laboratory	Approx. 40 million yen
Temperature calibration laboratory	Diverting equipment currently in use
Electrical calibration laboratory	Approx. 190 million yen
DC voltage	(Approx. 40 million yen)
Resistance	(Approx. 40 million yen)
LC	(Approx. 30 million yen)
AC voltage	(Approx. 50 million yen)
Electric power and energy	(Approx. 30 million yen)
Time and frequency	(Diverting equipment currently in use)
Total	Approx. 248 million yen

Note: Figures in parentheses mean breakdown of those of "Electrical calibration laboratory".

2. Equipment costs of the NCL-P and NCL-JP (per laboratory)

Length calibration laboratory	Approx. 50 million yen
Mass calibration laboratory	Approx. 50 million yen
Force and pressure calibration laboratory	Approx. 20 million yen
Temperature calibration laboratory	Approx. 5 million yen
Electrical calibration laboratory	Approx. 45 million yen
Total	Approx. 170 million yen

5) Staffing and training plans

The staffing plan of the NCL-SA assumes that the technical staffs of the Measurement Centre will move to the NCL-SA. However, if it is executed together with the NML plan described in 7.2.1 above, it is clear that the NCL will be short in technical staffs, since the NML is to take charge of research and development and requires technical staffs experienced in metrology and accordingly its staffing plan assumes that the technical staffs of the Measurement Centre will be transferred to the NML. Thus, we have to point out that it is urgent to make a careful plan to employ and train technical staffs before executing this plan.

We calculated the number of technical staffs for calibration services of each NCL's laboratory and made a staffing plan up to the year of 2000. Details of the necessary technical staffs for each calibration laboratory are described in the following section. The table below shows the employment plan outline. It assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Length calibration laboratory	5	6	6	7	8	9	9
Mass calibration laboratory	6	6	6	8	8	8	8
Volume and flow calibration laboratory	6	6	8	8	8	10	10
Force and pressure calibration laboratory	6	6	6	7	7	8	8
Temperature calibration laboratory	4	4	6	7	7	7	7
Electrical calibration laboratory	17	25	28	29	32	34	37
DC voltage / resistance	(6)	(9)	(10)	(11)	(11)	(12)	(13)
LC / AC voltage	(5)	(8)	(9)	(9)	(10)	(11)	(12)
Electric power and energy	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Time and frequency	(4)	(6)	(7)	(7)	(9)	(9)	(10)
Total	44	53	60	66	70	76	79

Note: Numbers of technical staffs in parentheses mean those of "Electrical calibration laboratory" in each parameter.

Since the NCL offers calibration services, it requires general affairs, financial affairs, planning, public information and other staffs, and office workers of reception, safe keeping, issuing test report and so forth, in addition to technical staffs. Provided the number of such staffs and office workers is 1.5 times as large as the number of technical staffs, the whole NCL requires approx. 100 employees at the beginning and approx. 200 employees in the year of 2000.

Since the NCL-P and NCL-JB are established newly, they require newly employed technical staffs. For these technical staffs, it is necessary to make a plan for employing, training and developing them before executing this plan.

6) Management plan

The NCL offers calibration services upon requests of the industry, etc. It is expected to gain some profits. We believe that calibration charges should be used to run the NCL for promoting nongovernmental management of such organization in Malaysia after the NCL begins its operations, though a huge amount of initial investment including constructing buildings, purchasing equipment and facilities, etc. should be born by the Government. Many overseas calibration organizations have self-supporting accounting systems, though calibration services are highly public business operations. The Governments give restricted subsidies. Thus, the calibration charges should be determined with consideration of the management conditions of the laboratories.

7) Implementation plan

We think that the NCL-SA should be established first and, after education and training of technical staffs make progress to some extent in the NCL-SA, the NCL-P and NCL-JB should be established. Therefore, the implementation plan will take the following steps.

Step 1: Establishment of the NCL-SA

1. Making a facilities and equipment plan and a renovation plan of the current SIRIM Measurement Centre
2. Employing and training technical staffs (Desk study and OJT by means of supporting practical operations)
3. Renovating the buildings and purchasing and installing facilities and equipment
4. Starting operations of the NCL-SA
5. Education and training of technical staffs including high level technique

Step 2: Establishment of the NCL-P

1. Making a facilities and equipment plan and a building plan
2. Employing and training technical staffs (in the SIRIM Measurement Centre or NCL-SA)
3. Constructing the buildings and purchasing and installing
4. Moving technical staffs to the NCL-P and employing additional technical staffs
5. Starting operations

6. Education and training (Educating and training the technical staffs already trained in 2. in higher level technique. Educating and training newly employed technical staffs from OJT practical training.)

Step 3: Establishment of the NCL-JB

Same as described in the NCL-P, in principle. Step 2 has a problem of securing the budget. If we do not take it into consideration, step 2 should desirably be started at 3 of step 1. Step 3 should also be started at 3 of step 1 in the earliest case, taking account of the calibration needs in Johor Baharu.

Fig. 7-40 shows the flow of these steps.

7.2.2.2 NCL establishment plan for each quantity

A. Dimensional calibration laboratory

The capability of this laboratory should be strengthened since demands for calibrating gauge blocks are increasing year by year. At present, the most demands are made for calibrating the class 0 gauge blocks. One or two demands for calibrating the class 00 gauge blocks are made every month, and such demands are increasing gradually. At present, the class 00 gauge blocks are calibrated by comparing them with the class 00 gauge block possessed by the SIRIM length laboratory. However, it is hard to meet the required accuracy with such method.

In the future, the light wave interference meters must be used for absolute measurements in Malaysia like in other overseas countries. For the time being, the class 00 gauge blocks should be calibrated by the NML since there are few requests. Other calibration works should be taken charge of by the NCL.

1) Facilities and equipment plan

When new facilities and equipment are installed in the NML, the calibration facilities and equipment currently possessed by the length laboratory of the SIRIM Measurement Centre will be transferred to the NCL-SA.

For the future increase of demand of calibration work, a certain duplication of the equipment may be considered.

2) Equipment layout plan

The facilities and equipment transferred from the length laboratory of the SIRIM Measurement Centre will be installed according to the new operation conditions. The shape measuring equipment and instruments currently installed in the force and pressure laboratory of SIRIM Measurement Centre will be moved to the gauge block calibration room and be used in the temperature and humidity conditions necessary for precision length measurements.

The length laboratory of the SIRIM Measurement Centre will be extended to outside, and the effective area will be increased to approx. 200 m^2. Fig. 7-41 shows the layout plan of large-sized equipment to be installed in the extended laboratory.

3) Laboratory Condition

The laboratory condition of this laboratory must be referred to those of NML and the followings must be taken into consideration.

1. The temperature and humidity should be controlled 20°C ±1°C and 60% ±5% respectively.

2. The cleanness is required.

4) Estimation of work amount and staffing plan

The number of applications increased in 1991 and is still increasing in 1992, though there were not so many applications in 1989 and 1990. As shown in Table 7-24, the number of applications will reach approx. 5000 in the year 2000, or six times as many as the current applications, provided applications increase at the same ratio. It is a quite sharp increase in comparison with the increase of applications in other fields, which is approx. three times as many as the current applications. Approx. 60% of operations of the length laboratory is related to the gauge blocks. If we apply the above-shown value, there will be 30,000 requests for calibrations per year, which means that 112 gauge blocks should be calibrated everyday. The NCL should have the capability to handle most of that work amount.

Provided the work amount does not increase, two additional technical staffs are required. If we take account of the future increase of works, technical staffs should be increased to nine by the year 2000 according to the technical staff increasing plan shown below. This plan assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	1	1	2	2	2	2
Assistant R/O	2	2	2	2	3	4	4
Technician	2	3	3	3	3	3	3
Total	5	6	6	7	8	9	9

4) Calibration works by NCL-P and NCL-JB

The calibration facilities and operation systems of the NCL-P and NCL-JB must be prepared and established in the order shown below. The equipment plan of the NCL-P and NCL-JB is the same as that of the NCL-SA.

1. Gauges blocks
2. Scales
3. Angle
4. Other length standards

B. Mass calibration laboratory

1) Facilities and equipment plan

The mass calibration laboratory of the NCL calibrates the class F1 or lower class weights using the class E2 weights calibrated by the NML. At present, the mass laboratory of the SIRIM Measurement Centre has the basic minimum standards and measuring instruments. The NCL will purchase some new equipment to carry out specified operations. The standard weights, balances, etc. possessed by the mass laboratory of the SIRIM Measurement Centre should be transferred to the NCL-SA.

The following shows the standards, equipment and instruments possessed by the mass laboratory of the SIRIM Measurement Centre and those transferred by the research section.

1. Balances used for transferring Class E2 to F1 standard weights

Weighing capacity/readability	Possession
60kg / 10mg	Possessed currently
20kg / 1mg	Not possessed
10kg / 0.1mg	Not possessed
5kg / 0.1mg	Possessed currently
1kg / 0.1mg	Possessed currently
1kg / 0.01mg	Not possessed
200g / 0.01mg	Possessed currently
100g / 0.001mg	Not possessed
20g / 0.001mg	Possessed currently
5 g / 0.0005 mg	Possessed currently

2. Balances used for transferring Class F1 to F2 and below

Weighing capacity/readability	Possession
50kg / 10mg	Possessed currently
20kg / 10mg	Not possessed
5kg / 0.1mg	Possessed currently
3kg / 0.1mg	Possessed currently
1kg / 0.1mg	Possessed currently
200g / 0.1mg	Possessed currently

Lacking equipment and instruments should be purchased newly. Table 7-25 shows a list of equipment and instruments to be acquired.

2) Equipment layout plan

The balance room of the SIRIM Measurement Centre is too narrow. The calibration room and balance room should be enlarged. The large weight calibration room should also be enlarged. Their work environments should be improved. The position and structure of the application reception room should be so improved that operation may be carried out smoothly. If the mass laboratory of the Measurement Centre is enlarged to the outside, its effective space becomes approx. 200 m^2. Fig. 7-42 shows the layout plan of the equipment and instruments to be installed in the enlarged laboratory.

3) Laboratory Condition

The laboratory condition of the laboratory must be referred to those of NML and the followings must be taken into consideration.

1. The temperature and humidity for precision measurement of class E2 should be controlled 23°C ±0.5°C and less than 60% respectively.

   Those of other measurement should be 23°C ±1°C and less than 60%.

2. The cleanness of the laboratory is required.

4) Estimation of work amount and employment plan

Judging from the work amount in these three years, the number of applications seems to have reached the limit though there were many applications in number. As shown in Table 7-24, the work amount in the year of 2000 may be two times as many as the current amount, even if applications will increase hereafter. The employee increasing plan shown below is necessary in the long run.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	1	1	2	2	2	2
Assistant R/O	2	2	2	3	3	3	3
Technician	3	3	3	3	3	3	3
Total	6	6	6	8	8	8	8

5) Equipment costs

The approximate costs of purchasing the additional equipment and instruments for the NCL-SA as described in the equipment plan are 10 million yen.

6) Calibration works by NCL-P and NCL-JB

The equipment and instruments of the same level as those of the NCL-SA should be used for mass calibration works by the NCL-P and NCL-JB.

C. Volume and flow calibration laboratory

1) Facilities and equipment plan

The facilities should be expanded to carry out the operations shown below in order to fulfill the industrial needs, in addition to the current operations.

1. On-site calibration of fluid flow meters using calibrating equipment (on automobiles)
2. Calibration of viscometers

The standard tanks and flow meters for calibration are necessary for on-site calibration of the liquid flow meters as well as cars for carrying them to factories. Calibration of the viscometers assumes that the NML establishes the standard of that field. Necessary instruments are viscometers on the assumption that the standard viscosity fluid is supplied by the NML. Table 7-26 shows list of equipment to be acquired. Calibration is accompanied by temperature compensation. Thus, the temperature must not change during calibration. The laboratory should be equipped with a stable air conditioner.

2) Equipment layout plan

The volume and flow laboratory of the SIRIM Measurement Centre will be used as is. Since a part of the equipment currently in use is to be transferred to the NML, a wider space will be available. Fig. 7-43 shows the layout of the equipment to be installed in that space.

3) Laboratory Condition

The condition of the laboratory must be referred to those of NML. The temperature and humidity of the laboratory should be controlled 23 ±2°C and less than 60% respectively.

4) Estimation of work amount and employment plan

Judging from the work amount in 1992, the work amount in the year 2000 may be four times as much as the current work amount as shown in Table 7-24, provided the work amount continues to increase.

Most of the current work is witness calibration. With new facilities, calibration works in the laboratory may increase. The employment plan to cope up with the increase of the work amount is shown below.

Witness calibration works, most of the current works, on the user sites are executed with the aid of other sections. To handle works which may increase in the future by the corresponding section by itself, ten technical staffs are necessary in the year 2000.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	2	2	2	2	2	2	2
Assistant R/O	2	2	3	3	3	4	4
Technician	2	2	3	3	3	4	4
Total	6	6	8	8	8	10	10

5) Equipment costs

The approximate costs of purchasing the additional equipment and instruments for the NCL-SA as described in the equipment plan are 8 million yen.

6) Calibration works done at other than the NCL-SA

The equipment plan described above expands the range of the calibration services of the NCL-SA and enables calibration in factories. On the other hand, witness calibration does not require any special instruments since technical staffs visit factories. Therefore, the NCL-P and NCL-JB will not have volume and flow calibration laboratories. If the NCL-EM is established in the future, technical staffs for witness calibration in Eastern Malaysia should be assigned.

7) Relation with NML volume/flow standards laboratory

There are stronger relation between NML Volume/flow standards laboratory and NCL Volume/flow calibration laboratory compared to other quantities. Accordingly, it is necessary to exchange technical information and interchange technical staffs of both laboratory. It is recommendable that location of NML and NCL are close by from those technical point of view.

D. Force and pressure calibration laboratory

1) Facilities and equipment plan

The force and pressure calibration laboratory should have the standard force meters and load cells calibrated by the NML in order to offer calibration services in expanded ranges up to 500 tons, which are greatly needed by the industry. For calibration on the user sites, the standard force meters calibrated by the NML are used. Calibrated load cells are used for calibration of the standard force meter in the laboratory. There are many industrial needs for calibration of the torque meters and hardness testers. Equipment for calibrating these meters and testers should be prepared.

The current calibration level of the pressure gauges in the range near the normal pressure seems to be satisfactory. However, the laboratory has no SI unit pascal standard pressure gauges, which should be prepared. As for PSI system calibration, the equipment currently in use should be used.

At present, mercury column manometers are used to calibrate the vacuum gauges for the range near the atmospheric pressure. They are capable of calibration in four units: Bar, cmHg, PSI and kg/cm^2. The reading accuracy should be improved.

There are no demands for calibrating the barometers and high vacuum gauges at present. However, there will be such needs in the future. An equipment installation space should be secured. The following shows the operations of the laboratory for calibration of force and pressure of the NCL.

1. Force
   - a) Calibration of standard force meters and load cells (Extended up to 500 tons)
   - b) Calibration of torque (New)
   - c) Calibration of hardness testers (New)

2. Pressure
   - a) Calibration of Bourdon's tube pressure gauges
   - b) Calibration of vacuum gauges
   - c) Calibration of barometers (New)
   - d) Calibration of high vacuum gauges (New)

Table 7-27 shows a list of required equipment and instruments. A certian duplication of the equipment may be necessary in the future.

2) Equipment layout plan

The force and pressure research laboratory of the SIRIM Measurement Centre will be used as is. Since the equipment which is used for dimensional measurement is to be transferred to the dimensional calibration laboratory, a wider space will be available. Fig. 7-44 shows the layout plan of the equipment to be installed in the space.

3) Laboratory condition

The condition of this laboratory must be referred to those of NML. The temperature and humidity of the laboratory should be controlled 23 ± 2°C and less than 60% respectively.

4) Estimation of work amount and staffing plan

Provided applications keep on increasing in the future like in the period from 1991 to 1992, works of this field in 2000 may be four times as much as the current works.

For calibration in the laboratory only, an additional technical staff should be employed immediately. To handle increasing works, eight technical staffs are necessary in the year 2000.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	2	2	2	2	2	2	2
Assistant R/O	2	2	2	3	3	4	4
Technician	2	2	2	2	2	2	2
Total	6	6	6	7	7	8	8

5) Estimated equipment costs

The approximate costs of purchasing the additional equipment and instruments for the NCL-SA as described in the equipment plan are 35 million yen.

6) Calibration by NCL-P and NCL-JB

The following shows the priority of the force and pressure calibration works carried out by the NCL-P and NCL-JB.

1. Calibration of standard force meters and load cells
2. Calibration of pressure gauges

The NCL-P offers on-site calibration services in Northern Malaysia, the center of which is the Penang State. The NCL-JB takes charge of Southern Malaysia, the center of which is the Johor State. Eastern Malaysia should be taken charge of by the NCL-SA as ever until the NCL-EM is established.

E. Temperature calibration laboratory

The temperature calibration laboratory of the NCL should offer calibration services using the standard thermometers supplied by the NML. It must be equipped with the standard thermometers, thermostatic baths and furnaces for comparison, and small number of fixed point apparatus for checking deviation of the calibrated values of the thermometers.

While the NML should have the facilities to calibrate extra-high-precision thermometers and temperature standards for special use, the NCL must possess the facilities for calibrating moderate accuracy thermometers for industry in the range from -80°C to 1400°C.

1) Facilities and equipment plan

If the NML is equipped with new facilities, the calibration facilities and equipment presently possessed by the SIRIM Measurement Centre should be transferred to the NCL-SA. The NCL-P and NCL-JB should be provided with the equipment for calibrating glass thermometers for the time being.

In the course of expanding scope of work, some additional equipment, such as those for humidity standard and fixed point realization, should be provided in the future.

2) Equipment layout plan

The temperature laboratory of the SIRIM Measurement Centre will be used as is. The temperature calibration laboratory should offer calibration services using mainly the facilities and equipment transferred by the temperature laboratory of the SIRIM Measurement Centre.

A room for installing the thermostatic baths, comparison furnaces and other heat generating instruments must be air conditioned normally. Electric measuring instruments must be installed in a partitioned area. The temperature and humidity for electric instruments must be controlled to 23°C ±2°C and 55% ±5%, respectively.

The installation plan is shown in Fig. 7-45.

3) Estimation of work amount and staffing plan

Provided applications keep increasing in the future like in the period from 1991 to 1992, works of this field in 2000 may be 2.5 times as much as the current works.

This laboratory should have at least three full-time technical staffs from the beginning. To handle increasing works, additional technical staffs should be employed according to the staff increasing plan shown below.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	1	1	2	2	2	2
Assistant R/O	1	1	2	2	2	2	2
Technician	2	2	3	3	3	3	3
Total	4	4	6	7	7	7	7

4) Calibration by the NCL-P and NCL-JB

As described above, the NCL-P and NCL-JB should calibrate glass thermometers only by using standard thermometers and comparison baths.

F. Electrical calibration laboratory

The electrical calibration sections must be established and expanded in a uniform manner with importance to the mutual correlation. Plans are made according to the basic principle shown below as a whole. A concrete plan for each section is proposed below.

1. The facilities must be renewed as necessity requires according to the required accuracy.

2. At least two sets of equipment of frequent use must be prepared for improved work efficiency.

3. The specifications of the facilities and equipment must be unified for improved compatibility.

4. Calibration systems must be purchased newly if the range and functions of calibration are be expanded.

5. Automatic measurement systems must be established as far as possible. Office work must be computerized.

F1. DC calibration section

1) Facilities and equipment plan

The NCL-SA must use the standard cells calibrated by the NML as the reference standards. It must be newly equipped with the standard potential dividers and current comparison type potentiometers. It must have two each precision calibrators and DMM's for enhanced functions and improved workability. It must also have two DC voltage and current generators to calibrate indicating instruments.

Fig. 7-46 shows the DC traceability system. Table 7-28 shows a list of equipment and instruments.

2) Laboratory conditions

The NCL-SA's laboratory for calibration of electric measures, except time and frequency, covers approx. 360 m^2, including the enlarged second floor of the SIRIM Measurement Centre. The conditions of the laboratory are as shown below.

1. The room temperature and humidity must be controlled to 23°C ±2°C and 55% ±10%, respectively.

2. Oil piping for renewing oil must be provided near an oil bath.

3. The amount of conditioned air must be suppressed for uniform temperature distribution.

4. Power supply lines must be provided for measuring instruments and general-purpose instruments separately. They must not be brought close to each other.

5. An exclusive grounding line for the measuring instruments must be provided.

6. Emergency power supply facilities, especially, one for the oil bath must be provided.

3) Layout plan in laboratory

Fig. 7-47 shows the layout plan of the equipment and facilities, including those for other parameters, in the electrical calibration laboratory.

4) Estimation of work amount and staffing plan

As shown Table 5-16 and Fig. 5-13 in Chapter 5 above, the electrical laboratory of the SIRIM Measurement Centre handles approx. 1500 requests for calibration services, which are increasing. On the other hand, as analyzed in Chapter 5 above, it is pointed out that the electrical laboratory of the SIRIM Measurement Centre cannot fulfill the industrial needs completely due to its insufficient capability. It is expected that the number of requests for calibration services will be more than twice as great as the current number in the year 2000. To handle such increasing needs, the staff of DC and the staff of resistance described below should be increased according to the staff increasing plan shown below.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	2	2	2	2	2	2	2
Assistant R/O	2	3	3	3	3	3	3
Technician	2	3	3	3	3	3	3
Total	6	7	7	7	7	7	7

5) Equipment costs

The approximate costs of purchasing the additional equipment and instruments for the NCL-SA as described in the equipment plan are 35 million yen.

6) Calibration by the NCL-P and NCL-JB

The calibration works of the NCL-P and NCL-JB and their facilities and equipment plans are described in F7.

F2. Resistance calibration section

1) Facilities and equipment plan

The resistance calibration section receives the 1 ohm standard resistor which are calibrated by the NML and controls a group of five 1 ohm standard resistors to maintain the NCL's reference standards. It calibrates the resistance ranges from 1 mΩ to 10 MΩ by means of comparison using the resistance converters. It is equipped with a large-sized oil bath to maintain and control the standards and to carry out requested calibration works. It also has direct current comparison type resistance bridges for calibration. Fig. 7-48 shows the resistance traceability system. Table 7-29 shows a list of equipment and instruments.

2) Staffing plan

The technical staffs of the DC section shown above should take charge of this field. The staffing plan is as described in 4), F1 above.

3) Equipment costs

The approximate costs of purchasing the additional equipment and instruments for the NCL-SA as described in the equipment plan are 40 million yen.

F3. LC calibration section

1) Facilities and equipment plan

The LC calibration section should use the standard capacitors (10, 100 and 1000 pF) calibrated by the NML as the NCL's reference standard and should offer calibration services using automatic capacitance bridges and LCR meters. The NCL takes charge of the capacity and frequency ranges in which specified accuracy may be obtained relatively easily. Calibration of high-frequency, large-capacity and high-voltage capacitors should be taken charge of by the NML. As for inductance, impedance, etc., the NCL covers the ranges which may be calibrated with LCR meters for the time being. When the calibration method is established, NCL's operation ranges should be expanded.

Fig. 7-49 shows the LC traceability system. Table 7-30 shows a list of equipment and instruments.

2) Staffing plan

As described in 4), F1 above, the staff of LC and AC voltage should be increased according to the staff increase plan shown below in order to handle increasing works.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	1	1	1	1	1	1
Assistant R/O	2	2	2	2	2	2	2
Technician	2	3	3	3	3	3	3
Total	5	6	6	6	6	6	6

3) Equipment costs

The approximate costs of purchasing the additional equipment and instruments for the NCL-SA as described in the equipment plan are 20 million yen.

F4. AC voltage calibration section

1) Facilities and equipment plan

The AC voltage calibration section should have the AC-DC difference standard which are calibrated by the NML and offer calibration services in the range from 0.2 mV to 1100 V at an accuracy of ±100 ppm or less using the standard AC voltage generator or precision digital voltmeter based on DC voltage.

As for AC current, it should have the AC shunts and impedance standards which are calibrated by overseas metrology laboratories and offers calibration services of precision digital voltmeters, impedance standards, AC shunts, etc. in the range from 1 mA to 100 A at an accuracy of ±200 ppm or less.

In addition to above equipment as AC calibration system, it should provide, the high voltage testing system up to AC 30kV, DC 50kV for the calibration services of voltage transformer high voltage meter, and withstanding tester.

Fig. 7-50 shows the AC voltage traceability system. Table 7-31 shows a list of equipment and instruments.

2) Staffing plan

The technical staffs of the LC calibration section should also take charge of this field. Thus, the staffing plan is the same as described in 2), F3.

3) Equipment costs

The approximate costs of purchasing the additional equipment and instruments for the NCL-SA as described in the equipment plan are 30 million yen.

F5. Electric power and electric energy calibration section

1) Facilities and equipment plan

The electric power and energy calibration section should have the single-phase and 3-phase standards which are calibrated by the NML and offer calibration services using power meters as the working standards. The NCL seems to fulfill most of the industrial needs, though the NML handles needs for high precision. The NCL will not have any facilities and equipment for electric power calibration for the time being, since there are few industrial needs and duplicate investment should be avoided. Fig. 7-51 shows the power and energy traceability system. Table 7-32 shows a list of equipment and instruments.

2) Staffing plan

Two technical staffs may handle the works of electric power and energy.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	0	0	0	0	0	0	0
Assistant R/O	1	1	1	1	1	1	1
Technician	1	1	1	1	1	1	1
Total	2	2	2	2	2	2	2

3) Equipment costs

The approximate costs of purchasing the additional equipment and instruments for the NCL-SA as described in the equipment plan are 30 million yen.

F6. Time and frequency calibration section

1) Facilities and equipment plan

The time and frequency calibration section should have the standards calibrated with the rubidium standard of NML and offers frequency calibration services using quartz oscillators as the working standards. The facilities and equipment currently possessed by the SIRIM Measurement Centre will be sufficient for these works. Fig. 7-52 shows the time and frequency traceability system. Table 7-33 shows a list of equipment and instruments.

2) Laboratory conditions

The acoustic laboratory of the SIRIM Measurement Centre will be moved to the NML. That space may also be used for the time and frequency calibration section of the NCL-SA, amounting to a floor space of approx. 120 m^2. The room conditions must be the same as those of the electrical calibration laboratory.

3) Staffing plan

Demands for calibration show rapid increase recently. Such trend seems to continue for the time being. There will be approx. 500 applications for calibration in 1993, while there were approx. 220 applications in 1992. Estimation of further applications is as shown below.

	1994	1995	1996	1997	1998	1999	2000
Demands (Estimate)	500	750	1000	1200	1400	1500	1600

To handle such increasing demands, we propose a staffing plan shown below.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	1	1	1	1	1	1
Assistant R/O	1	1	1	1	2	2	2
Technician	2	2	3	3	3	3	3
Total	4	4	5	5	6	6	6

F7. Electrical calibration laboratories of the NCL-P and NCL-JB

The NCL-P and NCL-JB are to offer calibration services in the following fields.

1. DC voltage / current
2. Resistance
3. AC voltage / current
4. LC
5. Electric power
6. Frequency / time

1) Facilities and equipment plan

The electrical calibration labortories of the NCL-P and NCL-JB must have the same facilities and equipment. They may have lower accuracy and ranges since they need not be equivalent to the levels of NCL-SA's facilitates and equipment. Fig. 7-53 shows the traceability system. Table 7-34 shows a list of equipment and instruments.

2) Calibration room conditions

The calibration room must be controlled to a temperature and humidity of 23°C ±2°C and 55% ±10%, respectively. Calibration services should cover only the ranges where the environmental conditions have no influences. No oil bath or other special facilities are provided. Other general environmental conditions are the same as those of the NCL-SA.

3) Staffing plan

The staffing plans of the NCL-P and NCL-JB are shown below. At the beginning, six technical staffs will handle calibration services. The staff will be increased gradually on the assumption that demands for calibration will increase as described in the section on the NCL-SA above. The plan shown below assumes that the first year is 1995.

	1995	1996	1997	1998	1999	2000
DC voltage / resistance	2	3	4	4	5	6
LC, AC voltage / electric power	2	3	3	4	5	6
Time and frequency	2	2	2	3	3	4
Total	6	8	9	11	13	16

4) Equipment costs

The approximate costs of purchasing the equipment and instruments for the NCL-P and NCL-JB as described in the equipment plan are 45 million yen.

F8. On-site calibration services

In addition to the current calibration services, it is recommended that technical staffs visit clients in on-site service cars to offer calibration services for popularization of measuring techniques and more careful services. On-site calibration services may eliminate such problems as temporary shutdown of manufacturing, which are caused if measuring instruments built in the manufacturing facilities of a factory are sent for calibration. In addition, such services can reduce the calibration periods remarkably. We consider that there will be great needs for such services and propose them as a part of NCL's preparation and expansion plan.

Fig. 7-54 shows an example of the functions and facilities. Though a service car has an air conditioner, there will be restrictions upon calibration works in the car judging from the environmental conditions only. Thus, the standards and measuring instruments to be installed in the service car should be almost free from influences of temperature and humidity. In other words, on-site calibration services may only have to cover measuring instruments used on the manufacturing sites. The precision standards and measuring instruments cannot be installed in the service car.

The service car has an air conditioner. It is equipped with the standards and measuring instruments systematically for good work efficiency. The same types of standards and measuring instruments are installed in the service car as far as possible for compatibility, easy handling, and maintenanceability. The measuring instruments may be detached and attached easily to meet hot and humid conditions.

The following shows the applicable calibration functions and ranges.

1. DC voltage and current
   1 mV to 1000 V, 10 μA to 36 A, best accuracy: 50 ppm

2. Resistance
   1 mΩ to 1010 Ω, best accuracy: 100 ppm

3. AC voltage and current
   1 mV to 1000 V, 100 mA to 50 A, best accuracy: 500 ppm

4. Electric energy
   2 W, single-phase to 4 W, 3-phase, best accuracy: 500 ppm

5. RF
   Counter / signal generator

Table 7-35 shows a list of equipment.

Applicable standards and measuring instruments are,

> DC voltage and current generators, AC voltage and current generators, DMMs, indicating instruments, standard resistors, decade resistors, DC potentiometers, standard potential dividers, standard shunts, ohmmeters, DC bridges, double bridges, insulation resistance testers, earth testers, wattmeters (2 W, single-phase to 4 W, 3-phase), power factor meters, phase meters, frequency counters, counters, oscillators, etc.

Table 7-1 Condition for NML Standard Laboratories

Laboratory	Floor Area (m^2)	Room Temperature and Humidity	Equipment Cost (1000 Yen)	Reinforcement of Floor	Location	Illuminance	Electro-magnetic Schield	Cleanness	Anti-Vibration	Others
Length	216	20±0.5 ℃, 50% or less (Precision Measurement Laboratory)	287,000	Necessary	1 F	1000 lx	–	Necessary	Necessary	
		20±0.5 ℃, 60% or less (General Measurement Laboratory)								
Mass	144	23±0.5 ℃, 60% or less (Precision Balance Laboratory)	150,000	Necessary	1 F	1000 lx	–	Necessary	Necessary	
		23±0.5 ℃, 60% or less (General Measurement Laboratory)								
Force	216	23±2.0 ℃, 60% or less	320,000	Necessary	Separate	1000 lx	–	–	Necessary	
Pressure	144	23±2.0 ℃, 60% or less		–	1 F	1000 lx	–	–	Necessary	
Volume/Flow	216 (Gas)	20±0.5 ℃, 60% or less (Basic Verification System)	220,000	Necessary	Separate	1000 lx	–	–	–	
	144 (Liq.)	23±2.0 ℃, 60% or less (General Measurement Laboratory)								
Temperature	144	23±1.0 ℃, 55± 5% (Precision Measurement Laboratory)	110,000	–	1 F	1000 lx	100 μV/m	–	–	
		27±2.0 ℃, 60± 5% (General Measurement Laboratory)								
Electrical	624	23±2.0 ℃, 60% or less	520,000	–	2 F	1000 lx	100 μV/m	–	–	Earthing (1Ω)
RF	528	23±2.0 ℃, 60% or less		–	1 F	1000 lx	100 μV/m	–	–	
Anechoic Rm	360	20±2.0 ℃, 70% or less	included in Bldg.		Separate	500 lx	–	–	Necessary	

Table 7-2 Comparison Table of Location

Location	Land Area	Transportation	Access	Electricity	Noise & Vibra'n	Accommodation
Kulim High-Tech Park	◎	△	△	○	N/A(*)	N/A(*)
KL Technology Park	○	○	○	○	○	○
Near SIRIM	○	◎	◎	△	○	◎

Legend : ◎ Excellent
○ Good
△ Fair

Note : (*) The construction of 'Kulim High-Tech Park' was under way at the site, therefore, no survey was practicable on the study items.

Table 7-3 Equipment List (Length)

1. END STANDARDS (GAUGE BLOCK)
   1) Iodine-Stabilized He-Ne Laser Measurement System
   2) Automatic Gauge Block Interferometer System
   3) Gauge Block Calibration Unit (Comparator)
   4) Gauge Block Set (1 - 100 mm, Steel, Gr.AA Special)
   5) Gauge Block Set (1 - 100 mm, Steel, Gr.AA)
   6) Gauge Block Set (1 - 100 mm, Tungsten Carbide, Gr.AA)
   7) Gauge Block Set (1 - 100 mm, Ceramic, Gr.AA)
   8) Long Gauge Block Set (Steel, Gr.AA)
   9) Thin Gauge Block Set (Gr.AA Special)
   10) Gauge Block Accessories Set
   11) Gauge Block Maintenance Kit
   12) Precision Ext. Micrometer Sets
   13) Precision int. Micrometer Sets

2. LINE STANDARDS (SCALES)
   1) Length Bench (20 m) w/Laser Measurement System
   2) 1m Length Comparator w/Laser Measurement System

3. ANGLE STANDARDS
   1) Autocollimators
   2) Combination Angle Gauges (0 - 90, 3" step)
   3) Combination Angle Gauges (0 - 90, 6" step)
   4) Precision Polygon (Ref. Gr.)
   5) Precision Polygon (Calibration Gr.)
   6) Taper Parallels Combination Set
   7) Engineers Parallels

Table 7-3 Equipment List (Length) (Cont'd)

4. OTHER RELATED DIMENSIONAL STANDARDS

1) Calibrated Steel Balls (1 - 25 mm, 1 mm step)
2) Calibrated Steel Balls (1 - 12.5 mm, 1 mm step)
3) Optical Flats
4) Optical Parallels (12 - 12.375 mm)
5) Optical Parallels (12 - 25 mm)
6) Universal Monochrome Light Unit
7) Toolmakers Flat
8) Master Cylindrical Plug Gauges (various size)
9) Master Ring Gauges (various size)
10) Master Taper Plug Gauges (various size)
11) Self-Centering Inside Micrometers
12) Depth Micrometers Set
13) Micrometer Heads w/Sliding Spindle
14) Screw Thread Micrometer w/Interchangeable Anvils
15) Thread Pin Gauges
16) Pin Gauges Sets
17) Thread Limit Plug Gauges
18) Thread Limit Roller Gauges
19) Thread Limit Setting Gauges
20) Precision Comparator Stands
21) Digital Height Measuring Machine
22) Centre Bench
23) Surface Plate w/Centre
24) Taper Testing Machine
25) Universal Measuring Block
26) Universal Measuring Machine w/Digital Readout
27) Testing Machine for Dial Indicators
28) Toolmakers Microscope
29) Precision Profile Projector
30) Roundness Measuring Machine
31) Surface Texture Measuring Machine
32) Screw Thread Gauging and Measuring Machine
33) Automatic Gear Inspection Machine
34) 3-Coordinate Measuring Machine
35) Granite Surface Plate
36) Component Measuring Microscope
37) Precision Gauge Measuring Centre
40) Temperature and Humidity Chart Recorder

Table 7-4 Equipment List (Mass)

1) Primary Standard Mass (OIML Class E1, 1kg)
2) Standard Weight Set (OIML Class E1, 1 mg - 20 kg)
3) Primary Standard Mass Comparator (1 kg/ 1 μg)
4) Mass Comparator (50 kg/5 mg, Class E1)
5) Mass Comparator (20 kg/1 mg, Class E1)
6) Mass Comparator (10 kg/0.1 mg, Class E1)
7) Mass Comparator (2 kg/0.5 mg, Class E1)
8) Mass Comparator (1 kg/0.005 mg)
9) Mass Comparator (500 g/0.01 mg)
10) Mass Comparator (200 g/0.001 mg)
11) Mass Comparator (50 g/0.001 mg)
12) Mass Comparator (20 g/0.001 mg)
13) Mass Comparator (3 g/ 0.1 μg)
14) Precision Balance (20 kg/50 mg)
15) Precision Balance (10 kg/10 mg)
16) Precision Balance (5 kg/ 1 mg)
17) Precision Balance (1 kg/0.1 mg)
18) Precision Balance (1 kg/0.05 mg) S.G. Balance
19) Precision Balance (200 g/0.01 mg)
20) Precision Balance (25 g/0.001 mg)
21) Precision Balance (4 g/ 0.1 μg)
22) Detector System for Determining Air Density
23) Anti-Vibration Balance Tables
24) Ultrasonic Weight Cleaning System
25) Aneroid Barometers
26) Fortin Barometers
27) Temperature & Humidity Chart Recorder

Table 7-5 Equipment List (Volume/Flow)

1. GAS MEASUREMENT
   1) Piston Prover (20 litre)
   2) Bell Prover (0.5 m^3)
   3) Bell Prover (3.5 m^3)
   4) Constant Volume Meter (65 m^3/h)
   5) Precision Platform Scale (600 kg)
   6) Storage Tank (1000 litre)
   7) Calibration Fluid (Light Oil)
   8) Instrumentation & Computers
   9) Hoist & Crane System
   10) Pumps, Pipings & Auxiliaries
   11) Sonic Nozzles (Low Pressure)
   12) Sonic Nozzles (High Pressure)
   13) Transfer Standard (65 m^3/h)
   14) Gravimetric Tank (50 or 100 l)

2. LIQUID MEASUREMENT
   1) Gravimetric Tank (500 litre)
   2) Gravimetric Tank (1000 litre)
   3) Load Cell System (2 ton)
   4) Load Cell System (5 ton)
   5) Load Cell System (10 ton)

3. VISCOSITY STANDARDS
   1) Standard Viscosity Meter
   2) Viscosity Standard Liquid

Table 7-6 Equipment List (Force)

1. FORCE

   1) Hydraulic Force Standard Machine (2 MN)
   2) Hydraulic Force Standard Machine (5 MN)
   3) Standard Dynamometers (100 kgf - 10 MN)
   4) Universal Force Calibration Unit (5000 kgf)
   5) Universal Force Calibration Unit (27000 kgf)
   6) Universal Force Calibration Unit (50000 kgf)
   7) Universal Force Calibration Unit (270000 kgf)
   8) Precision Proving Rings (various up to 500 tf)
   9) Precision Strain Gauge Load Cell (various up to 500 tf)

2. HARDNESS

   1) Hardness Standard Machine (Vickers HV30)
   2) Hardness Standard Machine (Rockwell HRB, HRC)
   3) Hardness Standard Machine (Rockwell Superficial)
   4) Hardness Standard Block (Vickers)
   5) Hardness Standard Block (Rockwell)
   6) Hardness Standard Block (Brinell)

3. TORQUE

   1) Torque Standard Machine (5 - 5K NM)
   2) Torque Transducer (5 - 5K NM)
   3) Torquemeter (5 - 5K NM)

Table 7-7 Equipment List (Pressure)

1. NORMAL & HIGH PRESSURE
   1) Air/Gas-Operated Digital Pressure Controller (0 - 10 kPa)
   2) Air/Gas-Operated Pressure Balance (100k - 1M Pa)
   3) Nitrogen Pressure Cylinder
   4) Oil-Operated Pressure Balances (200k - 500M Pa)
   5) Pressure Oscillating Quartz Force Transducers
   6) Precision Bourdon Tube Gauges
   7) Piston Gauge (Oil:0 - 6000 psi, Air:0 - 10 bar)

2. LOW PRESSURE
   1) Liquid (Water, Mercury) Column Manometer
   2) Standard Haas Barometer
   3) Mercury Column Barometer (1 - 100 kPa)
   4) Automatic Pressure Calibrator for Pressure Gauge

3. BAROMETER
   1) Interference Manometer (1 - 100 kPa)
   2) Precision Fortin-type Barometer
   3) Barometer Test Chamber

4. VACUUM
   1) McLoad Gauges (0.1～ 2 Pa)
   2) Ionization Vacuum Gauges (10^{-4}～10^{-1} Pa)
   3) Vacuum Gauge Comparator

Table 7-8 EQUIPMENT LIST (Temperature)

1. Temperature Fixed Point Cells (including Reference Substance and Crucible)

   1) Triple Point of Argon (-189.344 2 ℃)

   2) Triple Point of Mercury (-38.8334 ℃)

   3) Triple Point of Water (0.01 ℃)

   4) Triple Point of Galium (29.7646 ℃)

   5) Triple Point of Indium (156.598 5 ℃)

   6) Freezing Point of Tin (231.928℃)

   7) Freezing Point of Zinc (419.527 ℃)

   8) Freezing Point of Aluminium (660.323℃)

   9) Freezing Point of Silver (961.78℃)

   10) Melting Point of Paradium (1552 ℃)

2. Bath or Furnace for Realizing Fixed Points (with Regulator)

   1) Cryostat

   2) Bath for Medium Temp. Range (20~200 ℃)

   3) Bath for Medium High Range (200~700 ℃)

   4) Bath for High Range (500~1100℃)

3. Standard Thermometers

   1) Capsule Type Platinum Res. Thermometer

   2) Stem Type Platinum Res. Thermometer

   3) Radiation Thermometer (Silicon Detector Type)

Table 7-9 Equipment List (Electrical) - DC Voltage

	Equipment Name	Q'ty
1.	DCCP	1
2.	Reference Divider	2
3.	Null Detector	2
4.	Calibrator	1
5.	Amplifier	1
6.	DVM	1
7.	Transfer Voltage Standard	2
8.	100 l Liquid He Dewer	1

Table 7-10 Equipment List (Electrical) - Resistance

	Equipment Name	Q'ty
1.	DCCB w/Extender for V/I	1
2.	Transfer Standard 1kohm, 10kohm	1
3.	Shorting Bar	1
4.	Standard Resistor 10kohm	3
5.	Standard Resistor 10Mohm	1
6.	Standard Resistor 100Mohm	1
7.	Standard Resistor 11 pieces	1 set
8.	Calibrator	1
9.	Amplifier	1
10.	Null Detector	1
11.	Shunt	1 set
12.	DMM (8-1/2 digit)	2

Table 7-11 Equipment List (Electrical) - LC

	Equipment Name	Q'ty
1.	Capacitance Bridge	1
2.	Auto Capacitance Bridge	1
3.	LCR Meter w/Readwire	1
4.	LCR Meter w/Readwire	1
5.	Standard Capacitor	3
6.	Standard Capacitor 1000pF 20kV	1
7.	Standard Capacitor 10nF 2kV	1
8.	Current Comparator w/CT	1

Table 7-12 Equipment List (Electrical) - AC Voltage

	Equipment Name	Q'ty
1.	AC/DC Thermal Transfer Standard w/option	1
2.	Calibrator	2
3.	Amplifier	1
4.	AC Measurement Standard	1
5.	Inductive Voltage Divider (7 dial)	2
6.	AC Shunt 10mA-20A	1 set

Table 7-13 Equipment List (Electrical) - Power and Energy

	Equipment Name	Q'ty
1.	Multi Junction Thermal Converter	1
2.	Calibrator	2
3.	Amplifier	1
4.	Synthesizer	1
5.	Wattconverter	1
6.	Digital Phase Meter	1
7.	DMM	1
8.	Watthour Meter Testing System	1
9.	Standard Watthour Meter (3 phase, 4 wire)	2

Table 7-14 Equipment List (Electrical) - High Voltage

	Equipment Name	Q'ty
1.	CT Testing system	1
2.	Current Comp. CT Test Set up to 2000A	1
3.	Electronic Burden for CT	1
4.	Current Transformer	3
5.	High Current Generator System	1
6.	Regulator for High Voltage	1
7.	Up-Transformer (100kV)	1
8.	Standard VT (100, 50kV)	1
9.	AC High Voltage Meter (50kV)	1
10.	DC High Voltage Power Supply	1
11.	DC High Voltage Probe (100kV)	1

Table 7-15 Equipment List (Time/Frequency)

Equipment Name	Q'ty
Laboratory Type Primary Cesium Beam Frequency Standard	1
Cesium Beam Frequency and Time Standard	1
Distribution Amplifier	1
Linear Phase Comparator	1
Freq. Difference Meter	1
Quartz Frequency Standard	1
Rubidium Frequency Standard	1
Time Interval	1
Universal Counter	1
Frequency Synthesizer	1
GPS Receiver	1
Time Distribution System	1

Table 7-16 Equipment List (Time/Frequency) by parameter

Equipment Name	Q'ty
(Attenuation)	
Decade Transformer	1
Piston Attenuator	1
Level and Attenuation Calibrator	1
Attenuation Calibration System	1
Vector Network Analyzer	1
Standard Attenuator	1
(RF Power)	
Microcalorimeter	1
Power Bridge	1
Power Standard	1
Digital Power Meter	1
(RF Voltage)	
Micropotentiometer	1
RMS Voltmeter	1
(Noise)	
Standard Noise Generator	1
Noise Figure Measurement System	1

Table 7-17 Equipment List (Acoustic)

1. Anechoic Room
2. Dummy, 1"
3. Dummy, 1/2"
4. Microphone Power Supply
5. Microphone Preamplifier (2 sets)
6. Microphone, 1" (2 sets)
7. Microphone, 1/2" (2 sets)
8. Pistonphone (2 sets)
9. Power Amplifier
10. Sound Level Calibrator
11. Band Pass Filter
12. Ratiotransformer (2 sets)
13. 1:1 Special Purpose Transformer
14. Programmable Oscilloscope Calibrator
15. 1/3-1/1 Octave Filter Set
16. Pre. Inter. Sound Level Meter
17. Sound Level Calibrator
18. Barometer
19. Computer (CPU)
20. Video Graphics Color Display
21. Think Jet printer
22. Printer
23. Microphone Preamplifier
24. Microphone Power Supply
25. Programmable Pulse Function Generator
26. Programmable RC Oscillator
27. Universal Counter
28. AC Voltage Stabilizer
29. Regulated Power Supply
30. Temperature-Humidity Recorder
31. Multimeter
32. AC Voltage Stabilizer
33. AC Auto Voltage Regulator

Table 7-18 Equipment List (Vibration)

1. Vibration Calibration System

Table 7-19 Equipment List (Electrical - Photometry)

Equipment Name	Q'ty
1. Luminous Intensity Standard System	
1-1. Luminous Intensity Standard Lamps	3 set
1-2. Luminous Intensity Working Standard Lamps	3 set
1-3. DC Power Supply 50V, 35A, GP-IB	1
1-4. DC Power Supply 250V, 8A, GP-IB	1
1-5. 6m Photometer Bench	1 set
1-6. Shunt 50, 10, 3A	1 set
1-7. V(λ) Photo Sensor	1
1-8. Distribution Thermometer	1
1-9. DMM	3
1-10. Computer	1
2. Total Luminous Flux Standard System	
2-1. Total Luminous Flux Standard Lamps	3 set
2-2. Total Luminous Flux Working Standard Lamps	3 set
2-3. Integrating Sphere 2.5m	1
2-4. V(λ) Photo Sensor	1
2-5. DC Power Supply 250V, 8A, GP-IB	1
2-6. AC Power Supply 280V, 20A	1
2-7. Reference Ballast	1
2-8. DMM	3
2-9. AC Power Meter	1
2-10. Digital Pt. Resistance Thermometer	1
2-11. Computer	1
2-12. Spectroradiometer System	1 set
2-13. Life Test System of Standard Lamp	1 set

Table 7-20 Equipment List (Electrical - Magnetic)

	Equipment Name	Q'ty
1.	Nuclear Magnetic Resonance System	1
2.	Helmholtz Coil System	1
3.	Electromagnet System	1
4.	Fluxgate Magnetometer	1
5.	Gaussmeter	1
6.	Standard Magnet	1 set

Table 7-21　Allotment Plan of Calibration Works

QUANTITY	NML		NCL		
	R&D	CAL.	Shah Alam	Penang	Johor
Length	◎	△	○	○	○
Mass	◎		◎	○	○
Force	◎	△	○	△	△
Pressure	◎	△	○	△	△
Volume/Flow	◎	△	○		
Temperature	◎		◎	○	○
Electrical					
Voltage/Resistance	◎		◎	○	○
AC and LC	◎		◎	○	○
High Voltage	◎				
Power/Energy	◎		◎	○	○
Optical	◎	○			
Magnetic	◎	○			
Time/Frequency	◎	△	○	○	○
Acoustic	◎	○			
HF/Microwave	◎	○			

NML
- ◎ Research and Development of Standard
- ○ Calibration Works until Establishment of Standard
- △ Calibration Works (Partial)

NSL
- ◎ Calibration Works
- ○ Calibration Works (Partial)
- △ Calibration Works (Future)

Table 7-22 Conditions for NCL-SA Calibration Laboratories

Laboratory	Floor Area (m^2) (Expansion)	Room Temperature and Humidity	Equipment Cost (1000 Yen)	Reinforcement of Floor	Location	Illuminance	Electro-magnetic Schield	Cleanness	Anti-Vibration	Others
Length	192 (+96)	20±1.0 ℃, 60% ± 5%	—	Necessary	1 F	1000 lx	—	Necessary	Necessary	
Mass	192 (+96)	23±0.5 ℃, 60% or less (Precision Measurement Laboratory)	10,000	Necessary	1 F	1000 lx	—	Necessary	Necessary	
		23±1.0 ℃, 60% or less (General Measurement Laboratory)								
Force/Pressure	144(±0)	23±2.0 ℃, 60% or less	40,000	Necessary	2 F	1000 lx	—	—	—	
Volume/Flow	144(±0)	23±2.0 ℃, 60% or less	8,000	Necessary	1 F	1000 lx	—	—	—	
Temperature	144(±0)	23±2.0 ℃, 55± 5%	—	—	1 F	1000 lx	100 μV/m	—	—	
Electrical	480(+192)	23±2.0 ℃, 60% or less	190,000	—	2 F	1000 lx	100 μV/m	—	—	Earthing 1Ω

Table 7-23 Conditions for NCL-P and NCL-JB Calibration Laboratories

Laboratory	Floor Area (m^2)	Room Temperature and Humidity	Equipment Cost (1000 Yen)	Reinforce-ment of Floor	Location	Illuminance	Electro-magnetic Schield	Cleanness	Anti-Vibration	Others
Length	96	20±1.0 ℃, 60% ± 5%	50,000	Necessary	1 F	1000 lx	–	Necessary	Necessary	
Mass	96	23±0.5 ℃, 60% or less (Precision Measurement Laboratory)	50,000	Necessary	1 F	1000 lx	–	Necessary	Necessary	
		23±1.0 ℃, 60% or less (General Measurement Laboratory)								
Force/Pressure	96	23±2.0 ℃, 60% or less	20,000	Necessary	1 F	1000 lx	–	–	–	
Temperature	48	23±2.0 ℃, 55± 5%	5,000	–	1 F	1000 lx	100 μV/m	–	–	
Electrical	192	23±2.0 ℃, 60% or less	45,000	–	1 F	1000 lx	100 μV/m	–	–	Earthing 1Ω

Note : 'Floor area' and 'Equipment Cost' show as each laboratory.

Table 7-24 EXPECTED GLOWTH OF CALIBRATION SERVICE (PHYSICAL QUANTITIES)

YEAR	MASS	LENGTH	VOLUME	FLOW	FORCE & PRESSURE	TEMPERATURE
*1989	4374	336	1406		482	
*1990	4416	350	1425		518	583
*1991	7258	2260	296		704	1378
*1992	7950	7664	313	560	1206	1697
1993	8642	13068	419	750	1708	2016
1994	9334	18472	525	940	2210	2335
1995	10026	23876	631	1130	2712	2654
1996	10718	29280	738	1319	3214	2973
1997	11410	34684	844	1509	3716	3292
1998	12102	40088	950	1699	4218	3611
1999	12974	45492	1056	1889	4720	3930
2000	13486	50896	1162	2079	5222	4249
2001	14178	56300	1268	2269	5724	4568
2002	14780	61704	1374	2459	6226	4887
Expecting growth in next ten years :						
2002/1992	1.87	8.05	4.39	4.39	5.16	2.88

(Source : SIRIM, data from 1989 to 1992)

Note : Number of Calibration in Volume and Flow Laboratory was not separated before 1991.

Table 7-25 Equipment List (Mass)

1) Standard Weight Set (OIML Class E2, 1 mg - 20 kg)
2) Standard Weight Set (OIML Class E2, 1 mg - 20 kg)
3) Standard Weight Set (OIML Class E2, 1 mg - 500 g)
4) Standard Weight Set (OIML Class F1, 1 mg - 50 kg)
5) Standard Weight Set (OIML Class F1, 1 mg - 1 kg)
6) Standard Weight Set (OIML Class F2, 1 mg - 50 kg)
7) Standard Weight Set (OIML Class F2, 1 mg - 1 kg)
8) Mass Comparator (50 kg/10 mg, Class E2)
9) Mass Comparator (20 kg/ 1 mg, Class E2)
10) Mass Comparator (10 kg/0.1mg, Class E2)
11) Mass Comparator (1 kg/ 0.01 mg)
12) Mass Comparator (1 kg/ 0.1 mg)
13) Mass Comparator (200 g/ 0.1 mg)
14) Mass Comparator (200 g/ 0.001 mg)
15) Mass Comparator (5 g / 0.5 μg)
16) Mass Comparator (5 g / 0.001 mg)
17) Precision Platform Scale (600 kg/ 1 g)
18) Precision Platform Scale (300 kg/ 0.1 g)
19) Anti-Vibration Balance Tables
20) Ultrasonic Weight Cleaning System

Table 7-26 Equipment List (Volume/Flow)

1) Vehicle for Calibration Services
2) Standard Tanks
3) Standard Viscometer

Table 7-27 Equipment List (Force/Pressure)

1-1. FORCE

1) Load Cell (Tensile & Compression) w/Display Unit (0.5, 1, 3, 5, 10 tf)

2) Load Cell (Compression) w/Display Unit (50, 100, 200, 300, 500 tf)

3) Universal Force Calibration Unit (500 tf)

1-2. HARDNESS

1) Hardness Standard Block (Vickers, Rockwell, Brinell)

1-3. TORQUE

1) Torque Checker

2) Torque Transducer

2-1. NORMAL & HIGH PRESSURE

1) Air/Gas Operated Dead Weight Pressure Tester
(Oil:0 - 6000 psi, Air:0 - 10 bar)

2) Pressure Oscillating Quartz Force Transducers
Pressure Transducer (25, 50, 100, 250, 500, 1000, 2500, 5000, 7500, 10000 psi)

3) Bourdon Tube Gauges

2-2. LOW PRESSURE

1) Liquid (Water, Mercury) Column Manometer

2) Standard Haas Barometer

Table 7-28 Equipment List (Electrical) - DC Voltage

	Equipment Name	Q'ty
1.	DCCP	1
2.	Reference Divider	1
3.	Null Detector	1
4.	Calibrator	2
5.	Amplifier	1
6.	DMM	2
7.	Transfer Voltage Standard	1
8.	DC Calibration System	2

Table 7-29 Equipment List (Electrical) - Resistance

	Equipment Name	Q'ty
1.	Standard Resistor 1Ω	3
2.	Standard Resistor	2 set
3.	High Resistance Standard 1G-100T	1 set
4.	Digital Teraohmmeter	1
5.	Calibrator	1
6.	Amplifier	1
7.	Oil Bath w/Digital Thermometer	1
8.	Null Detector	1
9.	Shunt	1 set

Table 7-30 Equipment List (Electrical) - LC

	Equipment Name	Q'ty
1.	Auto Capacitance Bridge	1
2.	LCR Meter	1
3.	Standard Capacitance 1, 10, 100, 1000pF	1 set
4.	Standard Capacitance 0.01, 0.1, 1 μF	1 set
5.	Standard Capacitance (1MHz)	1 set
6.	Standard Inductance (1kHz)	1 set
7.	Standard Inductance (1MHz)	1 set
8.	Frequency Counter (100MHz)	1

Table 7-31 Equipment List (Electrical) - AC

	Equipment Name	Q'ty
1.	AC/DC Thermal Transfer Standard w/option	1
2.	Calibrator	1
3.	Amplifier	1
4.	AC Measurement Standard	1
5.	AC Shunt 10mA-20A	1 set
6.	Inductive Voltage Divider	1
7.	AC Calibration System	2
8.	DC High Voltage Divider (50kV)	1
9.	DC High Voltage Supply (50kV)	1
10.	Voltage Transformer (30kV)	1
11.	AC High Voltage Supply (30kV)	1
12.	Withstanding System (50kV)	1

Table 7-32 Equipment List (Electrical) - Power and Energy

	Equipment Name	Q'ty
1.	Power Generator System	1
2.	Wattconverter	3
3.	AC Power Meter	1
4.	AC Power Meter	1
5.	Digital Phase Meter	1
6.	PF Meter	2
7.	Wattmeter	3
8.	DMM	1
9.	Frequency Counter (100MHz)	1

Table 7-33 Equipment List (Time/Frequency)

Equipment Name	Q'ty
Rubidium Freq. Standard	1
Quartz Oscillator	1
Distribution Amplifier HP5087A	1
Time Transmission System	1
Freq. Difference Meter Tracor 527E	1
Synthesized Function Generator HP3325A	1
Synthesized Signal Generator HP8657B	1
Universal Counter HP5328B	1
Universal Counter	1
Oscilloscope Calibrator	1
Spectrum Analyzer	1
Multimeter Fluke 8840A	1
Digitizing Oscilloscope HP 54501A	1
Curve Tracer	1
Distortion Meter Calibrator	1
Wow and Flutter Calibrator	1

Table 7-34 Equipment List (Electrical) - NCL-P and NCL-JB

Equipment Name		Q'ty
1.	DC	
1-1.	Reference Divider	1
1-2.	Null Detector	1
1-3.	Calibrator	1
1-4.	Amplifier	1
1-5.	DMM (DC V, AC V, Ω, DC I, AC I)	1
1-6.	DC Calibration System	1
1-7	DC V/A Meter 12 pieces	1 set
2.	Resistance	
2-1.	Standard Resistor	1 set
2-2.	Decade Resistors 1000Ω	1
2-3.	Decade Resistors 100MΩ	1
2-4.	Shunt 2A-100A	1 set
3.	LC	
3-1.	LCR Meter	1
3-2.	Standard Capacitance 1,10,100,1000pF	1 set
3-3.	Standard Capacitance 0.01,0.1,1 μF	1 set
4.	AC	
4-1.	AC Measurement Standard	1
4-2.	AC Calibration System	1
4-3.	AC V/A Meter 20 pieces	1 set
5.	Power	
5-1.	Power Generator System	1
5-2.	Wattconverter	1
5-3.	AC Power Meter	1
5-4.	AC Power Meter	1
5-5.	Digital Phase Meter	1
5-6.	PF Meter	2
5-7.	Wattmeter	2

Table 7-35 Equipment List (Calibration Service Car)

Equipment Name	Q'ty
Calibrator	1
DMM (DC V, AC V, Ω, DC I, AC I)	1
Decade Resistors 1000Ω	1
Decade Resistors 100MΩ	1
Shunt 2A-100A	1 set
DC Calibration System	1
AC Calibration System	1 set
Power Generator	1
Digital Power Meter	1
Frequency Standard	1
SG	1
Frequency Counter	1
Air Conditioning System	1 set
Car	1

Fig. 7-1 Organization Chart of MNC

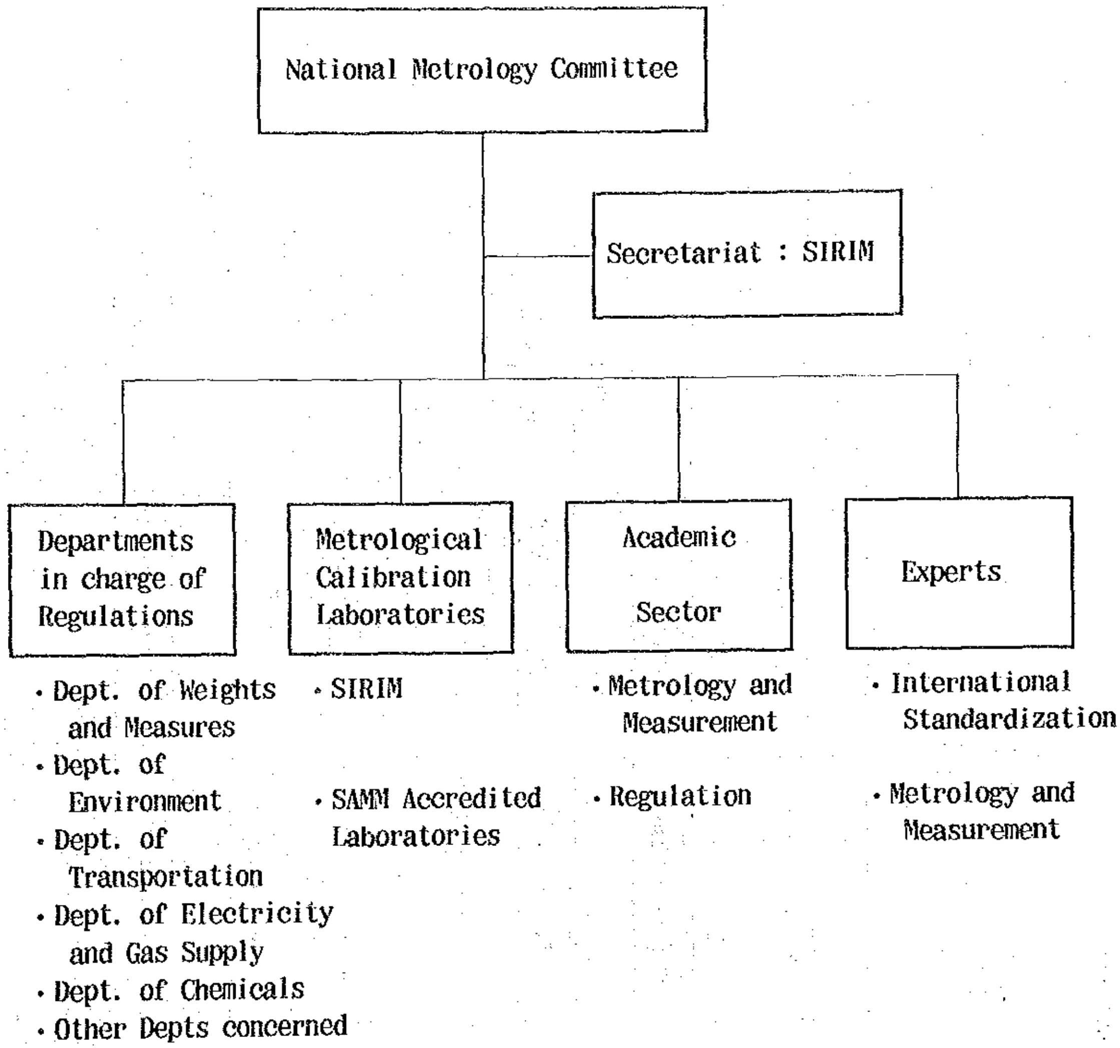
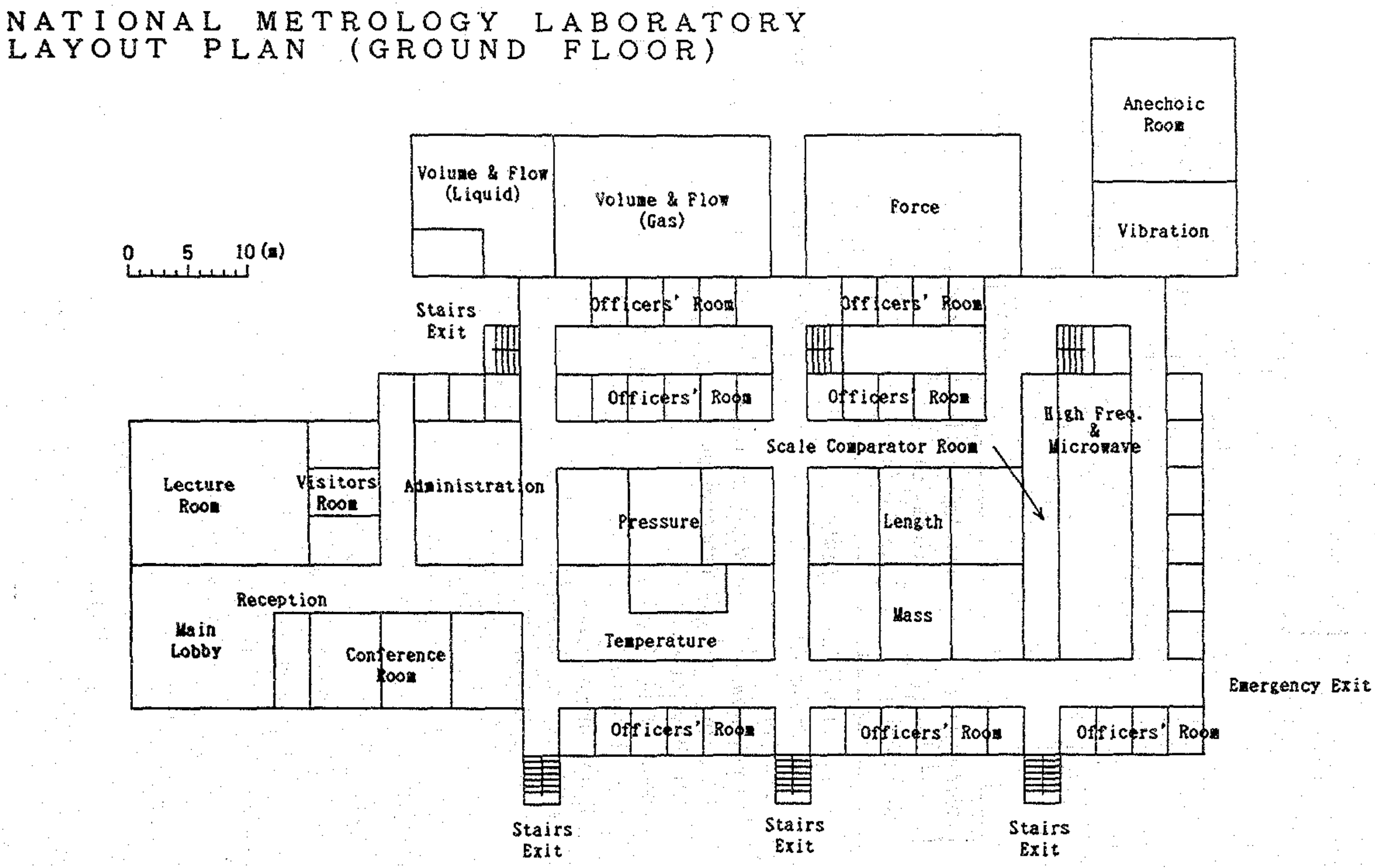


Fig. 7-2 Layout Plan of National Metrology Laboratory



NATIONAL METROLOGY LABORATORY
LAYOUT PLAN (FIRST FLOOR)

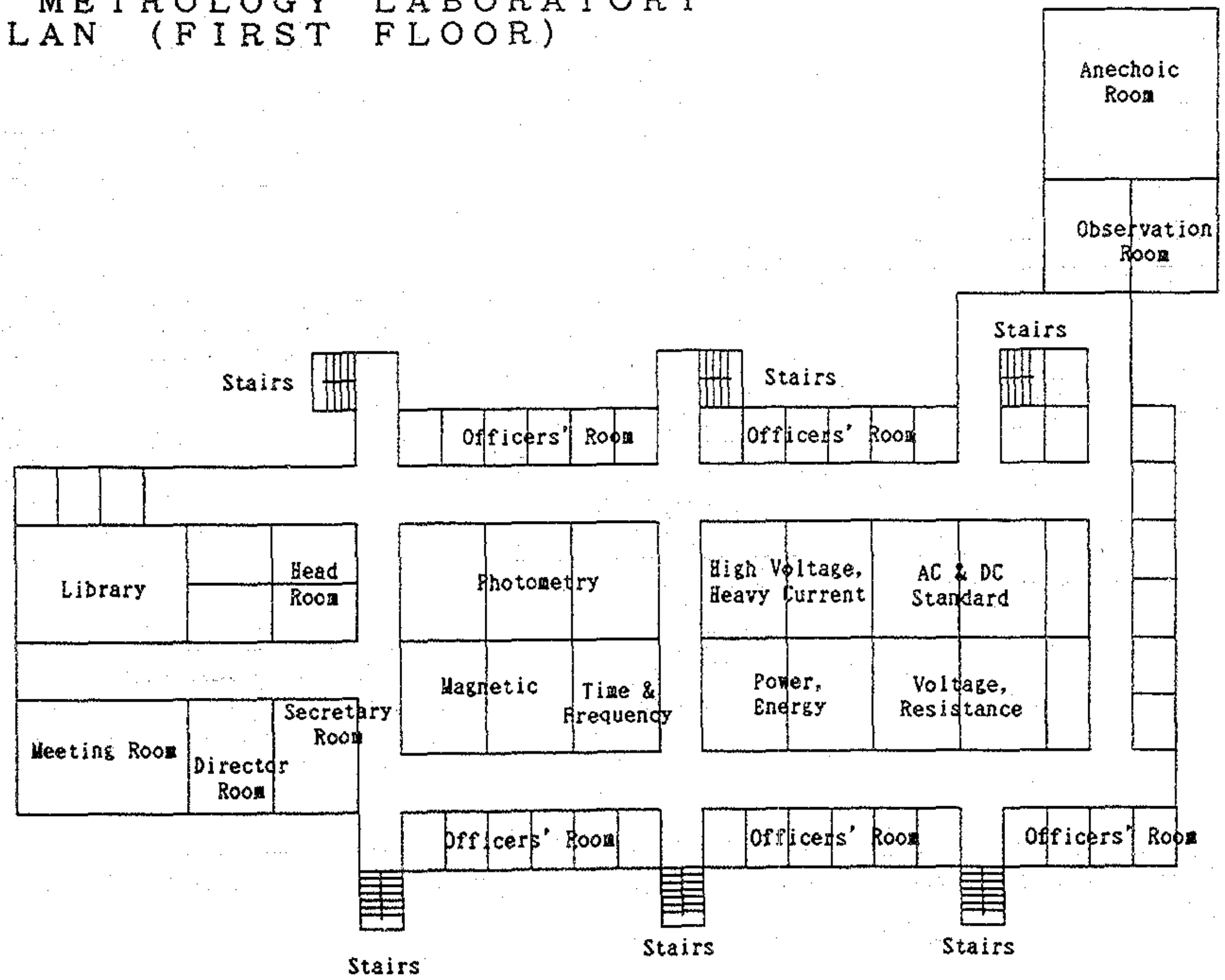


Fig.7-3　Implementation Plan

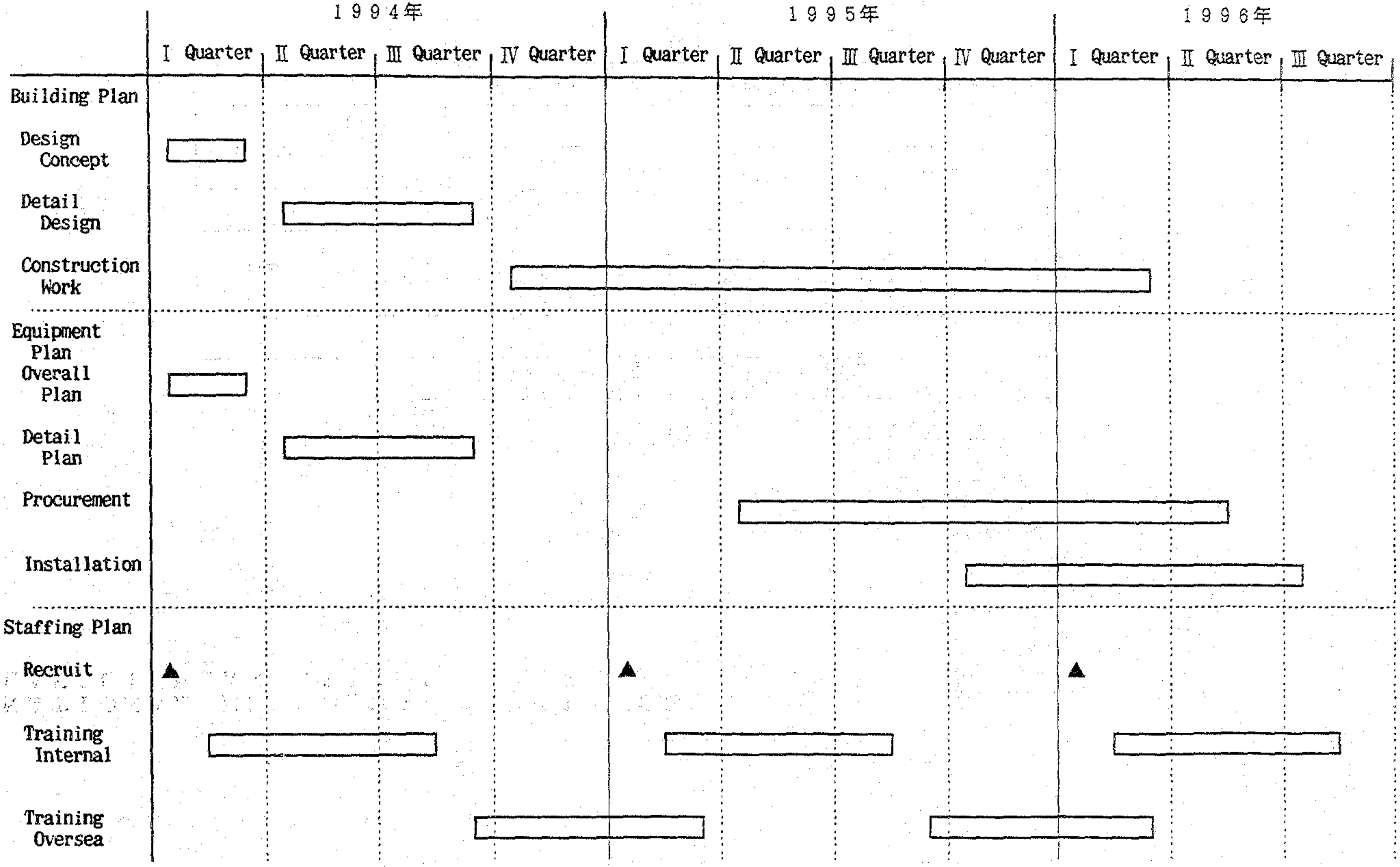


Fig. 7-4 Traceability Chart (Length)

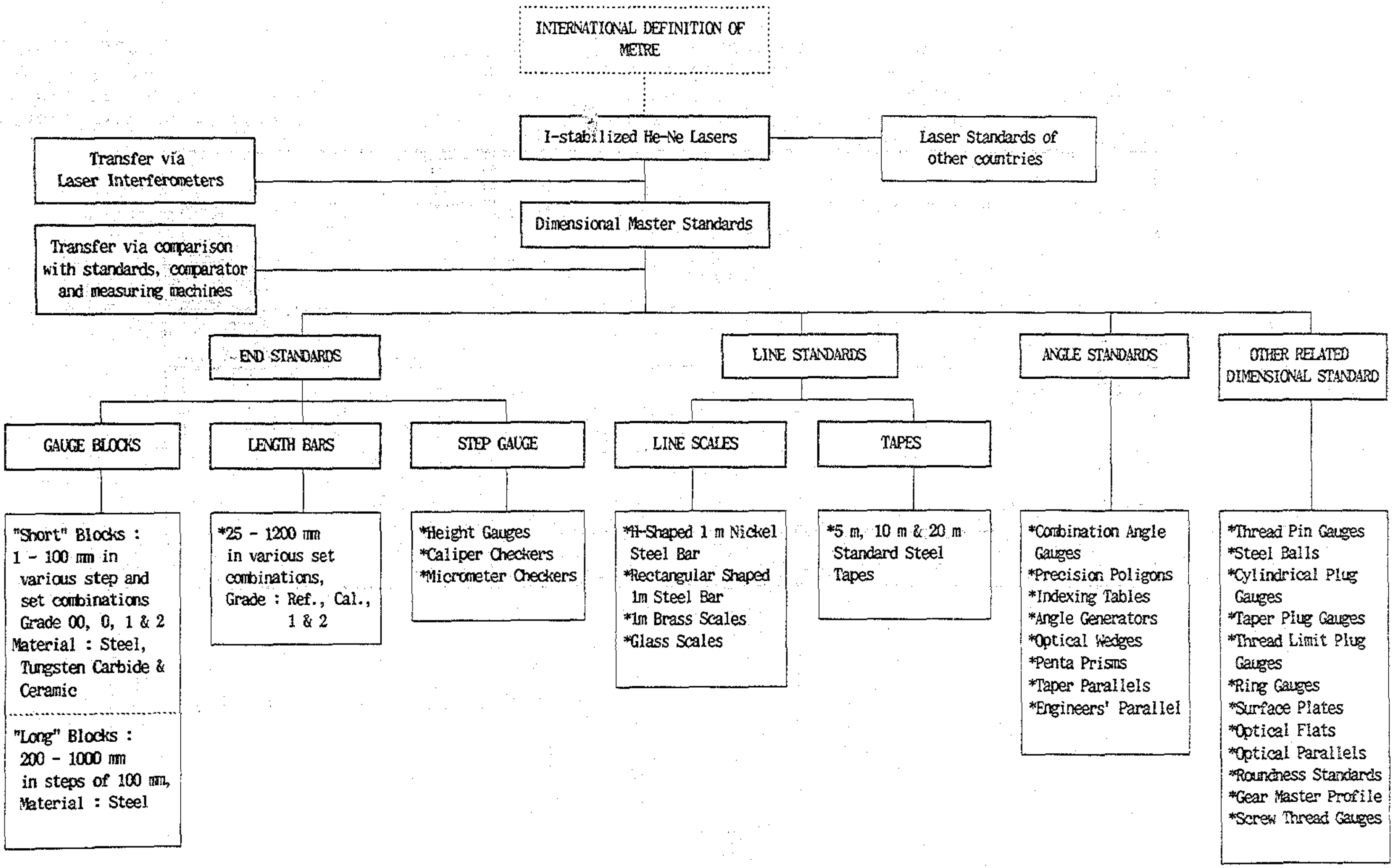
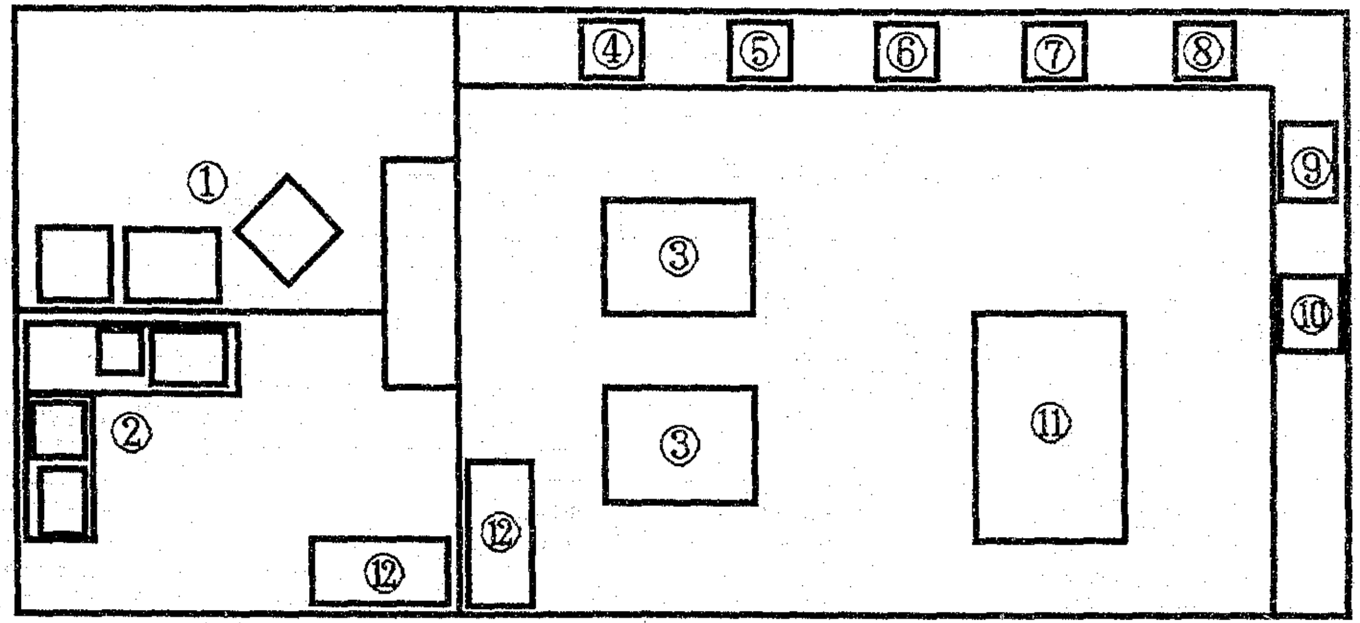


Fig. 7-5 Layout Plan of Length Standards Laboratory



①I-stabilized He-Ne Lasers
②Gauge Block Interferometer
③Surface Plate
④Surface Plate
⑤Roundness Measuring Machine
⑥Toolmakers Microscope
⑦Precision Profile Projector
⑧Universal Measuring Machine
⑨Gear Inspection Machine
⑩Screw Thread Measuring Machine
⑪Coordinate Measuring Machine
⑫Lockers

Fig.7-6 Traceability Chart (Mass)

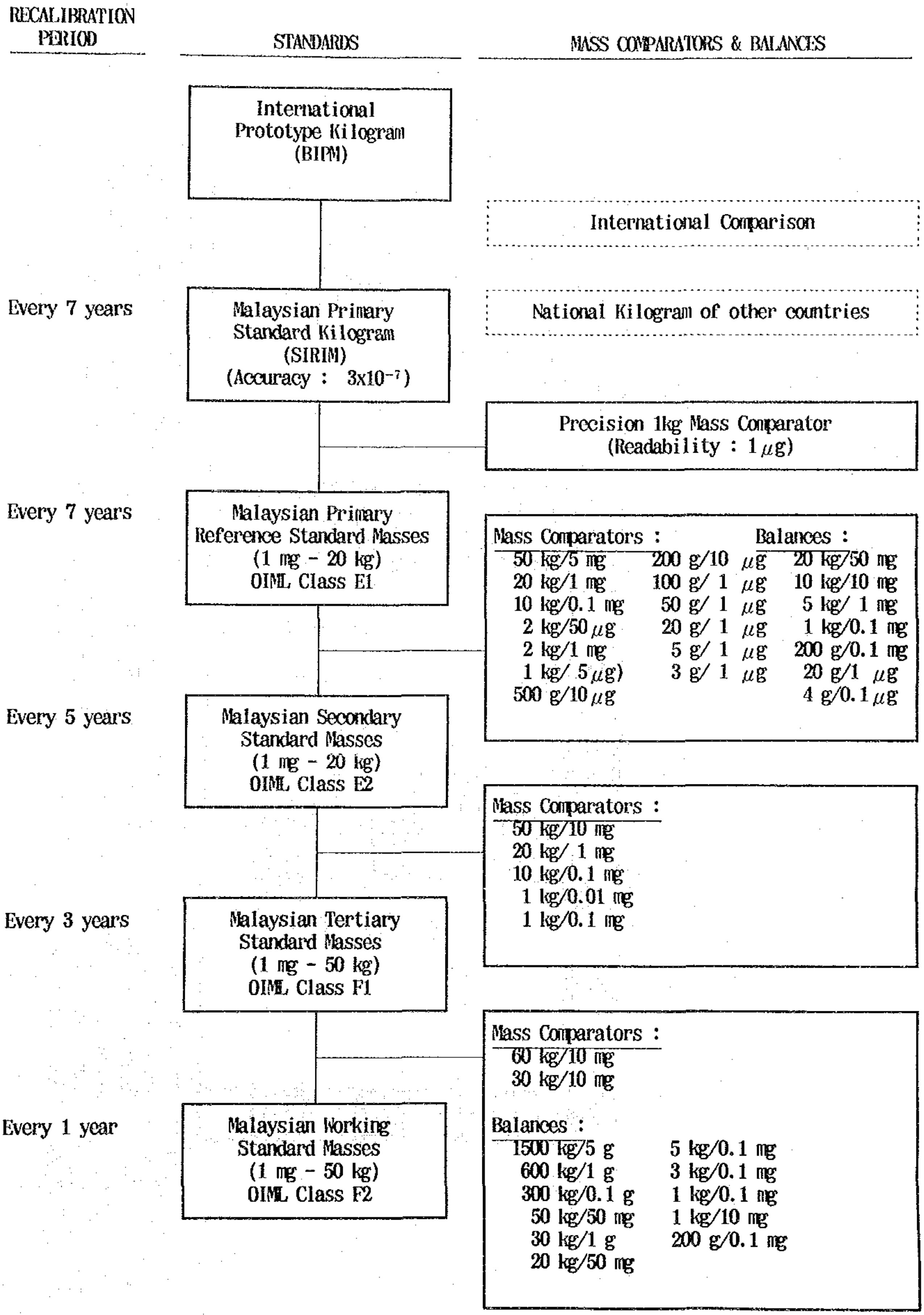
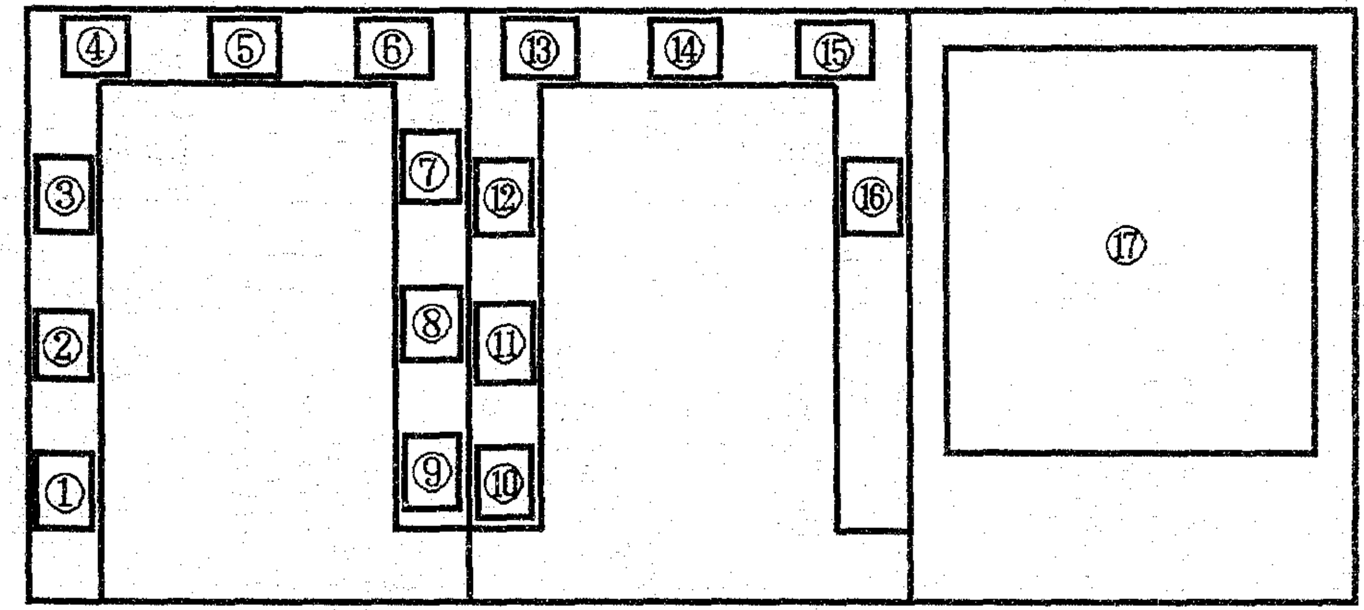


Fig. 7-7 Layout Plan of Mass Standards Laboratory



①Mass Comparator(3g)
②Mass Comparator(20g)
③Mass Comparator(50g)
④Mass Comparator(200g)
⑤Mass Comparator(500g)
⑦Mass Comparator(1kg)
⑧Mass Comparator(2kg)
⑧Mass Comparator(10kg)
⑨Mass Comparator(20kg)
⑩Precision Balance(20kg)
⑪Precision Balance(10kg)
⑫Precision Balance(5kg)
⑬Precision Balance(1kg)
⑭Precision Balance(200g)
⑮Precision Balance(25g)
⑯Precision Balance(4g)
⑰Remote Balance

Fig.7-8 Traceability Chart (Gas Flow)

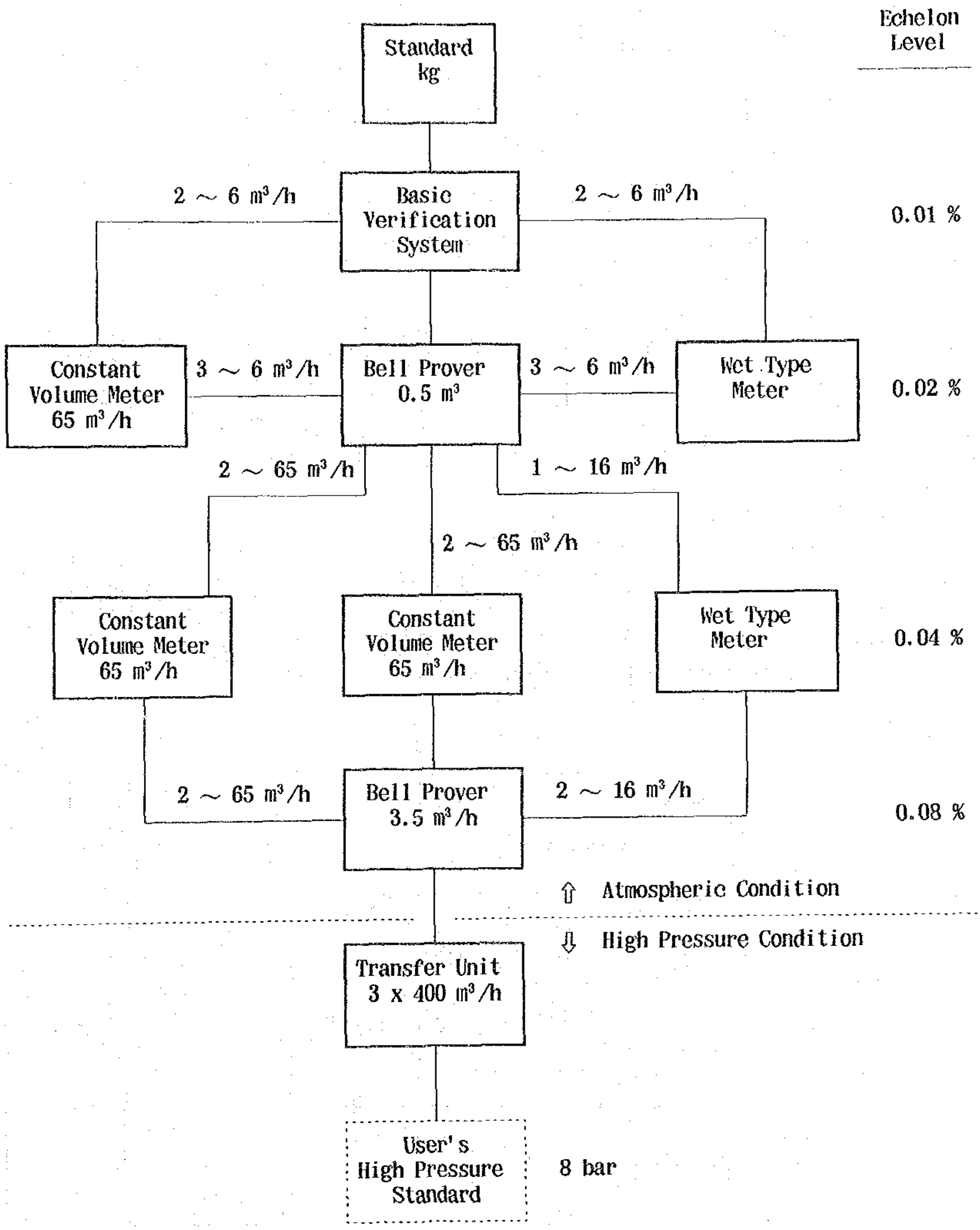


Fig. 7-9 : Basic Verification System

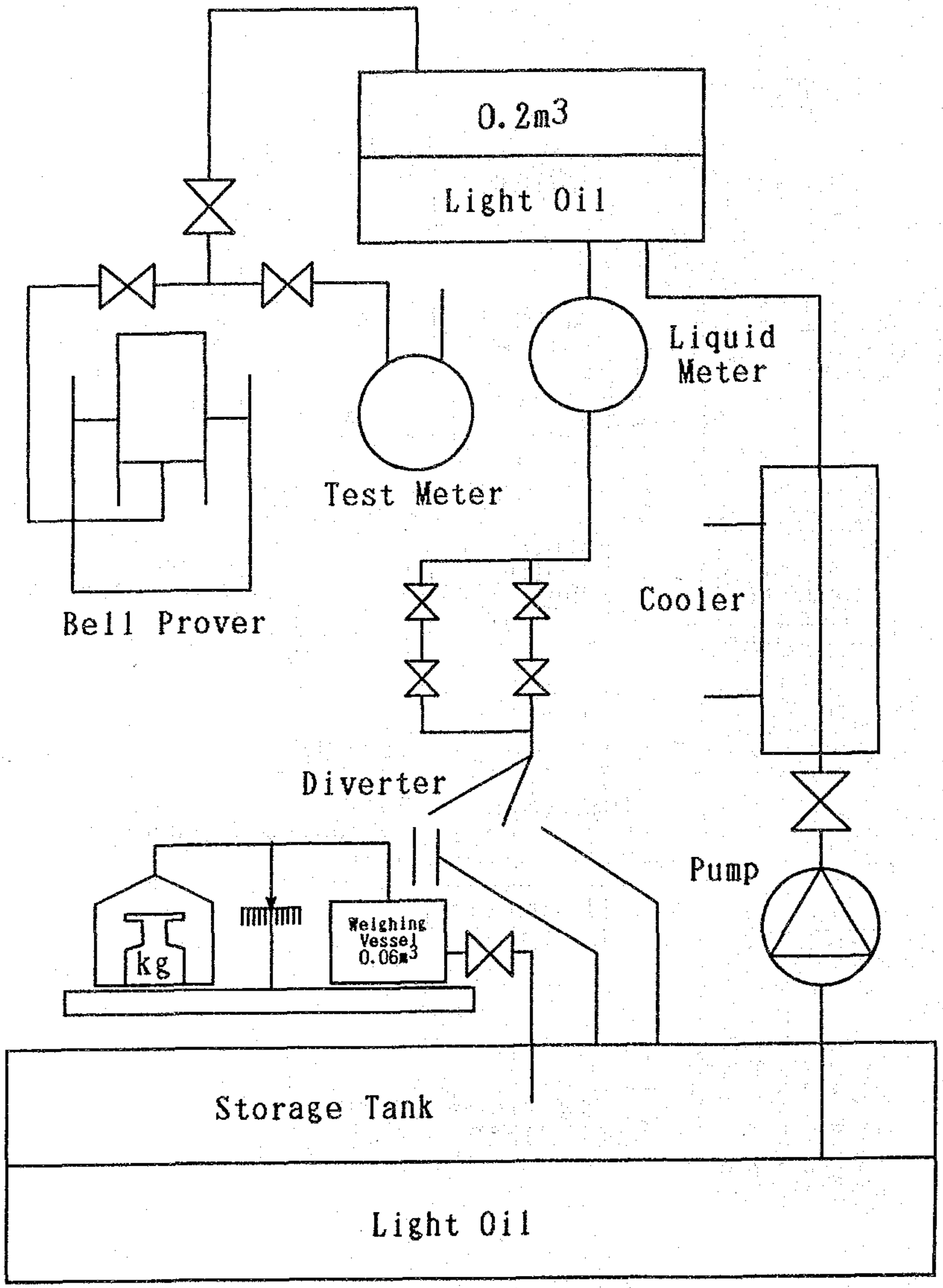


Fig.7-10 HIERARCHY DIAGRAM FOR MEASUREMENT OF VOLUME

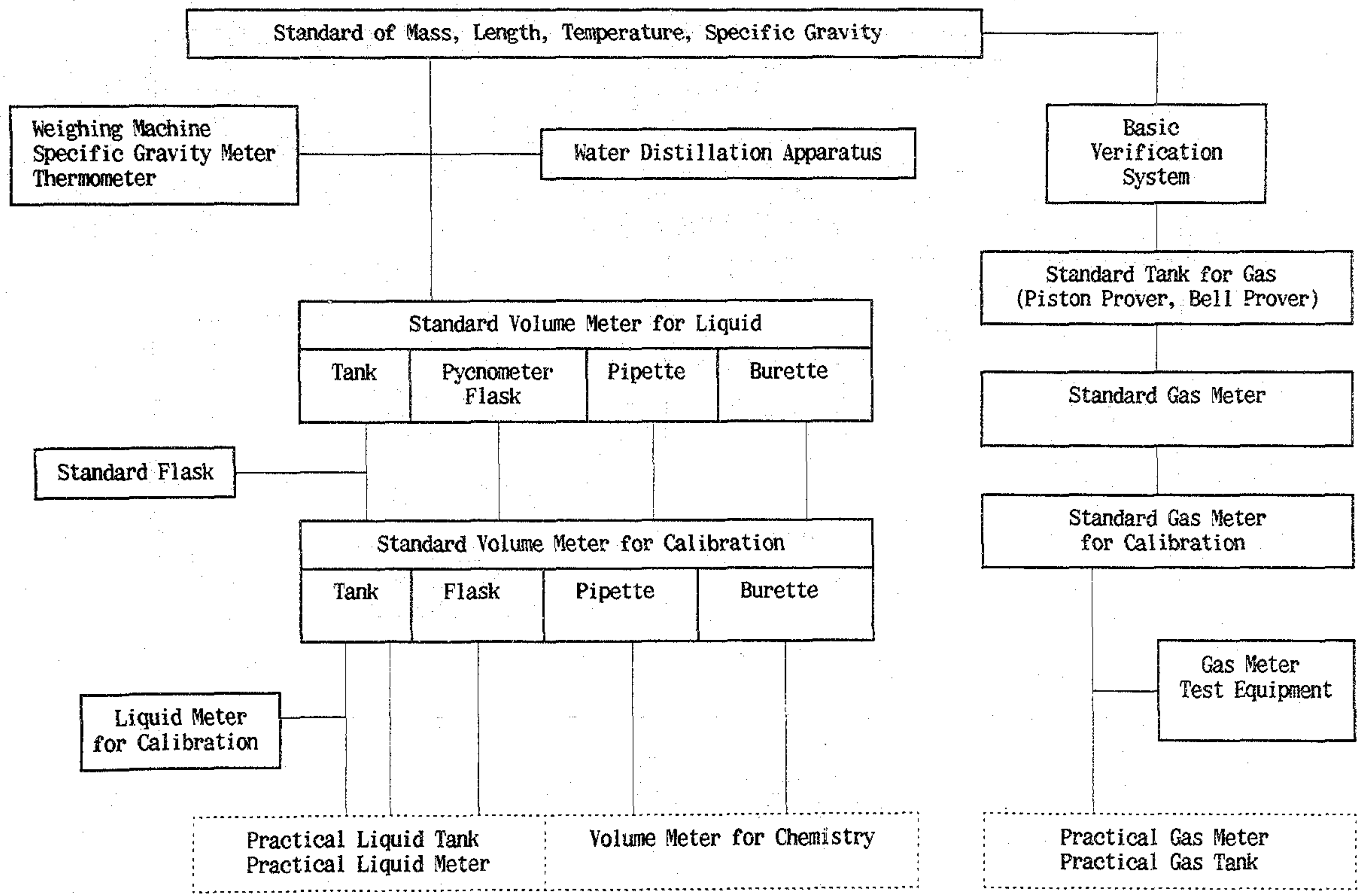


Fig. 7-11a) Layout Plan of Volume and Flow Standards Laboratory
(Gas Flow Measurement)

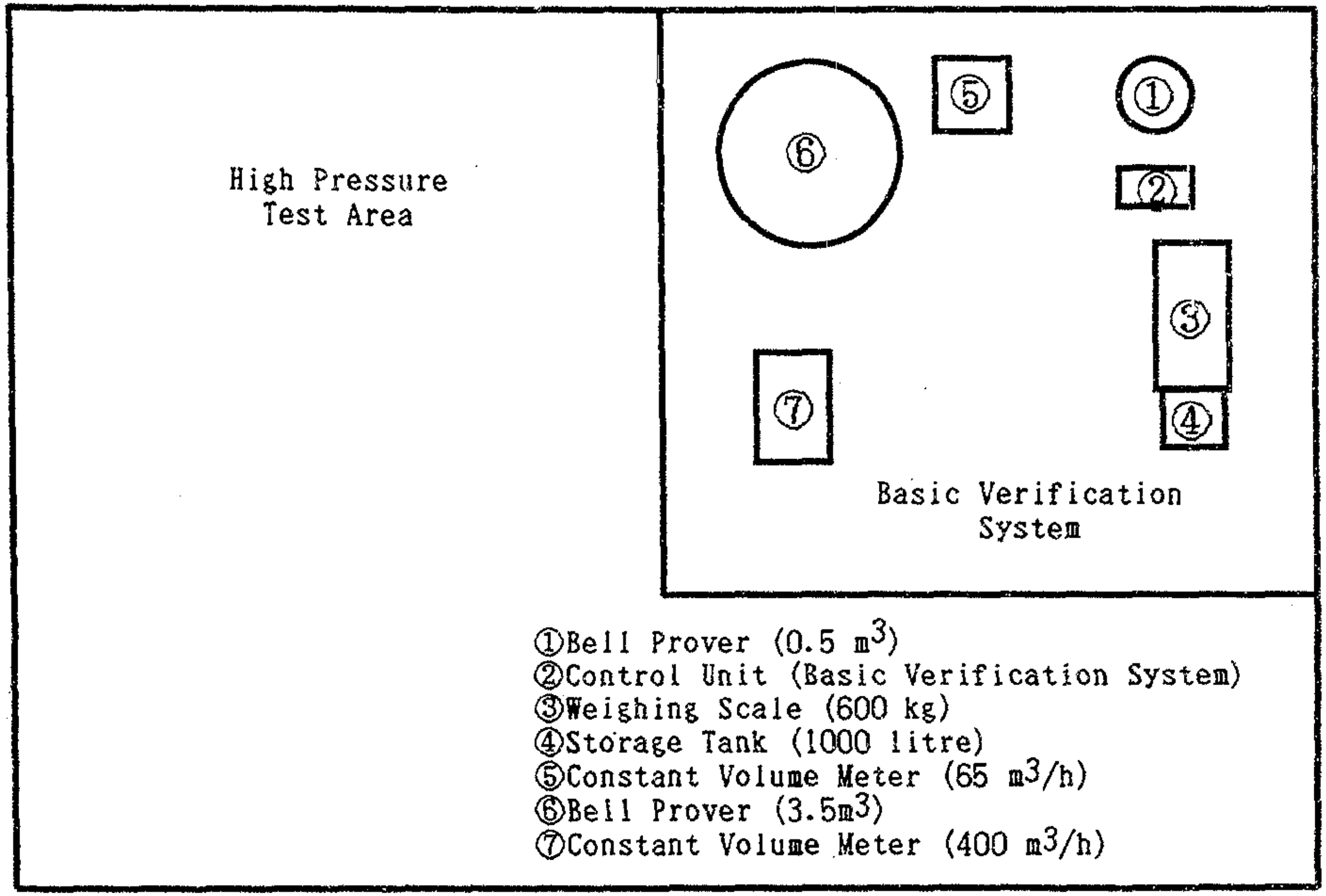
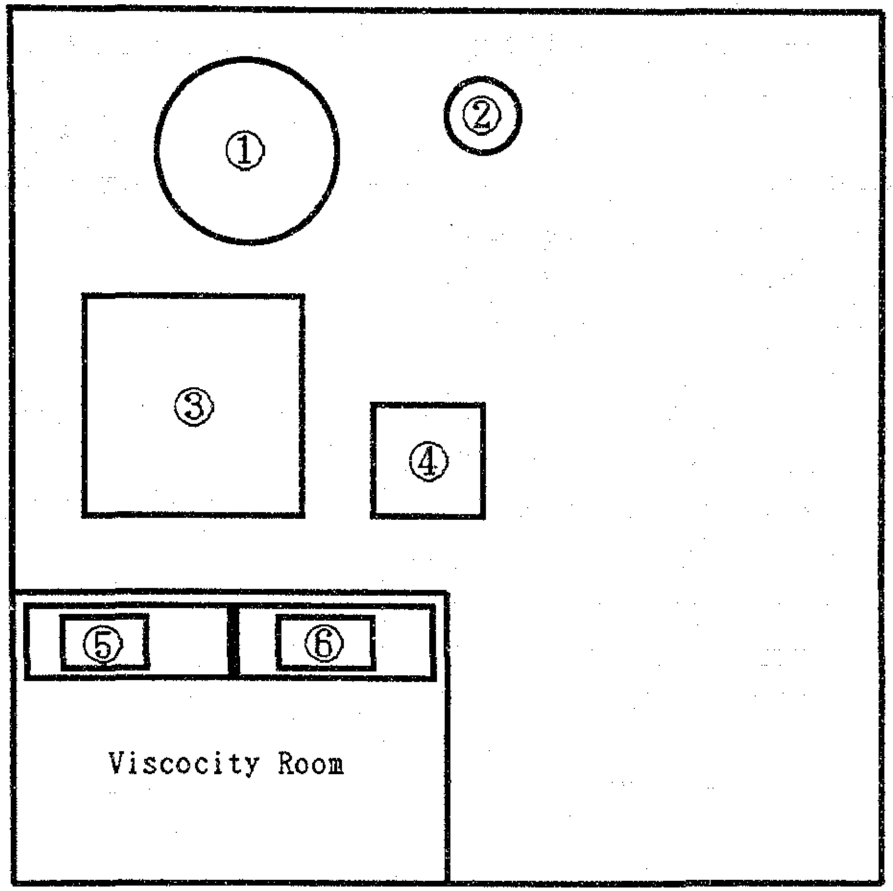


Fig. 7-11b) Layout Plan of Volume and Flow Standards Laboratory
(Liquid Flow Measurement)



①Gravimetric Tank (1000 litre)
②Gravimetric Tank (500 litre)
③Load Cell System (10 ton)
④Load Cell System (5 ton)
⑤Standard Viscocity Meter

Fig.7-12 Traceabirity Chart (Force)

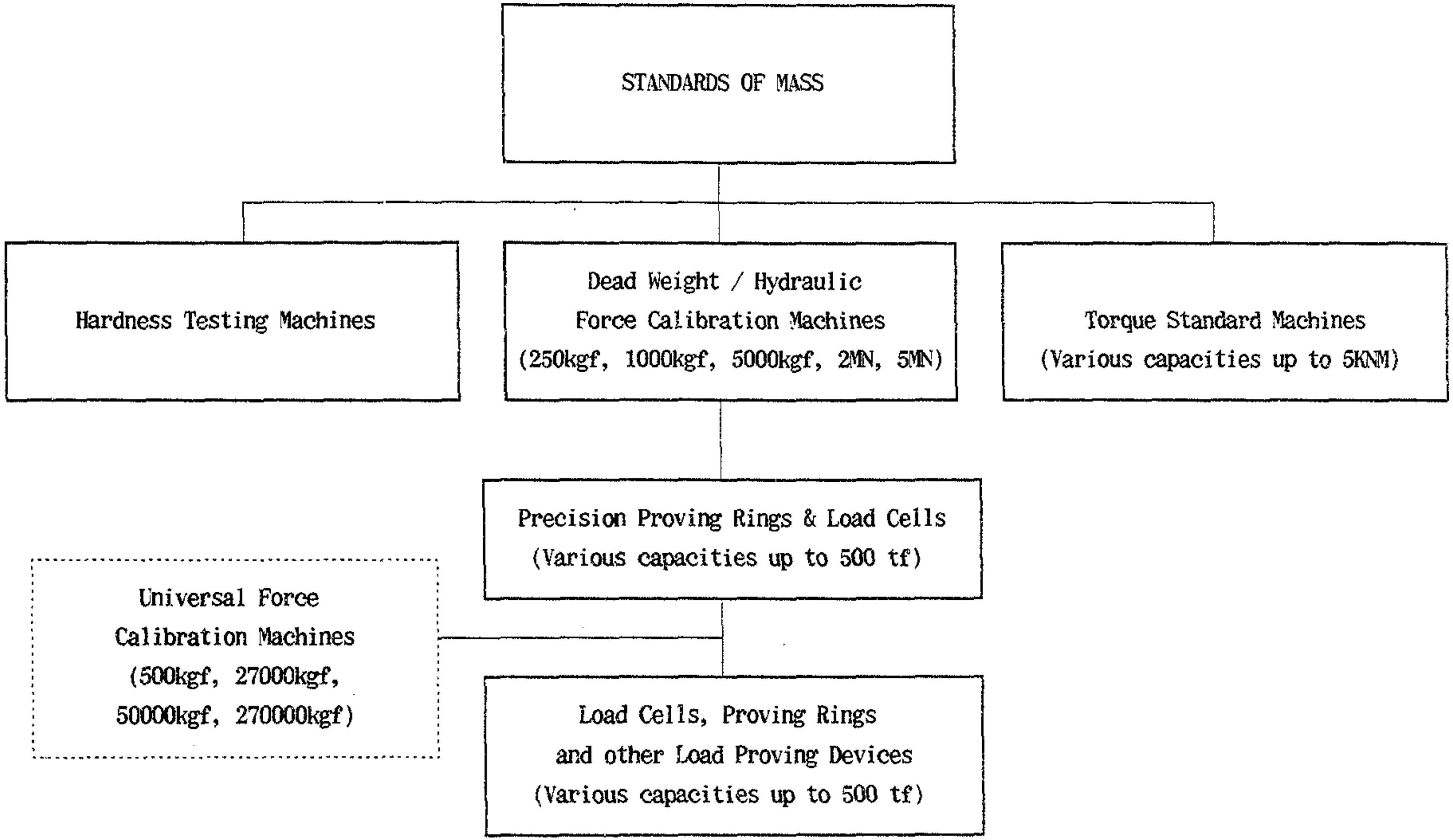


Fig.7-13 Traceability Chart (Pressure)

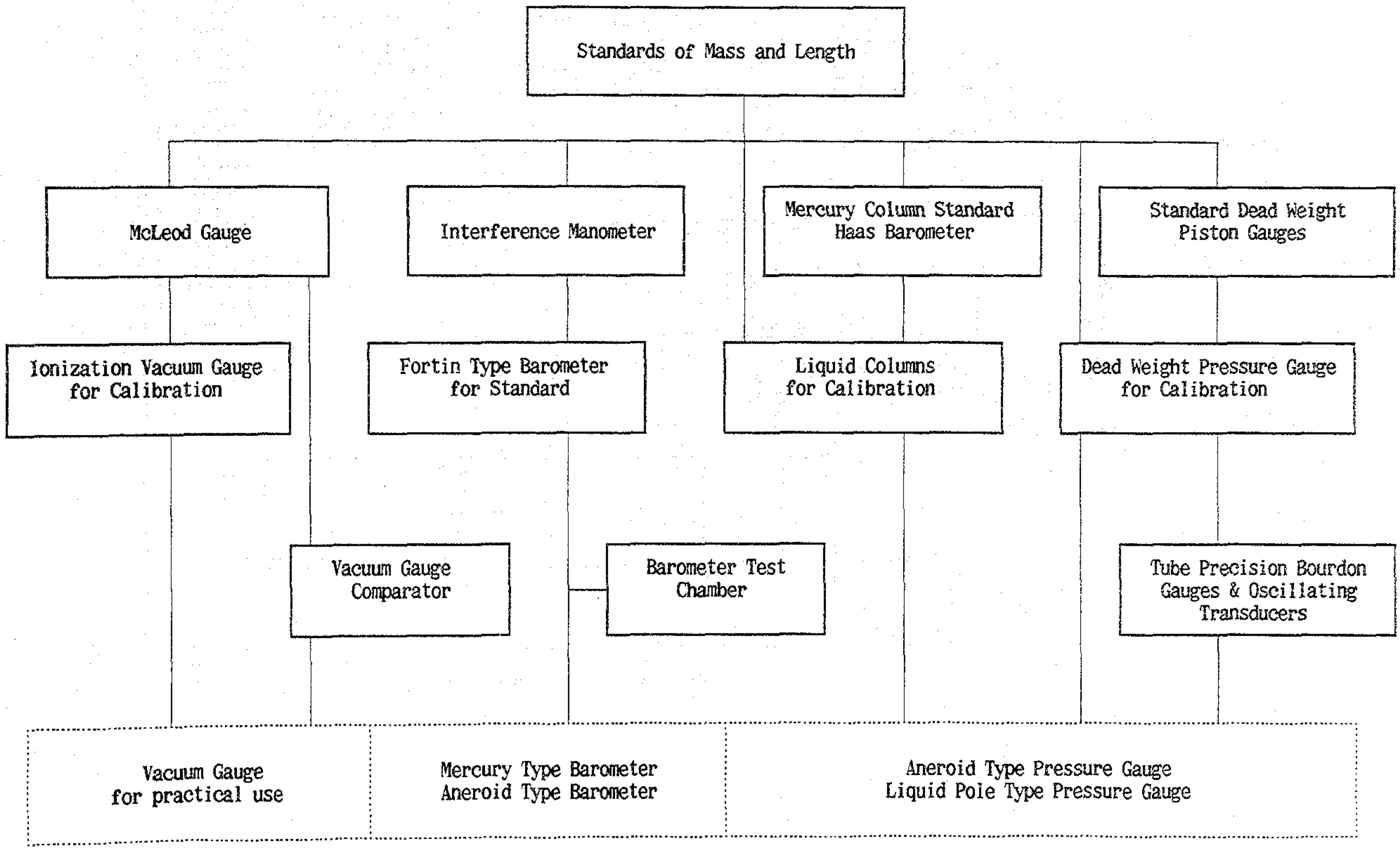


Fig. 7-14 a) Layout Plan of Force and Pressure Standards Laboratory

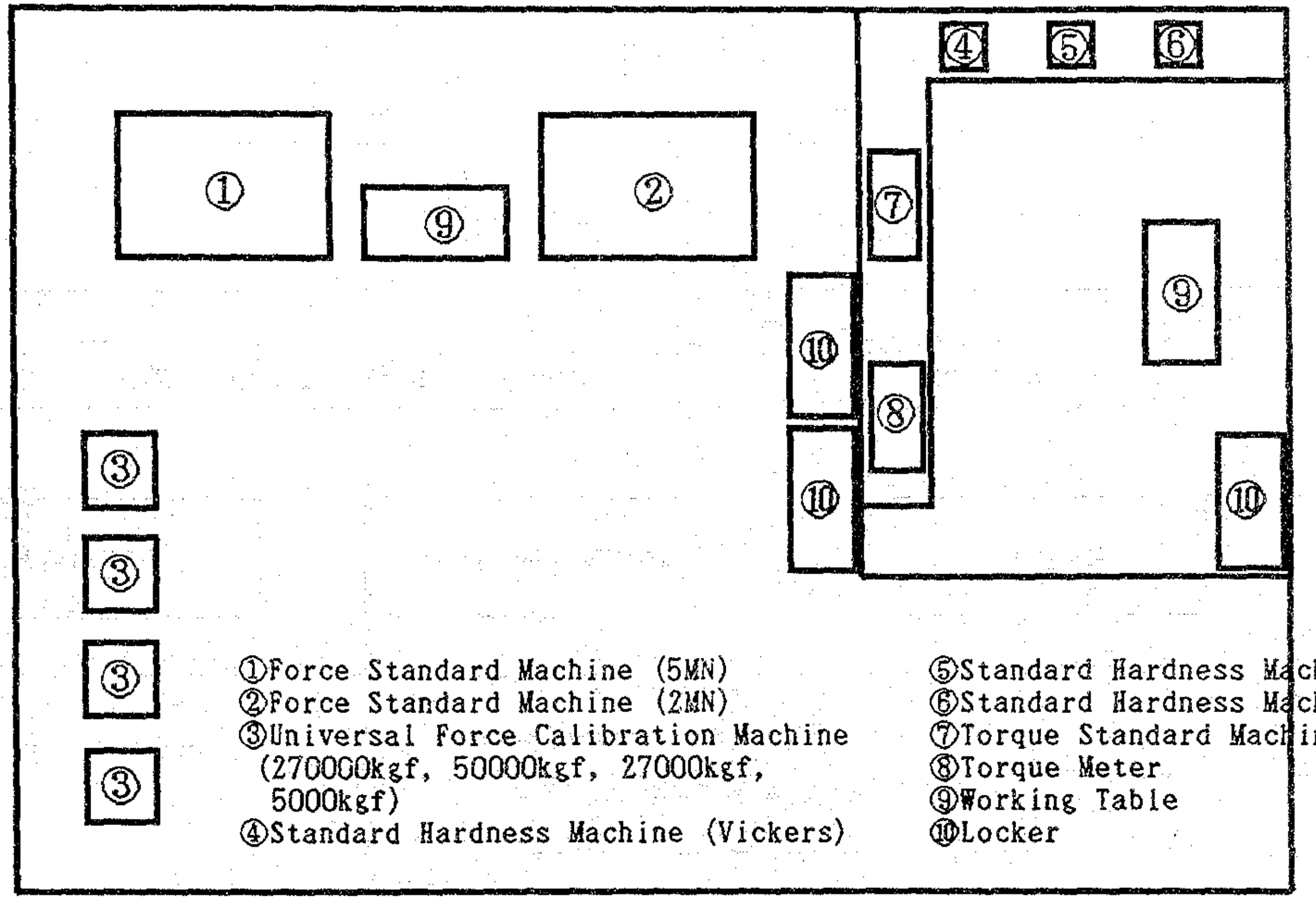
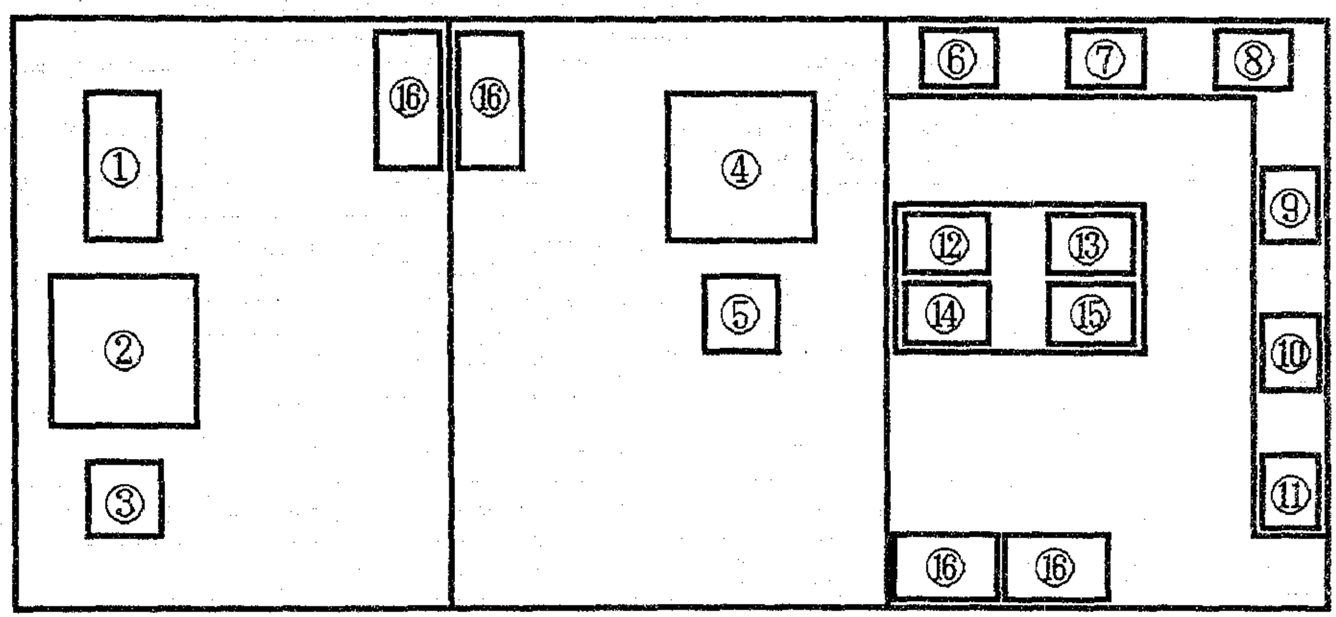


Fig. 7-14 b) Layout Plan of Force and Pressure Standards Laboratory



①Mercury Column Barometer
②Standard Haas Barometer
③Barometer Test Chamber
④Vacuum Gauge Comparator
⑤McLeod Gauge
⑥Pressure Balance (2 MPa)
⑦Pressure Balance (6 MPa)
⑧Pressure Balance (10 MPa)
⑨Pressure Balance (60 MPa)
⑩Pressure Balance (100 MPa)
⑪Pressure Balance (500 MPa)
⑫Pressure Balance (1 MPa)
⑬Pressure Balance (400 kPa)
⑭Pressure Balance (200 kPa)
⑮Pressure Balance (100 kPa)
⑯Locker

Fig. 7-15 Traceability Chart (Temperature)

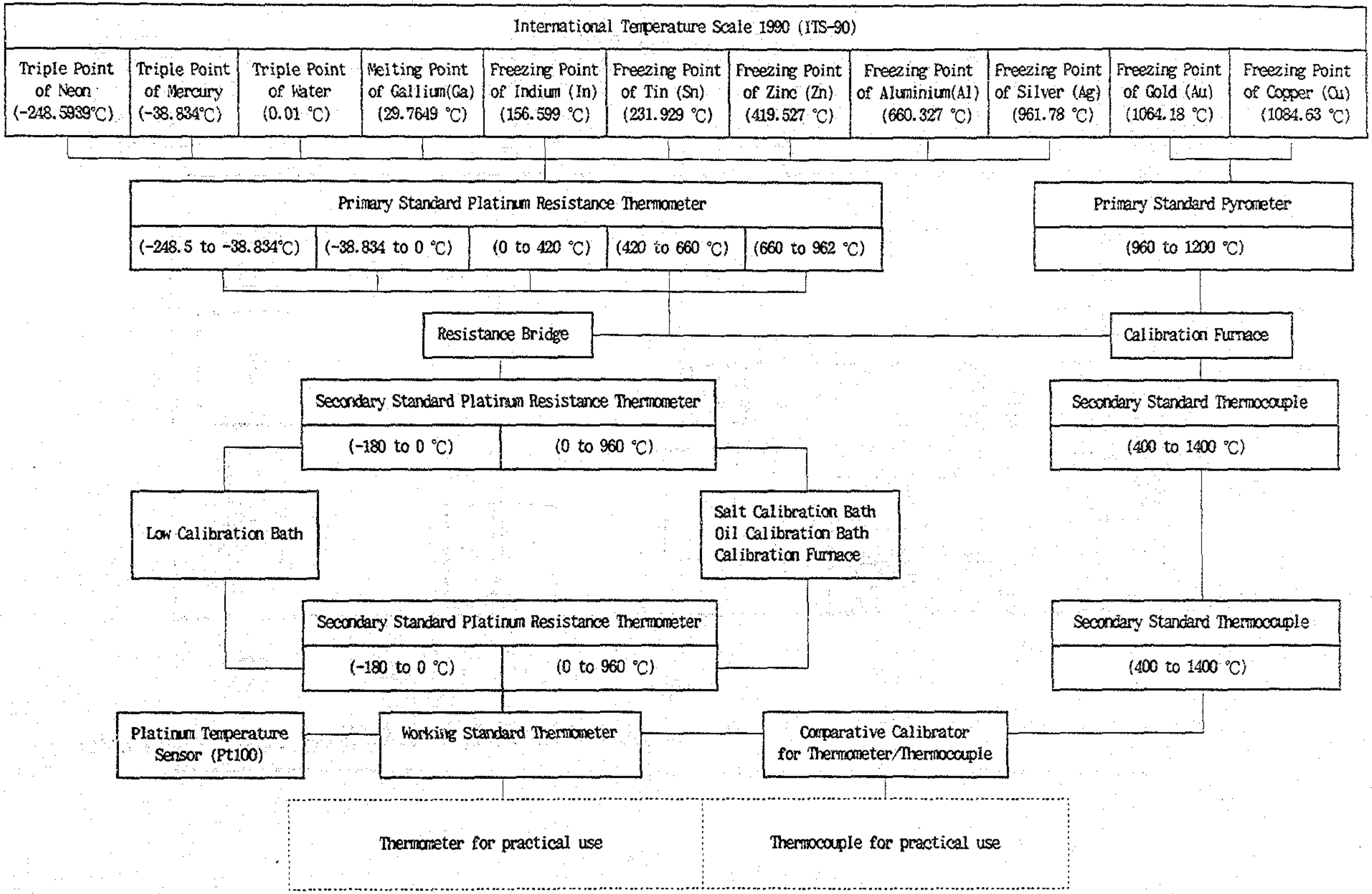
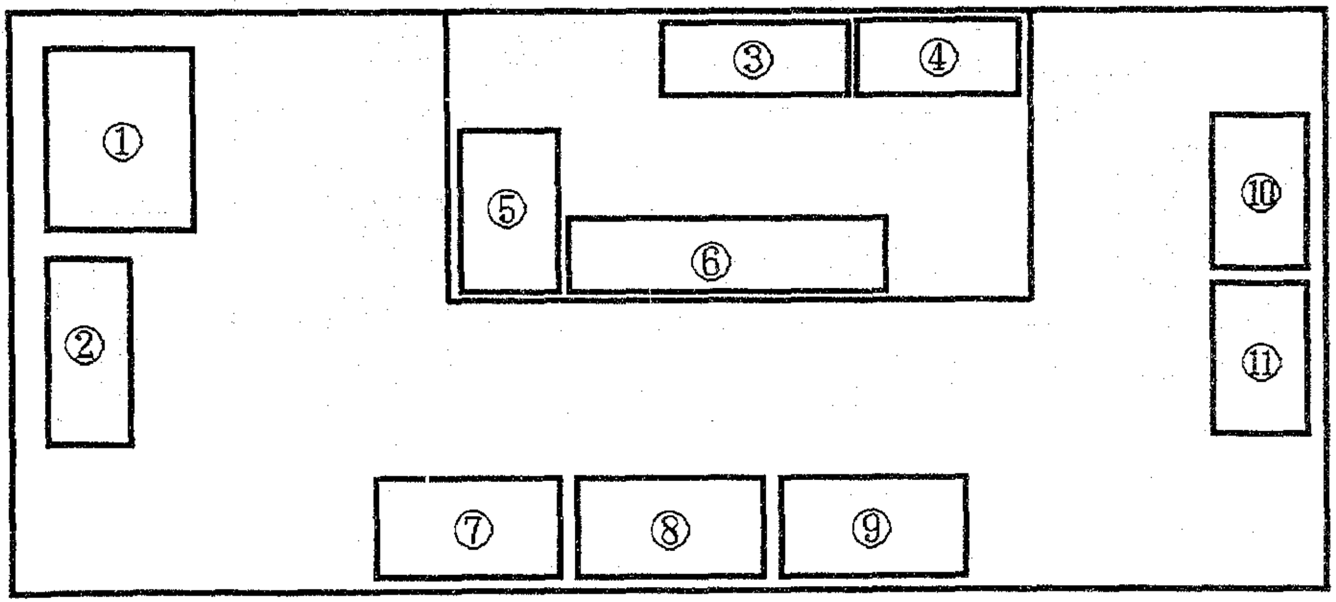


Fig. 7-16 Layout Plan of Temperature Standards Laboratory



①Fixed Point Unit (1000℃ and over)
②Comparative Unit (1000℃ and over)
③Working Table
④Storage Locker
⑤Measuring Table
⑥Measuring Rack
⑦Fixed point Unit (0~1000℃)
⑧Fixed Point Unit (0~1000℃)
⑨Fixed Point Unit (0~1000℃)
⑩Fixed Point Unit (below 0℃)
⑪Fixed Point Unit (below 0℃)

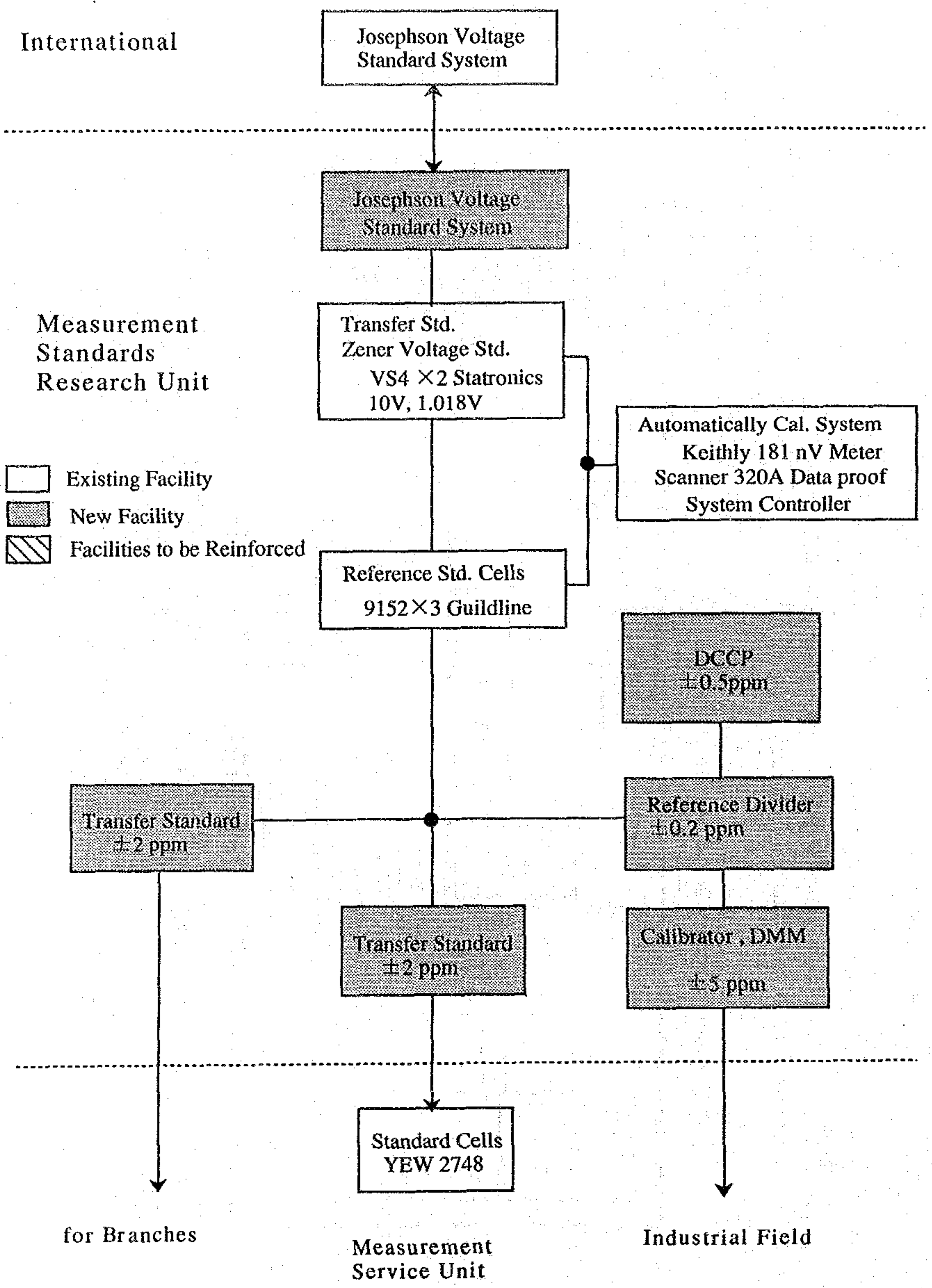


Fig. 7-17 Traceability Chart (Electrical-DC V)

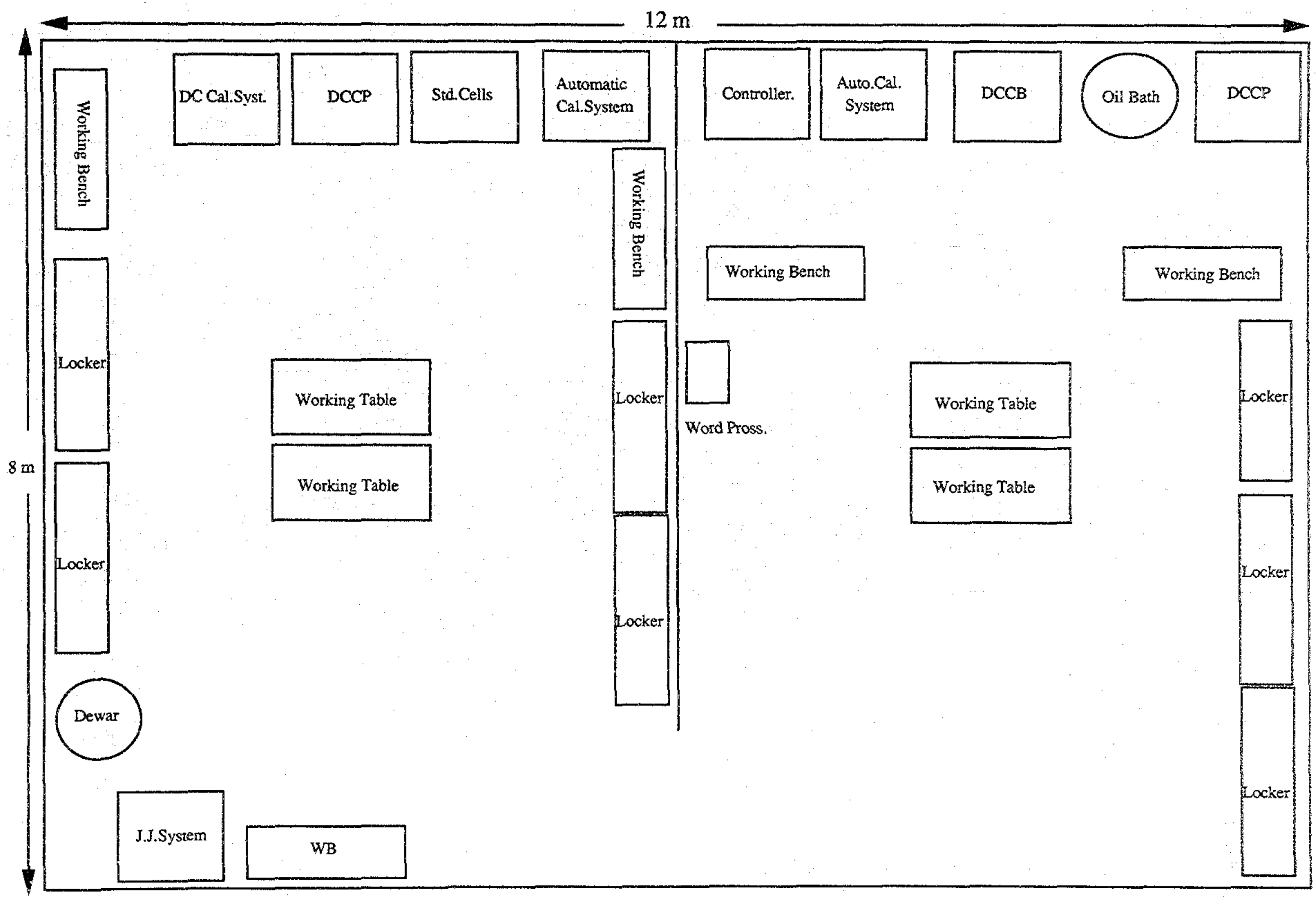


Fig. 7-18 Layout Plan of Electrical Standards Laboratory (Voltage and Resisitance)

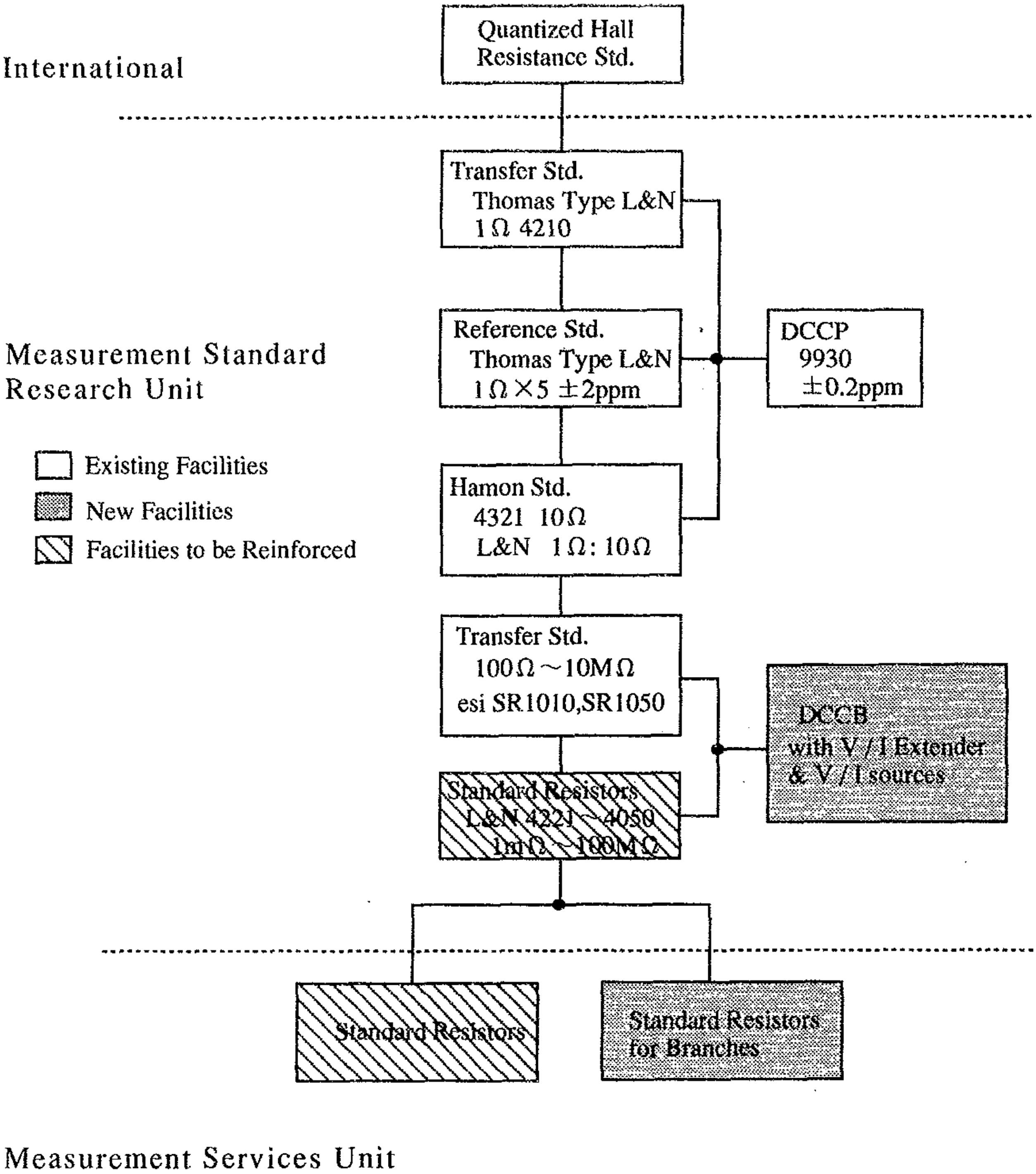


Fig. 7-19 : Traceability Chart (Electrical-Resistance)

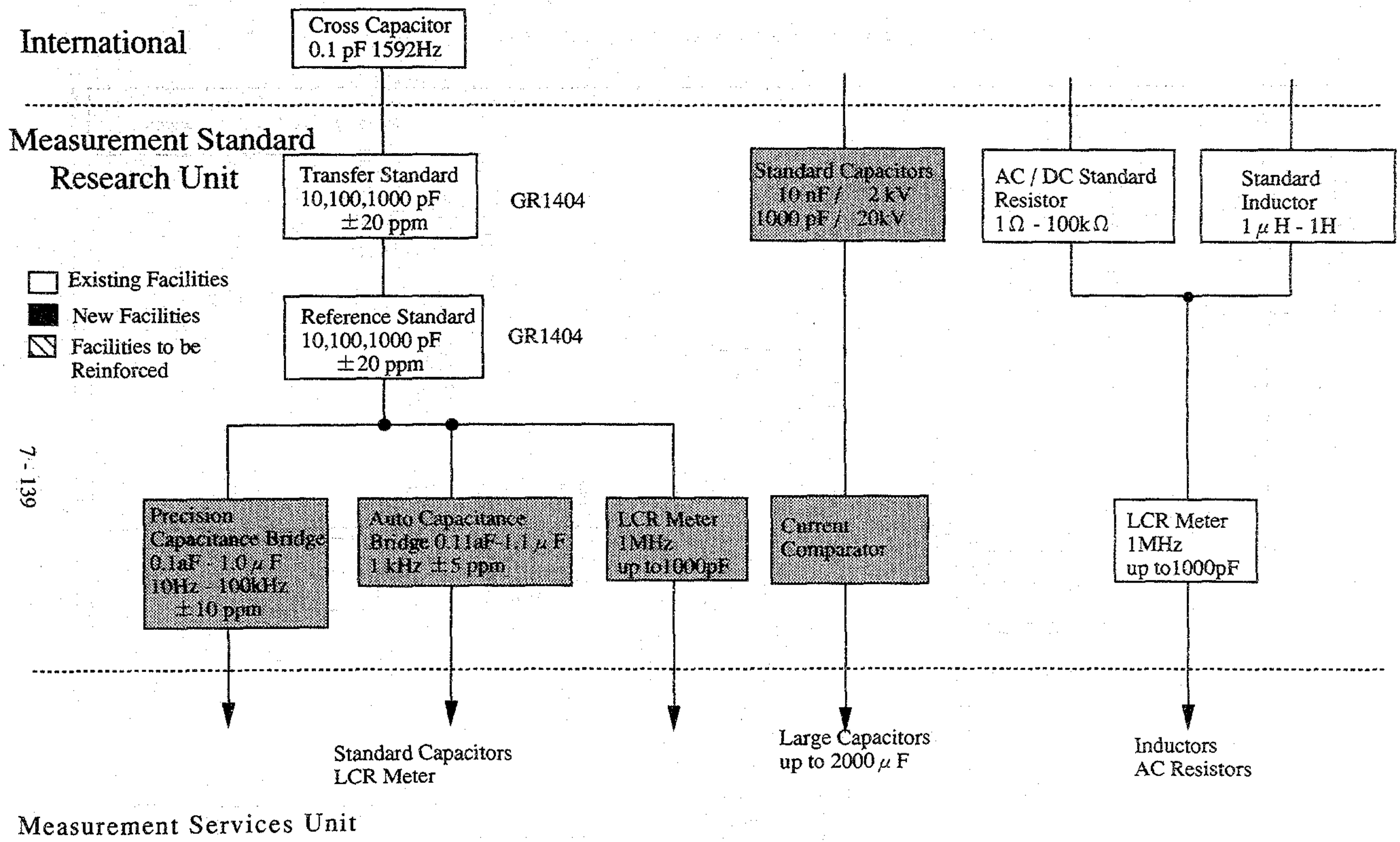


Fig. 7-20 Traceability Chart (Electrical-Capacitance)

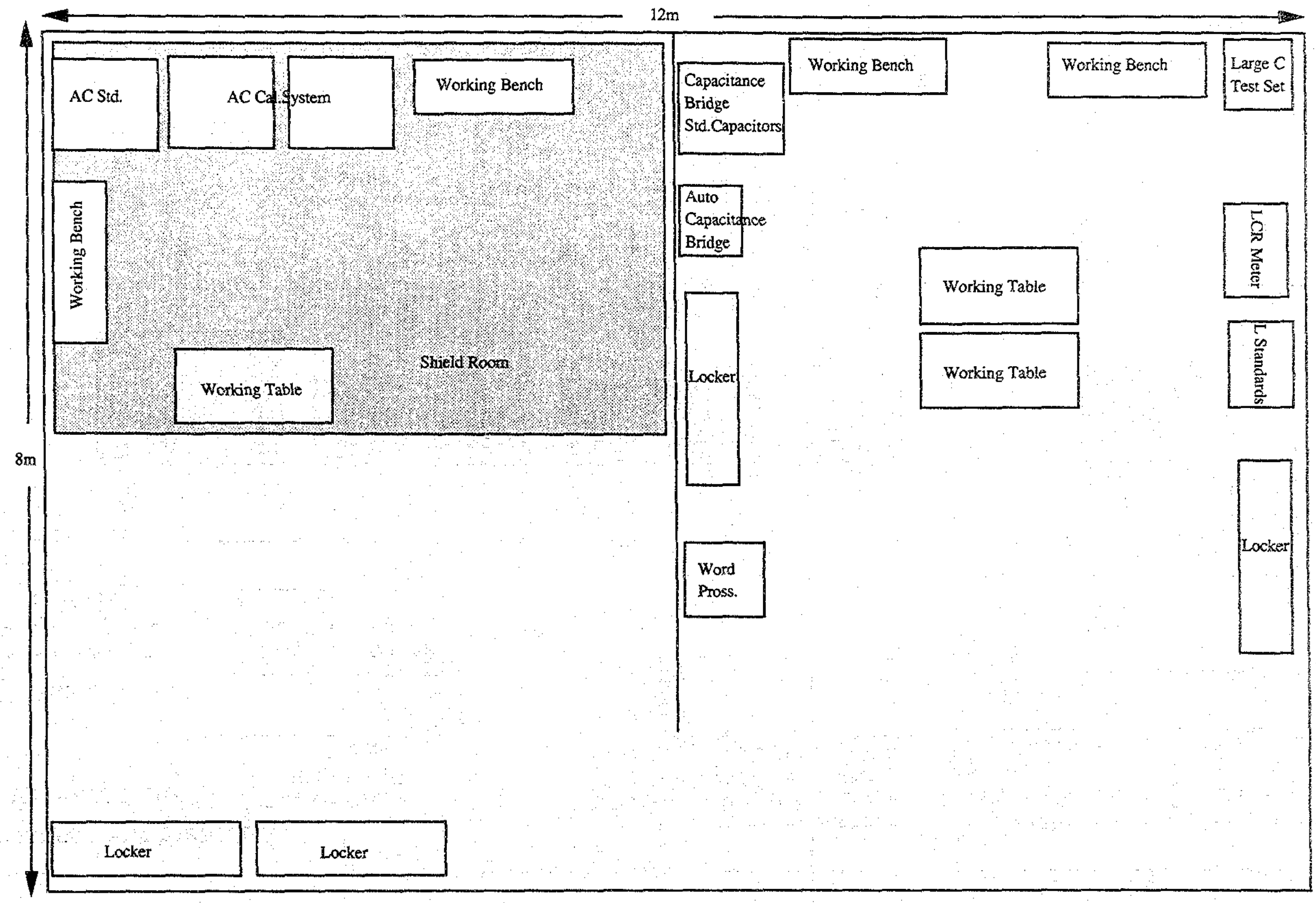


Fig. 7-21 Layout Plan of Electrical Standards Laboratory (AC and LC)

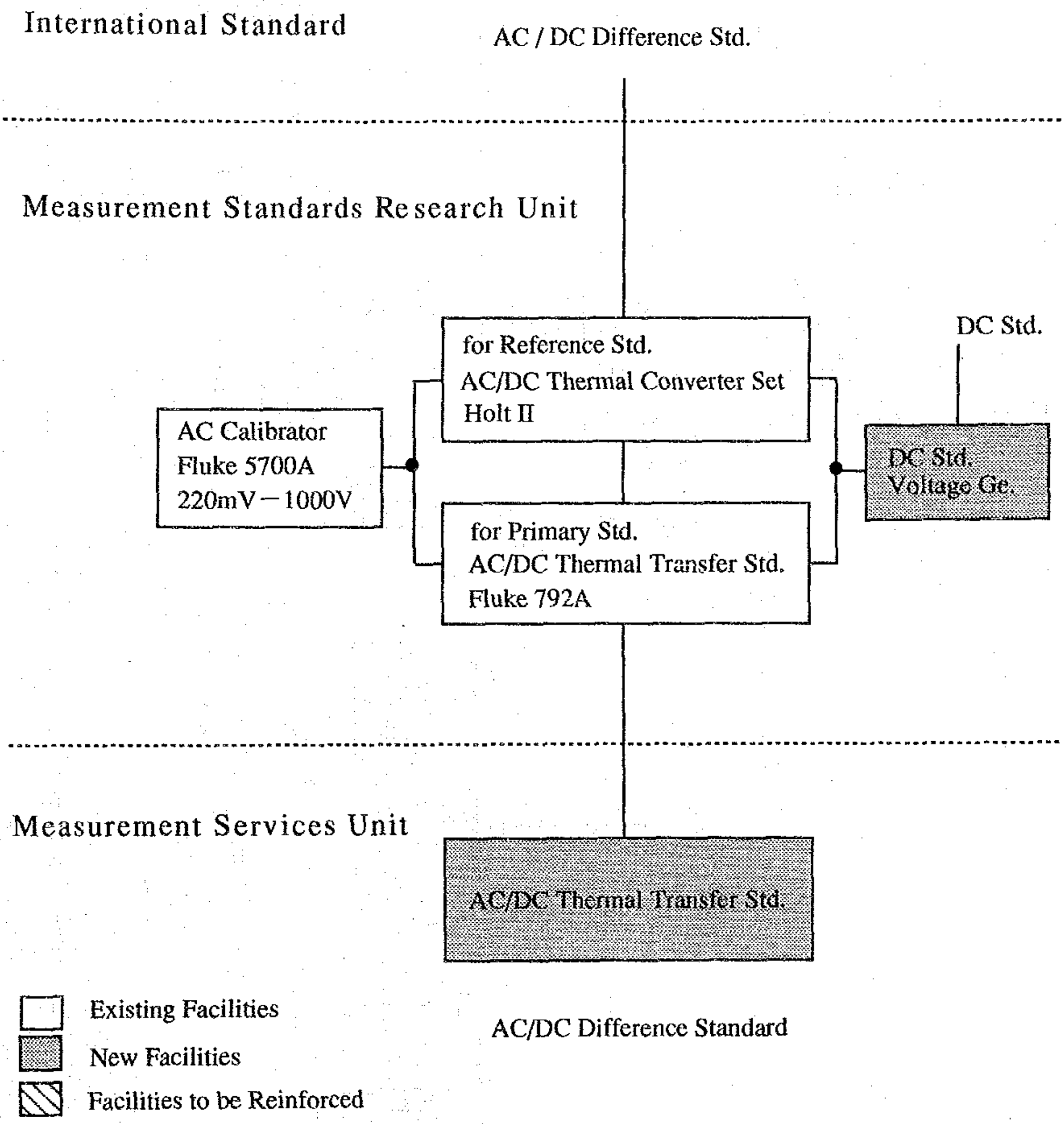


Fig. 7-22 Traceability Chart (Electrical-AC)

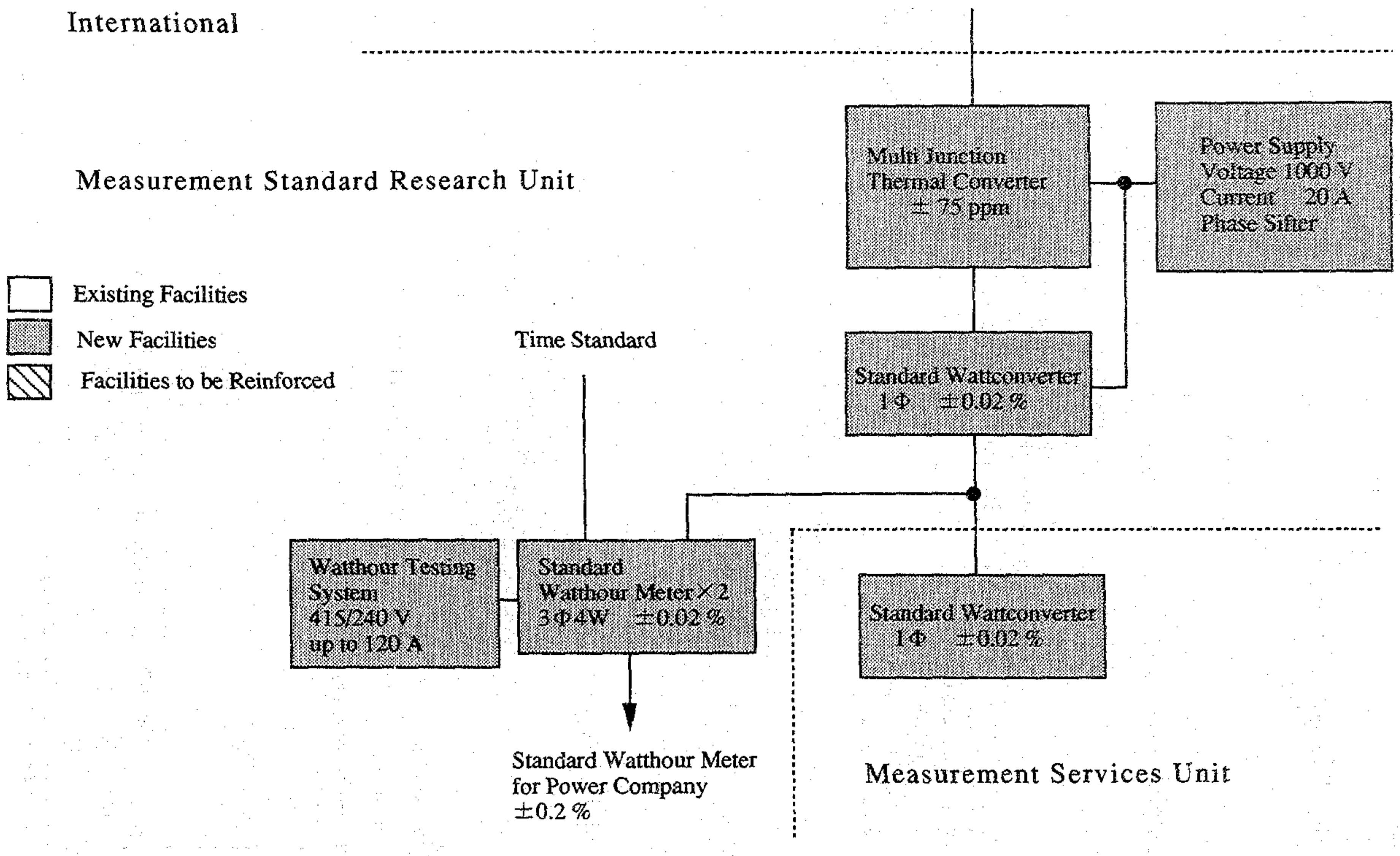
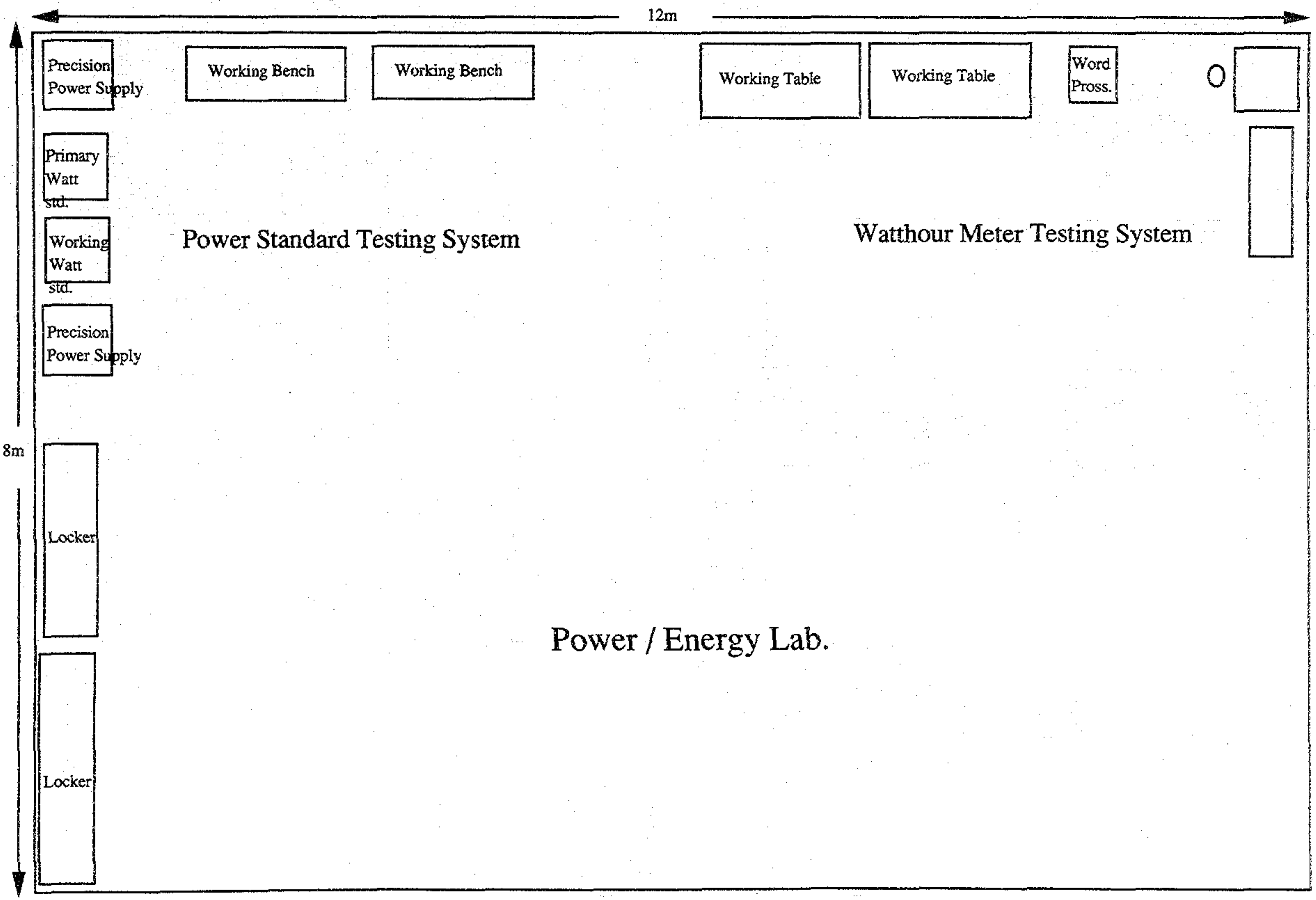


Fig. 7-23 Traceability Chart (Electrical-Power and Energy)

Fig. 7-24 Layout Plan of Electrical Standards Laboratory (Power and Energy)



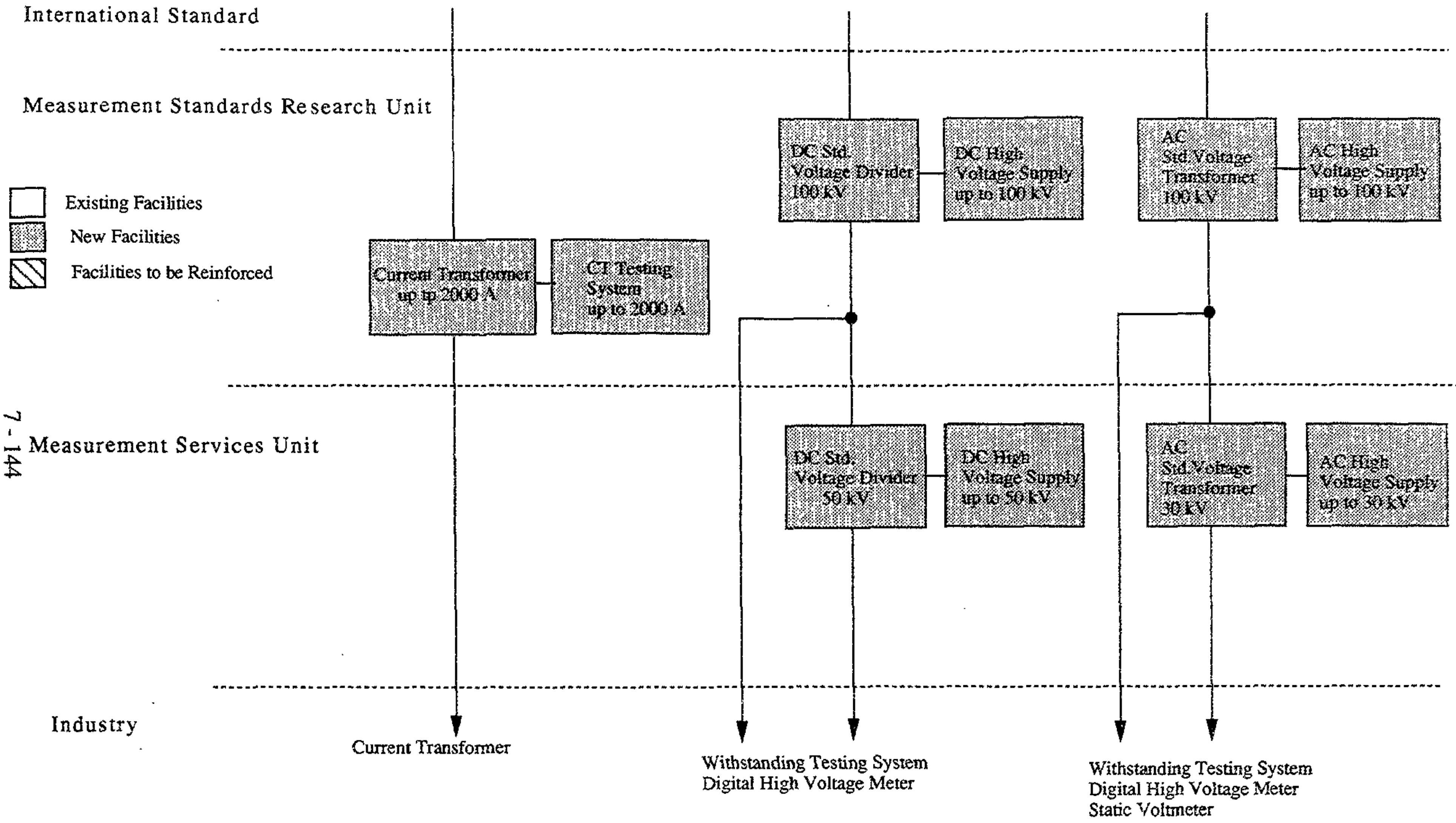


Fig. 7-25 Traceability Chart (Electrical-High Voltage)

Fig. 7-26 Layout Plan of Electrical Standards Laboratory (High Voltage)

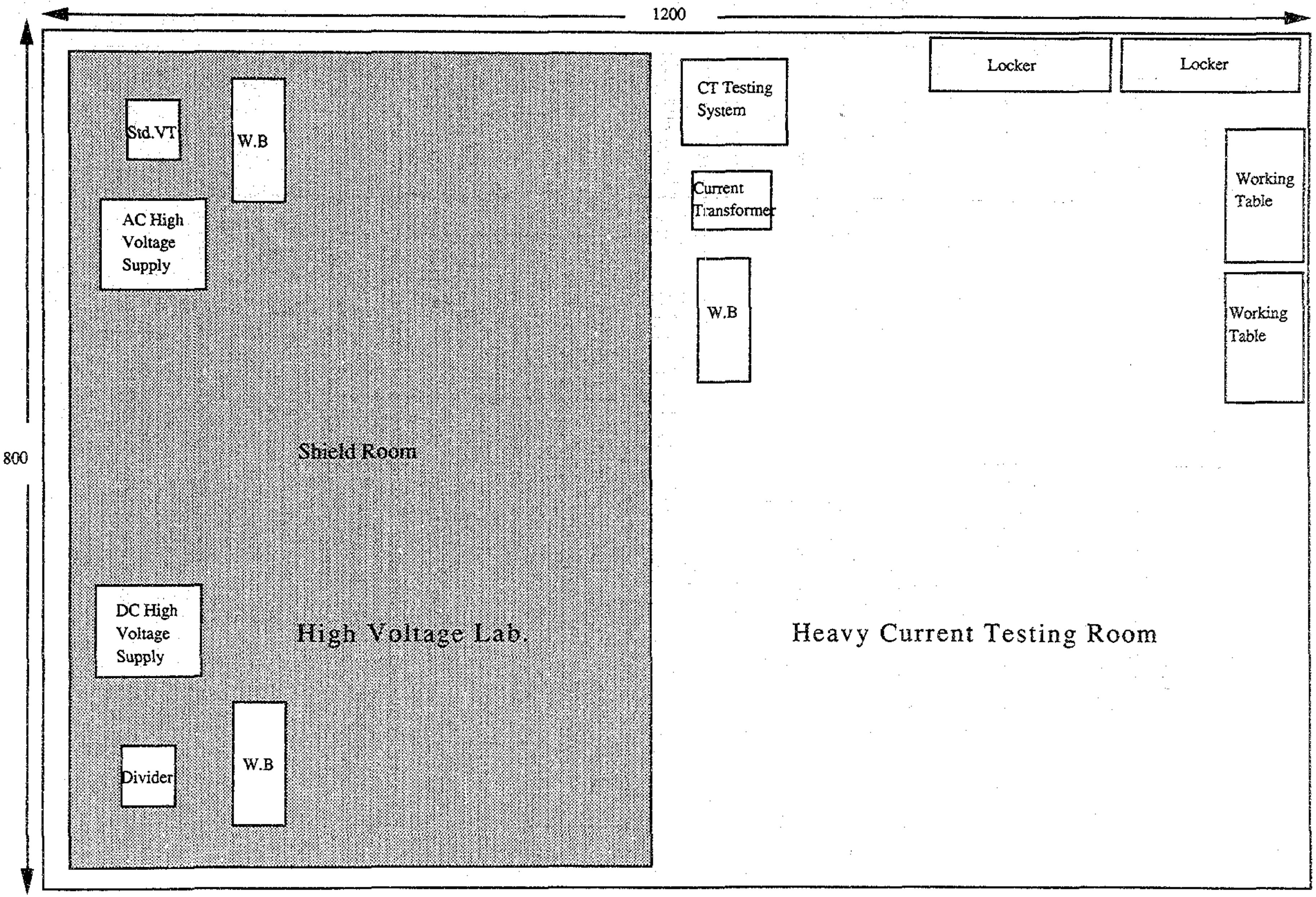


Fig.7-27 Traceability Chart (Time/Frequency)

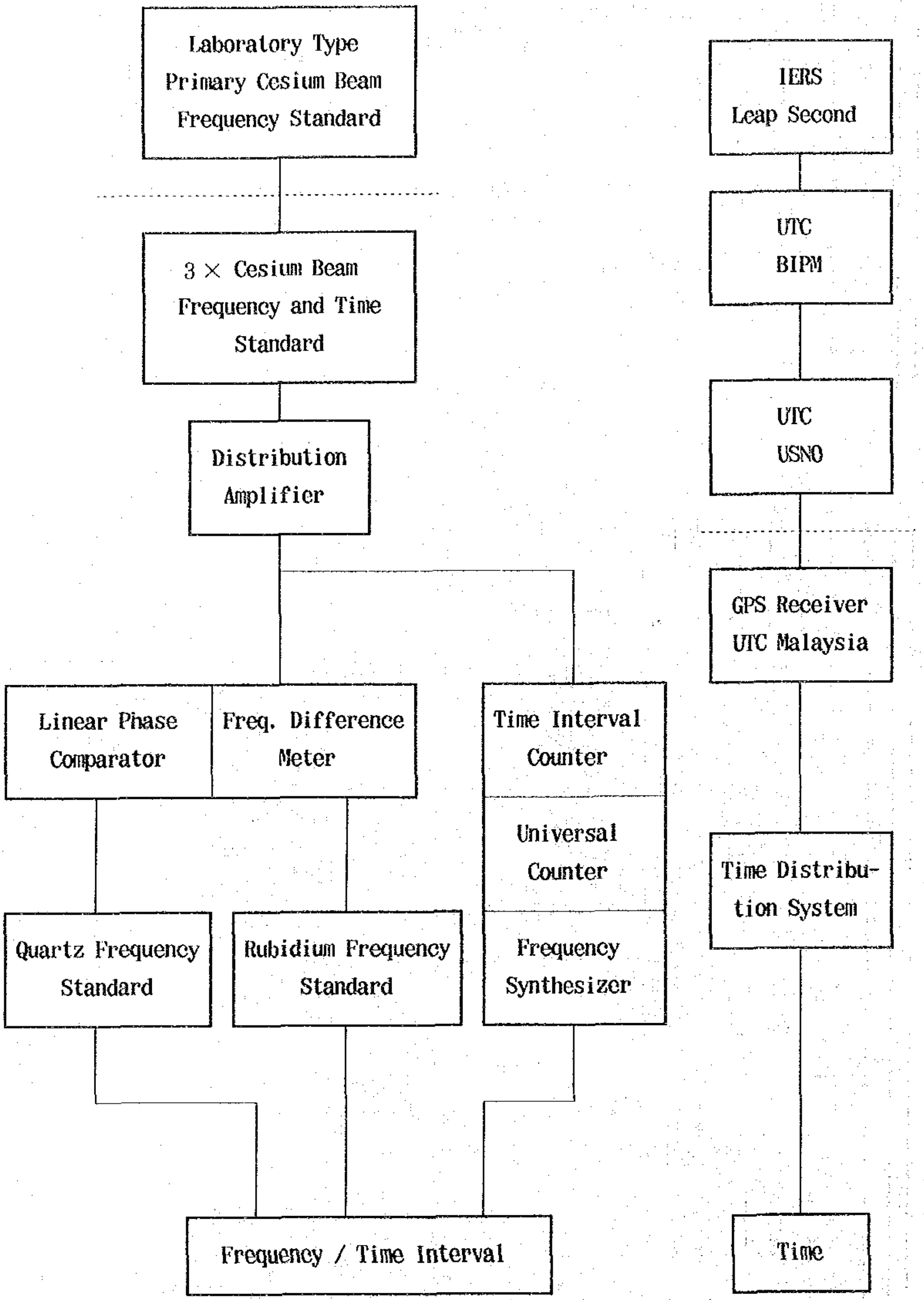


Fig. 7-28 Layout Plan of Electrical Standards Laboratory (Time/Frequency)

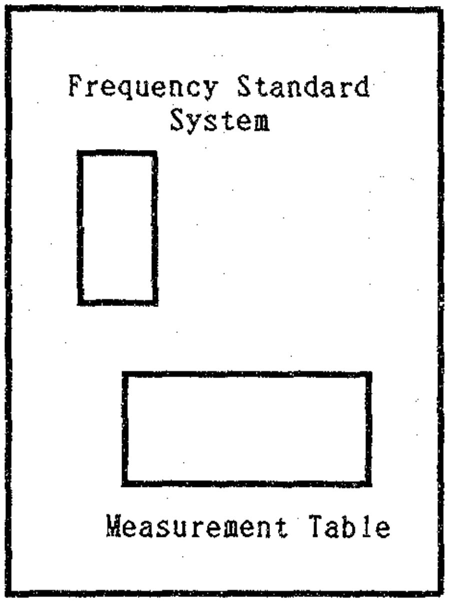


Fig.7-29 a)　Traceability Chart (RF and Microwave)

(Attenuation)

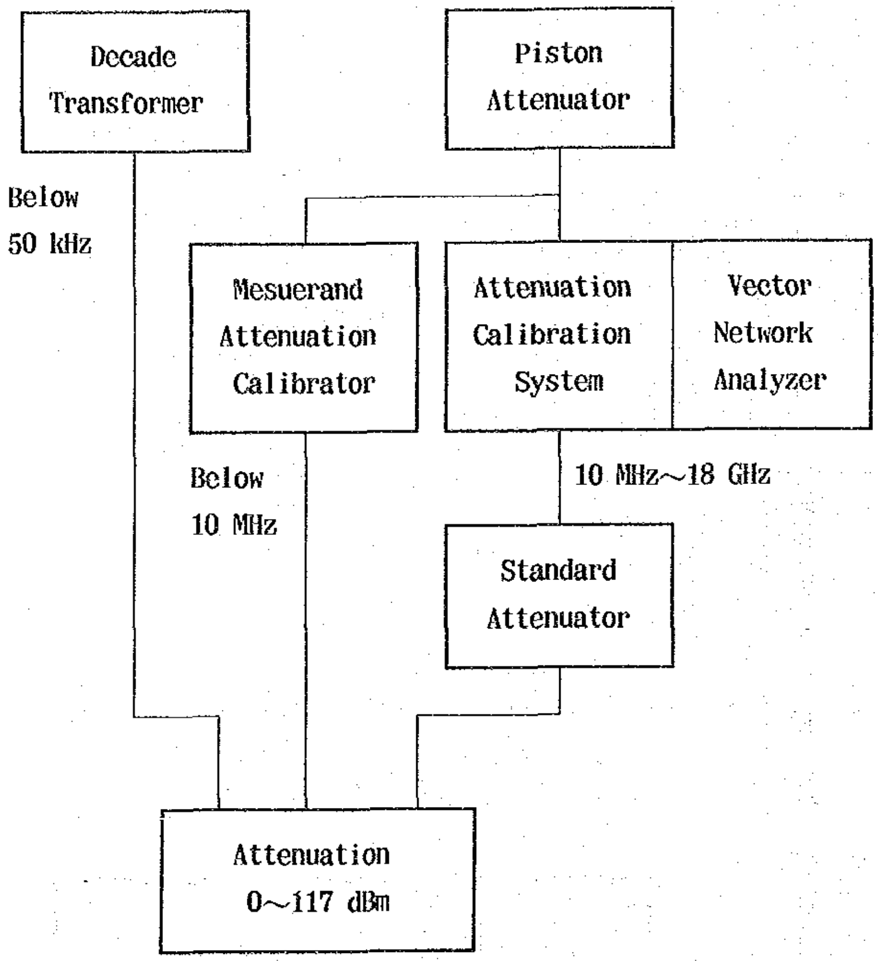


Fig.7-29 b) Traceability Chart (RF and Microwave)

(RF Power)

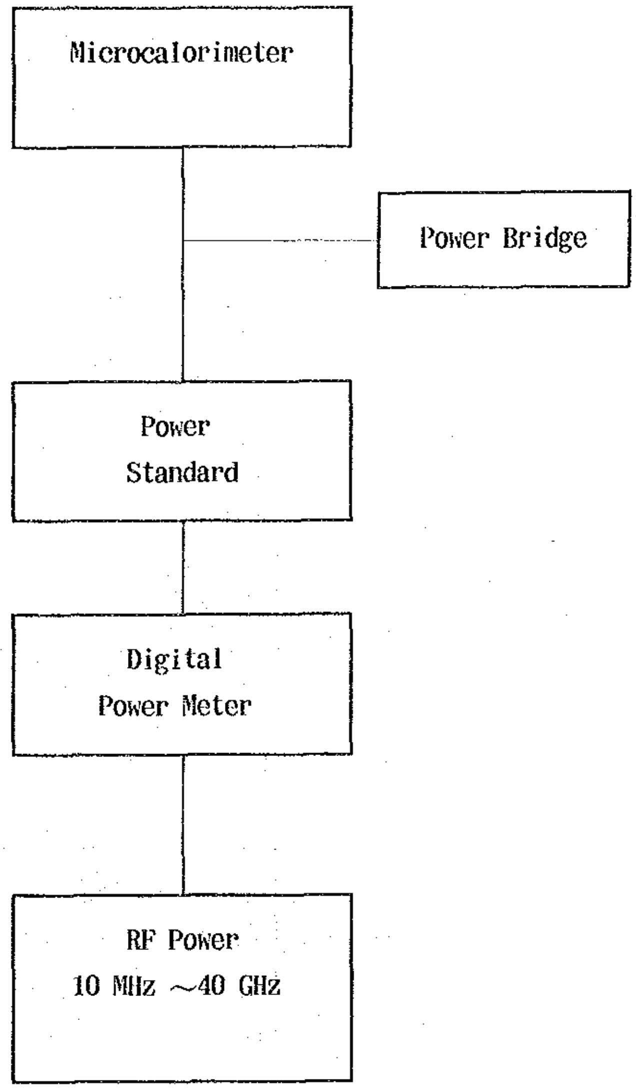


Fig. 7-29 c) Traceability Chart (RF and Microwave)

(RF Voltage)

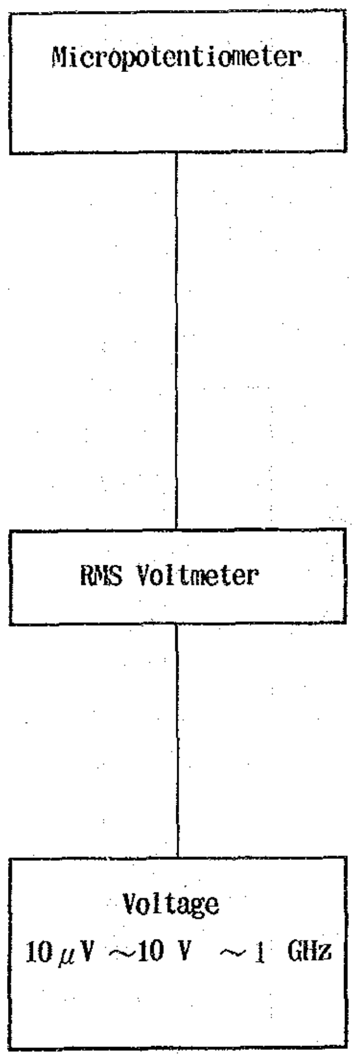


Fig.7-29 d) Traceability Chart (RF and Microwave)

(Noise)

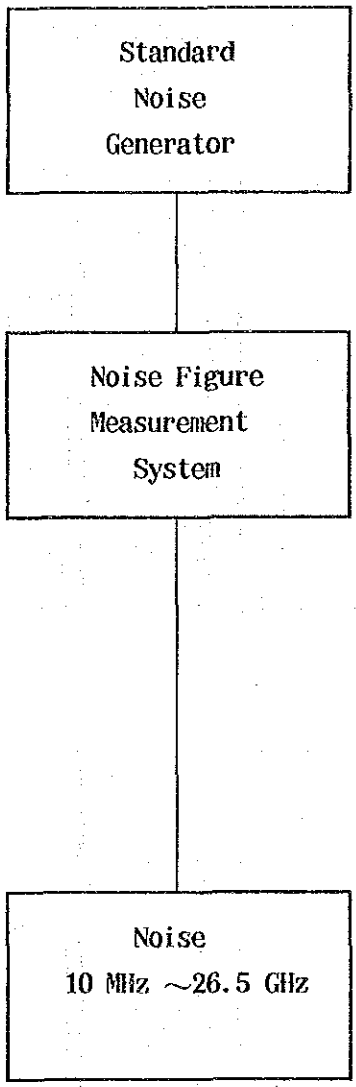


Fig. 7-30 Layout Plan of Electrical Standards Laboratory (RF and Microwave)

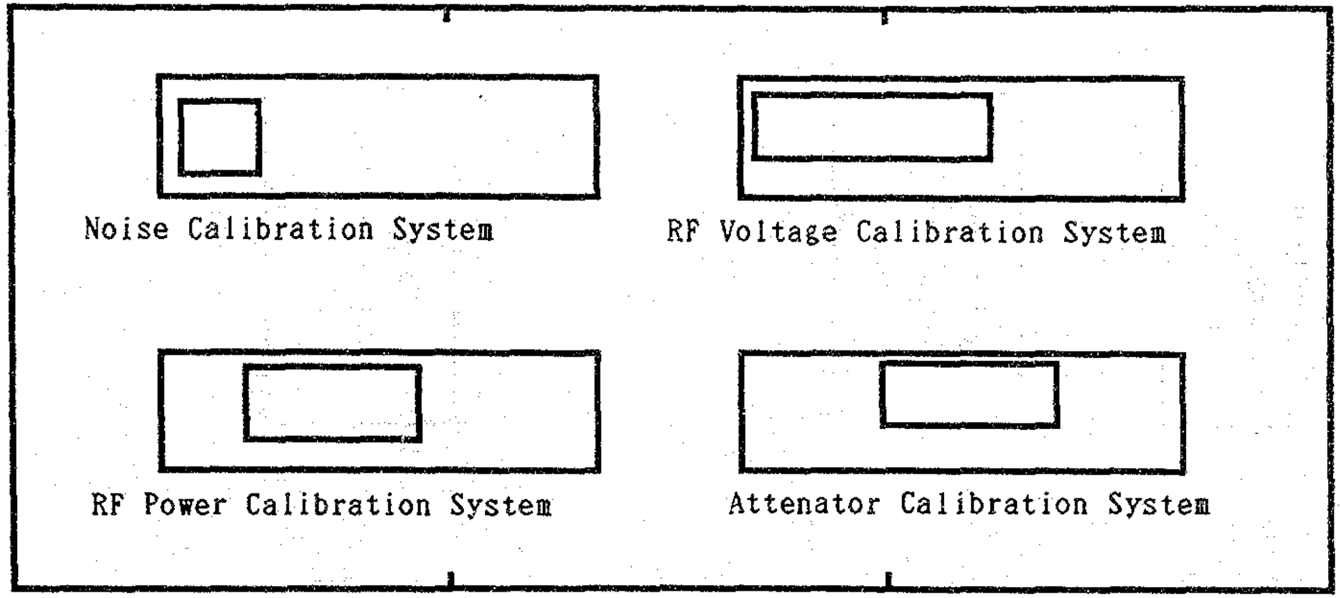


Fig.7-31   Traceability Chart (Acoustic)

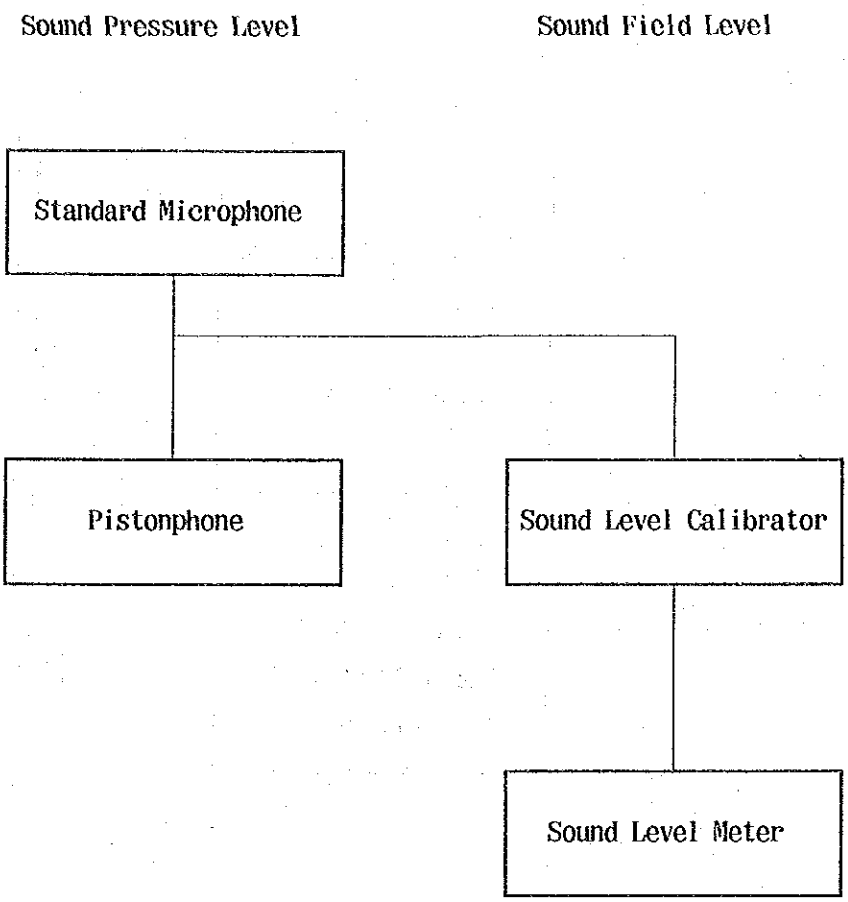
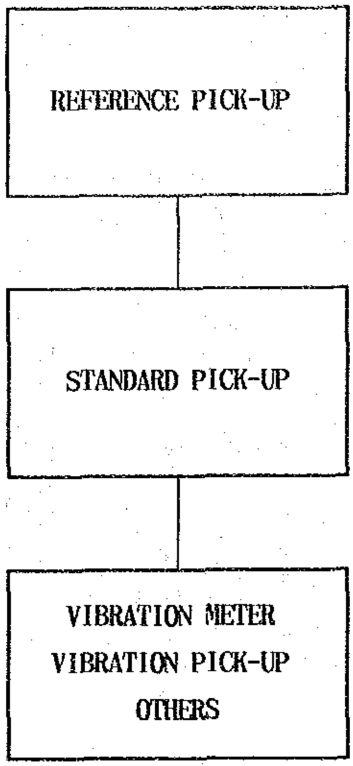


Fig.7-32 Traceability Chart (Vibration) - Comparison Calibration



<< BLOCK DIAGRAM >>

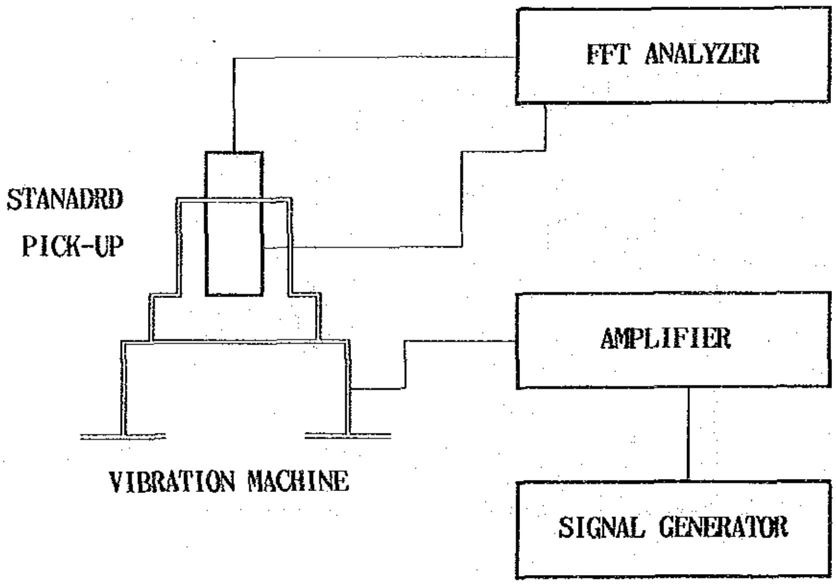


Fig. 7-33 Layout Plan of Electrical Standards Laboratory (Acoustic)

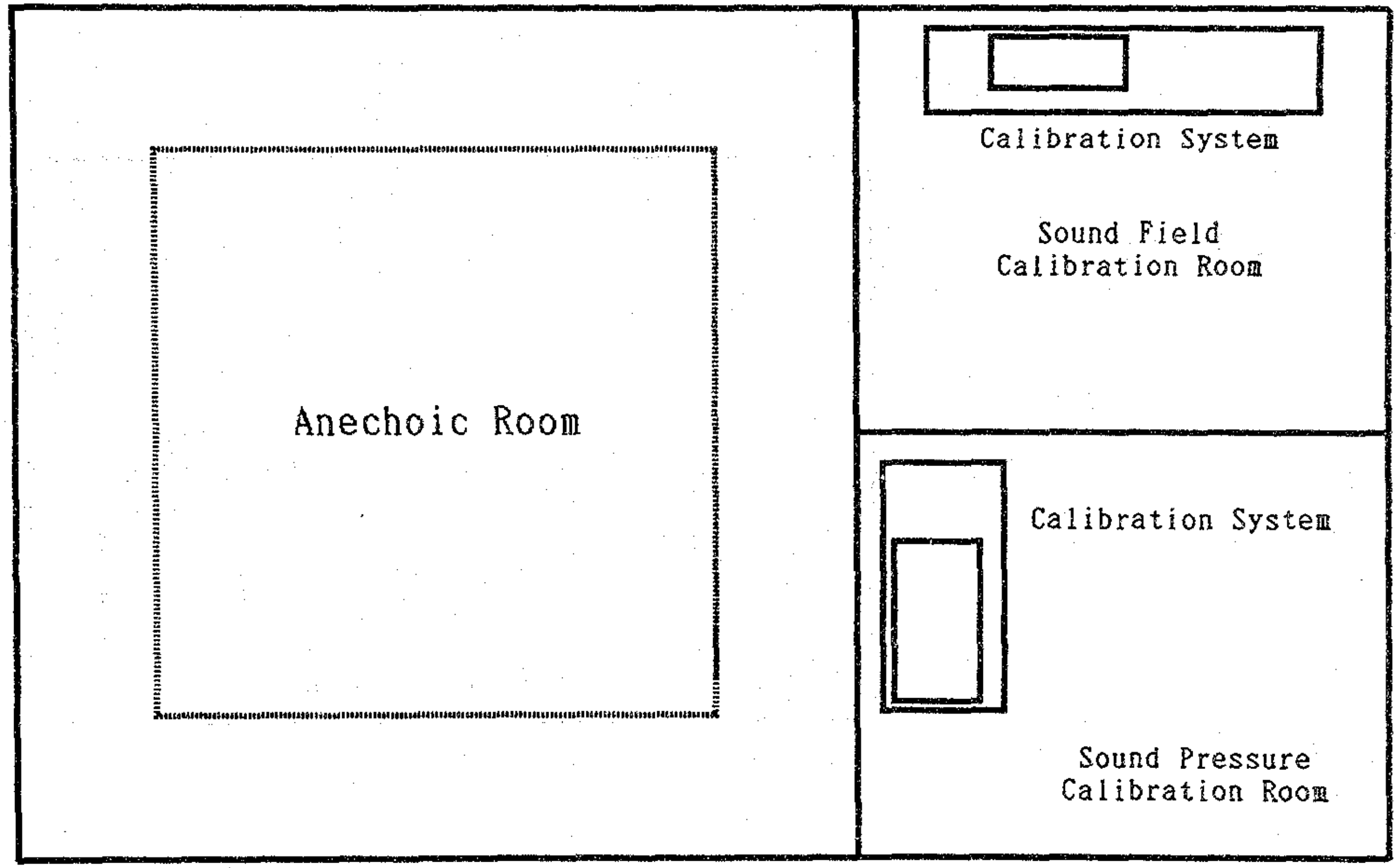
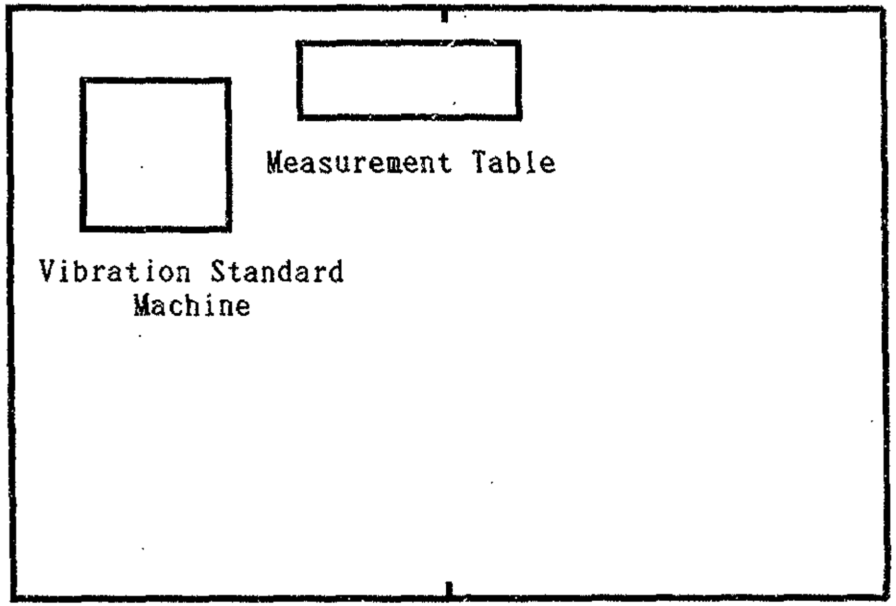


Fig. 7-34 Traceability Chart (Electrical-Photometry)



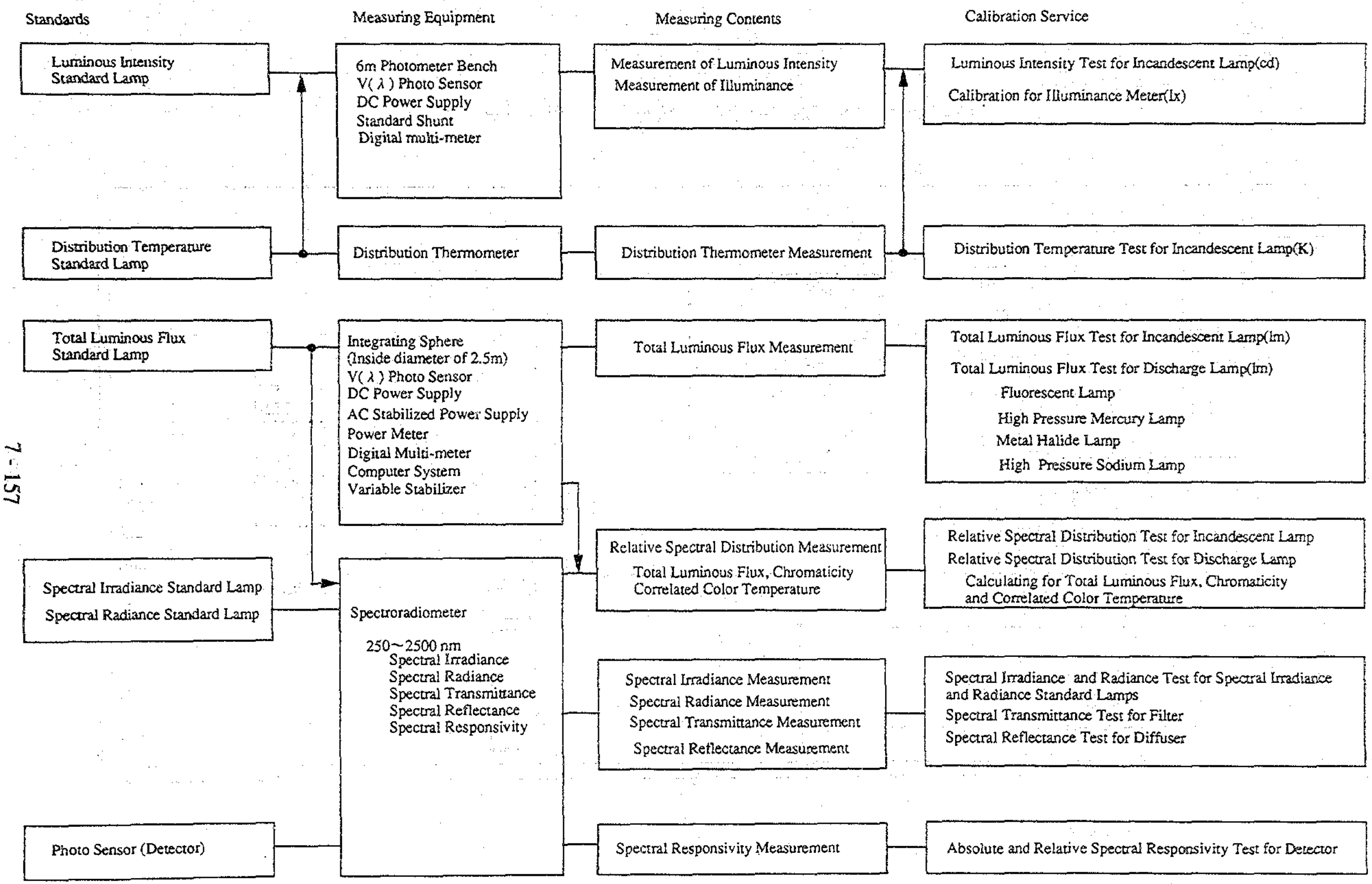


Fig. 7-35 Layout Plan of Electrical Standards Laboratory (Photometry)

it

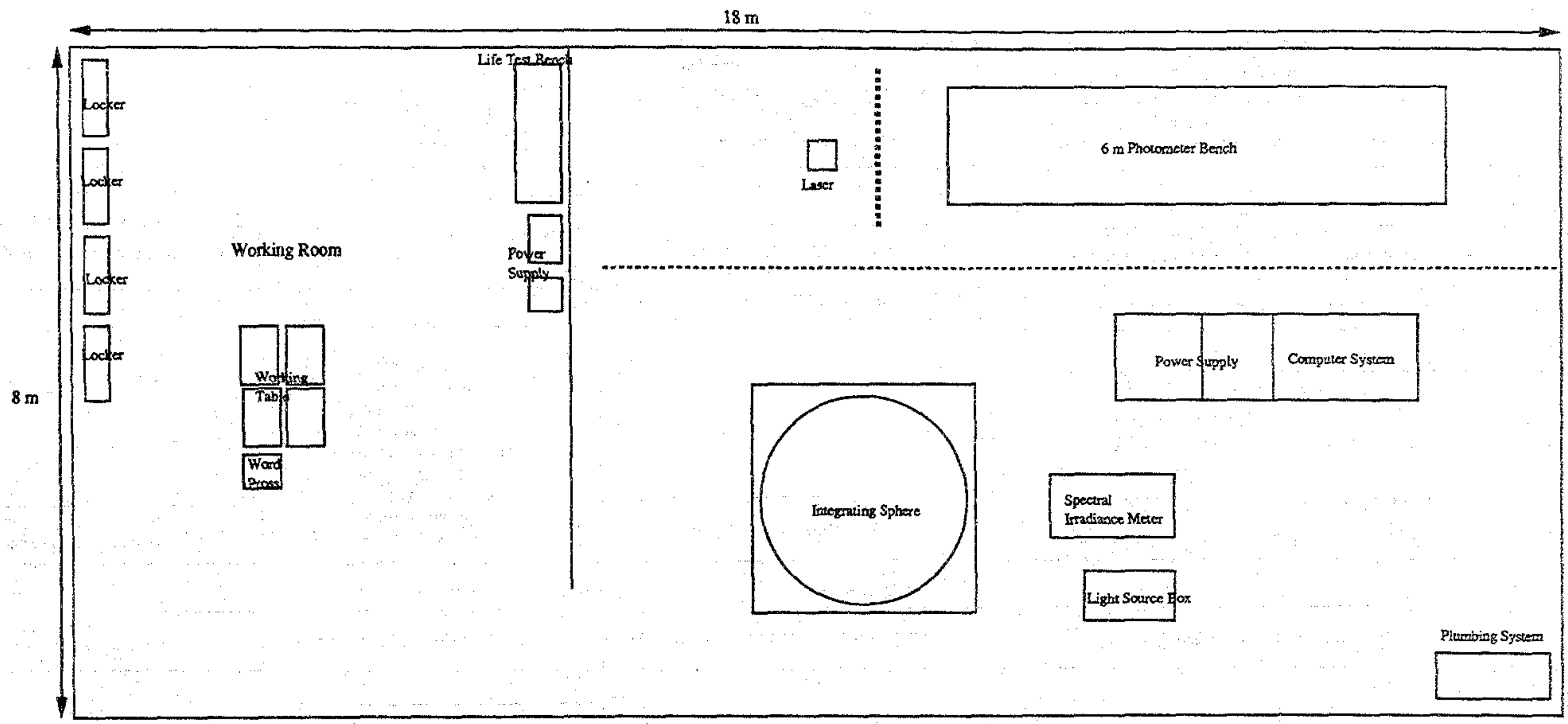


Fig. 7-36 Traceability Chart (Electrical-Magnetic)

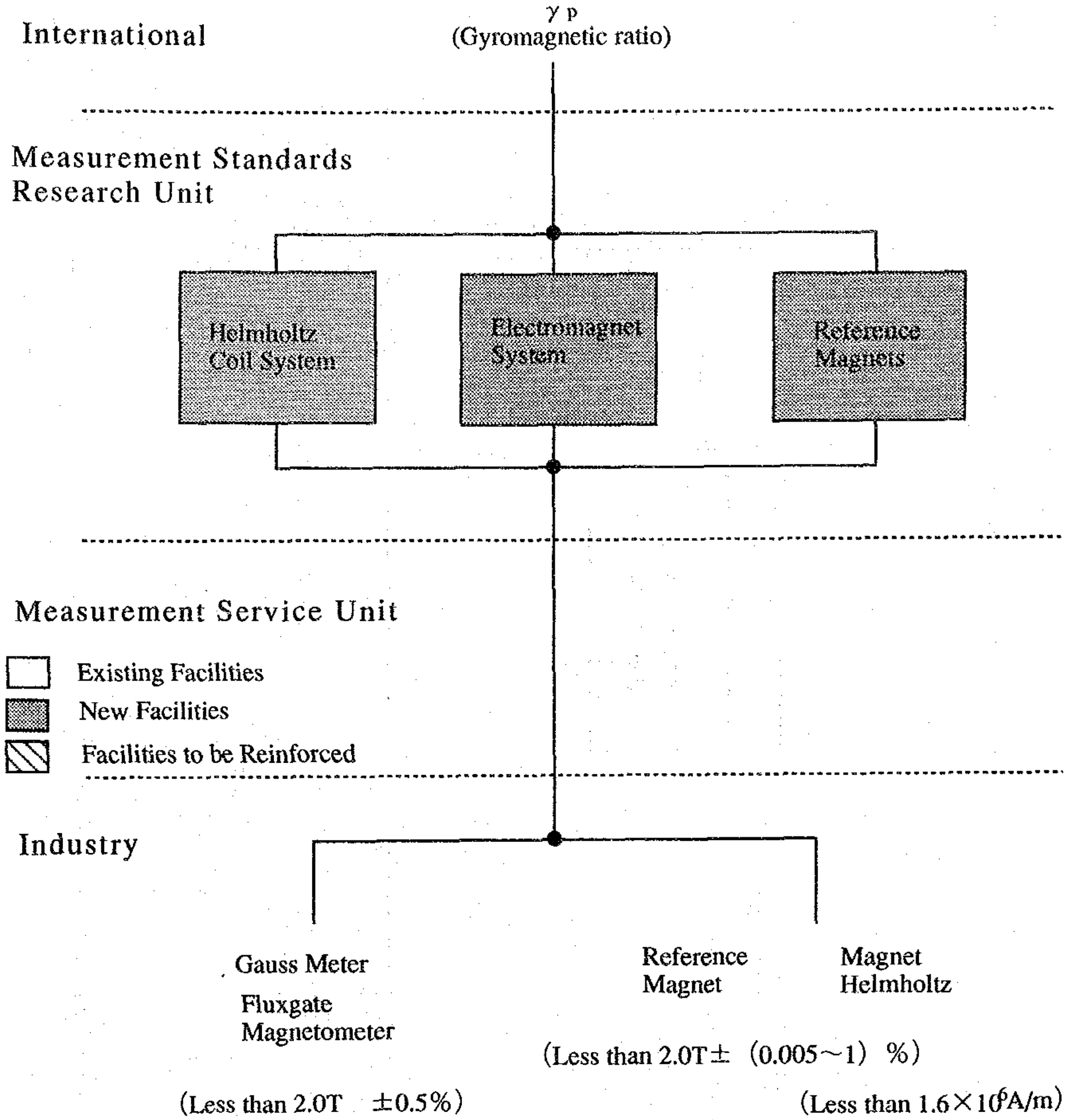


Fig. 7-37 Traceability Chart (Electrical-Magnetic)

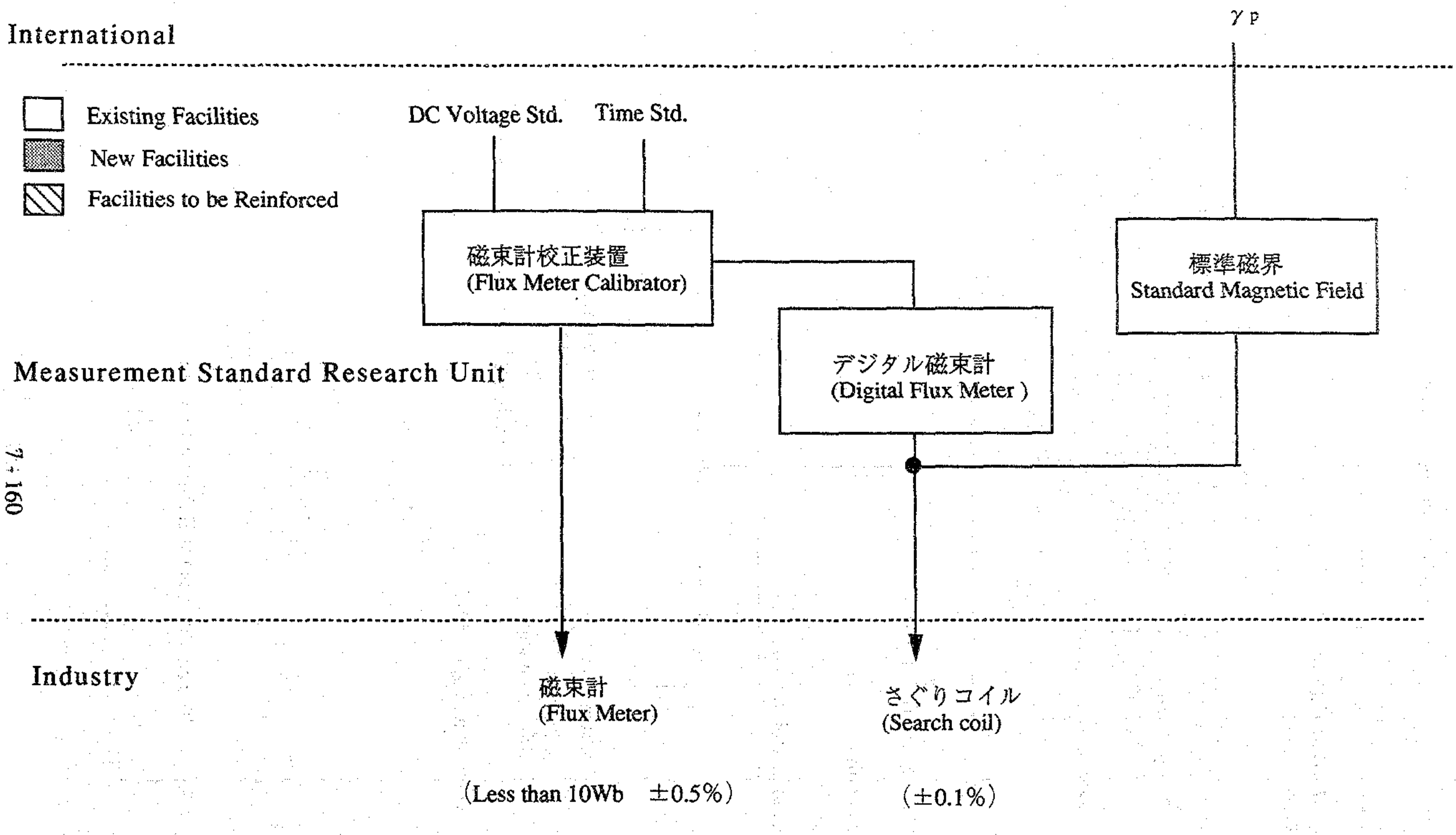
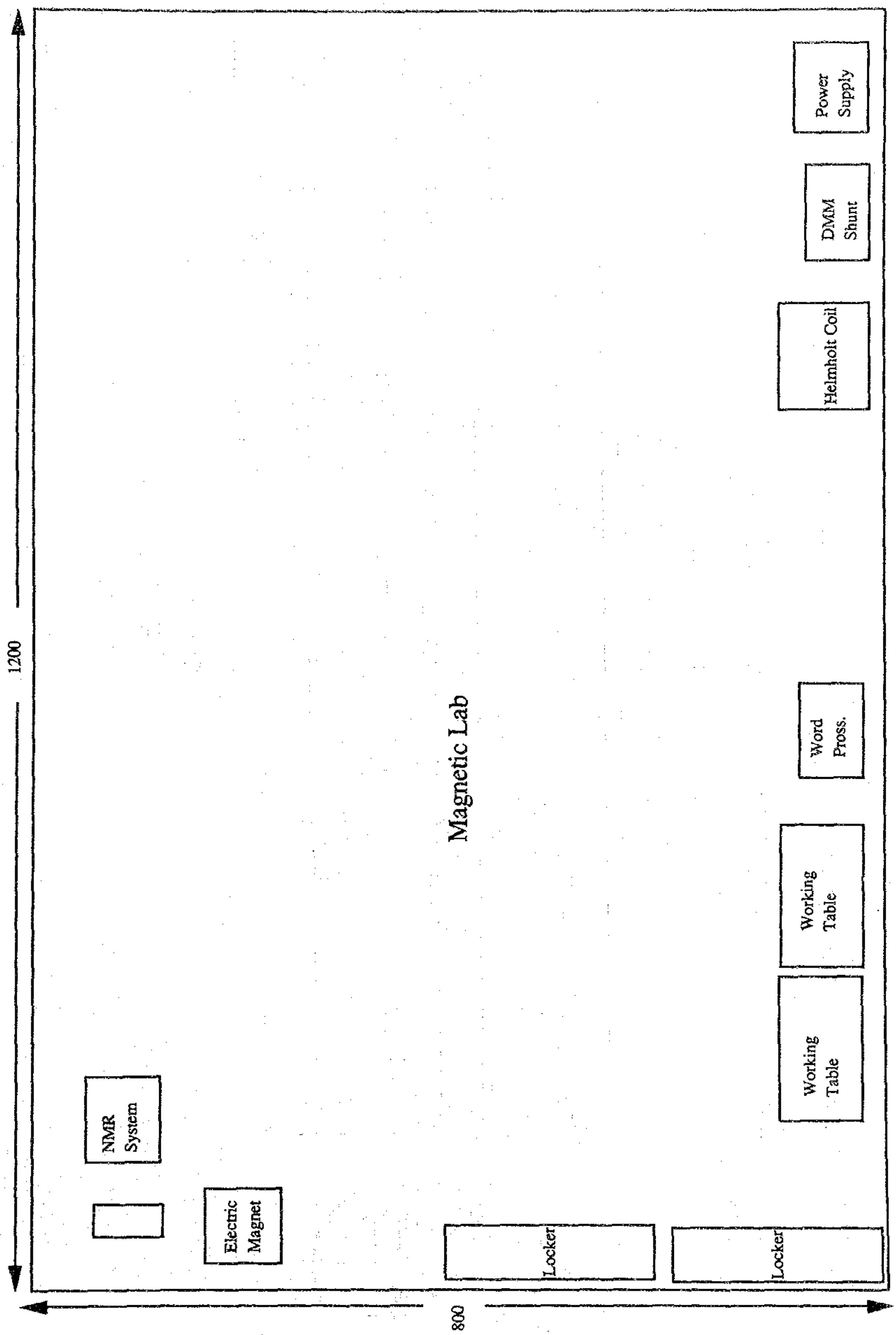


Fig. 7-38 Layout Plan of Electrical Standards Laboratory (Magnetic)


Magnetic Lab
1200
800
Power Supply
DMM Shunt
Helmholt Coil
Word Pross.
Working Table
Working Table
NMR System
Electric Magnet
Locker
Locker