Chapter 5　Measurement of Atmospheric Pressure

CONTENTS

Chapter 5　Measurement of Atmospheric Pressure

5.1　Definition and Units

5.1.1　Definition

The atmospheric pressure is the force exerted by the weight of the Earth's atmosphere, expressed per unit area in a given horizontal cross-section. Thus, the atmospheric pressure is equal to the weight of a vertical column of air above the Earth's surface, extending to the outer limits of the atmosphere.

5.1.2　Units

In meteorology, atmospheric pressure is reported in hectopascals (hPa). 1 hPa is equal to 100 Pa, the pascal being the basic SI (System of International Unit) . 1 Pa is equal to 1 Newton per square meter (N/m^2). And 1 hPa is equal to 1mb that was used formerly.

The scales of all barometers used for meteorological purposes should be graduated in hPa. Some barometers are graduated in the unit inHg or mmHg. Under standard conditions, the pressure exerted by a pure mercury column which is 760 mm high is 1013.250 hPa, so the conversion factors are represented as follows:

1 hPa = 0.750062 mmHg;

1 mmHg = 1.333224 hPa.

And because of the relation between inch and mm (1 inch = 25.4 mm), the following conversion coefficients are provided:

1 hPa = 0.029530 inHg;

1 inHg = 33.8639 hPa;

1 mmHg = 0.03937008 inHg.

Pressure data measured with the barometer should preferably be expressed in hectopascals (hPa).

5.2　Principle of Atmospheric Pressure Measurement

5.2.1　Mercury Barometer

(1) Principle of mercury barometer

When a one-meter long, open ended glass tube is filled with mercury and is then turned upside down into a container filled with mercury, part of the mercury flows out of the glass tube into the container. "Torricellian vacuum" is then produced at the top of the glass tube and the mercury level stabilizes at approximately 76 cm from the mercury level in the container (See Figure 5.1). Torricelli's experiment revealed that such a height indicates the ambient atmospheric pressure.

The principle of mercury barometer is to measure atmospheric pressure from precise measurement of this height.

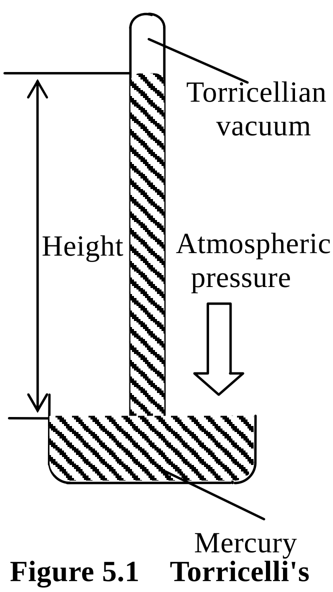

Figure 5.1　Torricelli's experiment

(2) Structure of the Fortin barometer

As shown in Figure 5.2, a mercury barometer consists of three main parts: the mercury cistern (right), the glass barometer tube (center) and the scale (left). The bottom of the mercury cistern is made of a wash-leather bag (sheepskin). The mercury level can be changed by rotating an adjusting screw. The barometer tube is secured with the wash-leather bag in the upper part of the mercury cistern in order to lead atmospheric pressure from the point at the bounded leather. An ivory pointer is put on the top of the mercury cistern, whose tip indicates

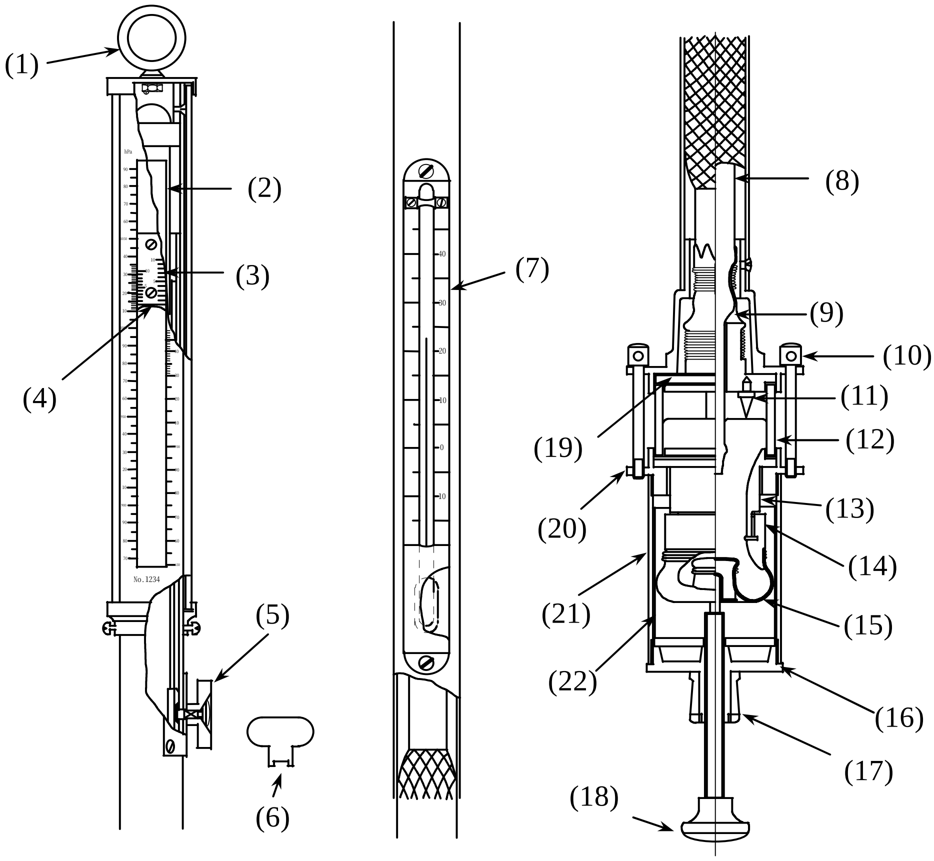

Figure 5.2 Structure of the Fortin barometer

(1) Hanger ring (2) Slot (3) Vernier (4) Top of the mercury column (5) Knob (6) Pin face wrench (7) Attached thermometer (8) Barometer tube (9) Vent wash-leather (10) Three screws (11) Ivory pointer (12) Glass cylinder (13) External thread wooden frame (14) Internal thread wooden frame (15) Wash-leather bag (16) Under cover (17) Screw bridge (18) Adjusting screw (19) Wooden base for leather washer (20) Metal frame (21) Brass cover (22) Mica plate.

the zero of the scale. When the level of the mercury touches the tip, the atmospheric pressure is read at the top of the mercury column. The precise height of the mercury column is measured with the vernier.

The main body has a hanger hook at its top and is used to hang the barometer from a latch on a hanger plate. The bottom is secured to the screw bridge through a vertical axis pivoting link with three screws. Both the hanger hook and the screw bridge can be rotated while the barometer is set on the hanger plate. This allows verticality checks at any time.

A mica plate is wound inside the brass cylinder to prevent the direct contact between brass and the wash-leather bag. The plate serves as a heat insulator as well as prevents contamination, discoloration, and wear.

(3) Handling precautions for mercury

High-purity distilled and refined mercury is used in mercury barometers. When the mercury surface oxidizes, the interface between the surface and the ivory pointer becomes unclear. Heavily contaminated mercury surface requires cleaning. Since mercury is a toxic substance, it is necessary to pay attention to the following when handling mercury.

1) A container of mercury must be sealed tightly to prevent leakage and breakage. Do not put mercury into any metal containers as mercury reacts and amalgamates almost all metals except for iron.
2) The floor of the room where mercury is stored or used in large amounts should be shielded and laid with an impervious covering. It must not be stored together with other chemicals, especially with ammonia or acetylene.
3) Mercury has a relatively low boiling point of 357 °C, and produces dangerous poisonous gas if on fire. It must not be stored close to a heat source.
4) Check the mercury handling room and personnel periodically to make sure that the amount of mercury does not exceed the dangerous limit. (The environmental regulation on water contamination affecting personal health limits the total amount of mercury to 0.0005 mg/l.)

(4) Correction of barometer readings

The mercury barometer’s reading should be corrected to the one and the standard condition. Standard condition is defined as a temperature of 0 °C, where the density of mercury is 13.5951 g/cm^3 and a gravity acceleration of 980.665 cm/s^2.

During actual observation, the reading should be corrected for the index error, temperature correction, and gravity acceleration as follows:

(a) Corrections on index error

Individual mercury barometers include index errors (difference between the value indicated by an individual instrument and that of the standard). The index error is found by comparison with the standard, and the value is stated on a "comparison certificate".

(b) Corrections for temperature

The temperature correction means to correct a barometric reading, obtained at a certain temperature, to a value when mercury and graduation temperatures are 0 °C. The temperature of the attached thermometer is used for this purpose.

The height of the mercury column varies with temperature, even the atmospheric pressure is unchanged. The graduation of the barometer is engraved so that the correct pressure is indicated when temperature is 0 °C. In a case that when temperature is above 0 °C, the graduation expands and the measured value will be smaller than the true value. This effect of temperature must be corrected from these two aspects collectively.

Correction for the expansion and contraction of mercury is much larger than that for the expansion and contraction of the graduation.

The correction value for temperature Ct is expressed as follows:

$$Ct = -H\frac{(\mu - \lambda)t}{1 + \mu t}$$

where:

H hPa is the barometric reading after the correction for index error.

t °C is the temperature indicated by the attached thermometer.

μ is the volume expansion coefficient of mercury.

λ is the linear expansion coefficient of the tube.

There is a small difference in absolute values for correction between temperatures below and above 0 °C. The values for correction at temperatures above 0 °C are negative and those below 0 °C are positive.

(c) Corrections for gravity

Gravity affects the height of the mercury column. After the corrections for index error and temperature, the reading under the local acceleration of gravity has to be reduced to the one under the standard gravity acceleration. This is called corrections for gravity.

The gravity value for correction C_g is derived by:

$$C_g = H_0 - H = H\frac{g - g_0}{g_0}$$

where:

g_0 is the standard gravity acceleration.

g is the gravity acceleration at an observing point.

H is the barometric reading after the index error and temperature corrections

H_0 is the value already corrected for gravitation.

The gravity acceleration used in corrections for gravity value is calculated to the fifth decimal place, in m/s^2. When the gravity acceleration at the observing point is larger than the standard gravity acceleration, the gravity value for correction is positive. Otherwise, the value for correction is negative.

To use a barometer for regular observations at a particular location, a synthesis correction table that summarizes values for correction for index error, temperature and gravity should be used.

5.2.2 Aneroid Instruments

5.2.2.1 Aneroid Barometer

Aneroid barometers have lower accuracy than mercury barometers, but thanks to their compact and portable configuration, aneroid barometers are easier to handle and use, and suitable for self-recording.

An aneroid barometer measures the distortion of an evacuated, sealed elastic capsule inside with change in atmospheric pressure. The aneroid barometer consists of a barometer capsule, a spring to prevent the barometer capsule from being crushed by the atmospheric pressure, and gears and levers that intensify and transmit small amount of variations.

The elasticity of the barometer capsule varies depending on temperature. A bimetallic plate is used for temperature compensation. Once pressure distort an elastic body, it doesn't completely return to its original shape even after the pressure is relieved. Due to this characteristics called hysteresis, an error will arrive from the sharp change in atmospheric pressure and the error will be subjected to secular change. To prevent this, special materials are used for the elastic body. Stacked thin capsules or bellows are used in a number of barometers.

The appearance of an aneroid barometer is shown in Figure 5.3 and its structure is shown in Figure 5.4. Two barometer capsules facing each other are balanced around the pointer rotation axis. Two gears are used symmetrically to reduce vibrations. Two hair springs are attached to the gears to omit backlash from the pointer rotation gear.

The hole for adjusting pointer should be covered with a screw cap (if any) or with thin paper to keep out dust and insects.

When kept in good condition, the aneroid barometer has a difference of about ±0.2 hPa from a mercury barometer. The reading of the aneroid barometer should be corrected with the correction value against the mercury barometer, which is obtained at each observation with the mercury barometer. When reading the barometer, pat the glass surface slightly and read the value in the unit of 0.1 hPa, with close attention to the parallax error.

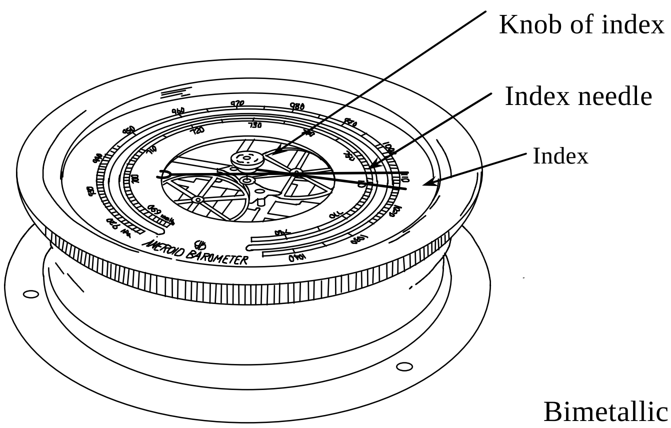

Figure 5.3 Appearance of the aneroid barometer

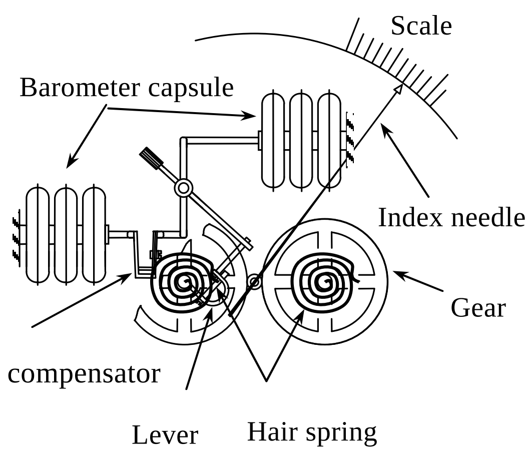

Figure 5.4 Mechanism of the aneroid barometer

5.2.2.2 Aneroid Barograph

The principle of the aneroid barograph is the same as that of the aneroid barometer, except for using a recording pen instead of the index needle. The structure of an aneroid barograph is shown in Figure 5.5.

The displacement of the barometer capsule (1) caused by the change in atmospheric pressure is transmitted to the recording pen (4) through the reed (2) and the lever (3). The recording pen (4) moves up and down on the side of the clock with recording drum (5) to record the changes in atmospheric pressure.

The barometer capsule (1) is vacuumed and balanced with atmospheric pressure through an internal helical spring. As the elastic modulus varies depending on temperature, temperature change on the equilibrium point is corrected by using a bimetallic plate (6) on the mounting part of the barometer capsule to compensate the effect of temperature.

The indicator can be adjusted by rotating the pointer adjusting knob (7) in the upper part of the barometer capsule (1) and by moving the pen arm (8) up and down.

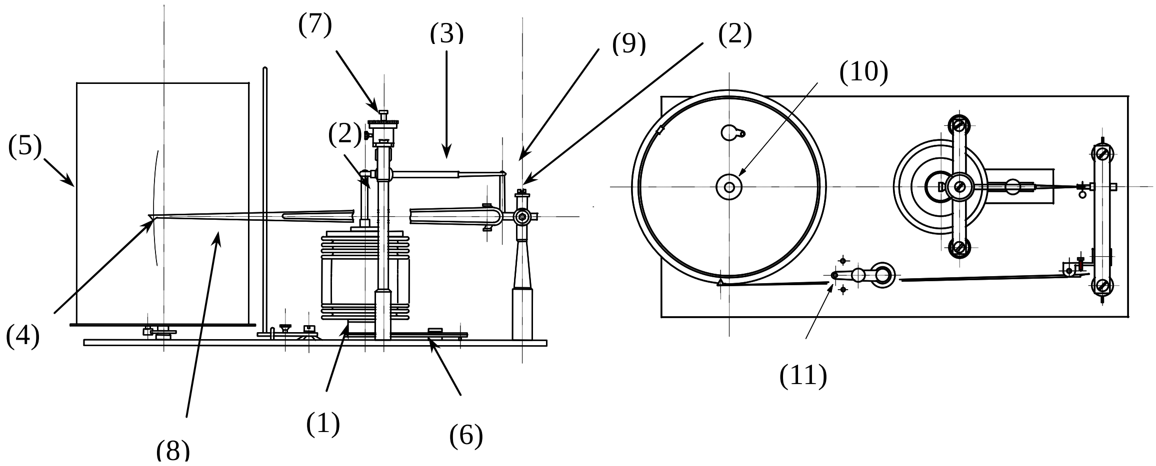

Figure 5.5 Structure of the aneroid barograph
(1) Barometer capsule (2) Reed (3) Lever (4) Recording pen (5) Clock-driven drum (6) Bimetallic compensator (7) Indicator adjusting knob (8) Pen arm (9) Pin with ring (10) Holding screw of the clock-driven drum (11) Gate suspension arm.

5.2.3 Electronic Barometer

Stable and continuous power supply is required to measure atmospheric pressure with an electronic barometer.

5.2.3.1 Cylindrical resonator barometer

Cylindrical resonator barometers measure atmospheric pressure by resonating a thin cylinder and reading the changes in resonance frequency caused by changes in atmospheric pressure.
The sensor is a metallic double cylinder with one end closed and the space of which between the outer and inner cylinders is vacuumed (See Figure 5.6). The natural frequency of the inner cylinder (cylindrical oscillator) changes depending on the pressure applied to its inside. The atmospheric pressure can be obtained by measuring this frequency.

This cylindrical oscillator is equipped with four piezo-electric elements, two of which are for driving and the others for detecting the resonance frequency (See Figure 5.7).

To eliminate the influence of temperature change, the cylindrical oscillator is provided with a temperature sensor for temperature correction.

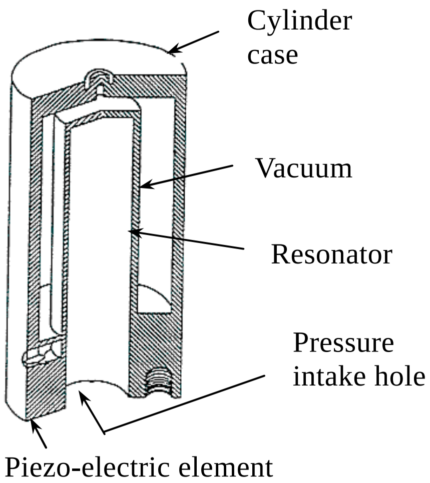

Figure 5.6 Cylinder of the cylindrical resonator barometer

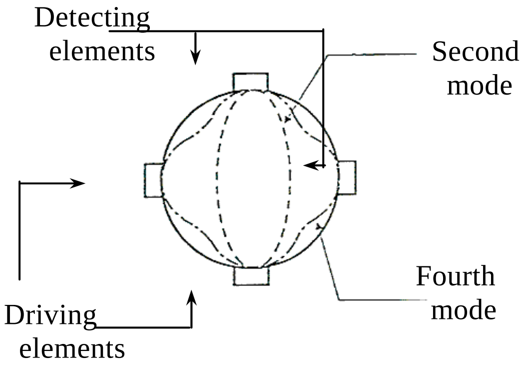

Figure 5.7 Resonance mode of detecting and driving elements

5.2.3.2 Electrostatic capacity barometer

This type of barometer has a pressure sensor in dimensions of some millimeters. It consists of silicon wafer to detect pressure, a silicon chip for substrate, and an insulating glass plate (See Figure 5.8). The silicon wafer to detect pressure is etched to form an electrode and a diaphragm, and a vacuum gap between the silicon and the glass plate is made.

The silicon chip for substrate is also etched to form the other electrode. These electrodes of silicon wafer and silicon chip separated by the vacuum gap form a kind of capacitor.

The shape of the diaphragm changes depending on atmospheric pressure, causing the vacuum gap to expand or contract. Such deformation causes the change in the electrostatic capacity of the gap and the electrodes. This slight change is detected as an electric signal and converted to atmospheric pressure.

This electrostatic capacity digital barometer features high precision and long-time stability.

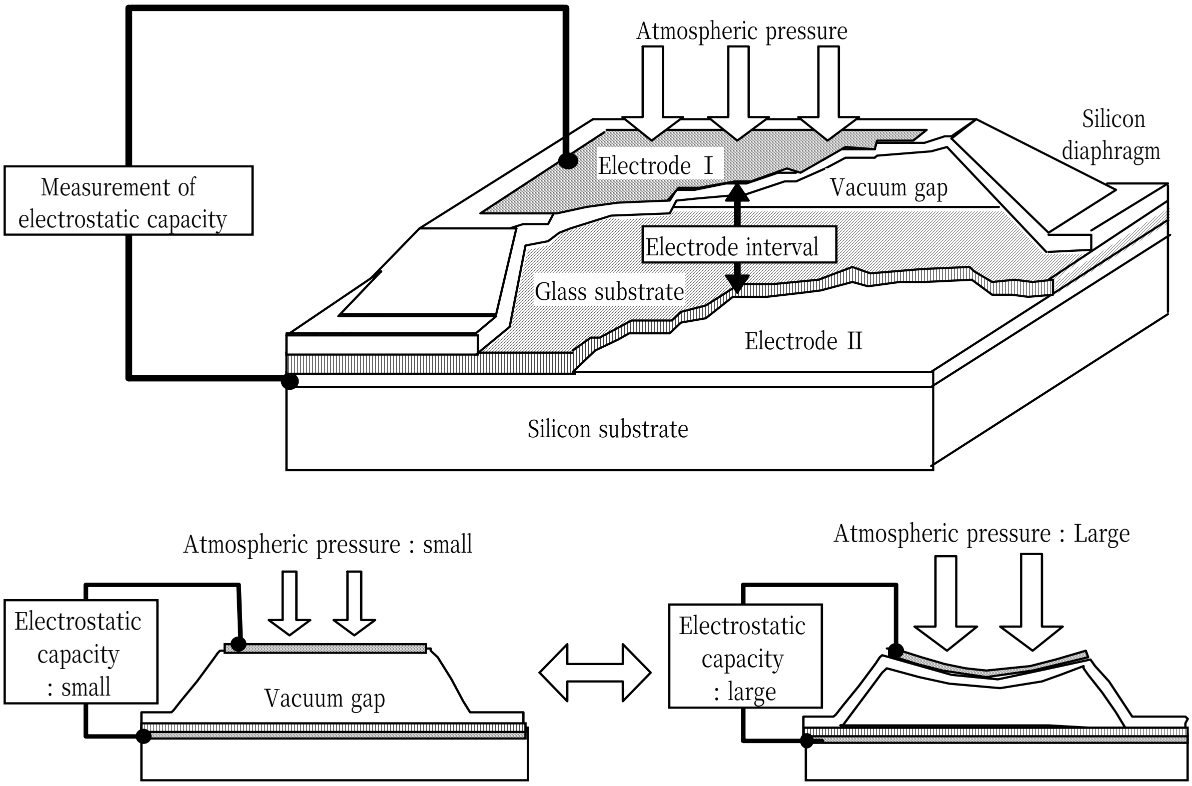

Figure 5.8 Pressure sensor of the electrostatic capacity barometer

5.2.4 Reduction to Mean Sea Level

To compare the atmospheric pressure value at a certain location to a value at another location, it is necessary to convert the values at the same referential altitude. It is internationally decided to use the mean sea level as the referential altitude, and the conversion is called reduction to mean sea level.

Various kinds of methods of the reduction are used in individual countries. For international comparisons, however, methods should be standardized to ensure data interchangeability. Two basic equations, hydrostatic equation and state of ideal gas equation are used in each country. Differences among the methods are found only in the ways to calculate the gravity acceleration and the mean virtual temperature.

When the vertical distribution of air temperature and humidity between the mean sea level and the observation point are known, reduction to mean sea level can be made accurately. However, the air temperature and humidity just at the observation point are generally known. Therefore, the atmospheric pressure at mean sea level is obtained assuming the standard vertical distribution of air temperature and humidity

Suppose there is a vertical air column from the observation point to the mean sea level. The relation between atmospheric pressure P at the observing point, in hPa, and atmospheric pressure P_0 at mean sea level, in hPa, is given by:

$$\ln\frac{P_0}{P} = \frac{1}{R}\int_0^z \frac{gdz}{T_V}$$

where:
T_v is the virtual temperature of the vertical air column, in K.
R is the gas constant of dry air, in $\mathrm{Jkg^{-1}K^{-1}}$.
Z is the height from mean sea level to the barometer, in meters.

Assuming that "*g*" is constant and is equal to the gravity acceleration at the observing point. The mean of virtual temperature is given by:

$$T_{Vm} = \frac{Z}{\int_0^z \frac{dz}{T_V}}$$

It results:

$$P_0 = P \cdot \exp\left(\frac{gZ}{RT_{Vm}}\right)$$

Therefore, the reduction to mean sea level value ΔP is given by:

$$\Delta P = P_0 - P = P\left(\exp\left(\frac{gZ}{RT_{Vm}}\right) - 1\right)$$

Now T_{Vm} is expressed as: $T_{Vm} = 273.15 + t_m + \varepsilon_m$ (K), where t_m is the average temperature of the air column, ε_m is the effect of air humidity. Assuming the lapse rate of air temperature to be 0.5℃/100m results:

$$t_m = t + 0.005 \cdot \left(Z/2\right)$$

where:
t is the air temperature at the observing point.

The value of ε_m is statistically determined as a function of the average air temperature. The relationship between t_m and ε_m is graphically shown in Figure 5.9. This is statistically derived from surface observation data obtained at eight meteorological observatories in Japan. This relationship is almost the same as that in the lower atmosphere under average conditions in Japan. The value of "*R*" is 287.05 $\mathrm{Jkg^{-1}K^{-1}}$. Use this formula to calculate the reduction

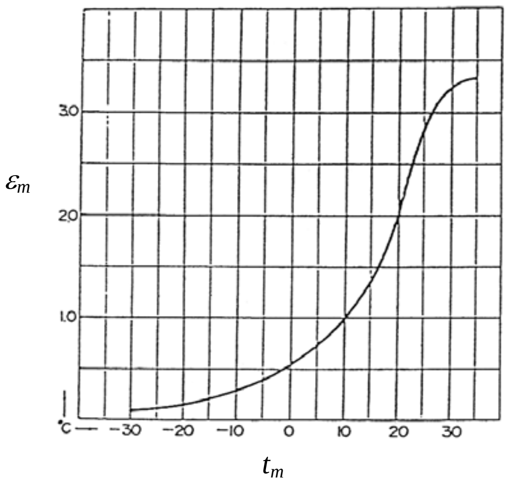

Figure 5.9 Relationship between ε_m and t_m

to one decimal place to mean sea level value ΔP as a function of air temperature t and atmospheric pressure P at the observing point. It is convenient to tabulate the reductions in advance. The air temperature at the observing point t should be the one at the height of the barometer, but the air temperature at the observation field is used instead as the difference is negligible. Similarly, "g" should be the average value down to the mean sea level, but its influence is also negligible.

$$\varepsilon_m = (At_m+B)\, t_m + C$$

$t_m < -30.0\ ^\circ C$	;	$\varepsilon_m = 0.09$
$-30.0 \le t_m < 0.0$	;	A = 0.000489, B = 0.0300, C = 0.550
$0.0 \le t_m < 20.0$	;	A = 0.002850, B = 0.0165, C = 0.550
$20.0 \le t_m < 33.8$	;	A = -0.006933, B = 0.4687, C = -4.580
$33.8 \le t_m$	;	$\varepsilon_m = 3.34$

5.3 Maintenance

5.3.1 Mercury Barometer

The maintenance of mercury barometers is carried out in the following ways:

1) Once a month, brush dust off the outer surface with a soft brush, and wipe metal and glass parts with a soft cloth. Check the barometer for flaws and cracks.
2) If dirt collects on the mercury level where the mercury comes into contact with the ivory pointer, turn the adjusting screw as shown in Figure 5.2 to lower level by approximately 3 mm. Restore the adjusting screw, and dirt will be removed. At this time, be careful not to shake the main body in an attempt to remove the dirt, as the inside of the glass tube may become dirty above the mercury level, resulting in unclear readings.
3) The degree of vacuum should not be checked unless it is definitely necessary to do.

5.3.2 Aneroid Instruments

5.3.2.1 Aneroid barometer

Clean the surface or the glass part of the aneroid barometer with a soft cloth or brush every week. (See Figures 5.3 and 5.4.)

5.3.2.2 Aneroid barograph

Check the aneroid barograph as indicated in Chapter 2: Measurement of temperature, and when there is a difference of ±0.3 hPa or more between the reading of the aneroid barograph and that of the mercury barometer, turn the indicator adjusting screw (7) to adjust the indicator in Figure 5.5.

5.3.3 Electronic Barometer

5.3.3.1 Cylindrical resonator barometer

As the humid air in the sensor of the cylindrical resonator barometer results in an error of approximately ±0.1 hPa in the pressure reading. Replace the desiccant enclosed near the sensor every month.

5.3.3.2 Electrostatic capacity barometer

Electrostatic capacity barometers have high performance and stability, requiring no daily maintenance.

5.4 Calibration

5.4.1 Mercury Barometer

5.4.1.1 Installation

As the structure of mercury barometers gives them low mobility, a standard electronic barometer is installed in their proximity for calibration. At the time of installation, it should be ensured that the height of the mercury barometer’s ivory point matches that of the pressure sensor inside the electronic barometer (Figure 5.10). Calibration can be performed a day after installation is complete.

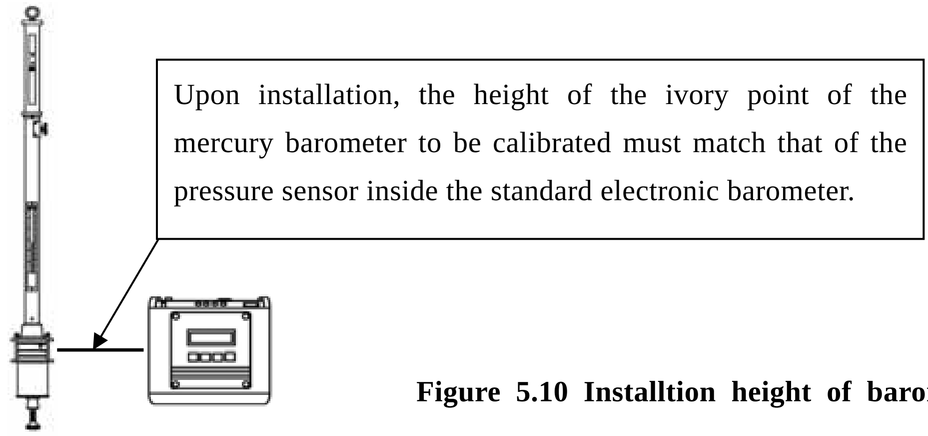

Figure 5.10 Installtion height of barometers

5.4.1.2 Calibration

Calibration is performed under conditions of a pressure change of 1 hPa/h or less and a wind velocity of 3 m/s or less. For each calibration, more than 20 atmospheric pressure readings should be taken with the standard electronic barometer and the mercury barometer to be calibrated. The numbers of readings of atmospheric pressure showing a tendency of increase and a tendency of decrease should be approximately identical. The same person must take all measurements to prevent reading errors.

Temperature correction and gravity correction must be applied to mercury barometer readings using the methods described in Section 5.2.1 Mercury barometers, (4) Correction of barometer readings, (b) Corrections for temperature, and (c) Corrections for gravity.

5.4.2 Aneroid Barometer

If aneroid barometer readings differ from those of the standard electrical barometer by ±0.3 hPa or more, the index knob shown in Figure 5.4 should be adjusted.

5.4.3 Electronic Barometer

5.4.3.1 Installation

For electronic barometer calibration, the barometer to be calibrated and the standard electronic barometer must be connected with a pipe, and a manual pressure adjuster must be used for setting as shown in Figure 5.11. Upon installation, the pressure sensors inside both barometers must be at the same height. Installation should be completed a day before calibration to allow the instruments to acclimatize to room temperature.

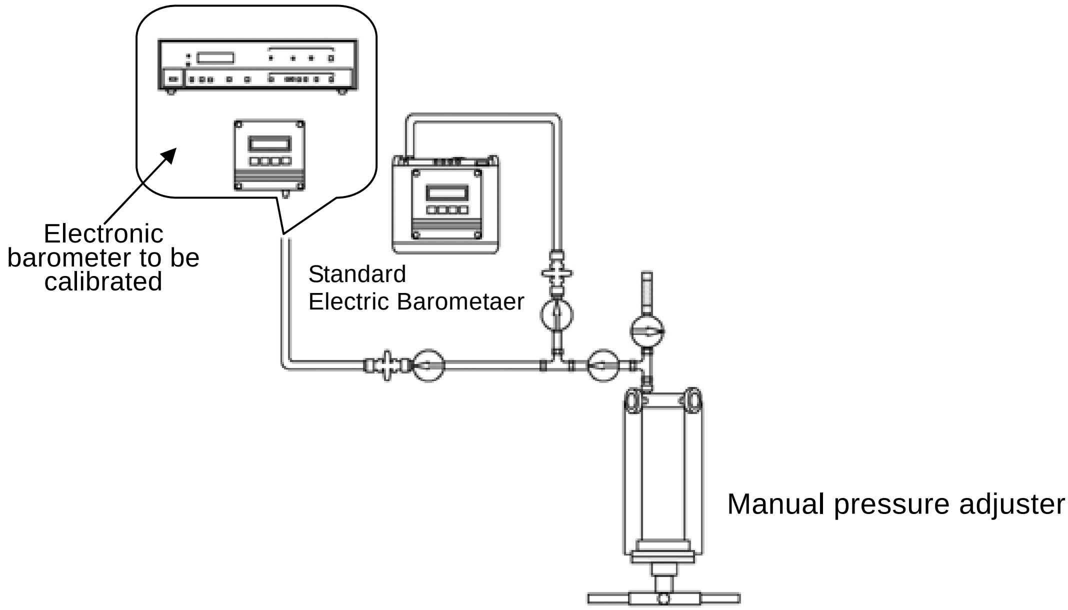

Figure 5.11 Setting and connection of barometers

5.4.3.2 Pressure inspection

Prior to calibration, the pressure should be gradually changed throughout the entire calibration range a few times using the manual adjuster. Comparative measurement at the calibration points should then be performed as described below.

Comparative measurement must be performed at least three times each with upward and downward pressure changes. The difference between the readings of the standard barometer and the barometer to be calibrated at each point should be recorded, and the average of the difference at each point can be taken as the error index for each calibration point.

Calibration points: 880, 920, 960, 1,000, 1,040 (hPa)

*If the specified facilities for pressure inspection are not available, an alternative simplified method can be used in which the barometer to be calibrated and the standard electronic barometer are placed at the same height in the atmosphere. Approximately 20 barometer readings are then taken to determine the correction value at atmospheric pressure.

5.5 Repair

5.5.1 Mercury Barometer

When the difference in observation values increases between the mercury and the aneroid barometers and the mercury barometer appears to be defective, repair it following the instructions as described below (See Figure 5.2).

1) The difference increase is probably caused by the impaired vacuum or the loose mounting of the ivory pointer. When the vacuum becomes impaired, drain and refill the mercury. When the ivory pointer mounting part becomes loose, disassemble and screw it up tightly.
2) When the knob (5) used to move the vernier (3) comes loose and causes a large backlash when the graduation is adjusted, tighten two nuts on the knob with a special tool (pin face wrench) (6).
3) Do not lubricate the adjusting screw (18) and the knob (5) excessively. Excess oil will spread and melt paint varnish, causing sticky thread. It will stiffen the screw all the more. In addition, the oil will soak into the wash-leather bag (15) and the wooden part, and contaminate the mercury. When the adjusting screw (18) is stiff, it is probably because the screw is bent or the thread is dirty. In these cases, replace the screw or remove and clean it with a brush and cloth.
4) When the level of a mercury barometer seems to be not working correctly due to an earthquake, for example, loosen three screws of the vertical axis pivoting link. Check the level and tighten the screws again.

5.5.2 Aneroid Instruments

5.5.2.1 Aneroid barometer

The aneroid barometer is a very precise instrument, and it cannot be easily disassembled or repaired on site.

5.5.2.2 Aneroid barograph

Repair aneroid barographs according to the repair instructions in Chapter 2: Measurement of temperature. When irregular movements of the pen arm are noticeable, repair it as follows (See Figure 5.5).

1) Pull out the pin (with ring) (9) and the connecting pin. Clean pinholes on the barometer capsule (1), reed (2) and lever (3) with volatile oil or benzine, and remove old oil. Polish the inside of the holes with an oil-absorbing toothpick and apply a thin film of high-quality clock oil inside the holes before assembly.
2) Feel how the pivots rattle with hands. Remove one pivot at a time. Clear out old oil and dust. When the pivot is rusty, polish it evenly with a lathe or oilstone and lubricate it with clock oil, as mentioned above in 1), before assembly.
3) The reed (2) must be centered on the crack of the lever (3). If not, check the pin and the crack for distortion, and repair any defective parts before reassembly.
4) To repair the clock-driven drum (5), refer to the relevant section in Chapter 2: Measurement of temperature.

5.5.3 Electronic Barometer

Cylindrical resonator and electrostatic capacity barometers mainly consist of electric components, and they rarely have mechanical parts. Therefore, it is rarely possible to repair these barometers on site.

5.6 Transport

5.6.1 Mercury Barometer

(1) Method of transport

When transporting the mercury barometer, fill the vacuum part with mercury and turn the barometer upside down to prevent any air from entering. This also applies to indoor transport, regardless of distance. For long distance transport, carry it in a leather carrying case keeping the barometer in the upside down position.

(a) Removing the mercury barometer

To remove the mercury barometer from the hanger plate, softly turn the adjusting screw (18) (See Figure 5.2) until the mercury column reaches the top of the tube. It may be difficult to notice by only feeling the adjusting screw or listening to its metallic sound. So, pay careful attention to the mercury column movement while rotating the adjusting screw. If the cistern has an air vent, it must be closed tightly at this stage.

After turning the adjusting screw, loosen three screws of the vertical axis pivoting link. Remove the screw in the upper part of the hanger plate. Hold the main body firmly with both hands, and remove it from the hanger plate.

(b) Turning the mercury barometer upside down

After removing the mercury barometer from the hanger plate, tilt it slowly and turn it upside down.

(c) Storing the mercury barometer in a leather carrying case

Check the leather carrying case so the barometer will not come off, that the shoulder belt is not worn, and the cap can be tightened securely. When everything is checked out, put the barometer, which has been turned upside down in step (b), in the leather carrying case slowly. When the mercury cistern is about to enter the leather carrying case, grab the adjusting screw securely with one hand and lift up the leather carrying case with the other hand so that the top of the mercury barometer bottoms on the leather carrying case. After putting the barometer into the leather case, fill cushioning material around the mercury cistern for support.

(2) Precautions of transport

When the temperature of the barometer rises during transport, the mercury expands and may break the glass tube or leak out. To prevent this, loosen the adjusting screw (18) one or two turns (See Figure 5.2) in advance.

Sling the leather carrying case over the shoulder, and do not swing it.

For long-time transport by rail or vessel, put the leather carrying case upright in a safe place so that the barometer is always upside down. If it is impossible to put the leather case upright, be careful not to allow it to tilt more than 30 degrees. For temporary placement during transport, put the leather case at a stable place so that it does not fall down accidentally.

Air transport of mercury and associated instruments are regulated by the International Air Transport Association (IATA).

5.6.2 Aneroid Instruments

Generally, aneroid instruments have a measuring range from 900 hPa to 1,050 hPa. Do not transport these barometers by air, as barometer capsules may break from exceeding its measuring range.

For transport of a clock-driven drums of the aneroid barograph, refer to Chapter 2: Measurement of temperature.

5.7 Installation

5.7.1 Mercury Barometer

(1) Checking the mercury barometer

After putting the mercury barometer out of the leather carrying case, check it for damage, distortion, and mercury leakage with keeping it reversed. After its integrity is confirmed, tighten the adjusting screw (18) (Figure 5.2) until it stops and the air is taken out.

(2) Turning the mercury barometer back to a vertical setting

After taking out the air by tightening the adjusting screw (18), hold the mercury barometer with both hands and turn it back to a vertical setting slowly. Then, turn the vernier knob (5) and check that it does not become fast nor run idle.

(3) Test for the presence of gas in the barometer tube

Holding the mercury barometer firmly with one hand, pat the brass cover (21) of the mercury cistern with fingers of the other hand a few times, and loosen the adjusting screw (18) a little. When the top of the mercury column (4) appears in the upper part of the slot (2), tighten the screw a half turn so that the top of the mercury column (4) is slightly hidden in the upper part of the slot (2). Holding the mercury barometer with both hands, tilt it slowly. While tilting the barometer to an angle of about 30 degrees, the mercury will reach the top of the barometer tube (8) and emit a metallic sound like a click. If the click is sharp and metallic, the mercury column has reached the top without meeting any gases. When performing this test, the operator should be aware of the danger of breaking the barometer tube by tilting the barometer too quickly.

(4) Checking the attached thermometer

Check the attached thermometer (7) for breakage or disconnection of mercury column.

(5) Checking the hanger plate

Check the integrity of the upper and lower milky white glasses, hanger hook, vertical axis pivoting link, and wall hanger hook of the hanger plate. Check the latch screw and the three vertical axis pivoting link screws for distortion or shortage.

(6) Installing the mercury barometer

The mercury barometer must be installed as vertically as possible to minimize reading error. Before installation, remove the attached thermometer and the latch screw, and loosen the centripetal screw. With the glass cylinder (12) filled with mercury, stand the barometer upright and insert the adjusting screw (18) into the center of the vertical axis pivoting link.

Next, hang the metal hook (1) from the hanger hook and attach the screw of the hanger hook. Using three screws, secure the vertical axis pivoting link to keep it in an up-right position.

Turn the adjusting screw (18) slowly until the mercury level in the mercury cistern is 1 mm below the ivory pointer. Do not lower the mercury level abruptly, as the air inside the brass cylinder (21) is compressed and leaks through the wash-leather bag to the mercury level, causing bubbles in the mercury tube (8). Make sure that no bubbles appear in the upper part of the mercury tube (8) during this process. If the wash-leather bag is too hard, the mercury level may not go down smoothly by loosening the screw. In such a case, pay close attention to a sudden fall in the mercury level. If the mercury level does not go down spontaneously, pat the adjusting screw (18) from below with the finger.

After the installment of the mercury barometer, reinstall the attached thermometer as before. Leave the barometer as is for at least a day for conditioning at room temperature.

5.7.2 Aneroid Instruments

5.7.2.1 Aneroid barometer

(1) Pre-install inspection

Before installing the aneroid barometer, check it for glass breakage. Make sure that the index (Figure 5.3) moves smoothly and stops at an arbitrary point. Shake the barometer slightly and listen to its internal sound to check for loose screws and nuts.

(2) Pre-install adjustment

Rotate the indicator adjusting knob to set the indicator to atmospheric pressure measured with a mercury barometer on site.

(3) Installing the aneroid barometer

The barometer should be installed inside the barometer room. If it is impossible, place the barometer in a place free from direct sunlight and extreme temperature changes. The barometer should be positioned in a place free from vibration and strong impacts. When installing the barometer on a pillar or wall, secure it tightly with wood screws to prevent it from falling.

A barometer specifically intended for horizontal installation should be used in its accessory case or wooden box for protection.

5.7.2.2 Aneroid Barograph

(1) Pre-install inspection

Before installing the aneroid barograph, check the main body (Figure 5.5) and the clock -driven drum (5) for breakage, distortion, loose or missing screws, and other disorders. If everything is fine, attach the clock-driven drum (5) to the main body. With the pin with ring (9) removed, make sure that the tip of the recording pen (4) aligns with the graduation line for time (curvature) of the recording chart. Make sure that the pen pressure is appropriate.

Insert the pin with ring (9) into the lever (3) and the reed (2). Turn the indicator adjusting knob (7) to adjust the reading to the atmospheric pressure measured with a mercury barometer on site. At this time, slightly vibrate it to make sure that the pen tip stays at the same point.

Finally, wind the spring of the clock-driven drum and make sure that it operates properly.

(2) Pre-install adjustment

Do not carelessly change the magnification on site, as it necessitates reinspection. Do not carelessly change the temperature correction bimetallic mounting position as well, as it affects the precision.

When the tip of the recording pen (4) does not align with the graduation line for time on the recording chart, the clock-driven drum may slant. Correct it referring to Chapter 2: Measurement of temperature.

(3) Installation of the aneroid barograph

As a general rule, the aneroid barograph should be positioned on a solid desk or table in the barometer room. Lay a rubber sheet or other cushion under the aneroid barograph to absorb vibrations of the building.

5.7.3 Electronic Barometer

Cylindrical resonator and electrostatic capacity barometers should be used according to operating instructions. Since they contain precise electronic parts and circuits, they should be installed in a place free from humidity, direct sunlight, and vibrations.