

Denis Dingens
Weatherinstruments

Dear Ladies and Gentlemen,

This booklet was composed to make it easier for You, to sell weatherinstruments in your specialized store. Often customers and even staff have difficulties or questions concerning handling weatherinstruments. You can use in a sales-conversation some of the contents of this booklet, shortly you will notice that the booklet contains important, even essential information about how to handle different weatherinstruments. One thing is for sure : your customers will surely approve and value the way you can inform them.

This booklet contains the manuals of Kontrabarometers, Torricellis, Sympiesometers, Mechanical barometers, Hygrometers and Thermometers. Simultaneously interesting views of different instruments will be introduced to you together with their historical background.

*To avoid and to prevent problems we suggest You to read this booklet and follow the instructions **before** activating a weatherinstrument.*

Even in this computer and multimedia-age, weatherforecasts are never customized to be correct for your own neighbourhood. Often there are major discrepancies between the forecast on the radio or television and the actual weather where you live. Weather instruments give you the possibility to correct these general forecasts to an accurate weather forecast for you own home, we call this the micro-climate-forecast. And what could be better than to have it always at the right end in weatherforecasting, to be the weatherman who tells the truth...

Yves Dingens
Managing Director
Denis Dingens Ltd

Robert Coens
Sales/Export
Denis Dingens Ltd

Table of Contents

Table of Contents	2
IMPORTANT: Manual Contra-Barometer	3
The Weatherchart	4
Usefull Hints	4
IMPORTANT: Manual Torricelli-Barometer	5
Calibration	6
Invention and Development of the Barometer	8
Environment	11
Aneroid Barometer and Thermometer	12
Hygrometer and Baroscope (Stormglass or Stormbottle)	13
Waterbarometer	15
Tendancybarometer	17
Digital instruments	18
Eco-celli	19
Calibration Eco-celli	20
Literaturelist	22

Contrabarometer

The contrabarometer and the Torricelli-barometer are very sensitive and precise weather-instruments. The big advantage of the contrabarometer is the easy to read measuring-scale. A difference of 1 millimetre in the mercurytube becomes a tenfold enlarged difference in the tube with the coloured liquid, thus 1 centimetre.

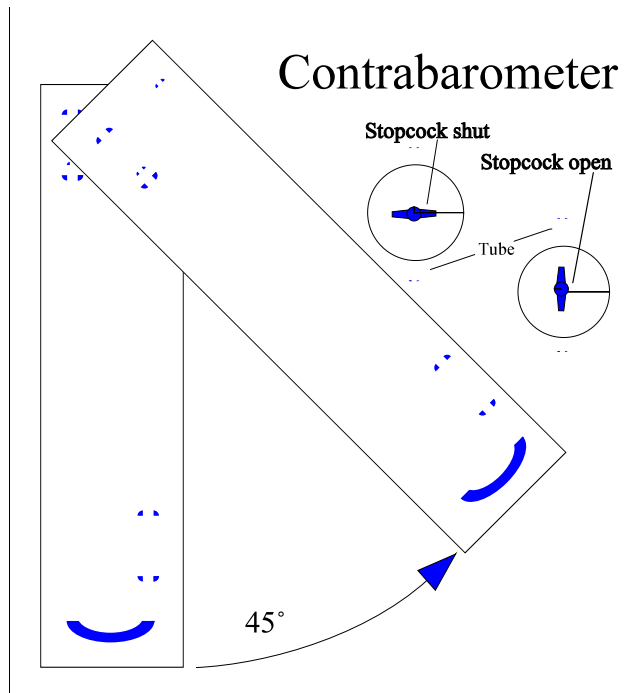
Manual for Contrabarometer

Be careful unpacking the barometer. Attention, the glass-tubes are fragile! After you prepared the displayplace of your barometer (solid mounting-bracket), you can put the instrument in place. Replace the rubber stopper by the glass plug. *Now, and not earlier, is the moment to open the stopcock.* The mercury starts his way downwards while the coloured liquid-column rises. The movement of both liquid-columns stabilizes on the actual airpressure.

When you want to move the barometer to another location you have to bring the barometer in an angle of 45° (see drawing). The mercury starts filling the upper reservoir on your left hand while the coloured liquid is gathered in the lower right-hand reservoir. When the mercuryreservoir is practically filled, you can shut the stopcock.

Attention!!! If the barometer during transportation or storage is exposed to excessive heat, it is prohibited to fill the mercuryreservoir completely. The heat expands the mercury in the tube what could result in breaking of the glass tubes. That is the reason that we advise to keep a little "bubble" in the mercuryreservoir. It gives the mercury the room it needs to expand. So, when filling the mercuryreservoir, close the stopcock while you still have left a little "bubble".

The dial on your contra-barometer shows the actual airpressure in inches and millibar (hectopascal). Because the right-hand indicating tube reads low pressure at the top and high pressure at the bottom, this system of barometer is called "Contra"-barometer. Descriptions or symbols on the dial like Rain, Change, Fair, ..., are put onto the scale to give you an idea of weather-behavior. Important in the usage of the contra-barometer is the interpretation of the trend of movement (rising or falling). In order to observe a trend, we mounted on/next to the right-hand tube a moveable indicator. Each time you take a reading of the airpressure, place the indicator equal to the level of the actual airpressure. Directly proportional to the differences in airpressure you can make an accurate weather-prediction for approximately six hours, valid for the microclimate of your neighbourhood.



The Weatherchart

This weatherchart is designed to assist you while making your own weather-predictions. The chart is the result of the consequent weather- and airpressure-registration during a very long period by a French monk. This monk measured each day the airpressure and made notes of the weather on that day. After years of registration and observation he could prove the link between airpressure and weather.

The indications on the weatherchart, compared with the reading of the airpressure on the contra-barometer and the airpressure-trend (falling, rising or stable), are making it possible to state a reliable weatherprediction for the next six to twelve hours.

Winter	High pressure readings	Summer
airpressure over 760 mm - 1,020 mbar - 30.10 inches		
Increasing frost - Fog Clear - Frosty weather Continuous frost Clear intervals - Hoarfrost Thaw - Cloudy Wind - Snow - Glazed frost	Rising rapidly Rising slowly Stable after rise Stable after fall Falling slowly Falling rapidly	Wind - Clearing rapidly Steady - Very dry Clear - Dry - Warm Cloudy to bright Cloudy and rain Sultry - Thundery
Winter	Middle pressure readings	Summer
airpressure between 750 to 765 mm - 1,000 to 1,021 mbar - 29.50 to 30.10 inches		
Showers - Cold rainfall Clearing slowly - Colder Cloudy to bright, misty Light wind - Damp Light wind - Thaw - Snow Wind - Rainfall - Warmer	Rising rapidly Rising slowly Stable after rise Stable after fall Falling slowly Falling rapidly	Showers - Rainfall - Cool Decreasing wind - Bright Cloudy to bright - Warm Light wind - Sultry Continuous rain Wind - Showers - Cool
Winter	Low pressure readings	Summer
airpressure below 750 mm - 1,000 mbar - 29.50 inches		
Showers - Rainfall - Cloudy Decreasing wind - Misty - Colder Decreasing wind - Drizzling rain Continuous showers Wind - Much rain Storm - Rain or snow	Rising rapidly Rising slowly Stable after rise Stable after fall Falling slowly Falling rapidly	Showers - Rainfall - Cloudy Decreasing wind - Bright intervals Decreasing wind - Light rain Continuous rain showers Wind - Plenty of rain Storm - Thunderstorm - Hail

Rapidly : more then 2 to 3 mm ; Slowly : less then 2 to 3 mm ; Stable : less then 1 mm

Useful Hints golden rule: **Move a Contra-barometer = 45°**

If you want to move a contra-barometer (perhaps to clean, to paint, ... the wall) you always have to bring the barometer in an angle of 45°. The mercury start filling the upper reservoir on your left hand while the coloured liquid is gathered in the lower reservoir on your right hand. When the mercuryreservoir is practically filled, you can shut the stopcock. The contra-barometer is ready for moving.

Attention!!! Fragile!!! How to prevent spontaneously breaking of the glass tubes?

Cause Excessive heat!!! Spots, solar rays, the greenhouse-effect in some windowdisplays are often the cause of such calamities. The mercury expands under the influence of heat. This expansion can build up such an amount of pressure that the glass tubes break.

Prevention A contra-barometer in display should always be displayed with the stopcock opened. In a working contra-barometer a pressure built-up in the mercury-column is impossible. If you want to store or move a contra-barometer, your first action is to follow the storage-instructions and be careful to leave a little "air-bubble" in the mercuryreservoir as an expansionroom for the mercury.

Cleaning and maintenance

We advise for a regular cleaning, at least once a year:

Wood (excepting black painted wood), the scale of parchment and brass parts will be treated with a fluff-free cloth and beeswax. DO NOT apply beeswax directly on the instrument. Apply a tiny amount of beeswax on the cloth. Polish carefully the instrument until it shines.

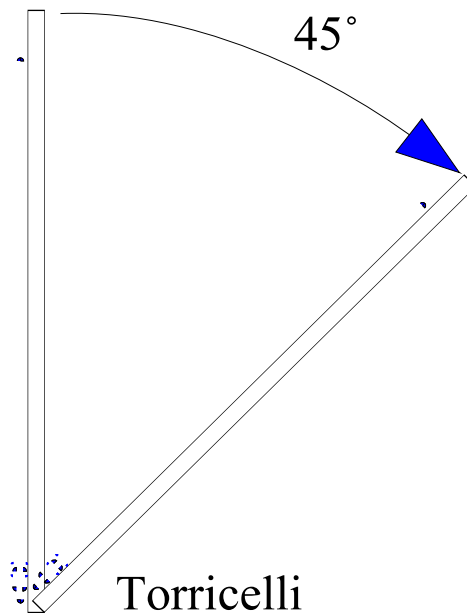
Black painted wood, glass parts, plexi can be cleaned with a window-cleaner (like Instanet, Mr. Proper, ...) and a fluff-free cloth. DO NOT apply window-cleaner directly on the instrument. Apply a tiny amount of window-cleaner on the cloth. Polish carefully the instrument until it shines.

Once a week dusting the instrument is sufficient to keep it in condition.

The Torricelli-Barometer

Our Torricelli-barometers are what you could call Syphon-barometers. A vacuum glass tube is filled with mercury. The curve with the mercury-container below has the same function as the bucket filled with mercury during the Torricelli-experiment.

You received this Torricelli-barometer in locked condition. In order to engage the Torricelli-barometer you have to lean it backwards in an angle of appr. 45° (see drawing). Now you can unscrew the mercury-container. The plunger in the container has to be removed. Slide the glass cover into the reservoir. Bring the Torricelli to an upright position and move it carefully to the mounting place. When you want to move a Torricelli, first lean it in an angle of 45°, the mercury starts filling the glass tube, then close the mercury-container. When you want to move the Torricelli for a longer period, or for storage reasons, you have to place first the plunger into the container.



Calibrating the Torricelli-Barometer

The location of the barometer plays an important role in measuring the airpressure (each 11.48 yard 1 mm (0.039") difference, or each 8.75 meter 1 millibar) is it necessary to calibrate the barometer. Our Torricellis are very easy to calibrate. The glass tube is vertically moveable. One can adjust the mercury tube until the Mercury-level is equal to the actual airpressure level. To know this actual level you have to contact the nearest airfield or meteorological institute. Check also the examples in the contrabarometer-section. It is necessary to calculate the actual airpressure for your location when the altitude differs from the airfield/institute. Calibrating a barometer is pretending if the barometer would be on a sealevel location. The Torricelli-barometer has to be calibrated before use.

Cleaning and maintenance

We advise for a regular cleaning, at least once a year:

Wood (excepting black painted wood), the scale of parchment and brass parts will be treated with a fluff-free cloth and beeswax. DO NOT apply beeswax directly on the instrument. Apply a tiny amount of beeswax on the cloth. Polish carefully the instrument until it shines.

Black painted wood, glass parts, plexi can be cleaned with a window-cleaner (like Instanet, Mr. Proper, ...) and a fluff-free cloth. DO NOT apply window-cleaner directly on the instrument. Apply a tiny amount of window-cleaner on the cloth. Polish carefully the instrument until it shines.

Once a week dusting the instrument is sufficient to keep it in condition.

Calibrating a Contra-Barometer

Why calibrating ?

A contra-barometer is a very precise instrument to measure the airpressure. Because the airpressure also changes with different heights, it is necessary to calibrate a contra-barometer for his location. A contra-barometer that indicate 760 mm on sealevel will indicate, without a calibration, on a height of 220 meter, 739 mm. By calibrating a barometer one insures that in identical weatherconditions on different heights, the same readout is given on the gradescale (in our example thus 760 mm). Airfields and weatherstations usually have two mercurybarometers, one set for sea level, the other set for the local height.

Preparation

The easy way

What is the local height ?

Make a phone call to the nearest airfield/weatherstation and ask for the actual airpressure. Mention the fact that you are calibrating a contra-barometer and check the height from the airfield/weatherstation. Is the height the same as on your location you can set the barometer equal to their barometer. Is there a difference in height, you have to calculate.

Ether in a dropping-bottle, coloured liquid (if needed) and tissues should be placed ready.

Preparation from the calibrationset : needle on the squirt, hose over needle.

Take the stopper out of the right hand tube. When necessary (as for the K1000) loosen the upper right holderscrew from the tube so that you easily can feed the plastic hose into the glass tube.

Method of Calibrating

When you are going to calibrate a contra-barometer the stopcock has to be opened.

Carefully feed the hose into the right hand tube. Bring the end of the hose a little bit deeper then the future liquid level. Take the surplus liquid out pull the lever from the squirt. The level of the fluid falls. Always take somewhat more liquid to compensate the liquid clinging to the glass tube. When this liquid falls the fluid level rises.

Attention !!! When taking the hose out be careful. The liquid make stains. Tissues ready !

To add coloured liquid the squirt has to be filled with the proper amount and colour anyline. This is achieved by using the hose to suck up the liquid. This way there is no air when you add the anyline. Feed the hose carefully into the right hand tube, just into the liquidlevel. By pressing slowly the squirt, liquid is added and the level rises. Add always more fluid then seems necessary, the volume from the hose pushes fluid away).

Add one or two drops Ether (with the help of the dropper) in the glass tube. The evaporation from the Ether cleans the inner tube. Caution : Only Ether can be used for this operation because it evaporate completely and it is harmless tot the coloured liquid.

When necessary fasten the holderscrew from the right hand tube. Put back the special glass stopper.

Clean liquids back in their bottles. Clean thoroughly the calibrationset with Ether. Keep bottles, squirt, and other parts together and keep them out of reach for children.

Or, with known factory settings, you can use the mathematical way :

Examples

On our chart of heights the village Soumagne is indicated with an average height of 220 meter. A customer in Soumagne lives on a slightly higher location : 250 meter. Each 10.5 meter difference of height is equal to a difference of 1 gradation (1mm) on the scale. One Millibar (or Hectopascal) difference on the scale is equal to a difference of height of 8 meter. The factory set calibration was for a height of 220 meter. It is necessary to calibrate the contra-barometer for the higher location. The contra-barometer-reading shows 740 mm.

Calculation (mm) :

$$250 \text{ meter} - 220 \text{ meter} = 30 \text{ meter}$$

$$(+) 30 \text{ meter (future location)} : 10.5 \text{ meter} = 2.85 \text{ mm liquid to take}$$

The level for the higher location has to be $740 + 2.85 = 742.85 \text{ mm}$ or $\sim 743 \text{ mm}$ on the graduation scale from the barometer.

An optician purchased some barometers. The shop is located in Theux, what means that the factory settings are normally set on 170 meter. A customer from the optician lives in Brussels. Where he lives the actual height is 60 meter. The contra-barometer shows now 1040 mbar.

Calculation (mbar) :

$$170 \text{ meter} - 60 \text{ meter} = 110 \text{ meter}$$

$$(-) 110 \text{ meter (future location)} : 8 \text{ meter} = 13.75 \text{ mbar liquid to add}$$

The level for the lower location has to be $1040 + 13.75 = 1053.75 \text{ mbar}$ or $\sim 1054 \text{ mbar}$ on the graduation scale from the barometer.

For both examples one can, to control the outcome, make a simple calculation in order to check the rightness of the calibration :

Example 1 :

Shop Soumagne (220 meter)	740 mm
Sealevel (0 meter)	719 mm
250 meter / 10.5 meter = 23.81 mm,	$719 \text{ mm} + 23.81 \text{ mm} = 742.81 \text{ mm} (\sim 743 \text{ mm})$
Customer Soumagne	743 mm

Example 2 :

Shop Theux (170 meter)	1040 mbar
Sealevel (0 meter)	1019 mbar
60 meter / 8 meter = 7.5 mbar,	$1019 \text{ mbar} + 7.5 \text{ mbar} = 1026.5 \text{ mbar} (\sim 1026 \text{ mbar})$
Customer Brussels	1026 mbar

Airpressure

One of the most important elements in meteorology is the measuring of the airpressure. The earth is surrounded by a thick layer of air (appr. 1000 kilometer). When climbing higher, the air becomes thinner. This layer of air is called "atmosphere". Scientists divide this atmosphere in different layers in order to be able to catalogue natural phenomena. These different layers are called Troposphere, Stratosphere, Mesosphere, The air in the atmosphere is composed out of different chemical elements like Oxygen, Nitrogen, Hydrogen, Methane, Carbon dioxide, In normal breathing-air there is appr. 21% Oxygen and 78% Nitrogen. The molecules of these gases are always moving. In the upper layers, where the gravitational pull is small, there are only few of these molecules so the pressure is low. Down to earth there are many molecules, constantly moving and colliding, so here is the pressure high. It is the constant colliding of these molecules that we can measure as airpressure. This pressure is often varying. When one measures the pressure in our regions one will notice that it varies between 28 and 31 inches. The changes in the airpressure are caused by approaching weather changes. By using the measurements from the changes it is possible to make accurate weather forecasts

Mercury

To a chemist mercury is known as Hg, number 80 in the Mendeleev-table, coming from the Greek "Hydor" (water) and "Arguros" (silver), so it means "watersilver". Through the centuries we come across different names, like "moveable silver" and "quicksilver" and finally "mercurius" from which our English "mercury" was derived. Mercury is a metal with a high density (13.6) that has a liquid form at room temperature. The melting-point of Mercury is -38.9° centigrade and the boiling point is 356.7° centigrade. This "special" metal has nowadays a bad reputation. Yet, one should not exaggerate, even if handling potential dangerous materials. If correctly handled, there is even no risk at all. You have a larger risk to get a Mercury-poisoning while eating fish in a restaurant or when your dentist is placing a new filling in your teeth. Some additional explaining is probably necessary :

Farmers and ranchers in agriculture use herbicides and insecticides. Lots of these chemical products are based on Mercury. At last these products get into the foodchain, some directly, some travel a long way through our rivers and land into the seas. Here are a lot of animals that assimilate the Mercury. Fishbones for example have one special ability : they accumulate Mercury. Any good cook will tell you that to prepare a fumet (fish-stock) he has to cook the fishbones no more than 20 minutes. If he exceeds this cooking-time, the mercury-salts will delute into the fumet and make it hazardous to your health.

Also the fillings used by dentists are based on Mercury : amalgams. Recent German researchers indicated that excessive use of amalgam-fillings is damaging your health.

The mercury in our barometers is completely sealed from the outside air, so there is no danger at all. The mercury becomes potential dangerous at the moment the tube actually breaks. The mercury that is spilled at that moment should be removed instantaneously. Be careful with jewelry, Mercury reacts with many metals (gold also !) and forms amalgams. The manual provides you with the safe method you'll have to use if a contrabarometer is damaged.

Historical

In a short period of the seventeenth century, the invention of six important scientific instruments had an enormous influence on the accelerated development of science. These instruments were the telescope, microscope, air pump, clock and barometer. They all made experiments and measurements possible which were unthought of before. It is also interesting that two of those instruments, the telescope and the barometer made known facts which were contrary to the popular theories of that time, which came from the teachings of Aristotle. The Christian Church had used them for centuries to support their teachings. Aristotle's theory, that a vacuum is logically impossible was proven incorrect by the evolution of the barometer. The origin and evolution of the barometer is fascinating history. As happened with many inventions, an incident out of daily life led to the discovery that a vacuum could be created. For centuries people struggled with the teachings of the old Greek Philosopher Aristotle, that something like this would be impossible and through coincidental circumstances, the contrary was proved.

Around 1635 people were constructing gigantic fountains in the place gardens near Florence. They installed a suction-pump to draw water through a pipe from a well. The water would not rise in the pipe any higher than 18 Florence Ell (36 Feet/11 meters). The famous physicist, Galileo Galilei (1564-1642), was asked for advice, but could not find the reason. Even a genius like Galileo was blinded by the dogmatism of that time. He could not imagine that as the water was being pumped out of the well that a vacuum was being created above the water in the pipe and it would not pump any higher.

When Galileo died in 1642, he left behind notes about the incident in Florence, in which he stated air must have some sort of weight, but unfortunately he hadn't made any further discoveries.

Galileo's successor as court physicist for the Duke of Toscana was Evangelista Torricelli (1608-1647). He became engrossed with the notes of his predecessor and experimented with water, attempting to create a vacuum, but more specifically to prove that air pressure was responsible for raising the water level within a vacuum. Since the length of the pipe used in Florence 11 meters (36 feet) was very awkward, he looked for a less complicated method. Torricelli was first to try to make an instrument that could prove the changes of the air: sometimes heavier and sometimes lighter. He wrote this to a friend in the summer of 1644, complete with a detailed description of the well-known experiment of the glass tube in a bowl with mercury. (It is unknown if Galileo or one of his pupils suggested the use of mercury)

For the experiment he used a glass tube of 1 meter (39 inches) long, which was melted close at one end. He completely filled it with mercury, closed the open end with his finger so the mercury would not escape, turned the tube upside down, submerged the open end in a tray half filled with mercury and removed his finger from the open end. The mercury in the tube dropped a few inches but remained at a height of approximately 76 centimeters (30 inches) from the surface of the mercury in the tray. Experiments like the one of Torricelli which refuted age-old theories were not then proclaimed from the housetops, especially not in the Italian world of scientists and research workers. In Western Europe however, away from the influence of Aristotle's teachings, many experiments were done with Torricelli's idea of a vacuum. To observe the higher powers in our atmosphere, research was continued.

The system with the open mercury tray was not very practical and many improvements were attempted. One idea was the use of small leather bags, attached to the tube, from which the mercury could not escape but were porous enough to admit the air. Wooden reservoirs were also tried, but it was Robert Boyle who came upon the best replacement for Torricelli's tube and loose tray. Boyle bent the tubes at the bottom so that the small bent end could serve as a reservoir. These tubes then came to be known as the siphon pipe.

The French philosopher and physicist, Rene Descartes (1596-1650), like Galileo was thrown back and forth between the old and new ideas. He became convinced that air could exercise pressure and this pressure was often quite different. In 1648, Descartes improved the tube design of Torricelli with a paper graduation dial. With this dial, the mercury barometer was introduced, although it was not yet known by the name. The honour of its discovery is given to Torricelli because he had already talked of an instrument in 1644, but the contribution of Descartes was very important in its development.

Mercury was an indispensable element for this type of barometer and it is very interesting to take a closer look at this unique metal. Its first favorable characteristic is that with its high specific gravity, it only needs a small glass tube to show air pressure values; whereas a barometer working with water would be 36 feet high (11 meters) (14 times longer than the Torricelli tube) as illustrated by the problem the people of Florence had with their fountains. In addition, water's vapor changes are so large that it leads to incorrect readings, while the vapor changes in mercury are so minute that they are hardly worth mentioning. At 66 degrees Fahrenheit (20° Centigrade), the vapor of water is almost 15000 times that of mercury. Another disadvantage of water is that it clings to the inside of the glass tube, and with a dropping barometer, some water stays on the glass wall making the exact height of the liquid hard to read. Mercury does not cling to the glass, it forms a convex surface in the tube, making it easy to read.

Descartes also theorized that air pressure had to decrease according to the height (elevation) in the atmosphere. Another French physicist, Blaise Pascal (1623-1662), agreed and in 1647 performed an experiment with Torricelli's tube at St. Jacobs Church in Paris. He read Toricelli's tube at the top and at the bottom of the tower.

There was a small but noticeable difference between the two readings. At the top of the tower the mercury reading was lower than at the bottom, hence the air pressure was lower at the top than at the bottom. Later, the experiment was repeated by Pascal's brother-in-law at the Puy de Dome in Auvergne which was 1500 meters (5000 feet) high. This experiment yielded better results than the tower in Paris because the elevation was much higher. The mercury readings showed that the air at the top of the mountain was quite obviously lighter than at the bottom. So, science was another step ahead and the foundation of altimetry was laid.

Inventors and scientists later based many discoveries on these findings and during the period of 1650-1660 a

connection was discovered between the weather and atmospheric pressures.

Also around 1650 we find the word "barometer" being used. Gradually instrument makers, opticians and clock-makers were engaged in the construction of barometers. They were first used only for scientific purposes, but between 1670 and 1680, they began to appear for private use. Shortly thereafter, barometers with the well-known graduation dial in English inches appeared. This barometer showed the weather indications like "Settled, Fair, Changeable, Much Rain, etc.". On the European continent graduations were shown in French and German Rhinelands using inches and later also in millimeters and millibar scales.

The Search for Scale Enlargements

Researchers for the perfection of the barometer wanted larger accuracy in reading because air pressures vary on the Torricelli scale only from 73 to 79 cm (28 3/4 to 31 inches) of mercury, which gives a range of 7 cm (2 3/4 inches) in extreme weather. However, in normal weather conditions the readout varies no more than 5 cm (2 inches). Methods to enlarge the readout scale were developed in the second half of the 17th century. The wheel system and the contra-barometer, both mercury barometers, were invented at about the same time at the end of the 17th century. A third system, the aneroid barometer, was developed around 1700, and perfected in the 19th century.

The contrabarometer today is a popular instrument. It is a twin tube system filled with mercury in combination with coloured alcohol or oil. There is some discussion who the real inventor of the system is but the dutch inventor and scientist Christiaan Huygens (1629-1695) introduced the system we still use. There were possible influences from Descartes who tried to multiply the changes in the mercury level by placing a glass tube with a tenfold smaller diameter on top of the mercury tube. The problem of this system was that it was difficult to handle and the vapour tension of water made accurate readings nearly impossible.

Huygens improved this design by bending the glass tubes so the length of the system became half as long and he used coloured alcohol or oil.

The left tube, filled with mercury, had on the top a container. The tube was bent in the middle and the tube on the lower right hand had also a container. The right hand tube upon the container continued to an open side on the same level as the left hand mercury container. The scale-enlargement (tenfold) was reached through the different inner diameters from container and tube.

Surprisingly enough, the contrabarometer enjoys a still growing popularity. Since the invention of Christiaan Huygens the materials improved and a stopcock is added. The contrabarometer is still, after more than 300 years, the most accurate way to measure the air pressure. The improvements, made by Huygens made it possible to make precise readings on sight.

Environment

Denis Dingens Barometers Ltd. pays a lot of attention producing and recycling our products in favour of the environment. To obtain optimum results we need your full cooperation. Please read the following instructions :

What to do in Case of Broken Tubes

1. Dismount the complete glasswork from the barometer and put it in a plastic bag. If possible, try to keep the fluids separate in glass containers with screwtop. Be careful ! Watch out for sharp pieces of glass, prevent cutting-wounds.
2. Mercury that is spilled on the floor can be retrieved by using a vacuumcleaner.
3. Before you use the vacuumcleaner you have to replace the dustsack inside by a new one. After cleaning take the sack out, seal it with tape and put it in the plastic bag.
4. If the coloured liquid is spilled, you should remove it quickly with the help from absorbic tissues, clean the stain with Ether, wash afterwards with soap and rinse with clean water.
5. Bring the remains to your local supplier or, if it is possible in your community, dispose them together with other chemical waste.

Our Sales Representatives visit on a regular basis the local suppliers and take care of the disposal and recycling of the glass and mercury.

In the design and production of our barometers we try to develop environmental-friendly techniques by using recyclable packaging, non-toxic or water-based colouring and impregnation fluids. In some cases, where earlier tropical woods were used, one uses today MDF. This is an artificial product of wood that often is processed in furniture and kitchen-manufacturing.

The special, hardened fire-proof glass we use, is completely recyclable. The filling of the tubes in the factory led in earlier days to spilling mercury or coloured fluids. Nowadays, by using a special vacuum system (own design) this is no longer possible.

All fluids, used in barometers, thermometers and stormbottles are hazardous. In case of spilling, it is necessary to clean thoroughly until even the last bit is disposed.

Mercury is **completely** recyclable. The coloured fluid has a strong colouring and corroding effect on synthetic or lacquered materials. Therefore it is necessary to remove the coloured fluid when spilled. Use absorbing materials and rinse with plenty of water afterwards. When the time interval between spilling and cleaning is too long, the colouring becomes permanent.

The Aneroid Barometer

From the early system of the barometer using mercury, we arrive at the box barometer, also known as a metal or aneroid barometer. With this system, air pressure can be measured without the use of mercury or any other liquid and the scale can be enlarged. Aneroid barometers were introduced by Lucien Vidie (1805-1866) of France. The idea to pump air from a bouyant box to measure its pressure fluctuation had already been discovered when the German philosopher Gottfried Wilhelm Leibnitz (1646-1716) corresponded with the Hollander Jacobus Bernouilli (1654-1705), in the years around 1700. They exchanged ideas for a portable barometer in pocket size, like a watch. It would contain no mercury, but instead, it was a small bouyant box containing springs to prevent the box from collapsing when the air was pumped out. Later Leibnitz explained that the box had to be metal, but never put his idea to work. Vidie developed these ideas and around 1840 he thought of the name "aneroide" wich is derived from the Greek word "an" (for alpha privans=without), "aer" (air), and "ëidos" (form). In 1844 he received a patent for his invention.

The box designed by Vidie was made of copper and had a ribbed cover. It was equipped with a number of steel springs inside wich prevented the box from collapsing when air was pumped out creating "contra pressure" (absence of pressure). Its most important feature was that the cover of the box would rise when air pressure dropped and would be pressed down whith rising pressure. A mechanism anchored to the center of the cover turned an axle wich moved the indicator arm according to the fluctuations of the cover. The elasticity of the box was refined and the cover reinforced by the cover's ribbed shape. Later Vidie installed more improvements, such as a spring assembly on the outside of the box instead of inside. Within ten years of his patent, or before 1850, aneroid barometers were being sold in Europe. The calibration of the aneroid barometer can be executed by turning the little screw at the backside (do not use force). Set the pointer first to minimal pressure, then to maximum (this is to loosen the inside spring). Now set the pointer to the actual airpressure. Nowadays are barometers essential in modern life : to predict the weather, as altimeter(aviation), as a decorative item,... but always it is a measuring instrument that brings us closer to the nature.

Thermometer

It is not known who the inventor of the original thermometer was. Foundations for the observation of temperature were probably laid in the years before Christ.

Soon after 1650 the first closed thermometers filled with alcohol appeared, they were an invention of Ferdinand II, Grand Duke of Tuscany. Under his directions temperature measurements with thermometers were recorded. At that time one also experimented with mercury as a thermometer liquid but because the expansion of alcohol is larger than that of mercury, the use of mercury was abandoned for the time being. As early as the 17th century we find the freezing point of water or the temperature of melting ice being used as a fixed point for low temperatures. As the fixed point for high temperatures one took the boiling point of water. Most thermometer scales were invented in the 18th century, some of wich were based on rather unreliable fixed points to say the least, such as the temperature of "a very deep cellar" or that of "melting butter".

One of the still used scales, was originally invented by the German Daniel Gabriel Fahrenheit (1686-1736), and was first made in 1717. He developed a scale where the temperature of melting ice 32° and the boilingpoint of water 212° showed.

Another, frequently used scale is the Centigrade-scale, created by the Swede Anders Celcius. Still, he set the boiling-point of water at 0°, and the freezing-point at 100°. It was his friend, Carl Lineaus, who turned that around to the known Celcius-scale, with boiling-point at 100° and freezing-point at 0° centigrade.

Nowadays only four of these numerous different scales are left : the Centigrade-, Fahrenheit-, Kelvin- en Réaumur-scales. The table below shows how they are related to each other :

	Celcius	Fahrenheit	Réaumur	Kelvin
a °C	a	$a \times 9/5 + 32$	$a \times 4/5$	$a + 273,15$
b °F	$5/9 \times (b - 32)$	b	$4/9 \times (b - 32)$	$5/9 \times (b - 32) + 273,15$
c °R	$c \times 5/4$	$c \times 9/4 + 32$	c	$c \times 5/4 + 273,15$
d K	$d - 273,15$	$9/5 \times (d - 273,15) + 32$	$4/5 \times (d - 273,15)$	d

Hygrometer

The origin of the hygrometer dates back from the 17th century although it could hardly be called an instrument then, for it consisted of an awn, the stiff bristle at the top of the chaff, of wild oats. A characteristic of this little barb is that it will coil itself up in dry weather and uncoil itself again when it is wet. It could be used as an hygrometer, even it was only a rough indicator for dampness or dryness rather than an accurate meter and its useful life was only short. As far as is known it was first mentioned by the French globetrotter Balthasar de Monconys who visited Torricelli in 1646 "who gave him wild oats to enable him to see if the weather is dry or wet".

Nowadays a hygrometer indicates the relative humidity of air in percentages. For health reasons it has become an indispensable little instrument in homes, offices, hospitals, etc.

Most types are based on the action of a bimetal coil with a tolerance of 10% and with metals with a large coefficient of expansion, reacting to dryness or humidity by shrinking or expanding. Hygrometers with a lower tolerance degree are the hairhygrometers. These instruments use suprathemic materials from a synthetic or a animal origin to measure the humidity and have a tolerance of appr. 5%.

A hairhygrometer with animal-hair is also suitable for use outside. The hair can withstand temperatures as low as -35°C and as high as 65°C. Outside you'll have more fluctuating humidity-degrees as inside. This is also an advantage because the hairhygrometer will regenerate itself.

Correcting the Hygrometer

Hygrometers should be readjusted at regular intervals (e.g. every 6 months) to prevent discrepancies. For this purpose place the hygrometer on or under a damp cloth for about 60 minutes. After this time the pointer should indicate appr. 98%. If this is not the case the pointer should be corrected by turning it to 98% with the aid of a screwdriver. An opening is provided at the rear of the hygrometer to enable this adjustment to be carried out.

The Psychrometer

In order to estimate the exact amount of humidity in the air one uses the psychrometer. This is an instrument that contains two thermometers. One thermometer measures the temperature in a room, the reservoir of the other thermometer is surrounded by a wet textile. This thermometer measures the "wet temperature". By using a table where you have to fill in the measured values, it is possible to read the exact amount of humidity in the air.

This method is only used for professional purposes, by example to estimate the effective temperature (then you have to measure the wind speed to with an anemometer and use a special for this purpose designed table).

Legally (in Belgium) is the allowed maximum effective temperature 28 °Effective (based on Centigrade-scales). We can assure you that only specially for this purposes trained people are able to work temporarily in these conditions.

Baroscope or Stormbottle

The storm glass, chemical weather-glass or as we call it, the stormbottle is an ancient weatherinstrument.

This device has been in existence for more than two hundred years, but the name of the inventor is unknown. Some give the honour to an Italian sailor, others say that it was discovered by accident by alchemists who were constantly experimenting with the substances composing the solution with which it is made.

According to Admiral Fitzroy who described them in his "Weather book" in 1863, they were introduced around 1750 and were on sale in the shop "Under the Goat and Compasses" at Old London Bridge.

The stormbottle is simply a glass bottle, about 6 inches long and hermetically sealed. It contains a solution with a mixture of potassium nitrate, ammonium chloride, camphor, alcohol and distilled water.

It was *claimed to be helpfull* in the prediction of changes in the weather, particularly high winds, storms or tempests.

In fine weather the crystals settle at the bottom of the bottle. In stormy weather the crystals rise.

From the many studies carried out by Admiral Fitzroy and others, of the various appearances presented in the liquid and crystals, a set of rules was deduced after comparing the storm-bottle with the weather over a long period. They were as follows :

Clear liquid = Bright weather

Crystals at the bottom = Thick air, frost in winter

Dim liquid = Rain

Large flakes = Heavy air, snow

Threads in upper portion of liquid = Windy weather

Small dots = damp weather, fog

Rising flakes = wind in the upper air regions

Small stars = In winter on bright, sunny days

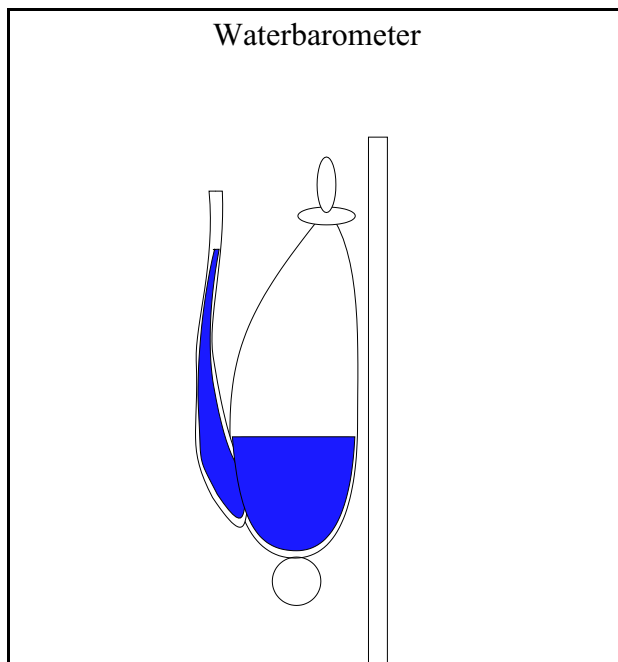
The stormbottle has lost much of his accuracy because the pollution in the air influences the rate of electrical tension. The chemical mixture in a storm-bottle can vary with the direction of the wind and electrical tension in the air. Temperature also affects the mixture. Normally it has to be fixed undisturbed in free air, not exposed to radiation, fire or sun, but in the ordinary light of a well ventilated room.

The Waterbarometer

This was a very popular instrument in the seventeenth century. In 1619 one tells in a still existing document about one Gijsbrecht de Donckere, who invented a waterbarometer and wanted it to sell. Here follows a piece of this Dutch text :

Actum XXen Septembris XVJe negenthiene

Is ghecompareert Cornelia Olorfs, huusvrauwe van Ghijsbrecht de Donckere, ingenieur van Haerlieder Serenissime Hoocheden, presenterende an het Collegie zeker instrument, nieuwelijnghe bij denzelven haeren man gheinventeert, ghemempt movus perpetuus, bij dewelcke men door het upclimmen van het water daghelic can zien de ruijdachtvcheijt van het weder, metghaders door het nederdalen het verzoeten van het wedere, ende door het te zeer hooch climmen ende brobbelen de anstaende tempeesten van de see. Ende is haer toegheleijt voor vereerijnghe dertich gulden. Hiernaer volght de maniere hoe men 'tzelve instrument moet regieren....



Especially in the Southern Neatherlands many of these “thunderglasses” were manufactured and used. It is a pity that the waterbarometer (sometimes called naval weatherglass) could not be used as a real instrument. An instrument is always constructed with a dial. On a waterbarometer one will find seldom such a dial. The basic principle from a waterbarometer does not allow a precise measurement from the airpressure. The surrounding temperature is one of the disturbing factors. On the drawing you can see a side view from a waterbarometer. This view shows you a glas, partially filled with a coloured liquid. Above this liquid is, totally enclosed in the glass, air. Because the opening from the spout is the only opening from the waterbarometer, the airpressure develops a certain force on the liquidlevel. The changes in temperature however expand or shrink the enclosed air and liquid. These changes influence the level of the liquid in such a way that a precise measurement from the airpressure becomes nearly impossible.

Influence from the weather on the waterbarometer :

Slowly rising from the liquid in the spout
Approaching storm who, if he does not change of direction, startts within 8 to 24 hours.

Quickly rising of the liquid
The storm is very close

Water drips out of the spout
It is storming

Quickly falling from the liquid level during a storm
The storm is almost past

Liquidlevel stable, appr. In the middle of the spout
Beautiful, stable weather

Filling the Glass and Colouring the Liquid

Colour distilled water with the supplied dye. Fill the waterbarometer with the coloured liquid until the level is appr. 1 inch above the start of the spout.

Tendancybarometer

Alexander Adie, a scottish optician, patented on december, 23rd 1818 the first portable barometer. He named his invention "Sympiesometer". This word comes from the combination of two Greek words : Sumpedzein (pressing together) and Metron (measuring). This barometer was significantly shorter than an mercury-barometer (wich needed a minimum length of 80 centimeter) and became very popular. The instrument was mainly used on ships. The instrument actually shows us tendancys of weather, so nowadays we call it a tenancybarometer.

The introduction from the aneroid barometer, sometimes called drum-barometer, in appr. 1870, made the instrument almost forgotten. Since 1997 Dingens Barometers produce tendancybarometers. Nowadays, this instrument is still hand-made, but we have now the advantage to use modern materials with technical better qualities than the original ones. This is the reason that the replica functions better than the original. Based on the principle of Adie, in 1997 a whole new range of high precision tendancybarometers where nominated for the "Golden Silmo for technical innovation" at the Silmo Fair in Paris.

Using the Tendancybarometer

The level from the red fluid in the tendancybarometertube rises or falls with the airpressure. High pressure lowers the level and low pressure let it rise. This short barometer is very temperaturesensitive and need a correction to indicate the right weather. That is the reason why you have to read the thermometer-dial (blue fluid) in combination with the barometer (red fluid) in order to estimate the weather forecast.

The difference between the two coloured fluid-columns is then set with the indicator on the right upperhand scale.

Example : When the red fluid is 8 grade marks above the blue fluid(="+"), the forecast is stormy weather ; when the red fluid is 8 grade marks below the blue fluid(="-") the prediction is very dry weather.

When you take in count that sudden changes in airpressure indicate short-notice changes in weather and, smooth changes in the airpressure indicate long periods of a certain weather, one can make very accurate predictions. The indicator on the right upperhand is not a element of decoration but a usefull tool to observ and to registrate the changes of weather. As conclusion of this manual one can say : the more you use the instrument in a proper way, the better your weather forecasts become.

Usefull hint

When the tendancybarometer is delivered to you with an interrupted red fluid-column (airbubble) you can solve this problem easily. For transportationpurposes the open end of the U-shaped tube is sealed with a rubber hose and plug. Hold the instrument upright, remove the plug for an instant and put it back on the hose. Push now on the hose. You'll see the fluidlevel change. The interruption will disappear now. Please remove hose and plug when putting the tendancybarometer into action. Store hose and plug together with the guarantee so you can solve problems later if they occur.

Calibration

The tendancybarometer shows tendencies of pressure. The calibration is relatively simple : At the moment the atmospheric pressure shows appr. 760 mm or 1013 mBar/hPa the level of the two liquids should be equalized (level red fluid=level blue fluid). The tendancybarometer is now ready to use. If you want to calculate the barometerreading, this is also rather simple : 1 dash difference(read on Celcius-scale) between red and blue fluids = 4 mm Hg.

Digital instruments

In the past years one can notice an increase in the digitalizing of the classical meteorological instruments. At first, there were only digital thermometers, but nowadays for each instrument, known to man, there is a digital counterpart. The principles of these digital instruments are almost always the same. A measuring component influences an electrical crystal. Changes in the electrical current are relayed to a processor where the data are processed and checked with the data of a stored table. The fitting value is generated and displayed on a screen. (mostly LCD (liquid crystal display)-module). Occasionally LED's (light emitting diodes) are used to display the values.

Out of the above one can easily deduct that the quality of the instrument relies completely on the quality of the measuring component. At this moment the digital technique allows us to measure very precisely temperatures even in a bigger range than we could with the classic instruments (temperature-readings in reactors, space, ...)

Even time is measured very exactly, although... A radio-signal(DCF77) is emitted by a tower in Frankfurt. The time signal is broadcasted about 1500 Km around this tower. Receivers, capable of translating this time signal, use the broadcast to calibrate their internal clock and to show the correct time and date on a display. The actual time-measuring is performed by an atom-clock in a scientific institute in Frankfurt. The receivers are programmed to compare regularly the displayed values with the received values. When there is a difference, the displayed value will be adjusted to the received value. The date and time, displayed by these devices is very exact (a deviation of 1 second is to expect in several hundreds of years!) and reliable.

With other instruments, the digital technology is not so full of success. When measuring the air pressure or estimating the exact humidity of air, there are lots of instruments available in the market that give an impression of exactness, but in actual use they show deviations in the measured values (more than 15% deviation!).

Caused by the massproduction of these devices there is a huge price-instability. Caused by the progress in digital techniques and the miniaturizing more and more functions are integrated in one single device. There is also a trend towards devices with wireless sensors, outside temperatures are measured on location and the values are transmitted (mostly on 433 Mhz) to a receiver.

Manufacturers also have an eye for environmental aspects. Some of the devices are equipped with solar panels (daylight is used to produce the electrical energy for the device). Most of these digital instruments are momentarily very polluting (used materials, batteries, consumer goods).

The life-time of a digital instrument is estimated at approx. 8 years. The liquid crystals will deteriorate after a certain time what causes a fading of the display. The inner electrical crystal will inflict an increasing error-margin. This increasing deviation is directly related to the life-time of the instrument. After a while the measured values become completely unusable.

When it is getting cold, the batteries in the outside sensors, will fail.(the same problem when trying to start your car when it is freezing). Due to the greater changes in temperature it is strongly advised to replace the batteries more often. In normal conditions the lifespan of the batteries used in digital instruments is approx. one year. Almost every instrument has an indication when to replace the batteries. When indicated, please do so immediately. Do not leave old batteries in the instrument. The chemical components in old batteries can cause irreparable damage to your instrument

Eco-celli®

The Eco-celli is a new type of barometer with the same precision of mercury-barometers. Yet the basic principle is completely different. Instead of Mercury, as in traditional fluid-systems, the functioning is based on the compressibility of gases. On the left upper hand of the barometer you can see the gas above the red fluid in the reservoir. This gas provides a constant counterpressure against the atmospheric airpressure.

- High airpressure: Airpressure pushes on the open side of the barometer onto the surface of the red fluid. The gas in the barometer will be compressed and one can see the falling of the red fluid level in the right hand tube.
High airpressure indicates fair weather.
- Low airpressure: The airpressure pushes less onto the surface of the red fluid. The gas in the barometer will expand and one can observe the rising of the red fluid in the right hand tube.
Low airpressure indicates bad weather.

A very important factor in measuring with barometers is the temperature. Due to high temperatures, fluids and gas will expand, causing an error in the readout on the scale. The eco-celli does not have that problem. In the construction of the eco-celli a high precision thermometer is used, mounted parallel to the barometer. This thermometer has the same expansion/compression-rate according to the temperature. With the help of a moveable scale, one sets the scale to the actual temperature (blue fluidlevel). The error caused by the temperature is so automatically corrected and one can read the correct airpressure.

On the barometer scale there is a second indexpointer. This is the tendencypointer which is very important in making your own forecast. At each reading of the airpressure you'll have to set the tendencypointer equal to the red fluidlevel of the barometer. When airpressure-fluctuations occur, the fluidlevel will differ from your pointer. The difference is the indication of the coming weather. The change, and the speed of change indicate when to expect changes in weather. Quick changes of the fluidlevel indicate sudden weatherchanges, slow changes promise slow and smooth weatherchanges. It is thus not the absolute value of the barometerpressure, but the changes in the fluidlevel that make reliable weatherforecasts possible.

When you, with the help of the seasonal weatherchart (page 4), regularly register airpressure-values on your barometer, you'll be able to make a reliable forecast for your own neighbourhood. The weatherforecast, distributed by the media, is only valid for greater regions. The forecasters do not bring into account the local influences like a forest, lake, river, This is called in meteorology the "micro-climate". With the help of your Eco-celli-barometer you'll be able to make accurate forecasts for your own "micro-climate, and this for a time-interval of 6 to 12 hours in advance.

The Eco-celli has some remarkable and important advantages:

- a) the system does not contain any hazardous elements (like mercury), but it contains a fluid based on red pigmented oil. The thermometer is filled with blue coloured alcohol.
- b) the scale is three times larger than the one of the classical Torricelli-barometer. Together with the contrast of the coloured fluid this is highly enhancing the readability of the scale.
- c) the barometer is handcrafted out of high quality capillary glass. In a special procedure all glass tension is removed during the production. This, together with the low specific gravity of the coloured oil, guarantees an easy and safe transportation of the barometer. Also, there are no restrictions for transportation by plane (in contrary to the mercurybarometers).
- d) due to the special construction of the eco-celli, there are no problems when it is taken off the wall or if you want to move it. One can even place it vertically, without having to close it! The rising or falling of red fluid will be reduced by the construction in order to prevent mixture of oil and gas.

ENGAGE THE BAROMETER:

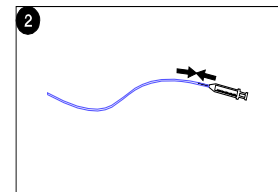
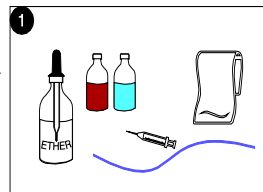
You received the barometer in closed condition: on the right upperhand of the barometertube You'll notice a rubber hose and a cork.

- Hang the barometer at the wall. If you notice interruptions between the fluidcolumn, pince with thumb and pointingfinger the rubber hose. You'll see that the interruptions will disappear towards the reservoir.
- Remove carefully the rubber hose and cork (store them on a safe place, You could need them later). Insert now the hollow glass plug. The purpose of this plug is to prevent the pollution of the fluid by dust.
- The barometer is now fully functional. Please wait about one hour, before taking measurements of airpressure. Due to the transport, the gas-pressure is higher then normal and the instrument has to be on the same temperature as the surrounding-temperature.
- Between barometer (red) and Thermometer (blue) is the barometerscale. When the instrument is climatized, one can start with measurement of the airpressure. Slide the scale until the thermometerpointer points at the fluidlevel of the thermometer.
- By doing this, the temperature-correction is executed, and you can read the correct air-pressure on the barometerscale.
- Set the second indexpointer to the fluidlevel of the barometer. This is the tendencypointer. The next time you'll perform a reading, You can see the difference and the tendency of the airpressure.

CALIBRATION

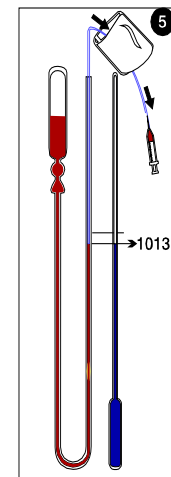
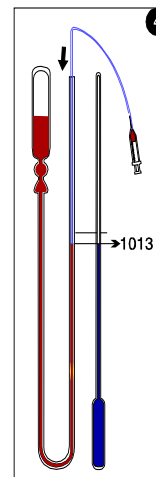
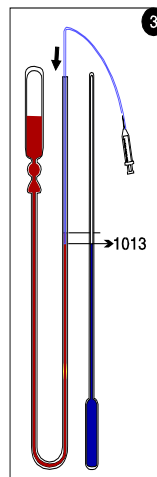
- The barometer You purchased, is calibrated to sealevel (0 meter). When You use the barometer in an area that has a different height, you'll have to calibrate your barometer. A calibration-set is therefore enclosed.

- Ask at a local weather-station, a nearby airfield, your optician, .. for the actual airpressure. Set this pressure on your instrument.



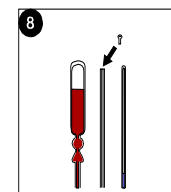
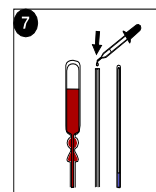
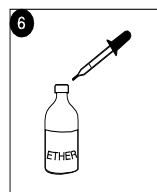
- You can also calculate the difference. For each 8 meter higher above sealevel, You'll have to subtract 1 hPa fluid.

- Subtract the calculated amount of fluid until the correct fluidlevel is reached. Please keep kitchenpaper in hand to prevent staining with the red fluid.



- Add a drop of Ether, the Ether will clean the inner tube and evaporate completely.

- The barometer is now calibrated on your height. Once the calibration is performed, you'll be able to measure the accurate air-pressure. When you change the height where you operate the barometer, You'll have to calibrate the instrument to the new height. If you go below your heightlevel, You'll have to add fluid, if You go higher, You'll have to subtract fluid.



IMPORTANT

- a) CAUTION WITH HIGH TEMPERATURES: The barometer is very heat-sensitive. Do not place this barometer on places that will be overheated by the sun. The barometer wont work properly and the thermometer will be damaged if the temperature is above 50° centigrade.
- b) OPTIMAL OPERATION: we advise you not to place the barometer in the direct neighbourhood of heaters or airconditioners. Due to the sudden temperaturechanges the barometer will deviate (gas reacts quicker then fluid on changes of temperatures).
- c) TRANSPORTATION: if the barometer is to be transported, one should close the barometer with the rubber hose and plug. The barometer can be safely transported or handled in vertical position. Do not move the opened barometer at excessive temperatures.
- d) RED FLUID SEPERATED: using the enclosed rubber hose with plug, one can unite the red fluid by pinching the rubber hose with thumb and pointingfinger. By opening and replacing firmly the rubber plug one can increase the amount of movement of the red fluid.
- f) SPILLING OF THE COULOURED FLUID: in case of spilling of the red fluid, one has to handle quickly. The fluid is not hazardeous, but is a very strong colorant. Use lots of water tho rince the stained places. Eventually one can use a handwarm mixture of soap and water to clean the stained places and to prevent permanent coulouring..
- h) MAINTENANCE: use a fluff-free and dry piece of cloth. Use of aggressive cleaningproducts is prohibited. Woodwork and metal parts can be maintained wioth the help of a bee-wax-containing spray and a fluff-free cloth. DO NOT spray directly onto the instrument! Spray a bit of product onto the cloth and rub gently the metal parts/woodwork.

URL: <http://www.barometers.com/ecocelli.htm>
e-mail: ecocelli@barometers.com

Literaturelist

Barometers : Stick or Cistern Tube by Edwin Badfield

Care & Restoration of Barometers by Philip R. Collins

Barometers by Anita McConnell

The History of the Barometer, © 1963 London W.E. Knowles Middleton

Het Weer, Uitgever de Lantaarn, Amsterdam © 1982 Harrow House Ltd
with a special contribution from Armand Pien

Handbuch der Nautischen Instrumente © Berlin 1890 Reichs Marine Amt

Barometers, by Bert Bolle, © 1978 Unieboek b.v. Bussum

Experimenta Nova Magdeburgica © Amsterdam 1672 Otto von Guericke

Micrographia © London 1665 Robert Hooke

A manual of the barometer © London 1849 J.H. Belville

A history of temperature measurement © London 1958 Negretti & Zambra

Popular weatherinstruments © Leopoldsburg 1995 Denis Dingens AG
(Version F-D-G-E)