The Bowers Museum of Cultural Art
Climate Control

Climate Control at the Bowers Museum is accomplished by using several pieces of equipment that are designed to work together. The basic, key elements of the HVAC (Humidity, Ventilation and Air Conditioning?) system are:

The Water Treatment System
The Chiller
The Boiler
Air Conditioners (AC) 1 through 10
Air Handlers (AH) 1 through 7
Humidifiers 1 through 7 (used with AHs)

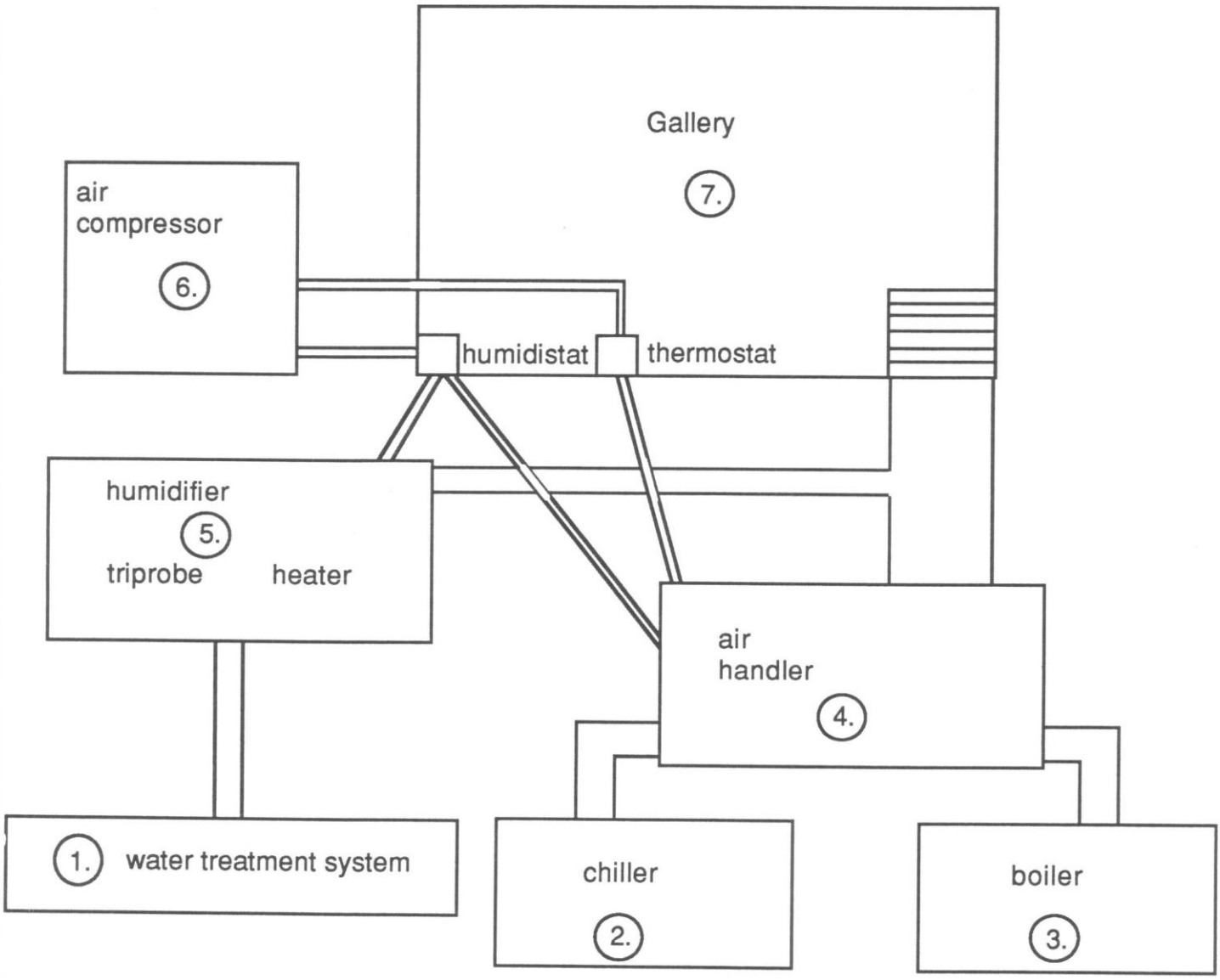
The water treatment system takes minerals and salts out of the water which could otherwise destroy the humidification equipment.

The chiller provides cooling for all of the AH units by providing cold water. Anytime air needs to be cooled down before it returns to a room, the chiller must be on and working properly. The water used by the chiller is not treated by the water treatment system.

The boiler provides heat for all of the AC and AH units by providing hot water. Anytime air needs to be warmed up before it returns to a room, the boiler must be on and working properly. The water used by the boiler is not treated by the water treatment system.

The AC units (with built in humidification and air handling) control the new building spaces. The AH units and humidifiers control the old building spaces. The air handler aspect of these units circulates air by means of a fan, and carries the air over two sets of coils: cold water coils to cool it and hot water coils to heat it. The humidifier can add steam (and so humidity) to the air - which also heats it. The humidifier can override the thermostat to open cold water coils and chill the air, dropping moisture out and lowering the relative humidity - after which it can be heated back to the proper temperature over the hot water coils.

These key players must all be working properly and at the same time to truly control the climate within the museum. There are many problems which can arise with any one or even a combination of these players. A detailed look at how each component of the overall scheme works may help us to anticipate and learn to overcome these potential problems.


Gallery
7.
air
compressor
6.
humidistat
thermostat
humidifier
5.
triprobe
heater
air
handler
4.
1.
water treatment system
chiller
2.
boiler
3.

Water Treatment System

The water treatment system supplies water to the humidifiers - in the old building and the new building. The treatment is by reverse osmosis. There are two basic phases to the treatment; first the water is filtered, and then salts are added (if the water were too pure, it would eat away at the metals that it comes into contact with).

For filtration, there are two large "bottles" near the water treatment equipment. These are color coded for the contractor's convenience. Hoses connect the city water supply to these filters, and after the water passes through there dissolved salts are added. The green plastic container holds the salt, and salt must be added regularly. The water then passes through a device which monitors the level of dissolved salts and into the very large reservoir (white plastic container). A pump at the bottom of the reservoir sends water into the humidification system. There are high water level and low water level sensors in the reservoir to "call" for more water or "call" for the water treatment system to stop when it is full.

At some point in the treatment process waste (or excess) water is created. This water is passed by a hose to a drain in the ground. There is a lot of water wasted this way.

There are two lights on the box to the right of the guage which monitors the salt content of the water. The green one is lit when the power is on; the yellow one is lit when the reservoir is full.

There is a green light on a box to the right of the above-mentioned box which is lit when the pump is running and the reservoir is being refilled.

The guage settings should read at ".7" and "x 100" on the two small dials, and the needle on the guage should indicate something approaching ".7" as well. There is a green light for values below the set-point and a yellow light for values above, so I believe it is better to have values below or at the set-point.

Obvious problems with water treatment:

1) the power goes off
2) a hose becomes detached
3) there is no salt in the salt container
4) the filters go bad
5) the sensors in the reservoir malfunction and it is empty
6) the sensors in the reservoir malfunction and it is overflowing
7) one of the cheap PVC pipes on the roof of the new building breaks (probably due to exposure to the elements)

Note: It is common for the waste water hose to flop around and send a great deal of water out onto the ground. This is not a real problem; the hose is usually stuck in a drain pipe in the ground.

The Chiller

The chiller is the very large green unit (located almost directly outside what Security calls the East Door) with four fans on top. It provides cold water for the old building AHs, so that air can be cooled or dehumidified. City water is supplied by large pipes, and there are pressure gauges and thermometers on the pipes leading in and out of the cooler. The thermometers should read at or a little below 50ºF and the pressure should be between 60 and 70 lbs. Water is moved through the chiller by a pump located near the air compressor. The pressure at the pump should also be 60-70 lbs. If something goes wrong with the chiller the temperature, pressure, or both of these values will be out of the usual range.

There are no parts of the chiller that should be adjusted by anyone but an authorized service person. The chiller will be off if there is a power failure; it should come back on if power is restored. The chiller turns its fans on or off as needed, so at times they may not be in motion. This is not a problem.

The Boiler

The boiler is an important element in the museum's climate control system in that it serves not only the old building but also the new. Heating (and reheating) throughout the institution is accomplished by this one component.

The boiler has an ignition system, a pilot, and burners under a tank of water. Pumps push water into the tank where heat from the flames of the burners bring it to a temperature of about 160 - 180ºF (read at the thermometer/pressure guage at the top left). Pumps then feed this hot water to the reheat coils of the air conditioners of the new building and the air handlers of the old building. If air is cold because of the outside temperature, it will be warmed as a result of the thermostat's "call for heat". As well, if the air has been cooled in the dehumidification process, it will be reheated to compensate. There is a thermometer/pressure gauge on the top left end of the boiler; there is a pressure gauge at the pump which serves the boiler, and a pressure gauge on the pipes above the boiler. The pressure on all of these gauges should read between 10 and 20 lbs. when things are running properly.

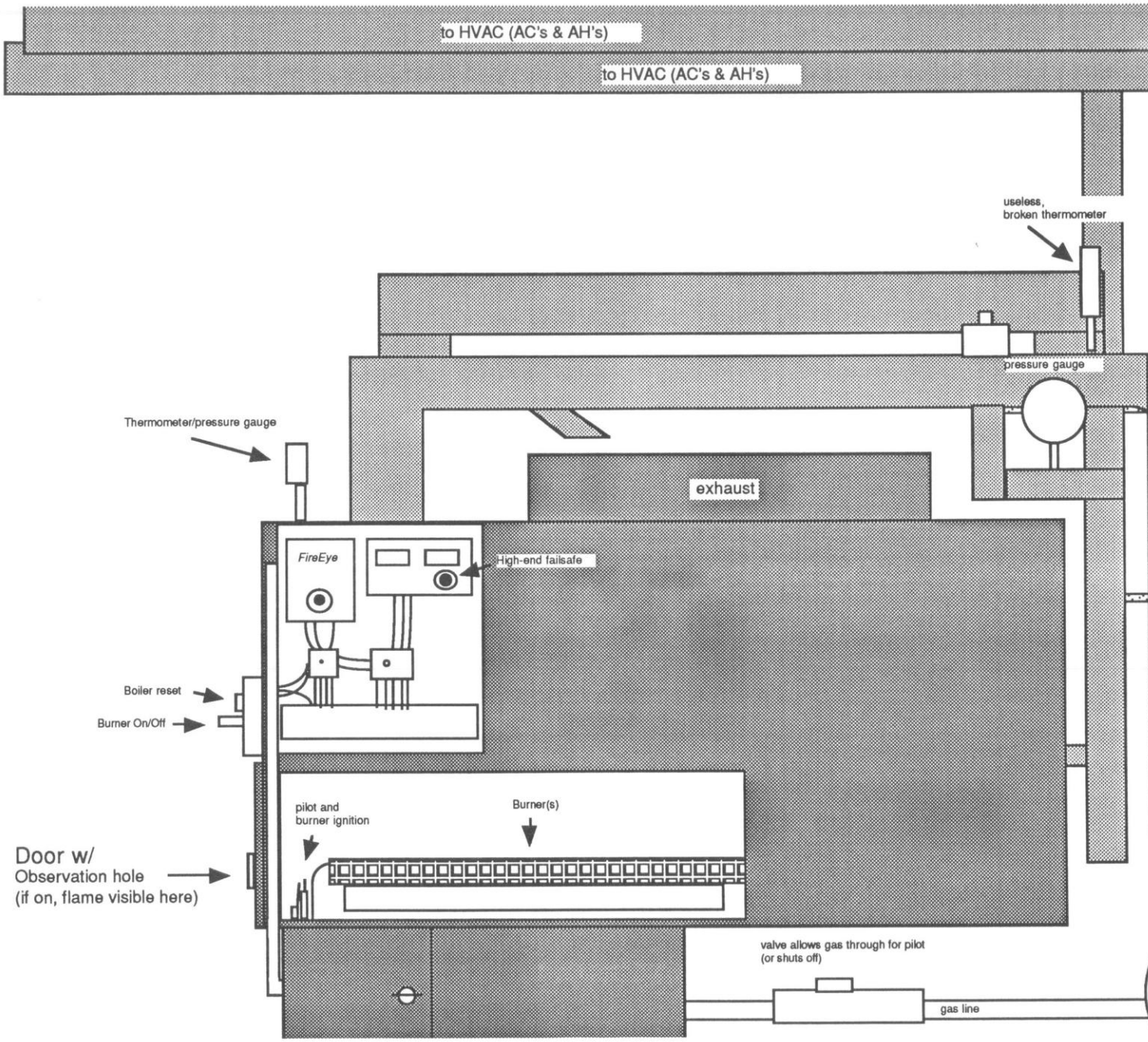
IF IT IS COLD THROUGHOUT THE MUSEUM, THE BOILER IS OFF!!!
- or the air compressor is off and the system has failed to cool.
Naturally, lower temperatures will then drive up the relative humidity.
(If it is cold in just one room in the museum, the problem is not with the boiler.)

There are four switches or buttons that are used in connection with boiler function: the "Fire Eye" button, the high-end failsafe button, the reset button, and the burner on/off toggle switch. The high-end failsafe button will pop out if the boiler exceeds the maximum temperature setting, and the boiler will shut off. This button is not one that we usually are concerned with. The other three are used to turn the burner back on if it has shut off (which it can do for no apparent reason, and occasionally does). The burners are turned off, then back on and the "Fire Eye" and the reset buttons are pushed - and this should bring the pilot and burners back on.

Obvious problems associated with the boiler:

1) water is not supplied
2) burners are dirty (black smoke)
3) burner, pilot, or ignition won't light
4) internal workings are grounded (ignitition) or wet
5) pressure release valve sticks
6) the high-end failsafe fails

It is important that all of the necessary valves leading to and from the boiler are open, and that the pumps are running, or the boiler might be working but not "on"; there is a flow switch that turns off the boiler when no water is supplied. Fortunately, it is virtually impossible for these to be closed or turned off except by conscious choice - unless there is a saboteur, these should not be a concern.


to HVAC (AC's & AH's)
to HVAC (AC's & AH's)
useless,
broken thermometer
pressure gauge
Thermometer/pressure gauge
exhaust
FireEye
High-end failsafe
Boiler reset
Burner On/Off
pilot and
burner ignition
Burner(s)
Door w/
Observation hole
(if on, flame visible here)
valve allows gas through for pilot
(or shuts off)
gas line

The Airhandler

The air compressor supplies a constant air pressure to the room/gallery through a tube in the wall. The thermostat at that location senses the relationship between this constant pressure and the ever-changing air pressure in the room by means of a bi-metallic strip reacting to temperature, just like in a thermostat in your home. Based on the temperature of the room, the strip will expand or contract, and this action will change the relationship and cause a "call for heat" or a "call for cool". For this discussion on air handlers, it will suffice to know that the thermostat recognizes one particular relationship as normal or optimal and will "call" in response to a variation from this established relationship. This is different from some conventional thermostats, where high and low limits might be set.

The thermostat sends an air pressure signal to the receiver controller located outside at the air handler. The receiver controller signals for hot or cold water valves to open or close.

If there is a "call for hot", hot water coils are opened up, cold water coils are shut, and picks up heat as it passes over them (of course, this may lower the rH and bring the humidifier into play). If there is a "call for cool", the cold coils are opened up, hot water coils are shut, and air from the room is cooled as it is circulated.

If there were a "call for dry" from the humidistat, the air handler would pass the air over cold coils to condense the moisture out of it, and then reheat it over hot coils and return it to the room.

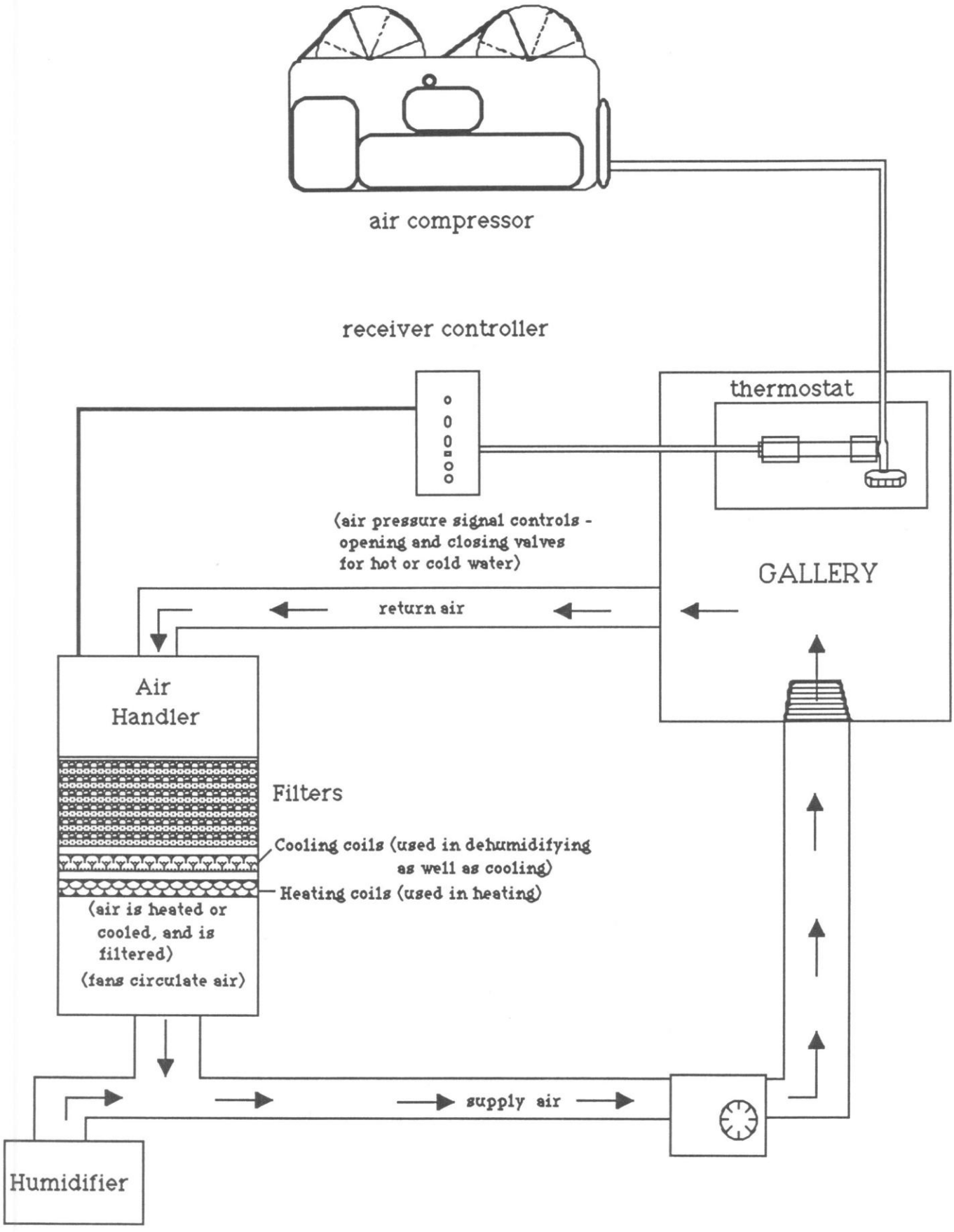
A system of filters (originally we used two-medium filters; this may have changed) exists in the air handler, and these are changed (quarterly?) by an outside contractor.

Obvious things that can go wrong with the humidification system:

1) the power goes off
2) the air compressor goes off, or there is a break in an air pressure line
3) water is not supplied
4) the thermostat breaks or loses calibration
5) the receiver controller fails
6) the valve sticks open or closed on a hot or cold coil

*Note: Our galleries are not closed systems. A drop or rise in temperature or relative humidity outside will force a drop or rise in temperature or relative humidity in the room. It may take time for the system to compensate for these changes. Most likely the system will humidify and then dehumidify, heat and then cool repeatedly - in smaller and smaller increments - until it eventually achieves a balance at the desired level (see calibration discussion).

The Air Handler



The Humidfier

The air compressor supplies a constant air pressure to the room/gallery through a tube in the wall. The humidistat at that location senses the relationship between this constant pressure and the ever-changing air pressure in the room by means of a hygroscopic membrane. Based on this relationship, the humidistat will "call for wet" or "call for dry" - see the later discussion on calibration of "-stats". For this discussion on humidifiers, it will suffice to know that the humidistat recognizes one particular relationship as normal or optimal and will "call" in response to a variation from this established relationship.

The humidistat sends an air pressure signal to the transducer located outside at the humidifier. The transducer converts this signal to an electrical one. The transducer sends a varying DC signal to a component called an SCR. This signal varies with the pneumatic signal from the "stat", and will signal the actual heating element to produce steam at varying intervals or a constant rate.

(If there is a "call for dry", most of the work is actually done by the air handler. The air from the room is circulated over open cold coils to condense the moisture out of it, and then is reheated over open hot coils and returned to the room.)

If there is a "call for wet", the transducer's signal activates the humidifier. First, a three-pronged probe (called a tri-probe) produces an electrical current in a water tank. If there is no water, then there is nothing to conduct this current, and the whole process stops. If there is water in the tank, then a heating element will turn on and boil the water into steam. This steam joins the air being circulated by the air handler and increases its relative humidity. If the air is not moving in the duct, a flow switch will cause the humidifier to remain "off".

There is a high-end failsafe device on the humidifier. This is to prevent too much steam from entering the room. There is a dial indicating a percent-rH value; if the air in the duct is more humid than this value, the humidifier will shut off.

Obvious things that can go wrong with the humidification system:

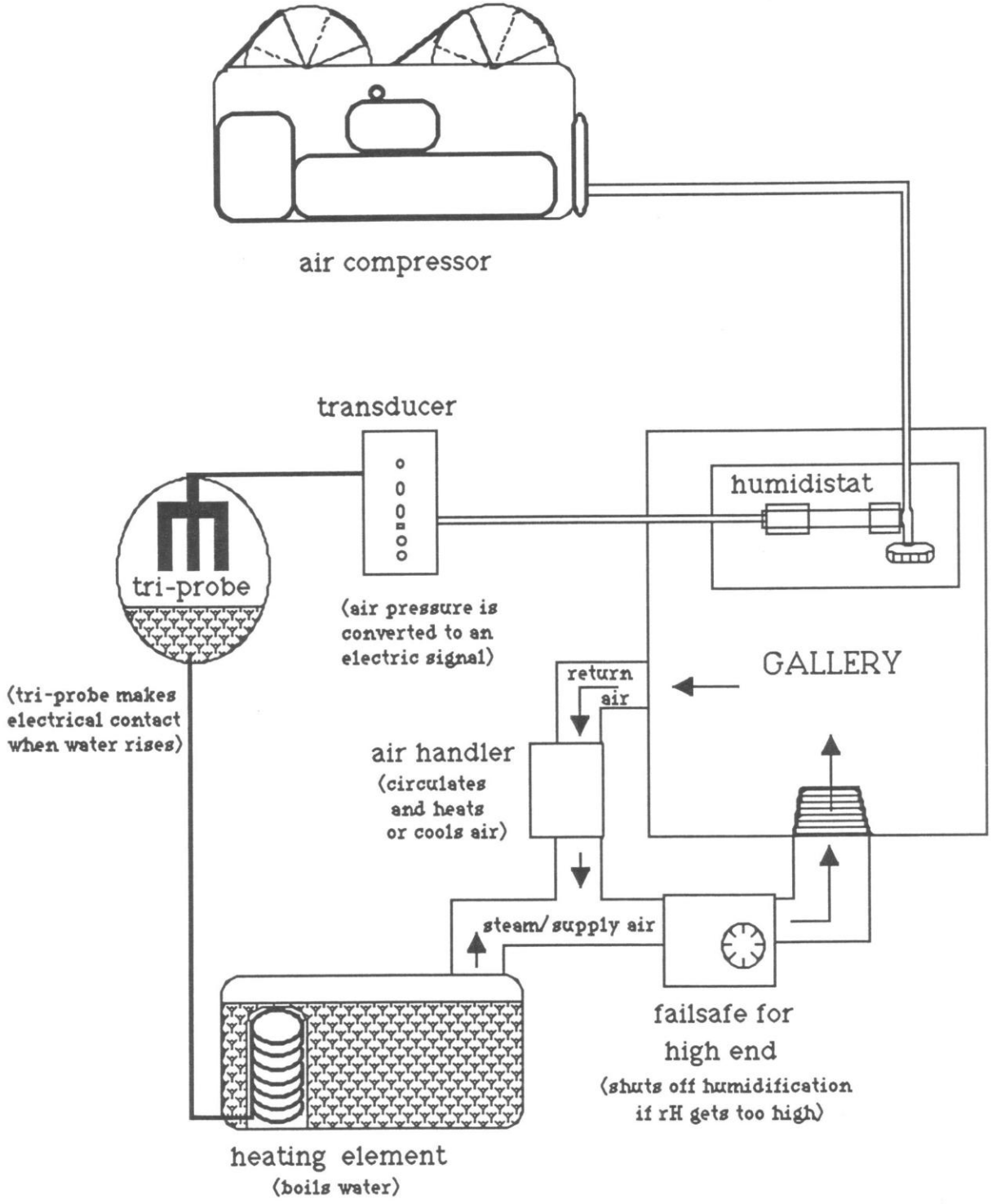
1) the power goes off
2) the air compressor goes off, or there is a break in an air pressure line
3) water is not supplied
4) the humidistat breaks or loses calibration
5) the transducer fails
6) the tri-probe corrodes and cannot sense water level
7) the heating coil corrodes and explodes
8) the high-end failsafe fails
9) no air flow in duct

common, but not so obvious things that go wrong:

10) bad fuses
11) the power module fails
12) the level controller fails

*Note: Our galleries are not closed systems. A drop or rise in temperature or relative humidity outside will force a drop or rise in temperature or relative humidity in the room. It may take time for the system to compensate for these changes. Most likely the system will humidify and then dehumidify, heat and then cool repeatedly - in smaller and smaller increments - until it eventually achieves a balance at the desired level (see calibration discussion).

The Humidifier



The Air Compressor

The air compressor is critical to the operation of any other aspect of our climate control system. The air compressor supplies air pressure to the thermostats and humidistats throughout the museum - in the galleries, offices, and collections storage; everywhere. If there is no pressure in the line, there is no call from the stat (actually, it fails into a cooling mode). Nothing will work properly without the compressor.

The compressor will stop in the event of a power failure. The back-up generator is supposed to kick on and keep this from wiping out climate control museum-wide.

The air compressor is a typical one; it has belts that could break, and it needs grease to keep the wheels turning. If there is a lot of grease on the ground in front of the compressor, it might be a bad sign. There are no parts of the compressor that should be adjusted by anyone but an authorized service person.

The Gallery and the "Stats"

In the galleries (actually, in all controlled spaces in the museum - with some minor variations) there are four aspects of the HVAC system present. There are supply air vents, return air vents, thermostats, and humidistats.

As for the vents, there is nothing anyone can do about them (easily) now. There are problems with their locations. For example, it is not a very good idea to have them halfway up the walls of a very tall space (Rancho Gallery and Galleria), because the hot air rises and the cold air sinks - and the thermostats are all located about four feet above the floor. Obviously, they should not be blocked. The supply air vent is a good place to test for the following:

a - is there air being supplied?
b - is the air the temperature (roughly) that we want?

If no air is moving into the room while the system is on, that's a bad sign - the fans should keep air circulating at all times. If a freezing cold room has cold air pouring in, that's also an indication something isn't working correctly. The same is true for hot air in an already hot room.

The thermostat has already been described briefly. The thermostat at a location senses the relationship between the constant pressure from the compressor and the ever-changing air pressure in the room by means of a bi-metallic strip reacting to temperature, just like in a thermostat in your home. Based on the temperature of the room, the strip will expand or contract, and this action will change the relationship and cause a "call for heat" or a "call for cool". There is a specific set-point temperature that these efforts seek to maintain. On the stat, there is a dial with numbers where this set-point can be dialed in. There is also a place for inserting a device to read the pressure in the line and a screw for making adjustments (see below).

It is possible for the thermostat to go out of calibration. This means that the relationship between the air pressure from the compressor and that in the room is being interpreted wrong. A device for measuring the effect of this relationship, and thus for recalibrating the stat (see below), measures lbs. of pressure at a specific place in the stat. This device is composed of a hypodermic needle attached to a length of tubing, which is in turn attched to a pressure gauge.

If the room is at the desired temperature - and no heating or cooling is called for - then there should be approximately 9 lbs. of pressure on the gauge. If there is a call for cooling, the gauge should read between 0 and 9 lbs; the lower the value, the more cooling required. If there is a call for heat, then the gauge should read above 9 lbs.

For calibration, the preferred method is to find out what the real temperature in the room is and dial it in on the stat. Then you use the adjustment screw to bring the pressure in the line to 9 lbs. - not calling for anything. Make small, gentle turns to alter the pressure - with this adjustment screw it is very easy to mess up by using too much force. Then you can dial back to your desired temperature set-point and everything should work fine. You must be very careful - THESE PARTS AND SCREWS ARE VERY DELICATE AND SENSITIVE!!! They are also quite expensive.

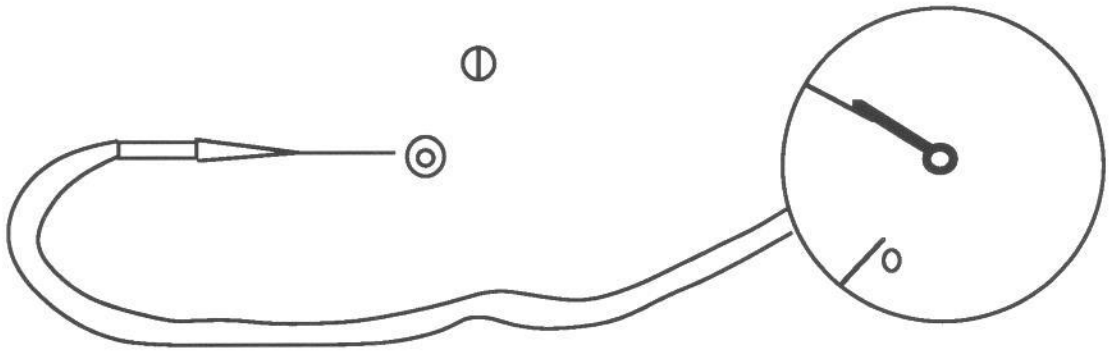
The humidistat is basically the same idea. As described earlier, the humidistat at a location senses the relationship between the constant pressure from the compressor and the ever-changing air pressure in the room by means of a hygroscopic membrane. Based on this relationship, the humidistat will "call for wet" or "call for dry". The humidistat recognizes one particular relationship as normal or optimal and will "call" in response to a variation from this established relationship.

The same pressure reading device can be used in the same way as with a thermostat to check how the humidistat is functioning. With the humidistat, 9 lbs. is also a point at which nothing is being called for - you can say that the stat is "satisfied". Below 9 lbs. is a call for dehumidification or "call for dry". Above 9 lbs. is a call for humidification or a "call for wet" or "call for steam." The process of recalibration should be treated in the same way as previously described, but with even more caution. The hygroscopic membrane is very, very, very sensitive and liable to break if touched. It is also quite expensive.

Calibration of pneumatic thermostats and humidistats

Using the pressure guage to read the pressure at the room thermostats and humidistats will help to determine if the system is functioning properly.

The hypodermic needle is carefully inserted into the hole provided.



9 PSI is "satisfied" (not calling for an increase or a decrease)

When the temperature and humidity are at the required levels, the gauge should read around 9 PSI on both stats.

A low PSI reading (0 - 8) on the thermostat is a call for cooling.

A low PSI reading (0 - 8) on the humidistat is a call for dehumidification.

A high PSI reading (10 -) on the thermostat is a call for heating.

A high PSI reading (10 -) on the humidistat is a call for humidification.

A **slight** counter-clockwise turn of the calibration screw will increase the PSI; clockwise will decrease.
The set-points currently in use are 70ºF for temp. and "Medium" for rH.
Set at true room temperature and make adjustments.

In the event it gets cold -

a) Make sure everything is on. Electricity, power switches, fuses, and time-clocks should be considered in this process.

b) Check the boiler and pumps. It should be at 160 - 180ºF and show 10 - 20 lbs. pressure. Try to restart it as described, or you should call for service.

c) Calibration of thermostats can be checked.

d) If you can't figure out why it's not working, call for service.

In the event it gets hot -

a) Make sure everything is on. Electricity, power switches, fuses, and time-clocks should be considered in this process.

b) Check the chiller and its pump. It should show about 50ºF and 60-70 lbs., or you should call someone

c) Calibration of thermostats can be checked.

d) If you can't figure out why it's not working, call for service.

At this point, you need to recognize that a climate control system should be on 24 hours. If it isn't, it's really more of a "climate influence" system. Still, even when it's on it can develop problems. Sometimes we can help keep it running right.

Things we can do here:

In the event of a power outage -

a) There are several fuses which have to be reset in the electrical room of the old building. Even after a very short power dip this should be checked out. Failure to do so means that the AHs are all off.

b) If power remains off, make sure that the emergency generator is on and the air compressor is running.

In the event of a dry situation (ie., Santa Ana winds, anything under 40%) -

a) Make sure everything is on. Electricity, power switches, fuses, and time-clocks should be considered in this process.

b) Check the water treatment system visually. There should be water in the reservoir, and the lights should be on, or you should call for service.

c) Calibration of humidistats can be checked.

d) If you can't figure out why it's not working, call for service.

In the event a space is "wet" (over 60%) -

a) Make sure everything is on. Electricity, power switches, fuses, and time-clocks should be considered in this process.

b) Check the chiller and pumps. The system can't condense out water without the cold coils. It should show about 50ºF and 60-70 lbs., or you should call someone.

c) Calibration of humidistats can be checked.

d) If you can't figure out why it's not working, call for service.