Meet Dave Bunnell, The Steam Whisperer

- Installing/repairing residential and commercial steam heating/hot water systems for over 20 years
- Trained as an Architect (at IIT)
- Trained in Home Energy Efficiency
- Property Maintenance veteran, since childhood.

Please Be Safe

- Manufacturers instructions take precedence over anything in this presentation or any other source.
- Carbon monoxide poisoning is the number one preventable cause of death in the US. When in doubt, get OUT!
- Steam burns can be deadly, be sure to be careful when working near heating equipment.

The Inherent Efficiency Advantages of Steam Heating

1 GALLON OF WATER BOILED INTO STEAM PROVIDES OVER 8,000 BTU'S OF HEAT, THE SAME HEAT AS....

- 48 gallons of heated water moved by a pump in a hot water system
- 9000 cubic feet of heated air moved by a fan in a forced air system

Steam Heat requires no added energy to move the heat into the spaces

When water is boiled into steam it expands over 1700 times in size (dynamite is only 1400 times). This expansion provides the power for steam to travel up to 23 mph through piping (over 50 mph in vacuum systems).

Steam uses Less electricity

- Steam peak power draw is about 20 watts.
- Hot Water is from 110 watts (standard boilers) to 450 watts (high efficiency boilers)
- Forced air typically about 925 Watts

Radiant Steam Heat Saves Fuel

- Radiant warmth like the sun allows lower thermostat settings with the same level of comfort…saving fuel Typical comfort levels are reached at about 69F versus 71 to72F…..a savings of 6% to 9% fuel use.
- Radiant heat produces less hot air that rises out leaks at the top of the structure, reducing air leakage.

Steam Heat Reduces Air leaks

- Extensive DOE studies have shown that **modern** ducted systems:

  1. Increase home air leakage 10% when the ductwork is not in use

  2. When the fan turns on, home air leakage increases 50%

- The average loss of heating/ cooling from modern ductwork is 23% before the air reaches the rooms.

Steam Heat is Healthier and Safer

- Air is not dried out by heating system.
- No ductwork full of dust, dust mites and filth that gets blown throughout a home
- Steam systems provide improved safety in fires.

1. Ductwork conducts smoke throughout structure.

2. Small holes in floors, ceilings, walls for pipes allow fires to be more easily contained to one room

Steam can provide better Temperature control

- Can be converted to room by room temperature control (the standard outside the US) for exceptional comfort and efficiency.
- Can respond rapidly to heating needs or very gently.

Other advantages

- For larger structures heating plant can be located away from occupants in a fire resistant enclosure that allows easy access for servicing and can be locked to prevent tampering.
- Leaks in steam systems typically cause little damage and are easily repaired (no system to drain, isolate, etc.)

Main Types of Steam Systems

1. One pipe steam
2. Two pipe steam

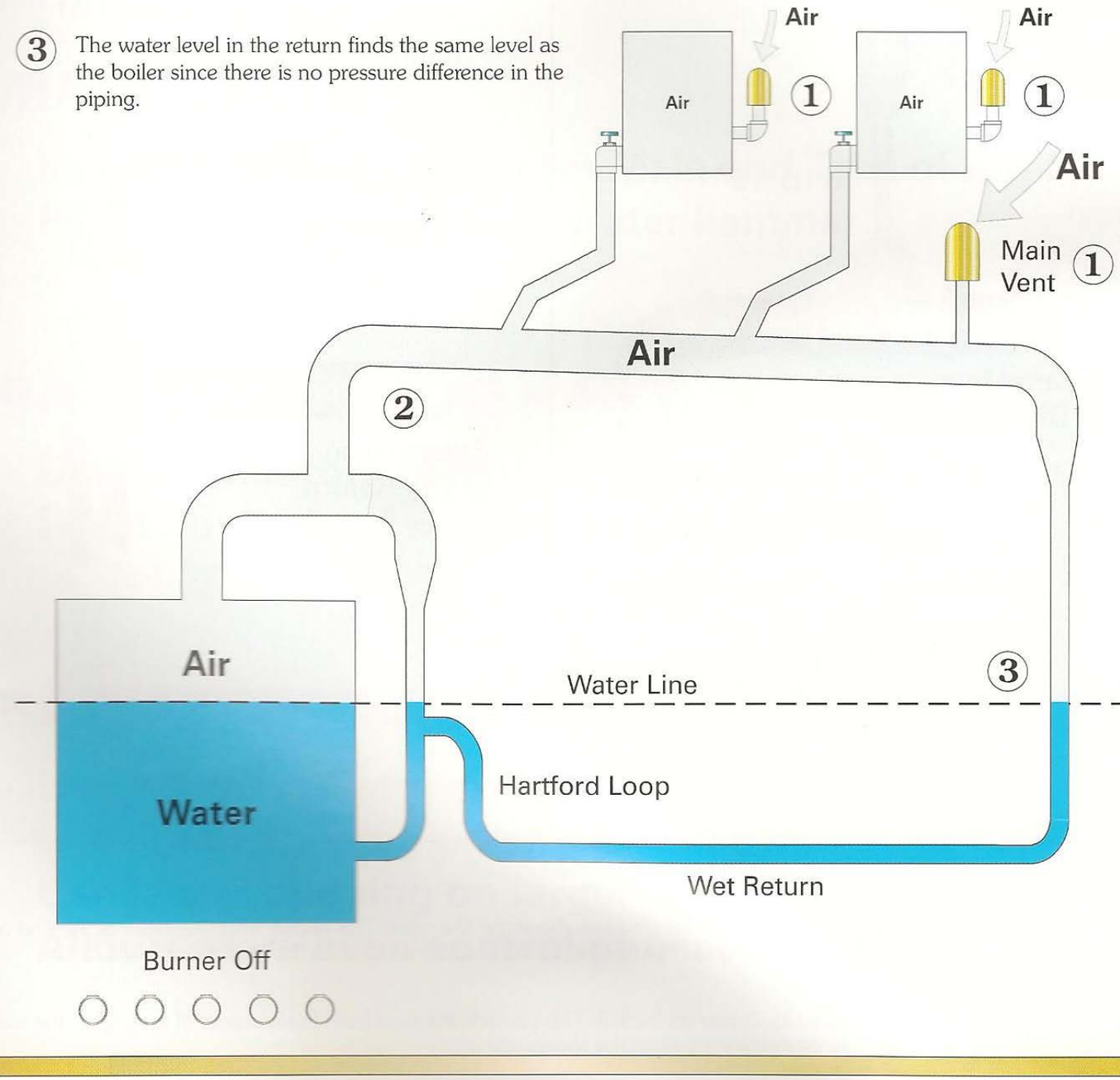
One Pipe Steam Radiator

One Pipe Steam Issues

- Radiators need to slope back to supply valves
- Supply valves must be fully open (most no longer close completely)
- Heat control of a radiator must be done at the air vent with an adjustable radiator vent or TRV.

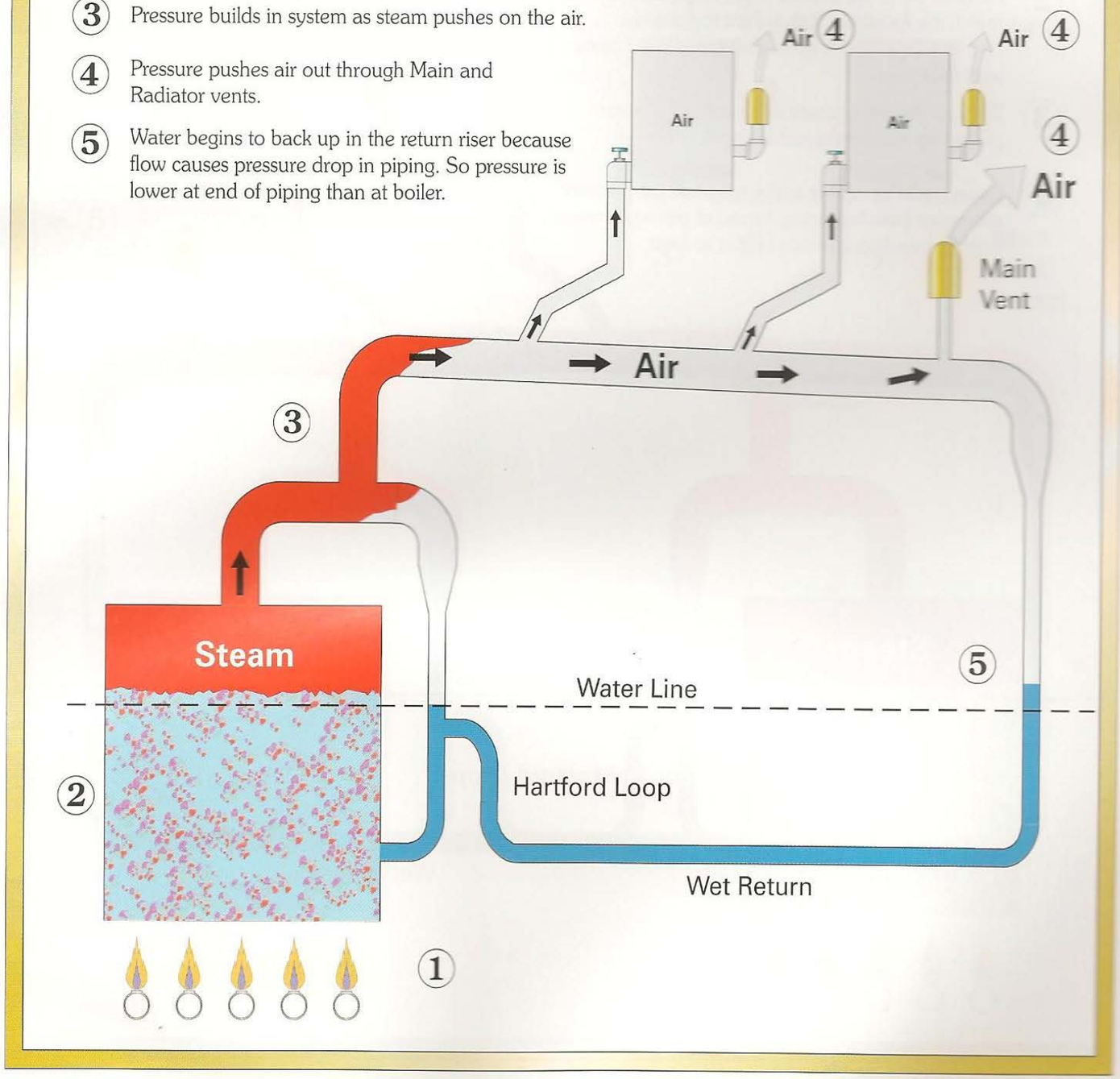
OFF CYCLE

1. Vents serve as vacuum breakers. When steam condenses, it causes a vacuum. The vents let air back in to fill the void.
2. The system fills with air.
3. The water level in the return finds the same level as the boiler since there is no pressure difference in the piping.



THERMOSTAT CALLS FOR HEAT

1. Boiler fires.
2. Water boils in boiler, creating steam. Surface level rises slightly because the steam bubbles displace water.
3. Pressure builds in system as steam pushes on the air.
4. Pressure pushes air out through Main and Radiator vents.
5. Water begins to back up in the return riser because flow causes pressure drop in piping. So pressure is lower at end of piping than at boiler.



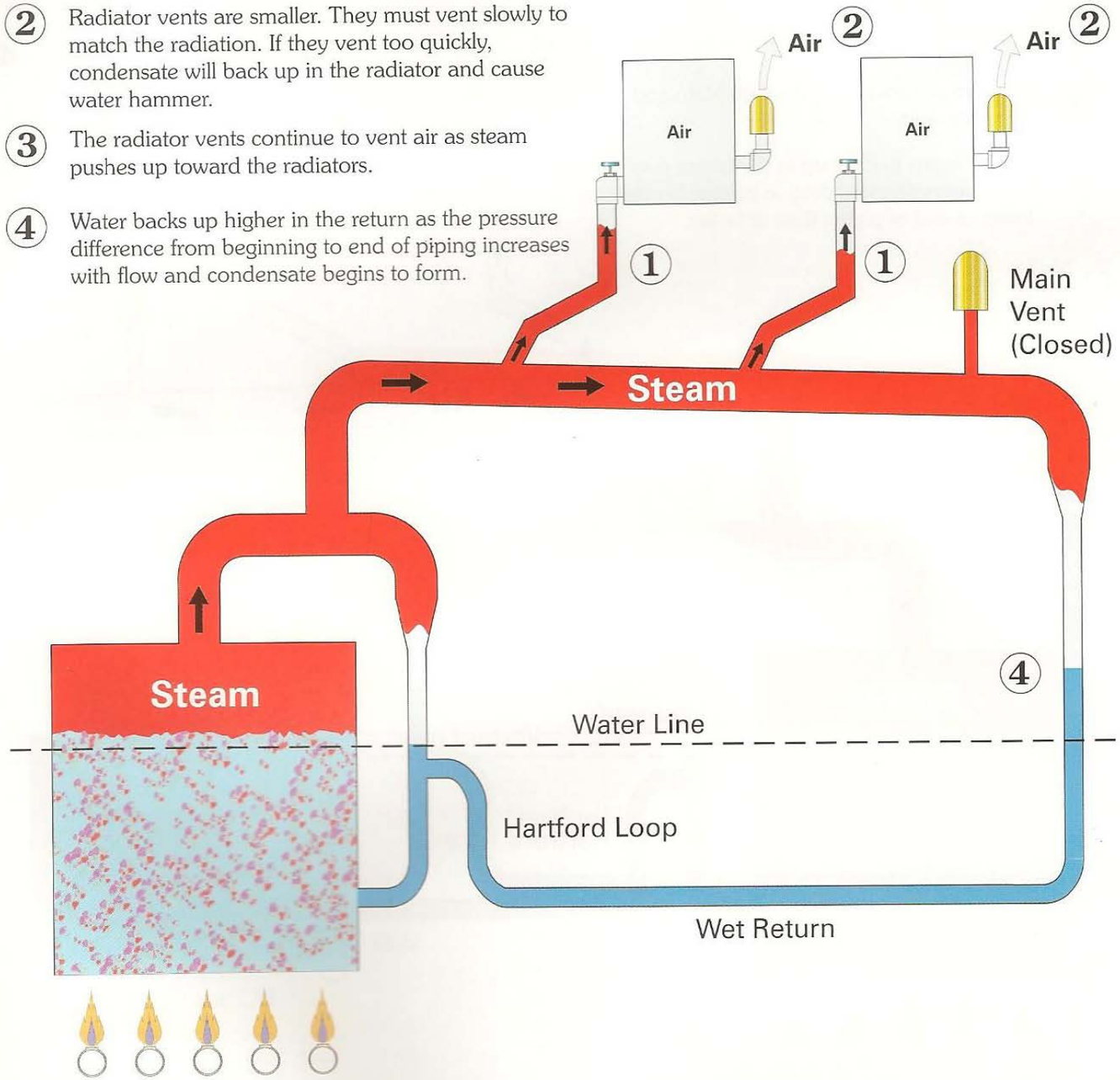
THE MAIN VENT

1. When the Main Vent works right it exhausts air quickly from the steam piping. So all branch lines receive steam at about the same time. This makes heating uniform throughout the building. If the main vent doesn't work, the first radiators get steam first, causing poor heat distribution. The Main vent closes as steam reaches it.

2. Radiator vents are smaller. They must vent slowly to match the radiation. If they vent too quickly, condensate will back up in the radiator and cause water hammer.

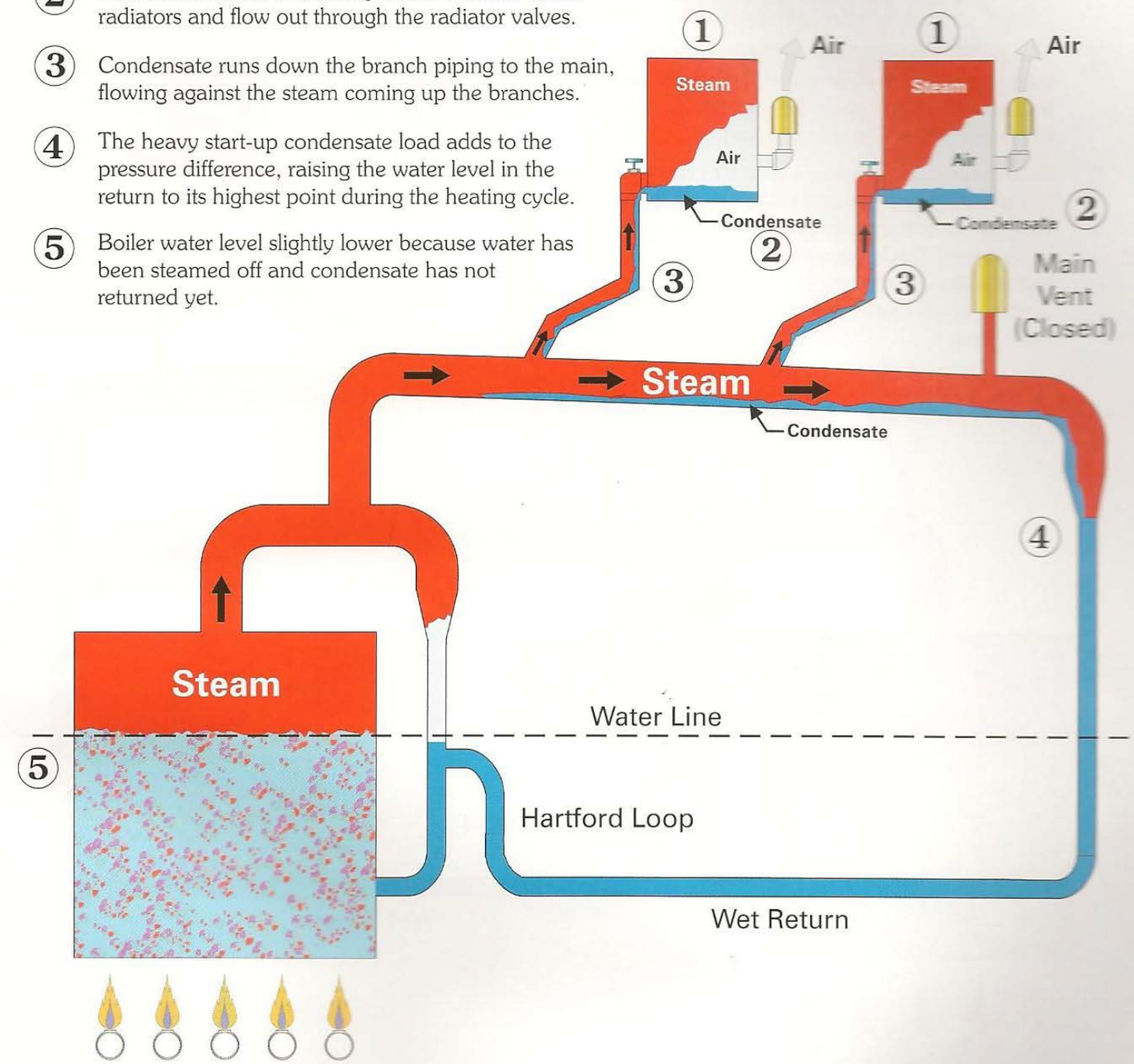
3. The radiator vents continue to vent air as steam pushes up toward the radiators.

4. Water backs up higher in the return as the pressure difference from beginning to end of piping increases with flow and condensate begins to form.



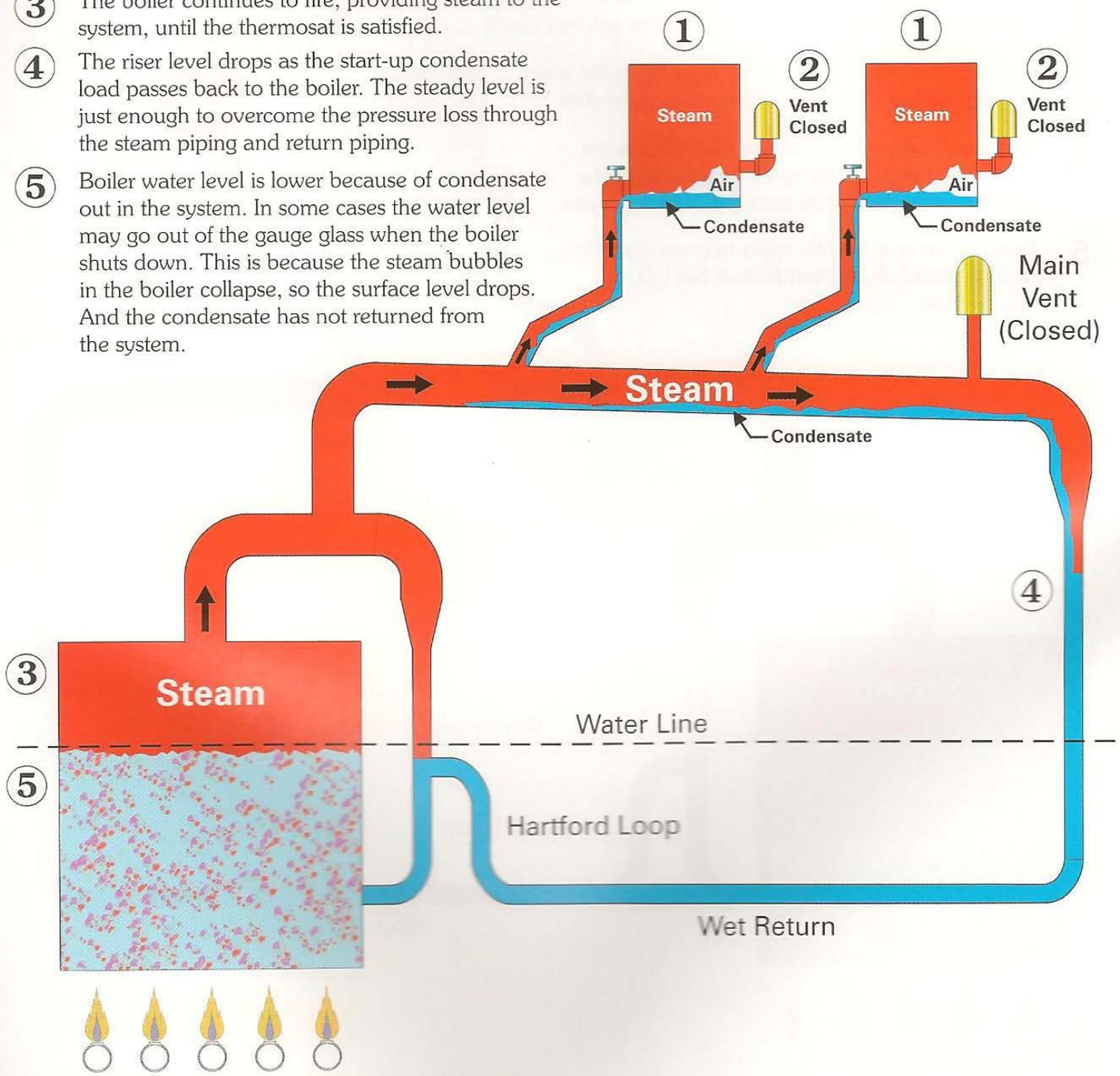
HEATING BEGINS IN RADIATORS

1. Steam pushes into the radiators. The radiators cool the steam. Steam begins to condense. The radiators begin to heat up and give off heat to the room as the steam gives off 970 BTU per pound in condensing.
2. Condensate starts to build up in the bottoms of the radiators and flow out through the radiator valves.
3. Condensate runs down the branch piping to the main, flowing against the steam coming up the branches.
4. The heavy start-up condensate load adds to the pressure difference, raising the water level in the return to its highest point during the heating cycle.
5. Boiler water level slightly lower because water has been steamed off and condensate has not returned yet.



STEADY STATE HEATING

1. Steam fills radiators until it reaches the radiator vents.
2. The radiator vents close when exposed to the steam temperature.
3. The boiler continues to fire, providing steam to the system, until the thermosat is satisfied.
4. The riser level drops as the start-up condensate load passes back to the boiler. The steady level is just enough to overcome the pressure loss through the steam piping and return piping.
5. Boiler water level is lower because of condensate out in the system. In some cases the water level may go out of the gauge glass when the boiler shuts down. This is because the steam bubbles in the boiler collapse, so the surface level drops. And the condensate has not returned from the system.



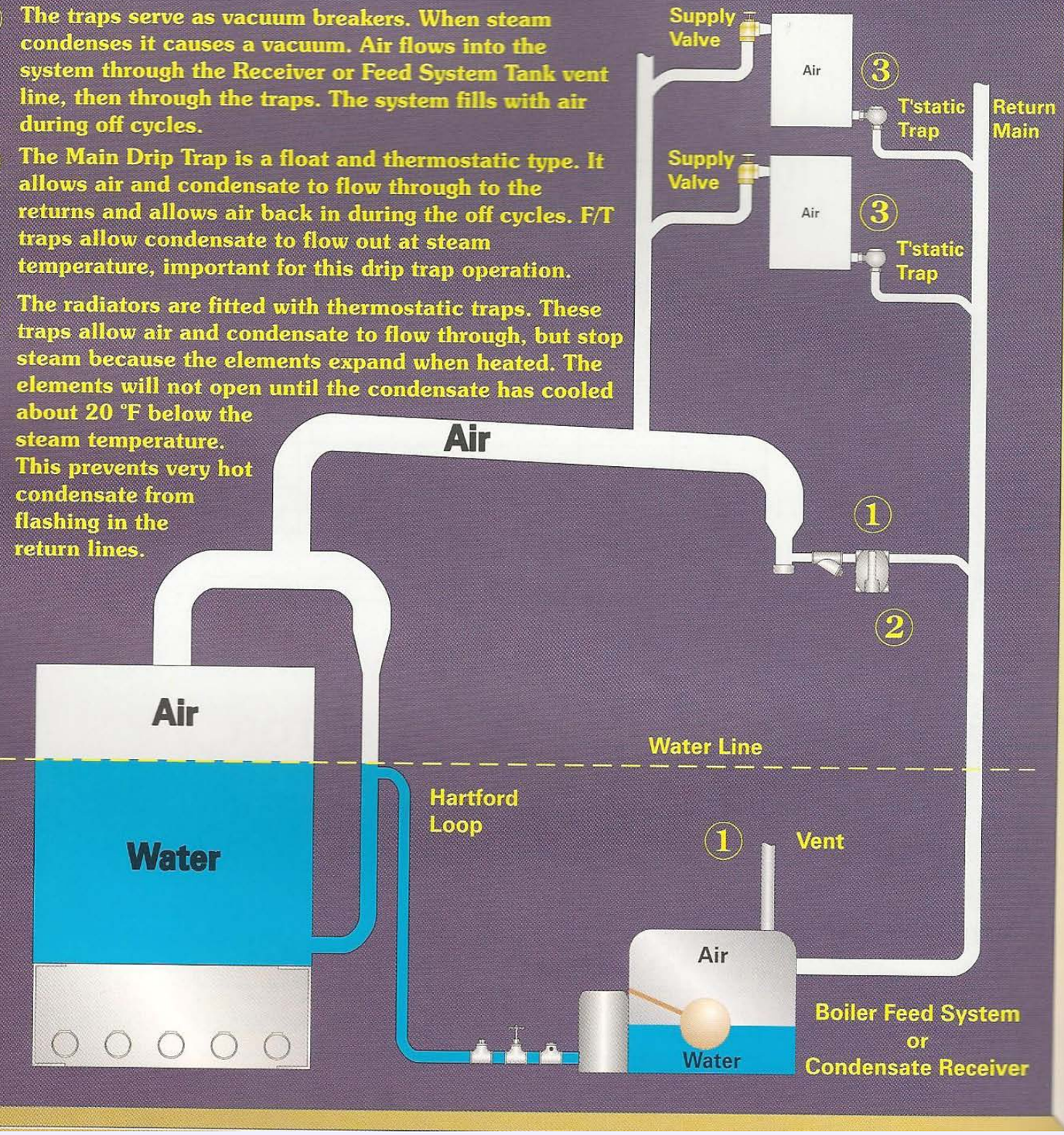
Two Pipe Steam Radiator

Bad Steam Traps

- Uneven heating, Banging, High fuel bills
- Most systems with radiator traps have extensive trap failure. Typical rebuilding should be every 7 to 10 years.
- Failed open traps allow the bad radiator to heat very well, while surrounding radiators won't.
- Failed closed traps cause that radiator to go cold.

TWO-PIPE STEAM SYSTEM
Off Cycle

1. The traps serve as vacuum breakers. When steam condenses it causes a vacuum. Air flows into the system through the Receiver or Feed System Tank vent line, then through the traps. The system fills with air during off cycles.
2. The Main Drip Trap is a float and thermostatic type. It allows air and condensate to flow through to the returns and allows air back in during the off cycles. F/T traps allow condensate to flow out at steam temperature, important for this drip trap operation.
3. The radiators are fitted with thermostatic traps. These traps allow air and condensate to flow through, but stop steam because the elements expand when heated. The elements will not open until the condensate has cooled about 20 °F below the steam temperature. This prevents very hot condensate from flashing in the return lines.



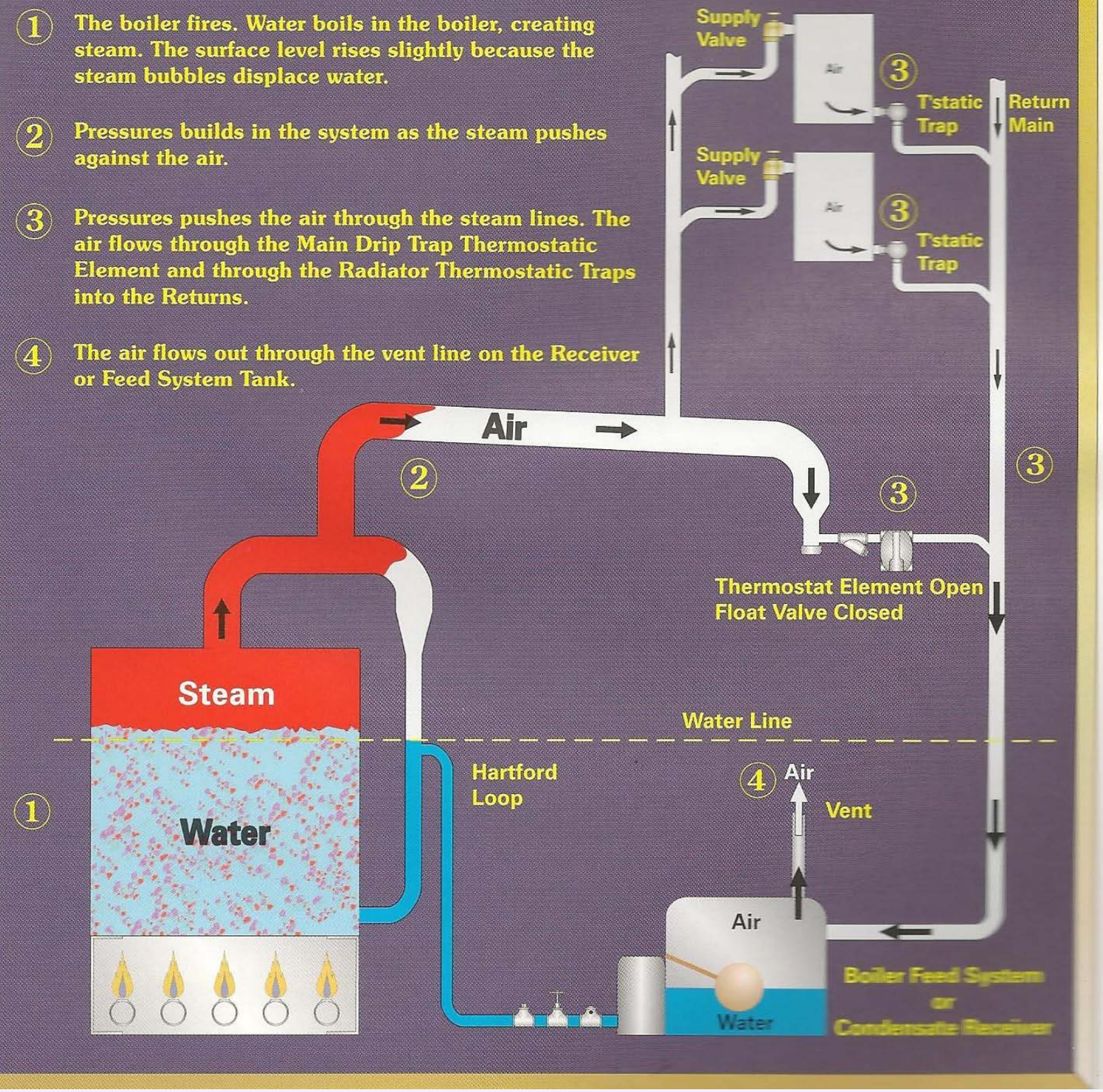
TWO-PIPE STEAM SYSTEM
Thermostat Calls for Heat

1. The boiler fires. Water boils in the boiler, creating steam. The surface level rises slightly because the steam bubbles displace water.

2. Pressures builds in the system as the steam pushes against the air.

3. Pressures pushes the air through the steam lines. The air flows through the Main Drip Trap Thermostatic Element and through the Radiator Thermostatic Traps into the Returns.

4. The air flows out through the vent line on the Receiver or Feed System Tank.

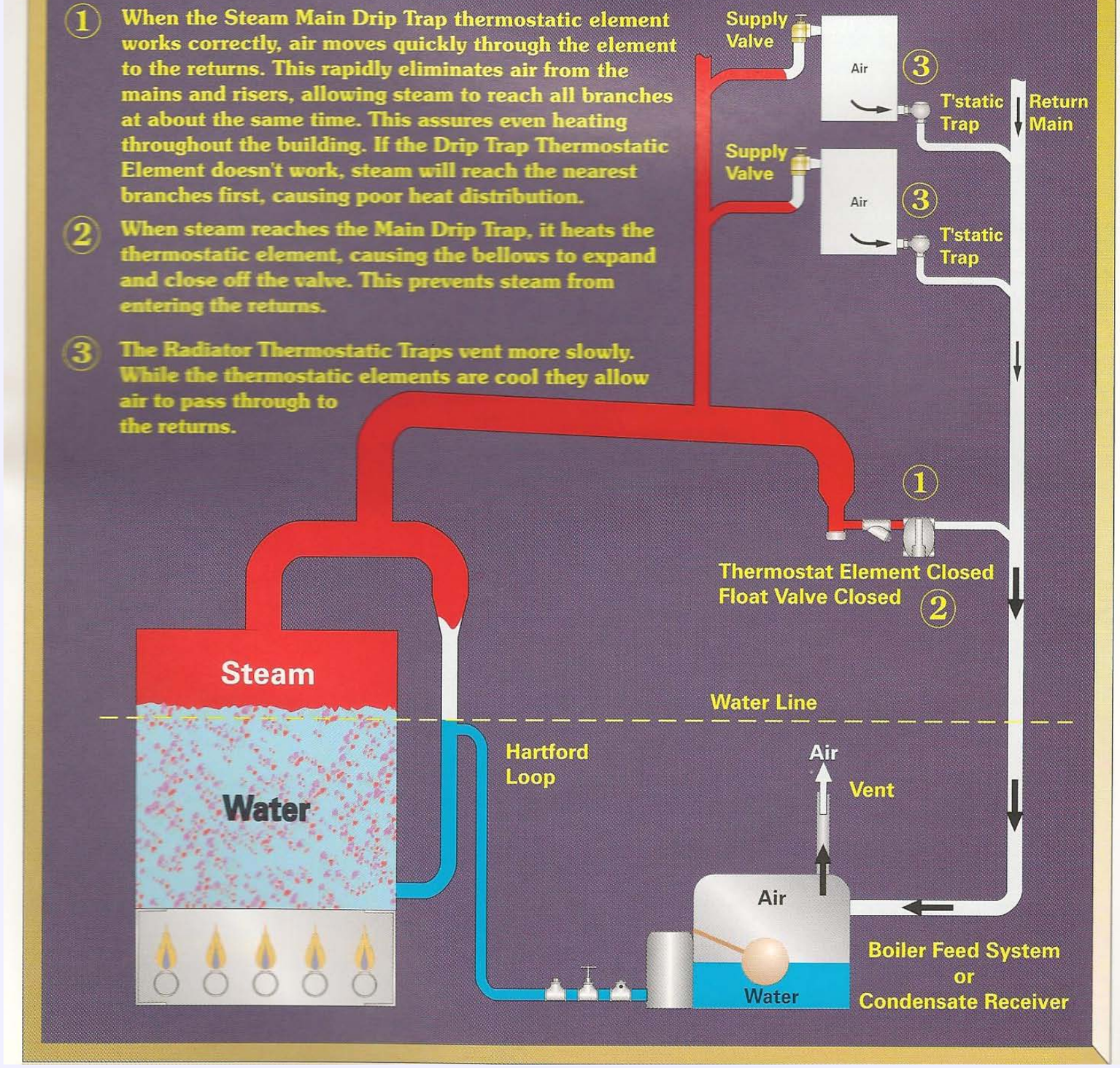


TWO-PIPE STEAM SYSTEM
The Steam Main Drip Trap

1. When the Steam Main Drip Trap thermostatic element works correctly, air moves quickly through the element to the returns. This rapidly eliminates air from the mains and risers, allowing steam to reach all branches at about the same time. This assures even heating throughout the building. If the Drip Trap Thermostatic Element doesn't work, steam will reach the nearest branches first, causing poor heat distribution.

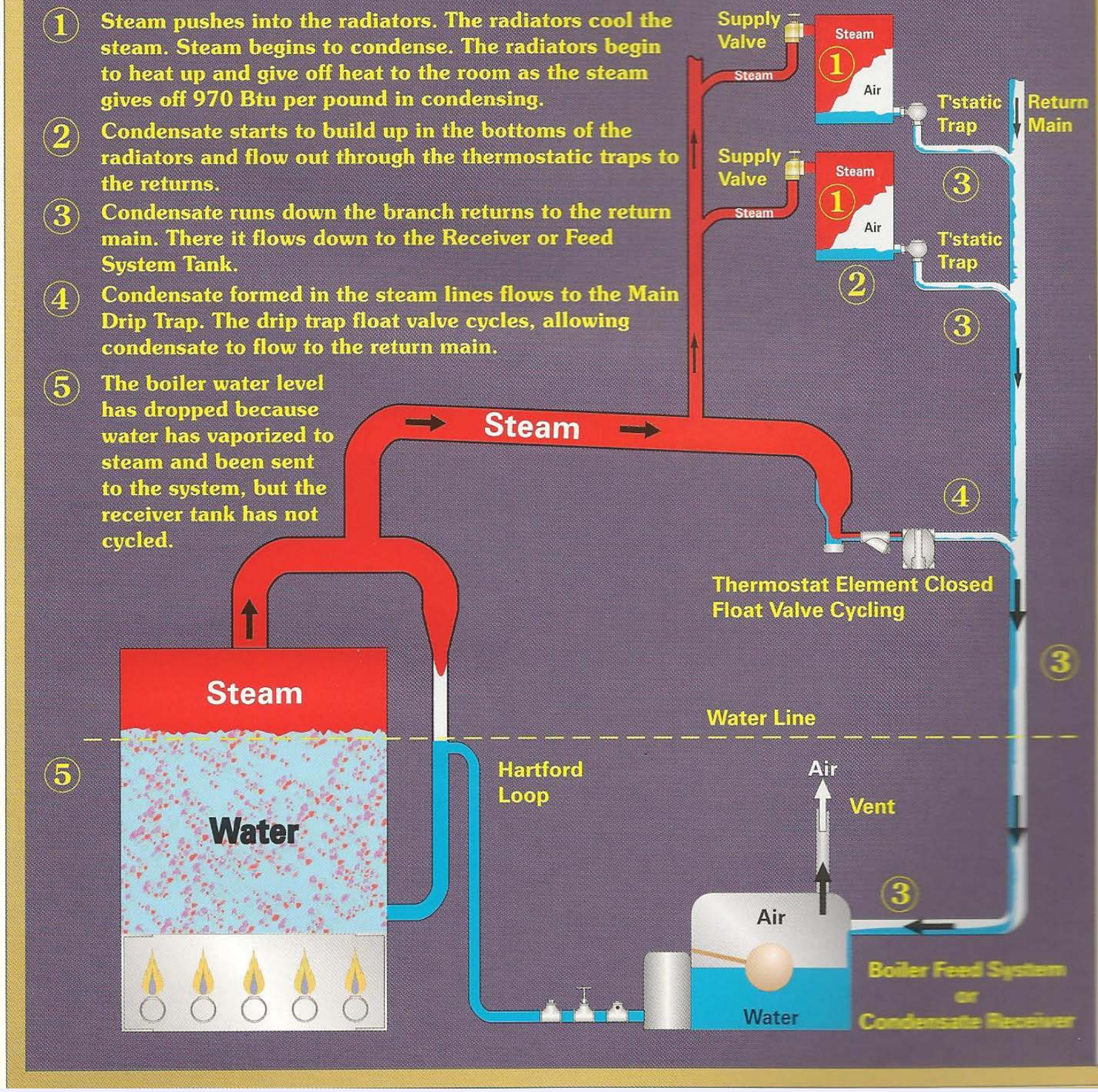
2. When steam reaches the Main Drip Trap, it heats the thermostatic element, causing the bellows to expand and close off the valve. This prevents steam from entering the returns.

3. The Radiator Thermostatic Traps vent more slowly. While the thermostatic elements are cool they allow air to pass through to the returns.



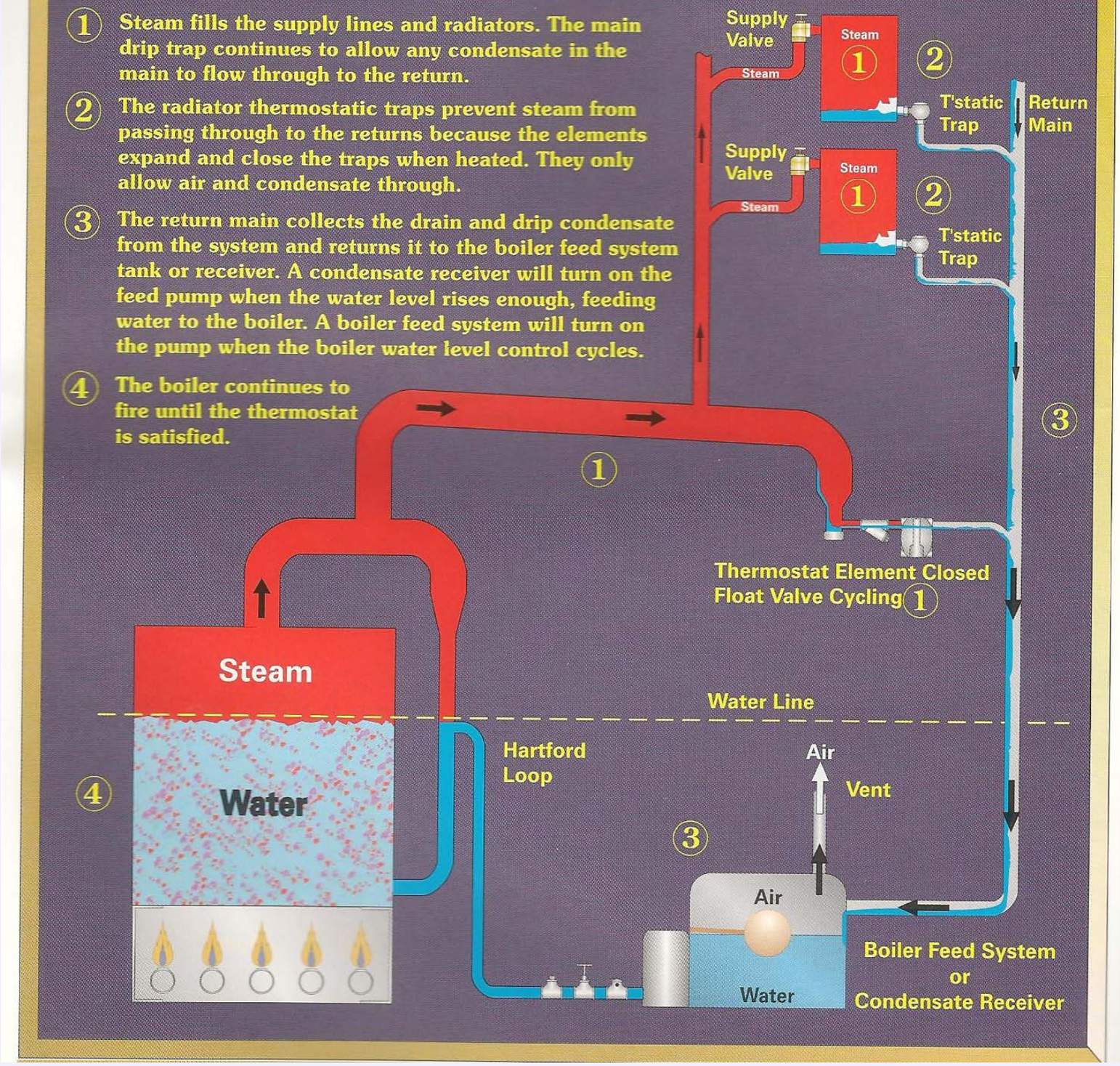
TWO-PIPE STEAM SYSTEM
Heating Begins in Radiators

1. Steam pushes into the radiators. The radiators cool the steam. Steam begins to condense. The radiators begin to heat up and give off heat to the room as the steam gives off 970 Btu per pound in condensing.
2. Condensate starts to build up in the bottoms of the radiators and flow out through the thermostatic traps to the returns.
3. Condensate runs down the branch returns to the return main. There it flows down to the Receiver or Feed System Tank.
4. Condensate formed in the steam lines flows to the Main Drip Trap. The drip trap float valve cycles, allowing condensate to flow to the return main.
5. The boiler water level has dropped because water has vaporized to steam and been sent to the system, but the receiver tank has not cycled.



TWO-PIPE STEAM SYSTEM
Steady State Heating

1. Steam fills the supply lines and radiators. The main drip trap continues to allow any condensate in the main to flow through to the return.
2. The radiator thermostatic traps prevent steam from passing through to the returns because the elements expand and close the traps when heated. They only allow air and condensate through.
3. The return main collects the drain and drip condensate from the system and returns it to the boiler feed system tank or receiver. A condensate receiver will turn on the feed pump when the water level rises enough, feeding water to the boiler. A boiler feed system will turn on the pump when the boiler water level control cycles.
4. The boiler continues to fire until the thermostat is satisfied.



Two Pipe Vapor/Vacuum

- Radiators/ piping often look identical to two pipe steam.
- Instead of trap, may have odd looking device on radiator outlet or just an elbow.
- May have odd looking devices hanging near boiler.
- Operates best at ½ psi or in vacuum.

Naturally Induced Vacuum Devices Near Boiler

Typical Problems with Steam Heat and The Symptoms

Normal for steam heating is…

- Quiet
- Toasty comfortable
- Extremely cost efficient.

- If you're aware of the steam system working, it's not working properly.

Boiler has too much capacity

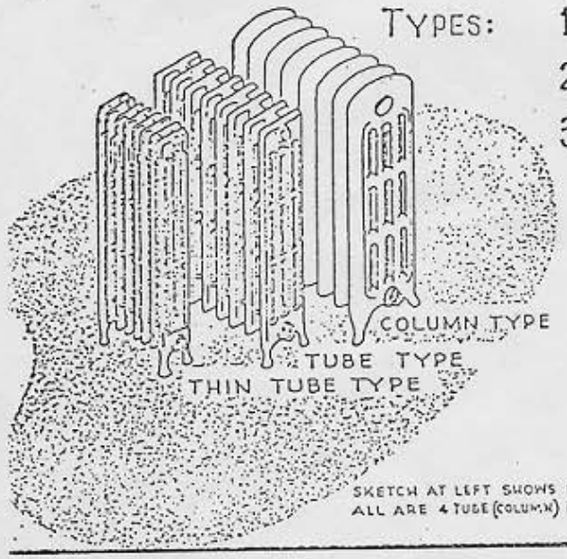
- How often: about 95 %
- Pipes bang
- Big temperature swings from on to off
- High fuel bills
- Too hot in some rooms, too cold in others.
- Air vents fail often

Too Big

Just Right

RADIATOR RATINGS

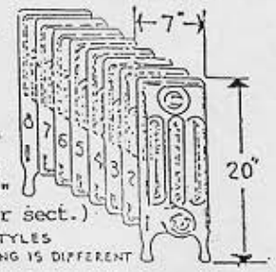
(ALL DIMENSIONS AND RATINGS ARE APPROXIMATE)



TYPES:

1. OLD STYLE COLUMN
2. TUBE STYLE
3. THIN TUBE STYLE

To identify the style of a radiator, count number of tubes or columns. Then check below on the width. When you have identified the style 1, 2 or 3, read the radiation per section on opposite page directly in line with the radiator style. EXAMPLE: Radiator sketched at the right is a 4 tube– 8 section– 7" wide– 20" high (2-1/4 sq. ft./per sect.)

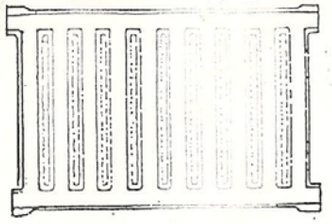


SKETCH AT LEFT SHOWS RELATIVE SIZES OF RADIATOR STYLES
ALL ARE 4 TUBE (COLUMN) 8 SECTION RADIATORS– EACH RATING IS DIFFERENT

COLUMNS OR TUBES ⇨	1	2	3	4	5	6	7
OLD STYLE COLUMN RADIATORS #1. 2½" /section WIDTH ⇨	4½"	7⅜"	9"	11½"	12½"	12½"	
2½" /section TUBE TYPE RADIATORS THESE RADIATORS ARE ALSO USED AS WALL TYPE (WITHOUT LEGS) 2. WIDTH ⇨			5"	7"	8½"	9¾"	12½"
1¾" /section THIN TUBE RADIATORS THESE RADIATORS ARE SO USED AS WALL TYPE (WITHOUT LEGS) 3. WIDTH ⇨		3¼"	4"	4¾"	6"	7⅛"	

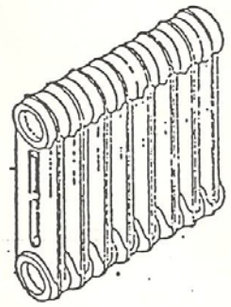
(ALL DIMENSIONS AND RATINGS ARE APPROXIMATE)

WALL TYPE



SIZE	SQ. FT.
13½" x 17" x 3"	5
13½" x 21" x 3"	6
13½" x 22" x 3"	7
13½" x 29" x 3"	9

SECTIONAL WALL TYPE



HEIGHT ⇨	37"	26½"	21½"	15"	13⅞"
SQUARE FEET RADIATION PER SECTION	2½	1⅘	1½	1	3/4

CHARTS BELOW GIVE THE SQUARE FEET OF RADIATION PER SECTION

	HEIGHT	45"	38"	32"	26"	23"	22"	20"	18"	17"	16"	15"	14"
COLUMN	1	3½	3	2½	2	1⅔	1⅔	1½	1⅓				
	2	5	4	3⅓	2⅔	2⅓	2¼	2	1¾			1½	
	3	6	5	4½	3¾	3¼	3	2¾	2¼				
	4	10	8	6½	5	4½	4	3½	3				
	5		10	8½	7		6	5	5		4		4
	6				7		6	5	4½	4	3¾		3
	HEIGHT	38"	36"	32"	26"	23"	22"	20"	18"	17"	16"	15"	14"
TUBE	3	3¼	3½	3	2⅓	2		1¾					
	4	4¼	4¼	3½	2¾	2½		2¼					
	5	5	5	4⅓	3½	3		2⅔					
	6	6	6	5	4	3½		3					
	7		7	6	5	4½	4½	3⅔	3½	3	3		2½
	HEIGHT	38"	32"	26"	25"	23"	22"	20"	19"	17"			
THIN TUBE	2	2.5	2		1.6		1.3		1.1				
	3	2.6	2.4		1.6	1.8	1.4		1.2				
	4			2.4	2.0	2.1	1.8	1.8	1.6				
	5			3.0		2.1				2.0			
	6		3.7	3.0	3.0			2.3	2.3				

HEAT EMISSIONS CHART (Based on Room Temperature of 70°F.)

Average water temperature in radiators F°.....	150	160	170	180	190	200	210	215
Heat emission BTU/HR per sq. ft.	110	130	150	170	190	210	230	240

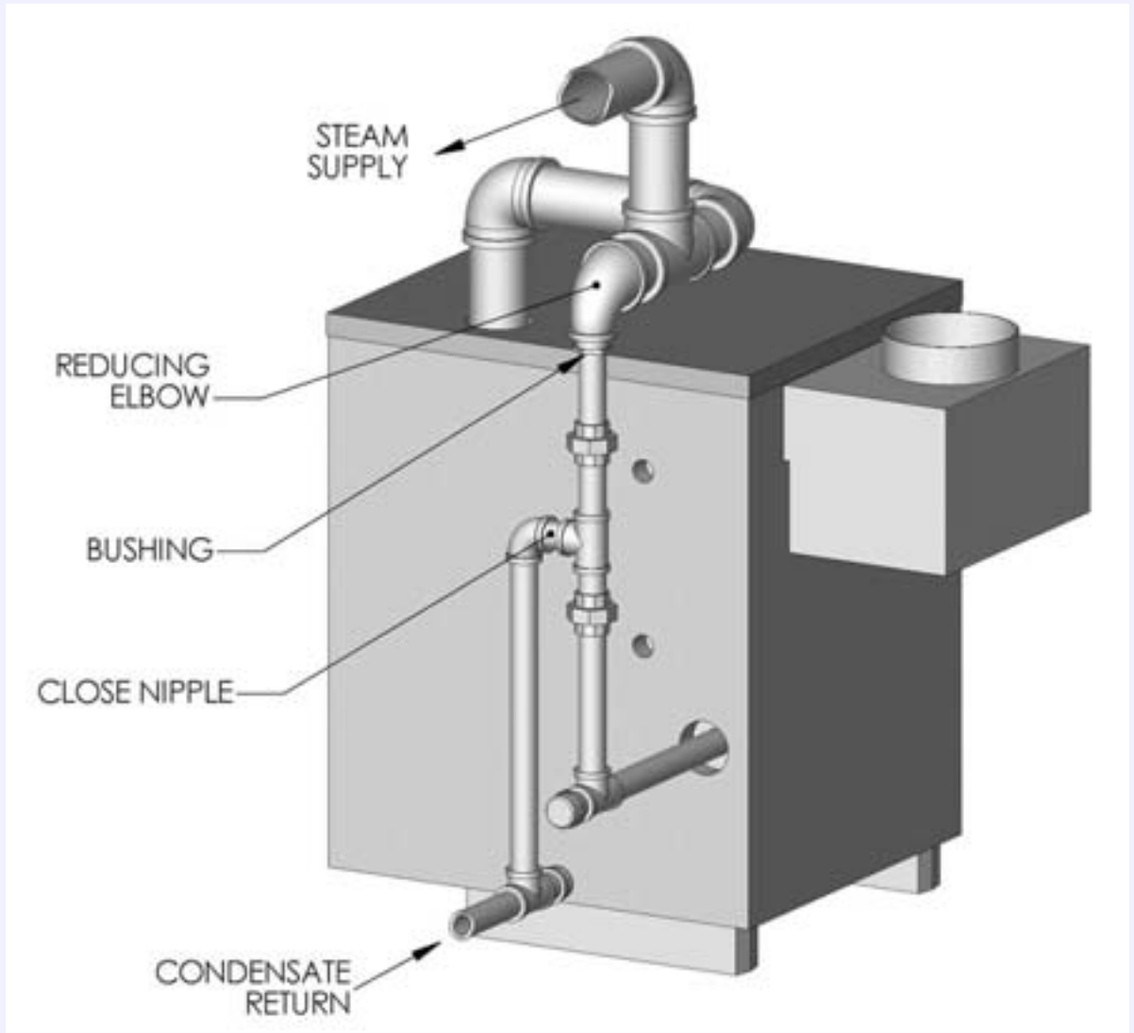
- Take this EDR and multiply by 320 and this should be about the output in BTU/ Hr of your boiler.
- Usually the existing boiler is sized about 80% too big or more. Many systems can use even smaller boilers, if the system is adapted.

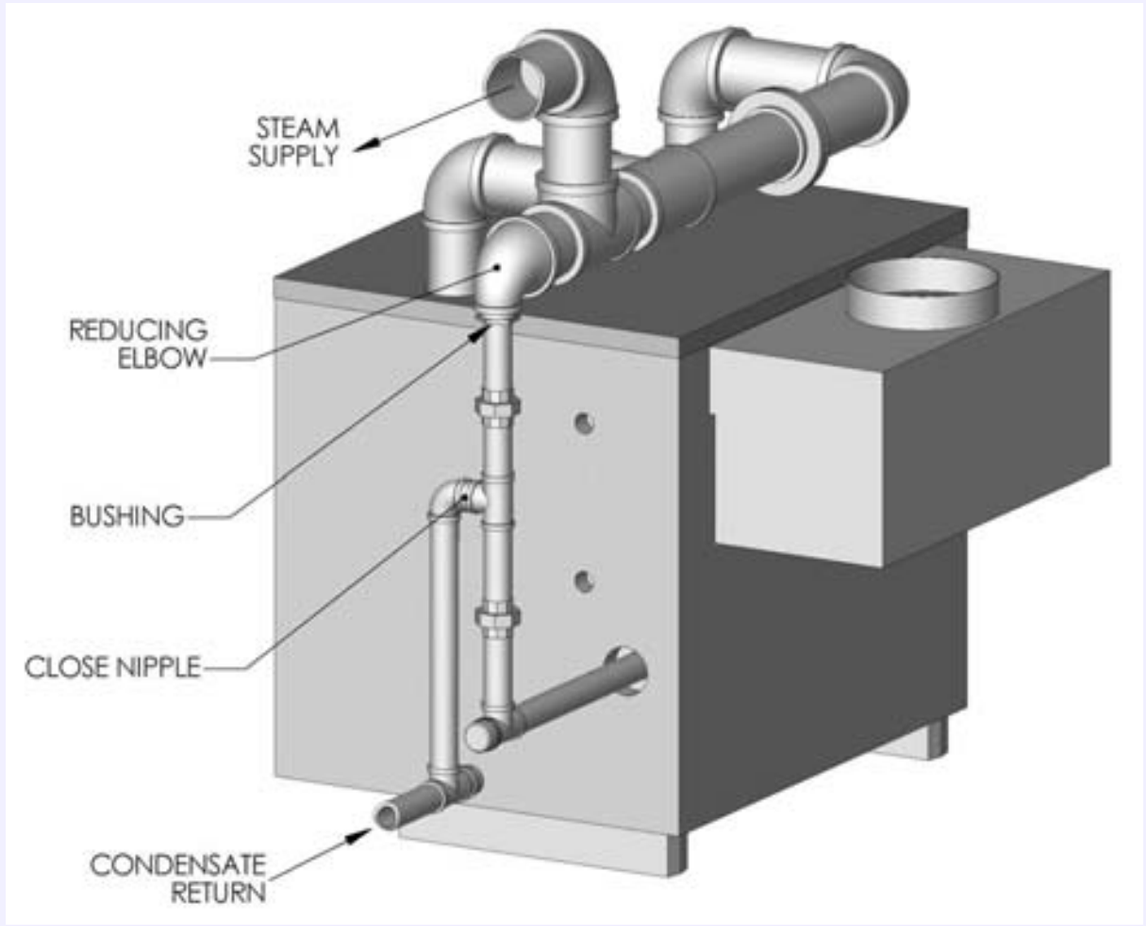
Boiler Piped Incorrectly

- About 95% of boilers
- Banging pipes/ radiators
- Uneven heating
- High fuel usage
- Boiler Overfills/ goes off on low water safety
- Air vents fail often

A look inside the pipes...

At Weil-McLain's School for Better Heating, instructor Mike Kaiser demonstrates the company's uniquely modified boiler, with its heat resistant glass tubing. This boiler shows what happens in the piping of a typical steam boiler as steam is made—a sight rarely seen.


STEAM SUPPLY
REDUCING ELBOW
BUSHING
CLOSE NIPPLE
CONDENSATE RETURN


STEAM SUPPLY
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CONDENSATE RETURN

B. WATER BOILER PIPING – MULTIPLE BOILERS

Refer to the *PB Heat Water Installation Survey and Hydronics Institute Residential Hydronic Heating Installation Design Guide* for guidance on multiple boiler installations.

C. STEAM BOILER PIPING – SINGLE BOILERS

1. Refer to the *PB Heat Steam Installation Survey and Hydronics Institute Residential Hydronic Heating Installation Design Guide* for guidance.
2. Install steam supply pipes as shown in Figure 4.3 for Model 63-03 to 64-07 and Figure 4.4 for Model 64-08 to 64-12. The minimum quantity and size of supply pipes are indicated in Table 4.1.

Use Threaded Fittings for Manifold Piping

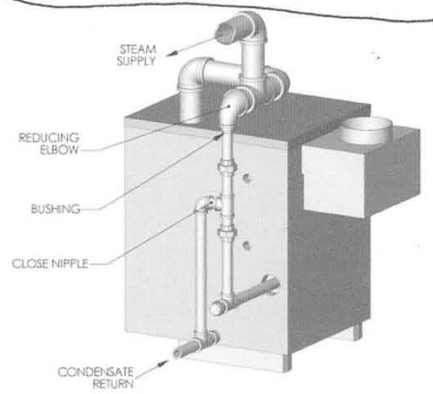


Figure 4.3: Steam Piping – Single Supply Connection

⚠ NOTICE

Use swing joints to attach to the header to avoid damage to the boiler due to thermal expansion and contraction of steam header pipe.

3. Pipe the steam header a minimum of 24" above the normal water line using swing joints to attach the risers into the steam header.

Use Threaded Fittings for Manifold Piping

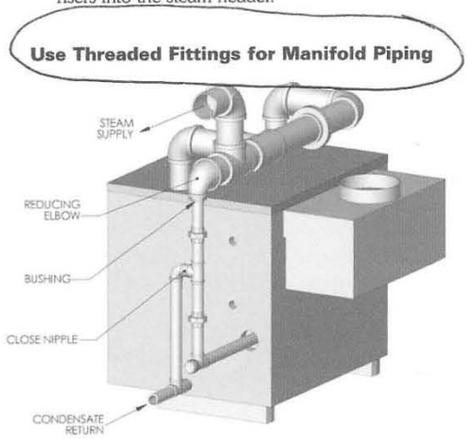


Figure 4.4: Steam Piping – Dual Supply Connections

⚠ NOTICE

- **Do not use bushings or concentric reducers in the horizontal header piping. This will prevent water from dropping into the equalizer and cause water carryover into the steam piping.**
- **Do not reduce the size or number of steam supply risers below the minimum shown in Table 4.1. Insufficient or undersized risers can cause damage to the boiler.**
- **Do not use a bullhead tee to provide steam supply to the system. This will cause water carryover into the steam piping.**

4. Use threaded fittings for manifold piping to provide flexibility for thermal expansion.
5. Connect the equalizing line as shown in Figure 4.3 or 4.4 assuring that the reducing elbow is facing down and that any bushings are vertical to prevent water build-up in the steam header.

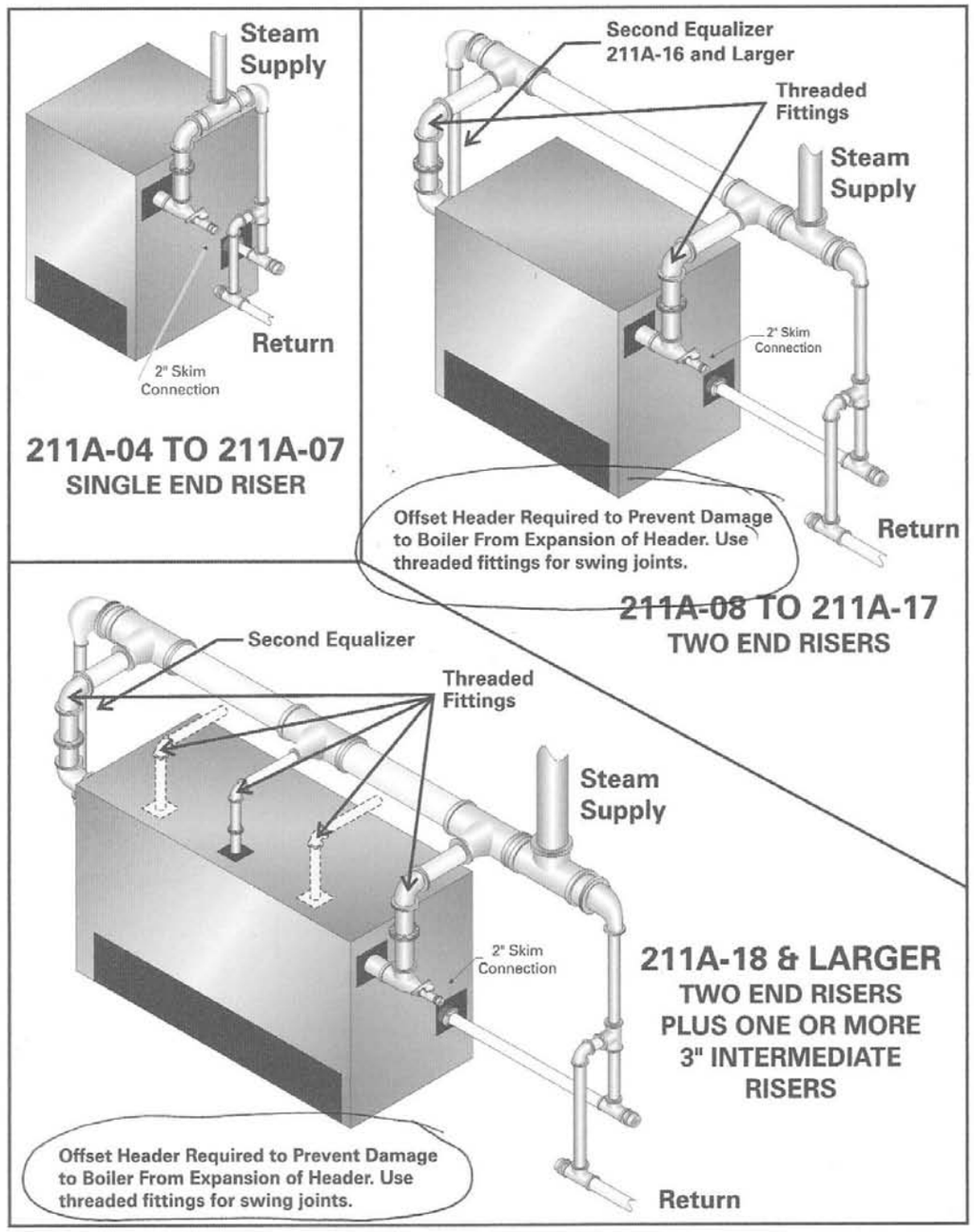
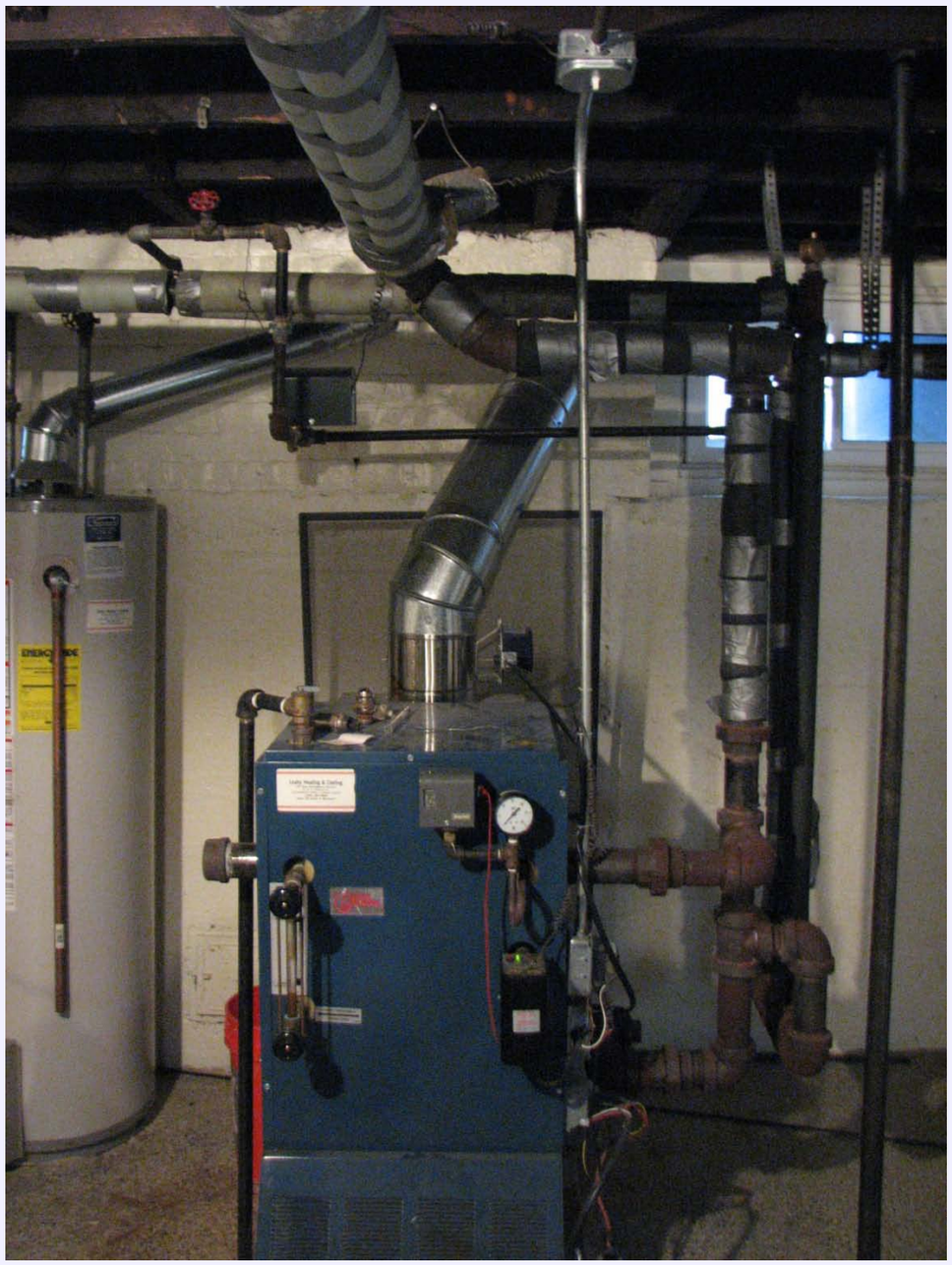


Figure 5.2: Supply and Return Piping – Pumped Return and Parallel Flow Gravity Systems

Correct

Correct

Incorrect



Incorrect

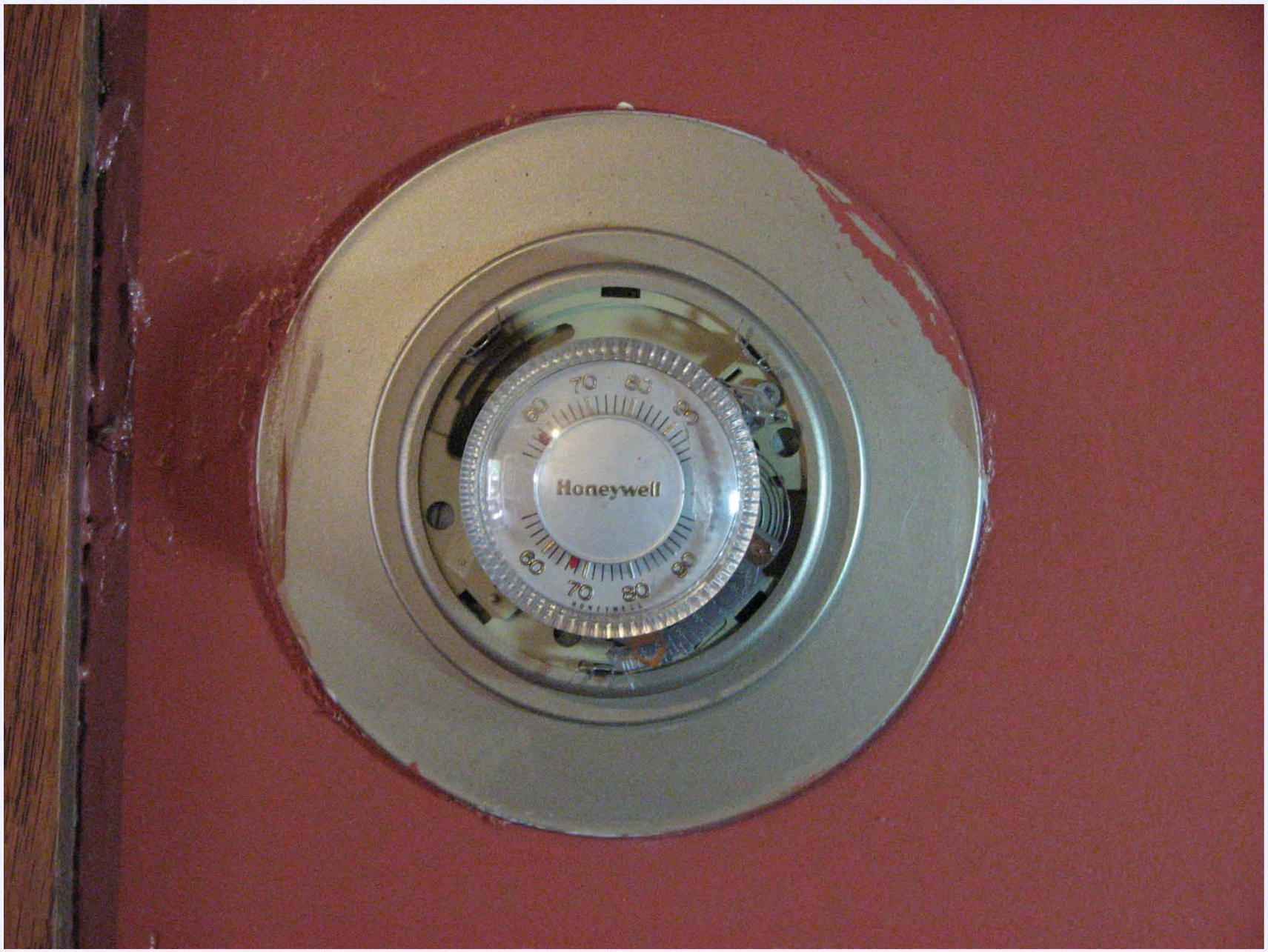
Incorrect

Incorrect

Thermostat/control set up incorrectly

- About 80%
- Some rooms too hot/ others too cold
- Large temperature swings.
- High fuel usage

Round thermostat



Inadequate steam main vent capacity

- About 75% in homes (95% in multifamily)
- Rooms near boiler hot, rooms farthest cold
- Big temperature swings from on to off.
- High fuel usage

Inadequate Vents

Typical 6 flat

Proper Vents

Typical 6 Flat

How to Check

1. Get a stopwatch. Run boiler for about 30 minutes to get system warmed up. While waiting find the longest pipe from the boiler to the farthest radiator.
2. Let system cool down for about 10 minutes.
3. Start boiler. When pipe coming out of boiler is steam hot, start a stop watch.
4. Follow the steam main pipe from boiler to the farthest radiator connection.
5. This pipe should get steam hot in about 2 minutes or less.

Typical steam boilers are designed to last 30 years or more

The average life is now about

14. 7 years.

Guess why?

Lack of or Improper Maintenance

Common Low Water Cut Offs Needing Weekly Maintenance

Flushing/Testing the Low Water Cut Off

If these controls haven't been checked weekly or they are over 15 years old, replace them. These controls are supposed to be replaced about every 10 to15 years due to wear and tear.

To Weekly Test These Types...

- Fire up the boiler
- Follow the pipe from the bottom of the control to its open end
- Put a bucket here to catch water
- Stand clear of the drain pipe (the water can be very hot) and open the valve for a few seconds
- Dirty water should come out rapidly and the boiler should shut off

If water does not come out rapidly or the boiler does not shut off right away

- Shut down the boiler and rebuild the control immediately!
- Do not use the boiler under any circumstances until it is repaired
- This is a very dangerous condition that can wreck the boiler and injure or kill people.

This is what you Don't Want

Electronic Low Water Cut Offs

Electronic LWCO Maintenance

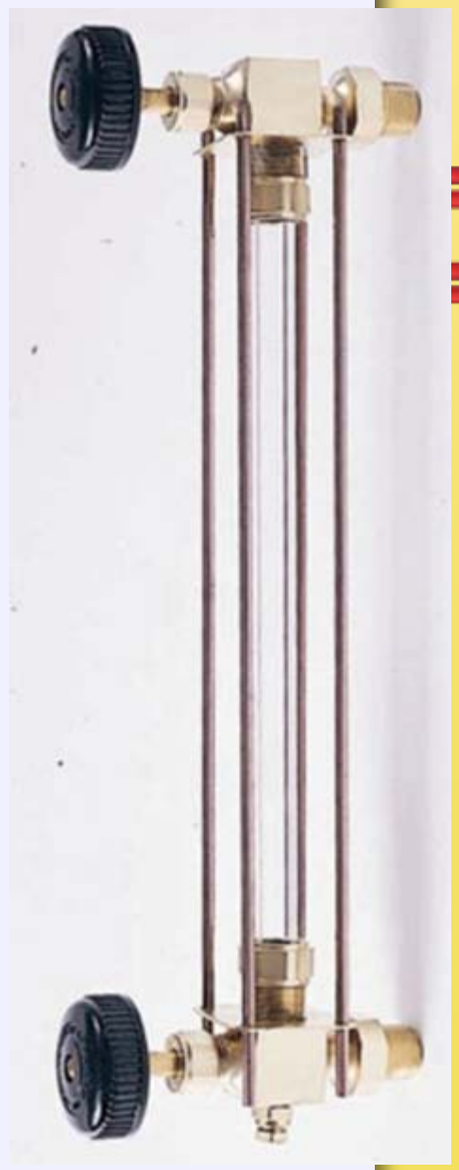
- Clean probe and inspect for cracks in the insulator or water leaks.
- Check operation
- Replace about every 10 to 15 years.

Check the Pressure

- Find the pressure gage on the boiler
- If the reading is over 2-3 psi, or always stays the same, the gage or pressure control is not working and/or you may have a plugged pigtail

Check the Gage Glass

With the boiler off about 15 minutes, check the water in the gauge glass on the side of the boiler



- Height of the water?

  It should be about ½ to 2/3 full.

  (Low or high is a problem.)

Gage Glass

Now turn on the boiler and wait for the pipes to get steam hot

- How dirty is the water?
- Is the water bouncing up and down?
  1/2"–3/4“ is normal (about the size of a quarter)
- More movement, or no movement could mean a serious problem.

System Leaks

- About 50% or more
- Water or steam should not be leaking out anywhere.
- Leaks commonly occur at steam supply valves and at radiator vents.
- Leaks also occur at main vents and around boiler gage glass
- 80 yr old underground buried wet returns are almost guaranteed to be leaking.
- Always install a water meter on the feed line of boiler to monitor water usage.

Checking for Leaks

Turn the thermostat way up for an hour or more and check the radiators with a simple room-by-room walk-through

- Look at every radiator and every valve for leaking water and steam, or stains, corrosion etc.
- Look at the steam pipes and boiler too for leaks

Fix Leaks ASAP.

Eliminating Corrosion

- Nearly all steam systems are slowly corroding.
- Fixing leaks, proper boiler piping and air vents help greatly to reduce corrosion.
- Adding boiler treatment chemicals as needed can nearly eliminate all corrosion of the system, greatly reducing maintenance needs, increasing the life of the boiler and the life of the system indefinitely.

Pipe Insulation

- All systems need the steam mains insulated for best operation. About 50% are not.
- An overheated basement and uneven heating are the most common signs that pipes need insulation.
- Insulation should be 1 to 1 ½ inch thick fiberglass all around the pipe.
- Do not use foam insulation, it can't take the heat.

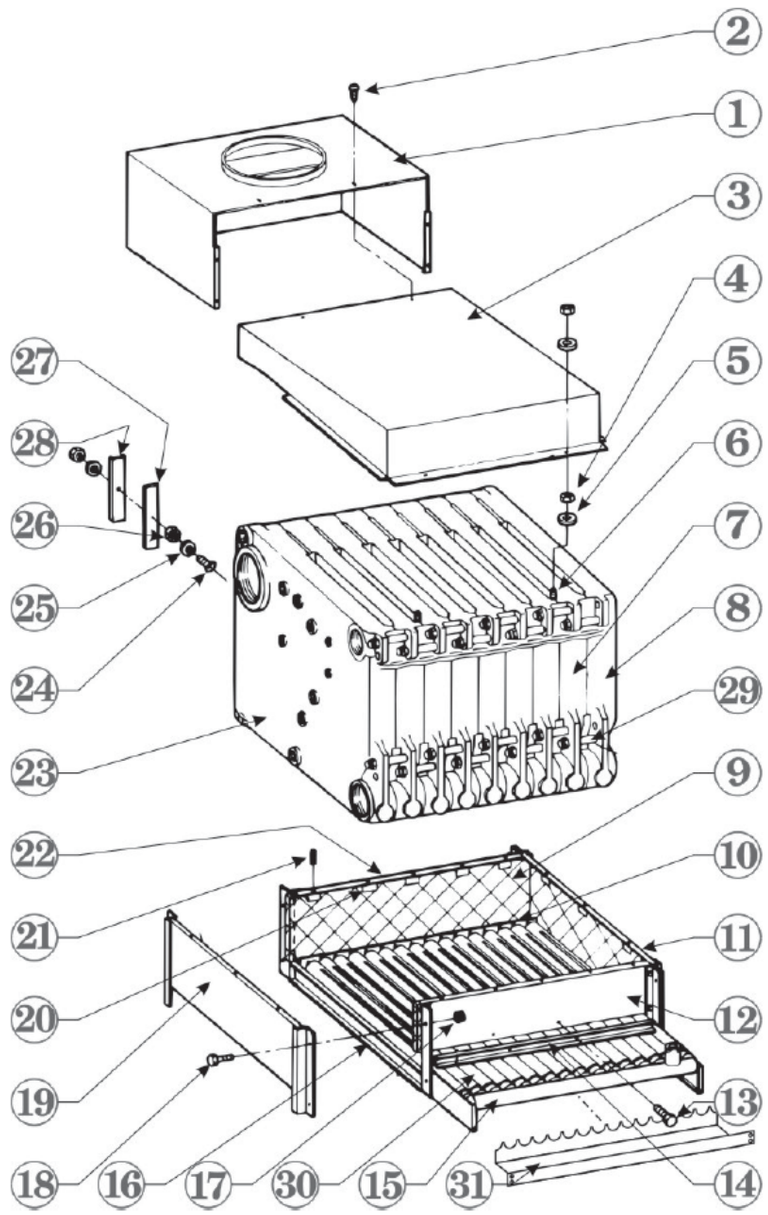
Hi Efficiency Steam Boilers

- Available for decades
- Proven technology
- Available in all sizes.

- About 10 to 12% fuel savings over typical residential boilers
- About 20 to 30% fuel savings over typical commercial boilers

Standard Efficiency Boiler

11 Replacement parts



ı Table

Base Insulation Size (Note 2)
4
5
A
B
C
A and K
B and K
A and J
B and J

ase Arrangement
mine base size for your

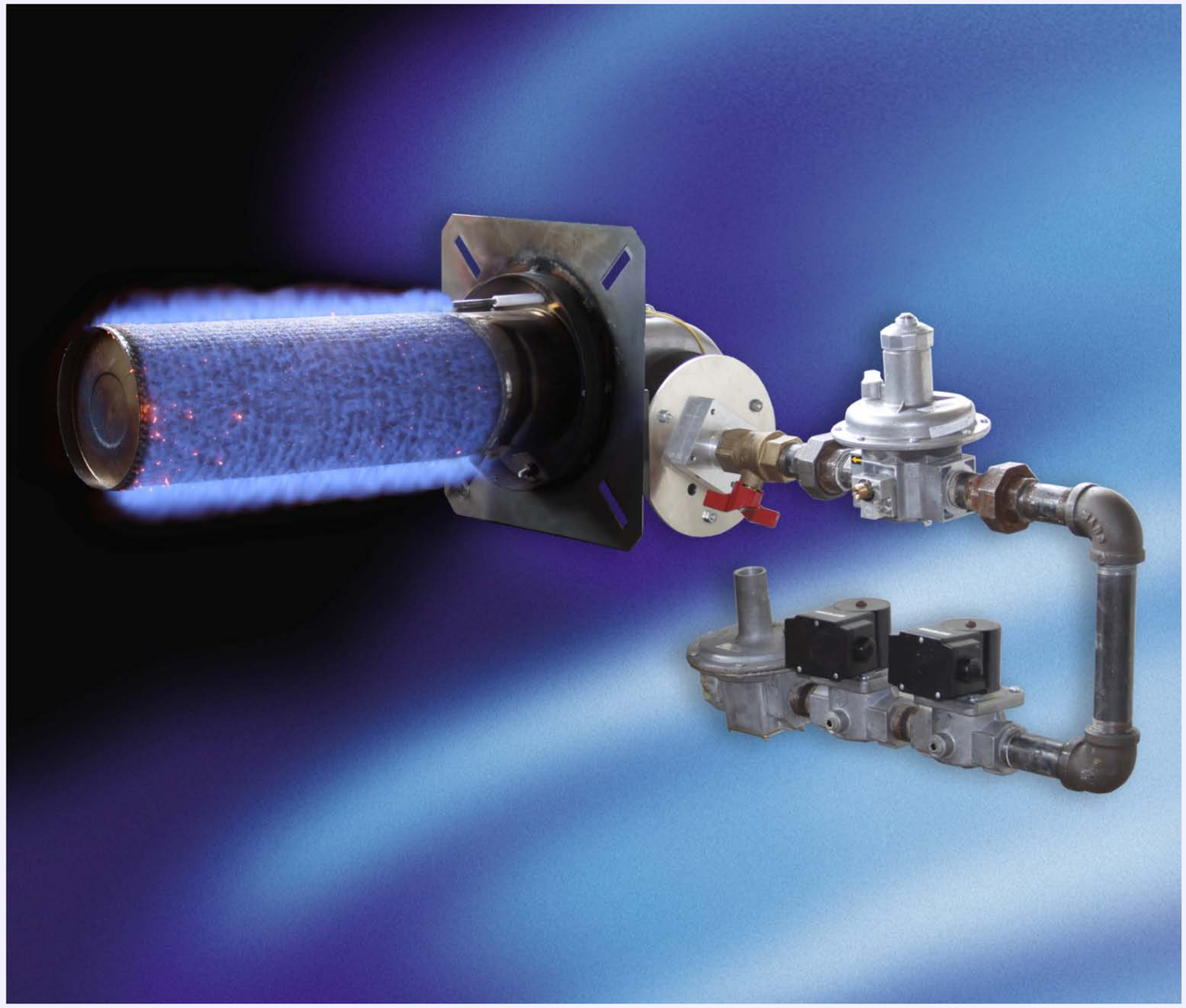
h front and back.

High Efficiency boiler

High Efficiency boiler

High Efficiency Boiler

High Efficiency Radiant Burner



Rebates/ Financing

- Pipe insulation rebates are now available for larger buildings (3 living units and up and commercial)
- Rebates are available for new controls for larger buildings
- Small rebates for High efficiency steam boilers.
- CIC and Gas company have loans available for improvements.
- Attic insulation rebates from various sources.
- Energy Efficiency audits.

Thank You's!

- PBHeat (Peerless Boilers) and Weil Mclain for use of their diagrams and training illustrations.
- To Frank "Steamhead" Wilsey, Gerry Gill and Steve Pajek, Dan Holahan and everyone at heatinghelp.com, Denny Malloy of Profit Products, Chicago and many others for all the shared information that went into this presentation.

Resources

- Dan Holahan has collected a great amount of information and written many books on steam heating available at heatinghelp.com.

For More Information...

Dave Bunnell

The Steam Whisperer

877 567-7070

www.thesteamwhisperer.net