MANUAL 2100-051

GAS HEAT FUNDAMENTALS AND MAINTENANCE PROCEDURES

REFRIGERATION, HEATING AND AIR CONDITIONING

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THE COMBUSTION PROCESS

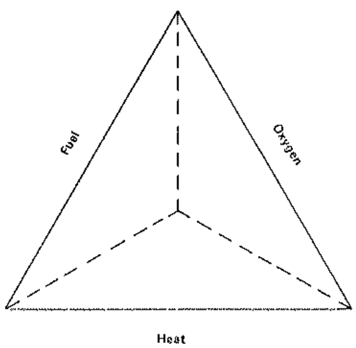
Servicing furnaces that use gas or oil as fuel is dependent upon understanding the combustion process. The shape, appearance and color of the flame tells a great deal about the condition of the components used to ignite and control the fuel. Often, minor adjustments will correct what might become a serious fault. Experience and knowledge gained through observation of different flames and their behavior will make the detection of potential trouble spots and their necessary correction much easier.

In order to produce combustion, three things are required:

1. FUEL — In the warm air heating business, this is normally natural gas, LP (Liquified Petroleum) gas or oil. (No combustion takes place in electric furnaces.)

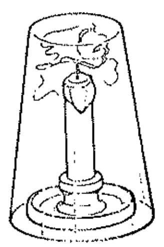
2. HEAT — Enough heat must be supplied to bring the fuel up to its ignition point; the temperature at which it will burn. This heat can be supplied by a previously lit small flame (a pilot) or an electric spark.

3. OXYGEN — The combustion process consumes oxygen which is obtained from the surrounding air or air supplied to the combustion chamber by a small blower.



Combustion Triangle

These three elements make up what is known as the "combustion triangle." All must be present in order to have ignition and a flame. This can be demonstrated by inverting a glass over a lighted candle. The oxygen is consumed and the flame is smothered.



MEASUREMENT OF HEAT
BTU
BRITISH THERMAL UNIT

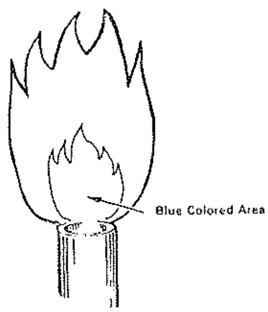
The amount of heat required to raise the temperature of 1 pound of water, 1 degree Fahrenheit.

Fuels are a form of energy. They follow the "Law of Conservation of Energy" which states that energy can neither be created nor destroyed but it can be converted into other forms of energy. When a fuel is burned, it is transformed into two other forms of energy--light and heat. This light and heat is flame.

There are two basic types of furnace flames: a "yellow flame" and a "blue flame." They will be described and illustrated in terms of the light (appearance of the flame) and heat (temperature) produced.

YELLOW FLAMES

The earliest gas burner was the open end of a gas pipe. The flame from this burner was bright yellow. Not only did the flame emit heat, but because of its luminous nature it also gave off light. The burner for this type of flame was commonly called a yellow or luminous flame burner. Examination of the yellow flame reveals a small blue area at the bottom of the flame near the opening (port) of the burner or pipe. The balance of the flame is a bright yellow

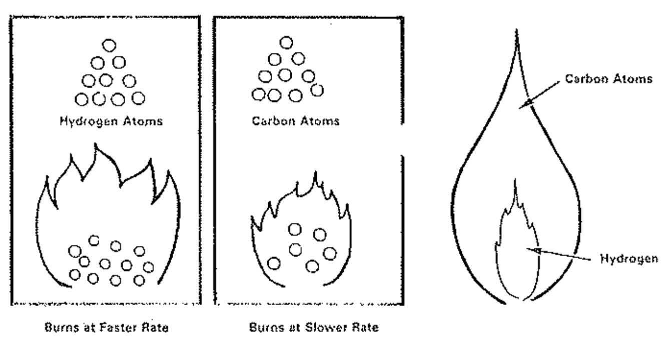


Earliest Burner Was a Pipe

Fuels are hydrocarbons (hydrogen and carbon atoms in varying combinations according to the fuel). When the fuel is ignited, the hydrogen burns with a bluish color. The remaining bright yellow luminous area of the flame is a characteristic of carbon at higher temperatures. The burning hydrogen at the base of the yellow flame heats the carbon particles until they glow and produce a large amount of light. This giving off of light is called *"incandescence."* Since there is no oxygen within the flame, the carbon atoms complete their combustion only at the outer edges of the flame where combustion air is present.

Fuels are grouped according to their heat (Btu) content. When a specific quantity of a fuel is burned, only a certain number of Btu's will be generated. There are heat content values for natural gas, fuel oil, cherry wood or anything that can be used as a fuel.

Hydrogen burns at a fast rate because it combines easily with oxygen in the air. When hydrogen burns, it does not give off a large amount of heat. Carbon will burn at a rather slow rate but it gives off a tremendous amount of heat energy. Consequently, fuels that contain a lot of carbon atoms are also fuels with higher heat content values. The greater amount of carbon present in these fuels means a larger volume of combustion air is going to be needed for complete combostion of the fuel to take place.



HYDROCARBON FUEL

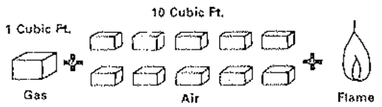
Carbon Content	Fuel		Heat Content Btu's Vol.		Combustion Air
Increasing	1. Natural Gas		1000 Btu/Ft³		10 Ft³
	2. Propane Gas	LP Gas	91,800 Btu/gal.	LP Gas	18 Ft³
	3. Butane Gas		102,000 Btu/gal.		
	4. #2 Fuel Oil		140,000 Btu/gal.		215 Ft³

The table shown above illustrates four fuels. They are listed by increasing carbon content. The chart correspondingly shows heat content values and combustion air requirements. These values assume the fuel is totally burned (complete combustion).

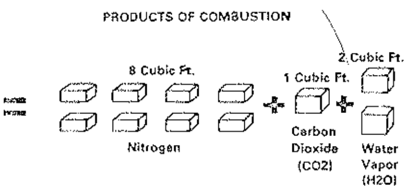
The two types of gas commonly used as a fuel are natural gas and LP. Most LP gas is a combination of Propane, Butane, and Pentane. Products of combustion for LP gas are the same as natural gas, however, they vary in amounts.

For complete combustion, one cubic foot of natural gas requires ten cubic feet of air plus a flame for ignition. The products of combustion then would be one cubic foot of carbon dioxide (CO_2) and two cubic feet of water vapor, with approximately eight cubic feet of nitrogen passing through the reaction unchanged. Air is 80% nitrogen and 20% oxygen, hence, 80% of 10 cubic feet is 8 cubic feet of nitrogen. For complete combustion of LP, one cubic foot of LP gas requires 18 cubic feet of air plus a flame for ignition. These products of combustion would be 2 cubic feet carbon dioxide (CO_2) and 3 cubic feet of water vapor (H_2O), with 14 cubic feet nitrogen passing through the reaction unchanged. Heavier than air, LP is a very dense gas. Leaking LP gas has a tendency to drop to the floor. Because it has little odor and puddles near the floor, it is sometimes difficult to detect.

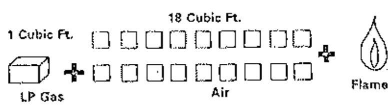
EQUATION FOR NATURAL GAS

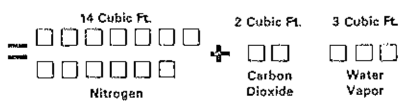


PRODUCTS OF COMBUSTION



EQUATION FOR LP GAS

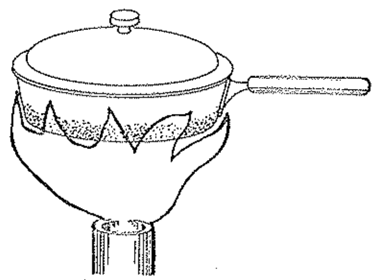




When a gas flame does not receive sufficient oxygen, the gas will not be completely burned (incomplete combustion). Incomplete combustion of gas results in the release of carbon dioxide (CO_2), water vapor (H_2O), aldehydes (acrid in odor and irritating to the eyes, nose and throat), and carbon monoxide (CO). Carbon monoxide is a deadly by-product of incomplete combustion.

Fumes are Deadly

Incomplete combustion occurs when a part of a yellow flame is cooled below its ignition temperature. Impingement on (touching) a cold surface such as the bottom of a cooking pot will cool the flame. When incomplete combustion results from impingement of the yellow flame upon a cool surface, the semi-solid carbon particles contained in the flame are cooled and will not burn completely. The black deposit on the bottom of the pan is called soot. Any time that soot is observed on or in fuel burning furnaces, it indicates incomplete combustion. This is caused by some part of the flame being chilled below its ignition temperature or lack of sufficient oxygen to insure complete combustion.



Incomplete Combustion Forms Carbon (Soot)

Remember that only carbon dioxide and water vapor (plus the nitrogen that passes through the flame unchanged) should be the by-products of combustion. A yellow flame needs a large area in which to burn, therefore its use is restricted. Yellow flame burners are not used on modern gas-fired furnaces.

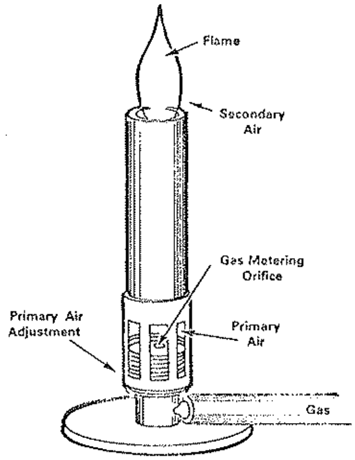
GASES

The following chart shows Btu/cu. ft., specific gravity and pressures of various gases.

Gas	Btu/Cu Ft	Specific Gravity	Pressures
Natural	950 - 1125	0.65	3-1/2" to 4" w. g.
Manufactured	500 - 550	0.45	1" to 2-1/2" w. g.
Mixed	700 - 900	Varies According to Mixture	3" to 3-1/2"
LPG			
Butane	3200	2.01	11" to 14"
Propane	2500	1.52	11" to 14"

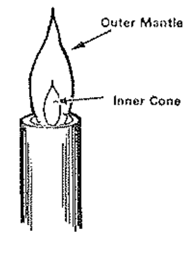
BLUE FLAMES

In 1855, Robert Wilhelm Von Bunsen discovered that an entirely different combustion process resulted when part of the air required for combustion was mixed with the gas before igniting it. So significant was his discovery that the burner he designed was named in his honor and called the Bunsen Burner. Its main operating characteristic is that it mixes part of the air needed for combustion with the gas before ignition. The flame from the Bunsen Burner is altogether different from that of the yellow flame burner. It is blue, much smaller in size, higher in temperature, non-luminous and easily adjustable. Because of the color of the flame, the Bunsen Burner is called a Blue-Flame Burner.



BUNSEN BURNER

The flame produced by the Bunsen Burner consists of several parts, the most prominent being the bright blue inner cone. Around this cone is an outer mantle or shroud, much less brilliant but also blue.

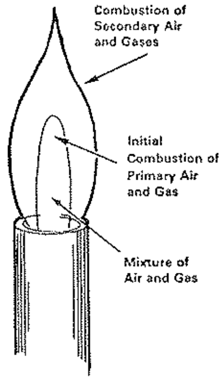


BUNSEN BURNER FLAME

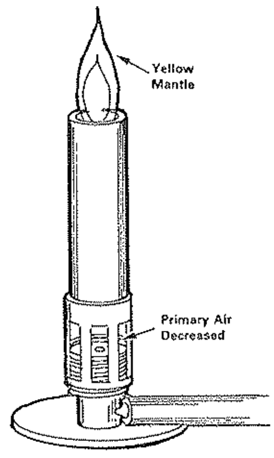
In a laboratory-type Bunsen Burner, gas and air enter the burner tube at the bottom. The air that enters with the gas at the bottom is called PRIMARY AIR. This air can be metered to the burner in controlled amounts by a slide shutt at the base of the burner. Approximately 50% of the air necessary for combustion is mixed with the gas before the mixture is ignited at the burner port. The remainder of the air necessary for combustion is supplied from around the flame and is called SECONDARY AIR.

With the addition of primary air to the combustion process, the resulting blue flame is smaller than a yellow flame. The blue flame is more concentrated (smaller and faster burning) and has a higher temperature than the yellow flame. The amount of heat (Btu's) produced by both flames will be equal if equal amounts of gas are burned.

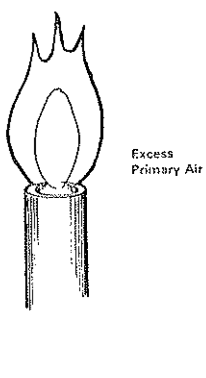
Combustion in a Bunsen Burner flame occurs in two distinct and well-defined zones. Oxygen, contained in the primary air, first combines with gas (hydrocarbons). The initial combustion of this mixture takes place on the extremely thin surface of the bright blue inner cone. The combustion process using primary air takes place only on the surface of the bright blue inner cone. The mixture of air and gas contained inside the bright blue cone is composed of unburned gas and primary air. The combustion process using secondary air takes place on the surface of the outer shroud. There is very little illumination from a blue flame. Absent in a correctly adjusted Bunsen Burner flame are the semi-solid carbon particles that are present in a yellow flame. Because there is enough oxygen present in the primary and secondary air to react with all of the carbon contained in the gas, the carbon remains in a gaseous state throughout the combustion process.



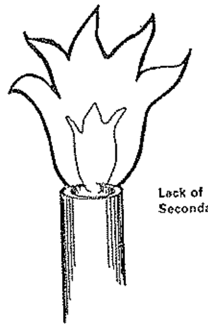
If there is an insufficient amount of primary air to the Bunsen Burner flame, there will not be enough oxygen available to react with all the carbon. Some of the carbon will form semi-solid particles. These carbon particles become incandescent and appear as a yellow tip on the outer cone of the blue flame. Complete restriction of the primary air in a Bunsen Burner will result in a yellow flame as described earlier.



1. EXCESS SUPPLY OF PRIMARY AIR. When this occurs the flame will be distorted and will lift away from the burner port. The flame will make a short blowing noise and could burn itself out.

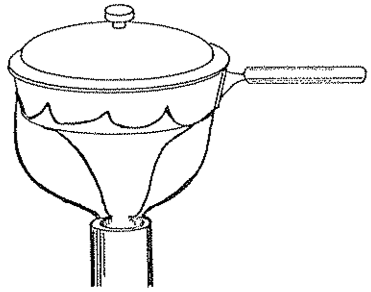


2. LACK OF SECONDARY AIR. Even though the primary air adjustment is providing a sufficient amount of primary air. incomplete combustion will result from a lack of secondary air. This is because the outer shroud does not have enough oxygen to support combustion.



Lack of Secondary Air

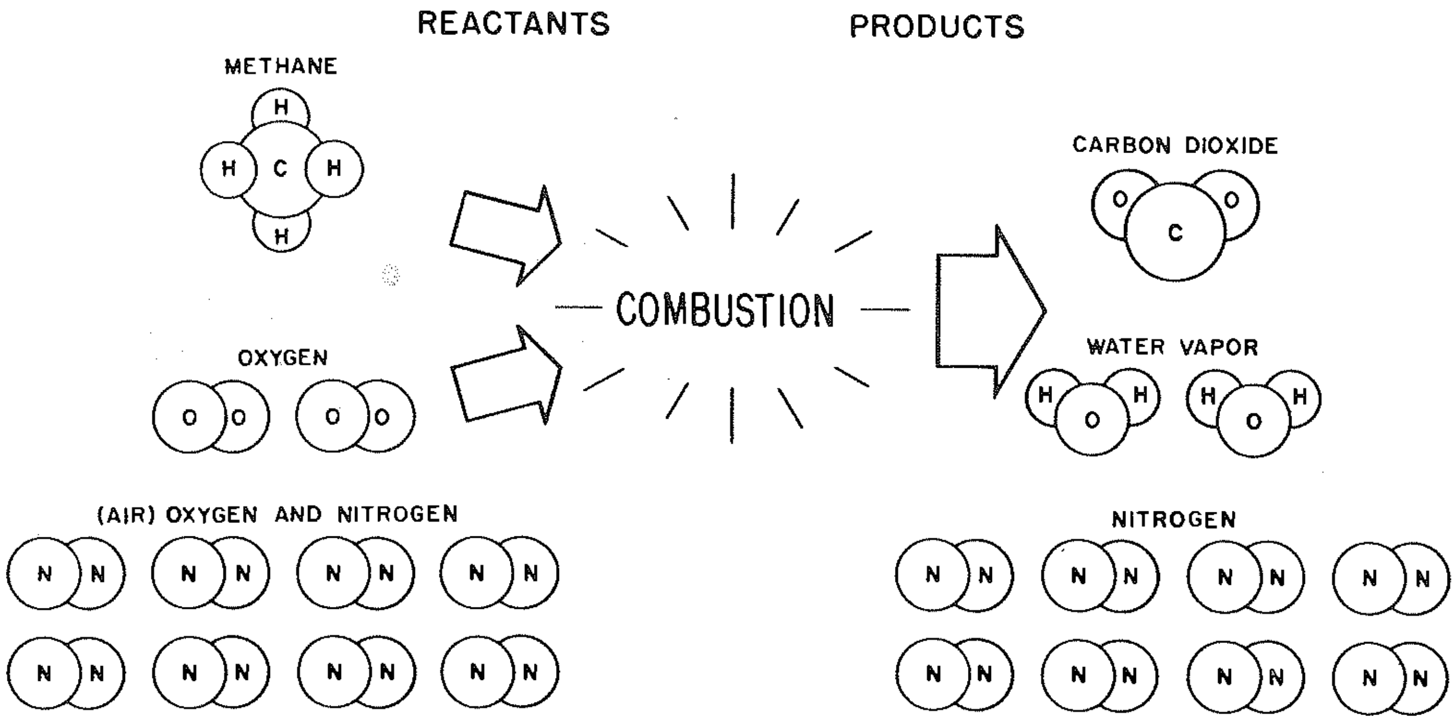
3. INNER CONE IMPINGEMENT ON A COOL SURFACE. If the bright blue inner cone impinges on a surface which is cooler than its ignition temperature, temperature is reduced, removing one of the basic requirements to support combustion--heat.



Blue Inner Cone Impingement "Bad"

Impingement by the outer mantle of a blue flame on a surface cooler than its ignition temperature will not interfere with the combustion process of the fuel. This is because the heat from the inner cone maintains the temperature required for combustion and no semi-solid carbon particles are formed. Soot, aldehydes and carbon monoxide will not be produced by an impinged outer mantle of a blue flame. However, impingement of the blue flame should be avoided because a flame directly hitting a metal creates hot spots. These hot spots can result in weakened areas, sometimes called matal fatigue.

Blue flames are adaptable to many appliances such as stoves, water heaters and gas furnaces.



Combustion of methane and air.

THE PRODUCTS OF INCOMPLETE COMBUSTION ARE AS FOLLOWS:

1. CARBON DIOXIDE (CO_2)
2. WATER VAPOR (H_2O)
3. CARBON MONOXIDE (CO)
4. ALDEHYDES (IRRITATES EYES, NOSE & THROAT)
5. SOOT (UNBURNED CARBON)

THE PRODUCTS OF COMPLETE COMBUSTION ARE AS FOLLOWS:

1. CARBON DIOXIDE (CO_2)
2. WATER VAPOR (H_2O)
3. NITROGEN (THAT PASSES THROUGH THE FLAME UNCHANGED)

AIR FOR COMBUSTION AND VENTILATION

A supply of air is essential to a gas appliance, Figure 1. Proper venting action cannot be maintained unless there is ample air at the draft hood. Normally, the air is supplied by infiltration through cracks around doors and windows. In some instances, especially in new houses of tight construction, it is necessary to provide special means for supplying air to the appliances.

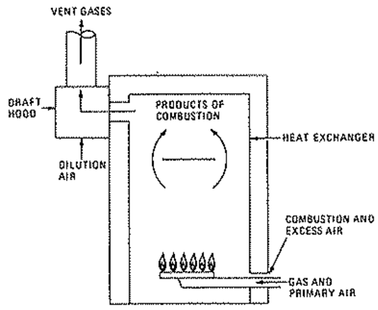


Fig. 1. Typical appliance air supply.

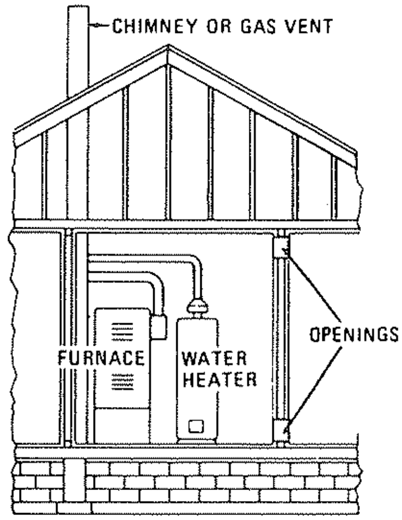
Outside air openings or openings to ventilated areas are required when appliances are enclosed in a special room; in multi-story vent installations where the appliances are separated from living spaces; and in basementless homes where appliances are installed in a closet or small utility rooms.

For each 1,000 Btu of gas burned, there may be up to 30 cubic feet of air required for combustion air, draft hood dilution air and general ventilation of the space occupied by the appliance. Range hoods and exhaust fans further increase the need for air. Supplying the total air requirements for ventilation is as important as the venting system itself.

MAKE-UP AIR to be removed from a dwelling by exhaust fans should not be drawn from the same space that the combustion air for an appliance is drawn. RETURN AIR, which is the air returning for reheating by a forced-air furnace after circulating through a house, should be isolated from the combustion air space as well. If not, in either of these two cases, the possible lowering of pressure in the combustion air space can cause the appliance draft to be disturbed.

CONFINED SPACES

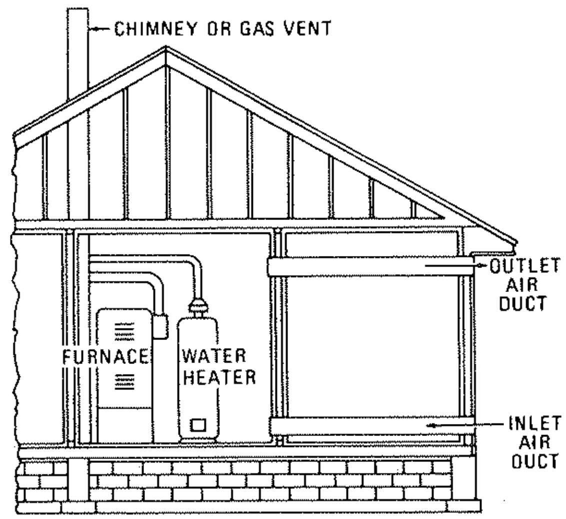
A room in which appliances are installed must be considered as confined regardless of size if a source of air supply is not directly available. Figures 2, 3, 4, 5 and 6 represent different methods of supplying air to different situations of a confined space. The sizing and location recommendations shown in the figures are based on information contained in NFPA No. 54.



NOTE: Each opening shall have a free area of not less than one square inch per 1,000 Btu per hour of the total input rating of all appliances in the enclosure.

Fig. 2. Providing all ventilation air from inside building.

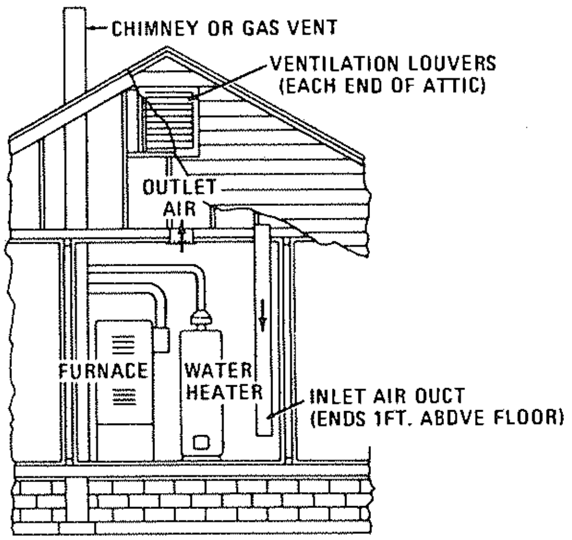
Of the two ventilating air openings shown in Figures 2 to 6, one opening should be located within 12 inches of the floor and the other within 12 inches of the ceiling. Even for short appliances, the space between the louvered areas should never be less than 3-1/2 feet. If connected with ducts, the cross-section area of the duct shall not be less than the free area of the louvered area.



NOTE: Each air duct opening shall have a free area of not less than one square inch per 2,000 Btu per hour of the total input rating of all appliances in the enclosure.*

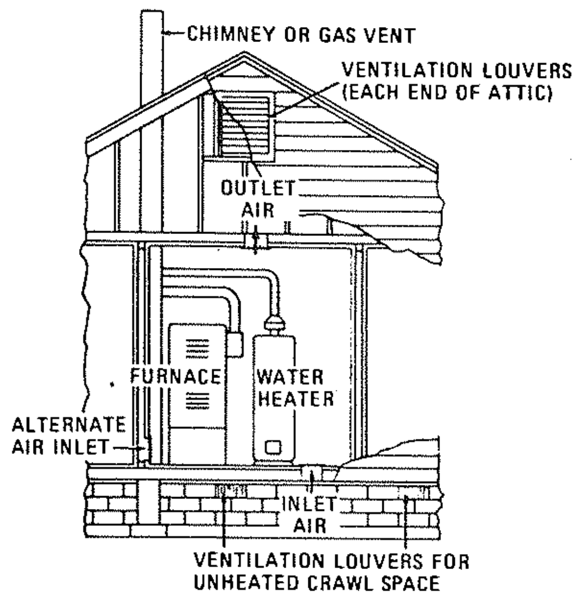
**If the appliance room is located against an outside wall and the air openings communicate directly with the outdoors, each opening shall have a free area of not less than one square inch per 4,000 Btu per hour of the total input rating of all appliances in the enclosure.*

Fig. 3. Providing all ventilation air from outdoors.



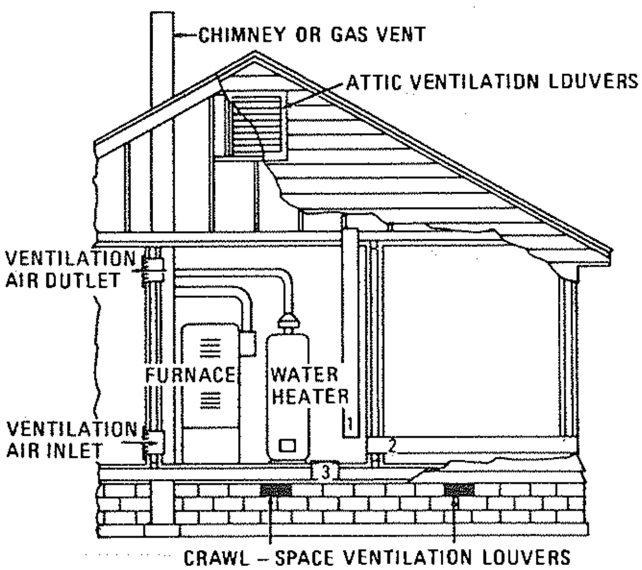
NOTE: The inlet and outlet air openings shall each have a free area of not less than one square inch per 4,000 Btu per hour of the total input rating of all appliances in the enclosure.

Fig. 4. Providing ventilation air from ventilated attic.



NOTE: The inlet and outlet air openings shall each have a free area of not less than one square inch per 4,000 Btu per hour of the total input rating of all appliances in the enclosure.

Fig. 5. Providing ventilation air from crawl space with air outlet into attic.



NOTE: Ducts used for make-up air may be connected to the cold air return of the heating system only if they connect directly to outdoor air.

Attic Ventilation Louvers shall be installed at each end of attic with alternate air inlet No. 1.

1, 2, and 3 mark alternate locations for air from outdoors. Free area shall be not less than 1 square inch per 4,000 Btu per hour of the total input rating of all appliances in the enclosure.

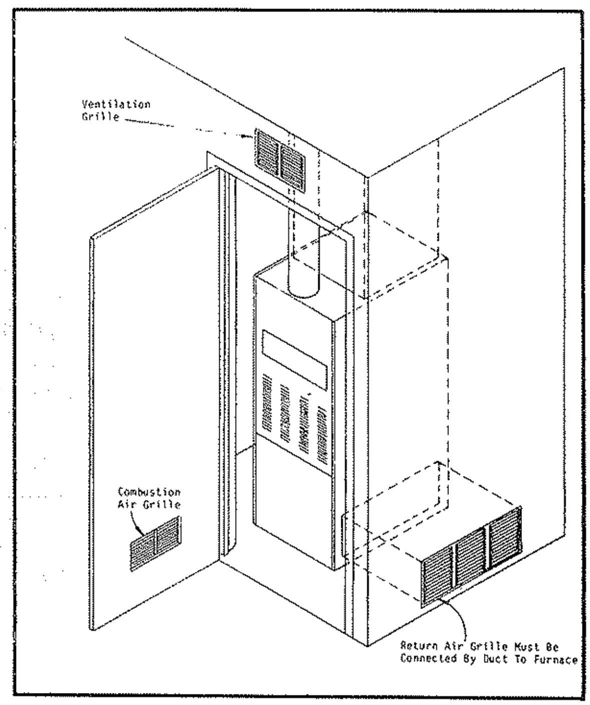
Crawl-Space Ventilation Louvers for unheated crawl space shall be installed with alternate air inlet No. 3.

Each Ventilation Air Opening from inside the building shall have a free area of not less than 1 square inch per 1,000 Btu per hour of the total input rating of all appliances in the enclosure.

Fig. 6. Providing ventilation air from inside; dilution air from outside.

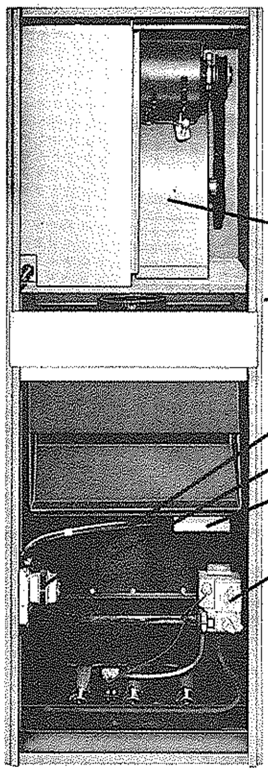
CAUTION: WHEN A FURNACE IS INSTALLED IN A CLOSET OR UTILITY ROOM, NEVER USE THIS ROOM AS A RETURN AIR PLENUM.

FIG. 7 — FURNACE LOCATED IN CONFINED SPACE



BASIC GAS HEATING UNITS

In this next section, the student will be exposed to the basic component parts of a gas fired heating unit. Below you will see a gas fired furnace that has been "cutaway" to reveal the basic component parts. These components will be discussed individually and in relation to the whole unit.



TYPICAL DOWNFLOW GAS FIRED FURNACE

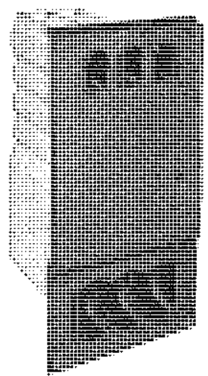
DESIGN OF HEAT EXCHANGERS

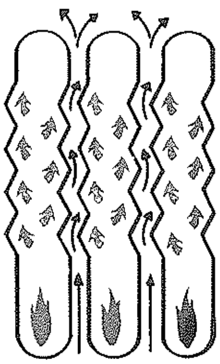
In a gas furnace combustion takes place inside a heat exchanger. Air passing over the outside surfaces of the heat exchanger absorbs heat from the flame. Most heat exchangers are usually made of cold rolled steel, although some are made of cast iron. Sometimes a heat exchanger will have a vitreous enamel coat to protect it from toxic elements in the air. The water vapor that is a product of combustion can chemically react with these elements producing acids that attack and corrode the metal. Halogenated propellants in aerosol cans are an example of this. The shape of a heat exchanger is designed so that in normal operation, expansion and contraction of the metal will not cause fatigue of the steel, which could result in a rupture or crack.

Oblique design of the exchanger tubes causes the hot gases inside the heat exchanger to turbinate, changing direction and velocity seven times, providing faster and more efficient heat transfer to system air.

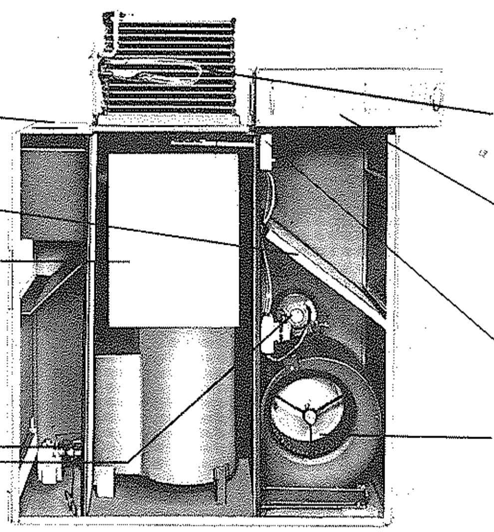
Dovetailing and scientifically spacing of exchanger tubes assures maximum delivery of conditioned air to living spaces, summer or winter.

HEAT EXCHANGER construction is of heavy gauge steel die formed tube sections, all of which are welded to form a safe, gas-tight, one-piece assembly.





LO-BOY



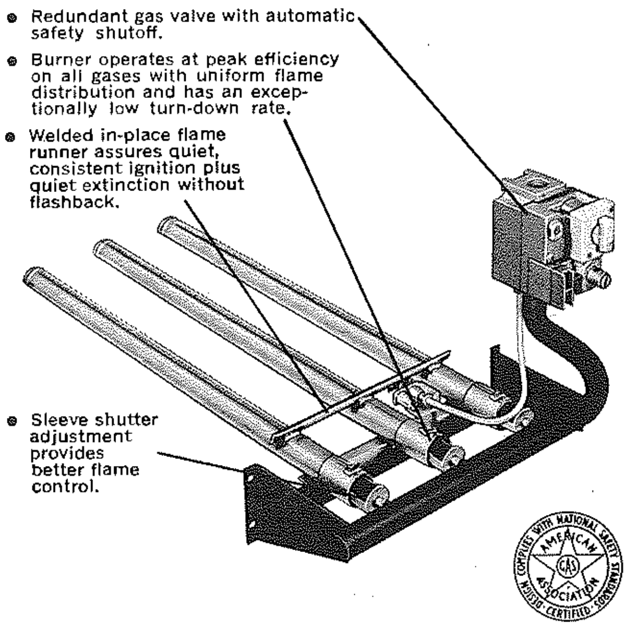
Model G152

The heat exchanger is usually divided into several sections (clam shells) to gain more heating surface. At the bottom of the heat exchanger is a cavity designed to accept burners. As the gas is burned in the heat exchanger, the products of combustion go up through the inside shell, collect at the top and are directed toward the vent. Air from the conditioned space is circulated over the heat exchanger. As it wipes across the surface, it is heated and delivered back to the conditioned space to warm the room. Most gas furnaces are designed to have somewhere between 45 and 100 degree temperature rise of the air that crosses the heat exchanger. If air enters the furnace at approximately 69 degrees F. it could leave the furnace at approximately 160 degrees F.

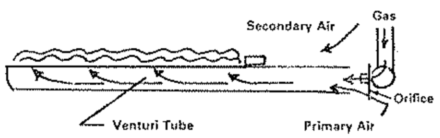
DESIGN OF BURNERS

As was noted, gas burners fit into the cavity at the bottom of the heat exchanger. The number of burners will vary according to the size of the furnace. There are many different styles and shapes of burners. The burner pictured has one row of continuous ports and is called an atmospheric gas burner. A mixture of both air and gas enters the burner, mixes and is ignited on the surface of the ports.

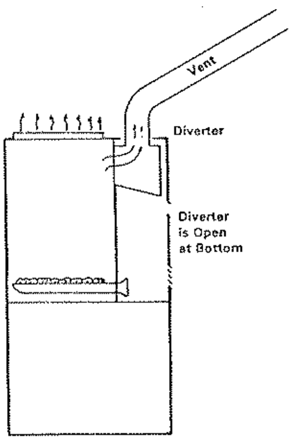
QUIET, EFFICIENT JET TUBE BURNER



In order to burn gas completely, it is necessary to supply primary air and secondary air. Primary air is that air which is sucked into the venturi tube (see drawing) as a result of the aspirating (suction) of the jet of gas as it shoots across through the throat of the venturi (see drawing). None of the normal atmospheric type gas burners get sufficient primary air for complete combustion. Some additional air is needed. Secondary air is that additional air needed for combustion which comes in around the outside of the burner and joins with the gases at or near the burner ports. The primary air is mixed thoroughly with the gas inside the burner head, so the gas-air mix that is delivered out the ports is well mixed. Primary air starts moving into the burner the instant the gas is turned on. Secondary air is brought in by draft through the heat exchanger.



Draft is the movement of air and combustion by products through the heat exchanger and up and out the chimney. It is not fully established in a gas furnace until the heat exchanger gets hot. In a gas furnace there is a back draft diverter which completely breaks chimney draft at the vent outlet from the furnace (see drawing). The draft in a gas furnace is the function of the chimney temperature.

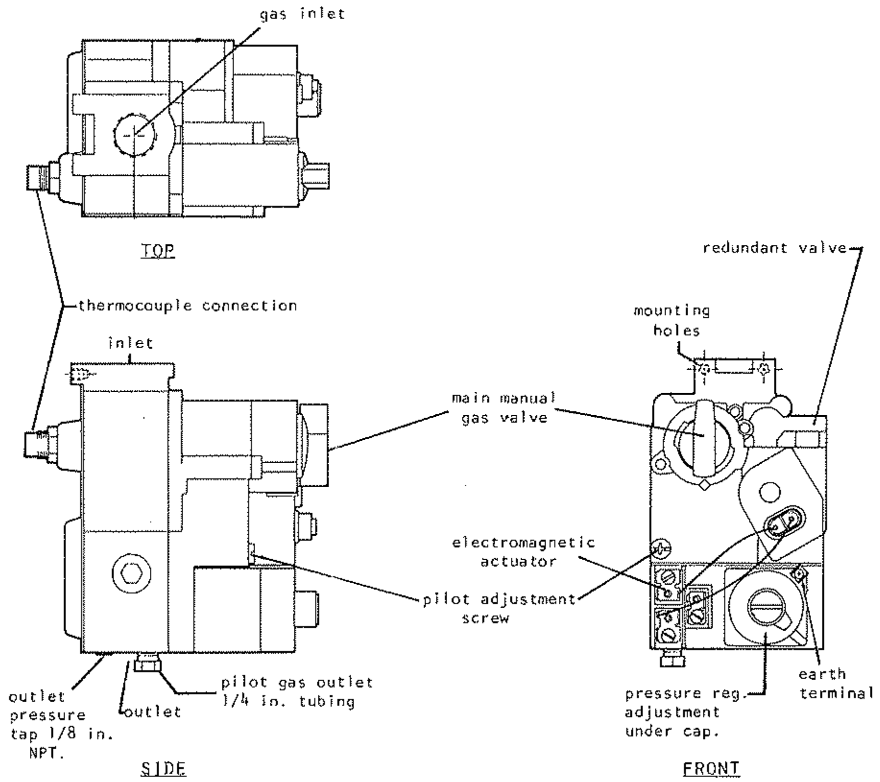


The above has been a description for those furnaces using natural gas. There are slight changes to adapt a furnace to use LP gas. This will primarily be in the orifice size. Kits are available to make this kind of changeover.

MAIN GAS VALVE

Most modern furnaces today use a COMBINATION GAS VALVE and pressure regulator but at this point only the main gas valve portion will be described. The function of the main gas valve is to control the flow of gas into the burners of the furnace. The gas pressure is regulated by the regulator in the valve. The automatic valve is opened and closed by the thermostat to allow gas to flow into the burners.

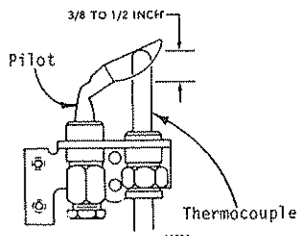
The valve contains a valve disc which seats on a valve seat and this is attached to an iron core plunger which is spring loaded to keep the valve disc on the valve seat. A coil with insulated wire is wound into a cylinder shape and placed at the end of the valve plunger. When current is applied to this coil, there is a magnetic field created inside of the coil which attracts the iron core plunger, overcoming the spring tension and lifting the plunger upward into the magnetic field. This action lifts the valve disc off the valve seat allowing gas to flow to the burners. When the holding coil is de-energized electrically and there is no further magnetic field, the spring forces the plunger down, sealing the valve disc to the valve seat. This effectively stops the gas flow to the burners and shuts them off.



—VR800 DUAL AUTOMATIC VALVE COMBINATION GAS CONTROL—

DESIGN OF PILOT BURNERS

A pilot flame which burns constantly is used to ignite the flame on the main burners. A pilot is nothing more than a miniature gas burner. It also uses primary and secondary air for combustion. In order for one pilot to ignite several burners, a cross-over igniter is used. This is nothing more than a piece of metal used as a bridge between the burners. As gas comes out of the main burners, a portion of it flows through the slot of the igniter until it comes in contact with the pilot light. The alignment of the cross-over igniter is critical. A mispositioned burner can cause noisy, delayed ignition.

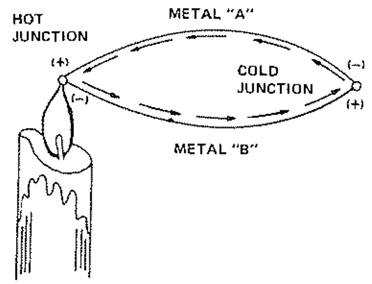


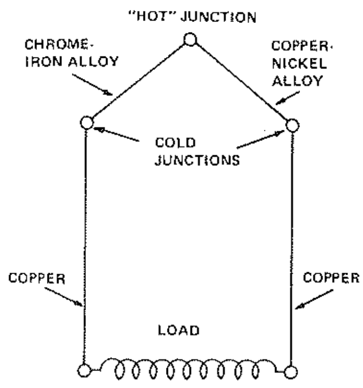
PILOT BURNER FLAME SHOULD ENVELOP 3/8 TO 1/2 INCH OF THERMOCOUPLE OR THERMOPILE TIP.

If for some reason the pilot light was extinguished and the burner ignition could not take place, raw gas could collect in the furnace to the extent that it would cause an explosion if and when it was finally ignited. Therefore there must be a means of detecting when the pilot light is or is not lighted. This is accomplished by means of a thermocouple which is installed so the pilot flame constantly keeps the end of the thermocouple hot. Heat from the pilot flame on the thermocouple actually generates a minute amount of electricity measured in millivolts. This small amount of electricity is enough to hold open a small pilot valve which permits the gas to enter the burners. If the pilot flame goes out, the pilot valve closes stopping the flow of gas to the burners. The electrical operation of this safety device will be discussed later.

PILOT SAFETY DEVICE CIRCUIT

The ignition pilot is installed near the burners in the heating unit for the purpose of providing a safe means of igniting the gas at the burners. The ignition pilot is constantly supplied gas from the combination gas valve and once lit, should be on all the time. It is obvious that it is absolutely necessary that the pilot light be on before the main burners are fed gas from the main gas valve. This is accomplished by the PILOT SAFETY DEVICE CIRCUIT which is a millivoltage power supply. Therefore the other very important function of the standing ignition pilot flame is to produce heat energy that is converted into a very small amount of electrical energy. The device used to make this conversion is called a THERMOCOUPLE.



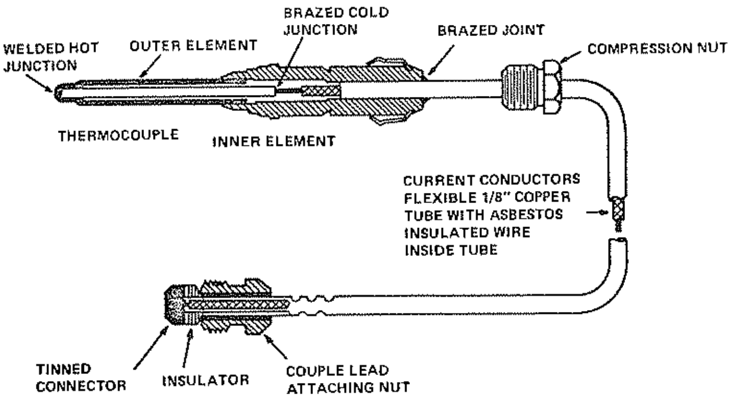


THERMOCOUPLE

The thermocouple is made by two wires of dissimilar metal that are welded together at their ends, making "junctions." By heating only one of the junctions with a flame while the other junction remains cool, a very small electric voltage is generated and a small current will flow through the connected wires (conductors).

The junction that is heated is the "Hot-Junction" and the other junction is the "Cold-Junction." The amount of voltage generated by the thermocouple depends on the TEMPERATURE DIFFERENCE between the "Hot" and "Cold" junctions, and will vary as the temperature difference varies.

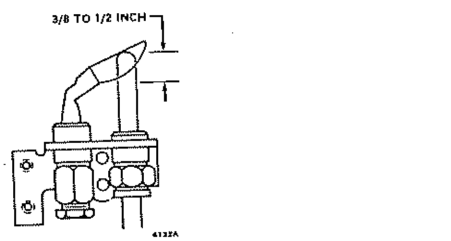
Note that the cold-junctions are connected to a load by conductors, thus we have a "Complete Electrical Circuit" (a source of electrical energy; a conductor from source to load; a conductor from load back to the source). The thermocouple converts "heat" energy into "electrical" energy in millivolts. "Milli" means one-thousandth (1/1000). Millivolt means 1/1000 of one volt, i.e., 3 millivolts = 3/1000 = .003 volts.



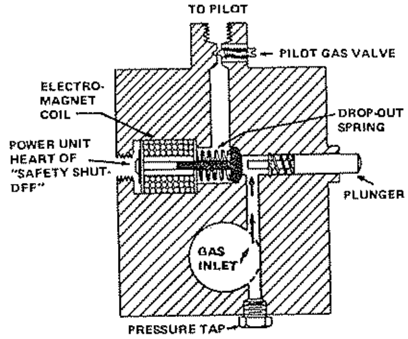
THERMOCOUPLE (Cutaway)

Refer to thermocouple electrical drawing and note the parts that make up the thermocouple. Metals "A" and "B" are welded together forming the hot-junction. The "Inner-Conductor" is a wire that leads to one side of the load-connection end of the thermocouple. Over the entire length of the inner-conductor is an insulator. Its purpose is to keep the inner and outer conductors separated (prevents short-circuiting). The "Outer-Conductor" in the form of a tube that surrounds the insulation and inner-conductor, it too leads to the remaining side of the load-connection end of the thermocouple.

In order for the thermocouple to properly generate electricity the pilot flame must envelop the "hot-junction tip" from 3/8" to 1/2". When the pilot flame is not burning or is misapplied, the generation of electricity will be insufficient or will stop. By electrically connecting the load-connection end of the thermocouple to an electro-magnet (similar to that used to operate the automatic main gas valve) which is powered by millivoltage, an automatic main gas valve can be "opened" and "closed." This automatic gas valve is the safety shut-off mechanism of the combination gas valve.

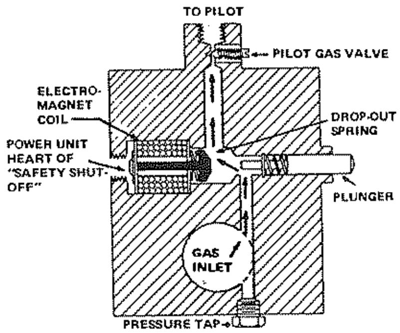


The drawing shows the safety shut-off in the "closed" position. The safety is located upstream of the automatic main gas valve. When the electro-magnet is de-energized, the closing-spring forces the valve disc to "seat," preventing gas flow into the remainder of the combination gas valve parts.



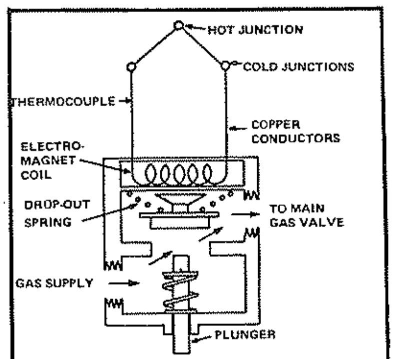
GAS VALVE "SAFETY" (CLOSED)

The electro-magnet is energized which means that it is "safe" to let gas flow to the burners in that the pilot flame is burning properly. Therefore the gas will be safely ignited. In order to light the pilot, push in and hold down the depression plunger while igniting the pilot flame with match. Continue to hold down the plunger until the thermocouple hot-junction generates sufficient millivoltage, the safety will be held open. Release depression plunger and the electro-magnet will hold the valve "open."



The electric main gas valve cannot be opened unless the gas pilot is lit and the flame sufficient to light the main burner. The pilot sensor or thermocouple proves both the existence of the pilot flame and its size.

Bard provides 100% safety shut-off on both their natural and LP gas furnaces. Liquified Petroleum gas (LP) requires 100% safety shut-off and even though it is not required by code on natural gas units, Bard believes it is an extra safety feature. On an LP unit, when the pilot flame goes out the pilot valve must close, preventing any pilot gas from entering the heat exchanger. The reason is that LP gas is heavier than air and unlike natural gas, will not dissipate up the flue. Instead it will puddle in the bottom of the heat exchanger causing a hazardous condition when an attempt to relight the pilot is made.



PILOT SAFETY VALVE

ELECTRONIC PILOT IGNITION SYSTEMS

The electronic pilot ignition system (sometimes called an intermittent ignition device) is designed for use in standard residential-sized gas furnaces. This system has several energy conservation features. Gas is saved because the electronic pilot ignition eliminates the continuous pilot burner flame. The pilot flame is ignited by electric spark and burns only when there is a call for heat. This ignition system also ranks high in convenience and reliability. If the pilot flame should be blown out, the pilot will automatically relight if the call for heat still exists.

Standard intermittent ignition system components include the Intermittent Pilot Module and Intermittent Pilot Dual Valve Combination Gas Control.

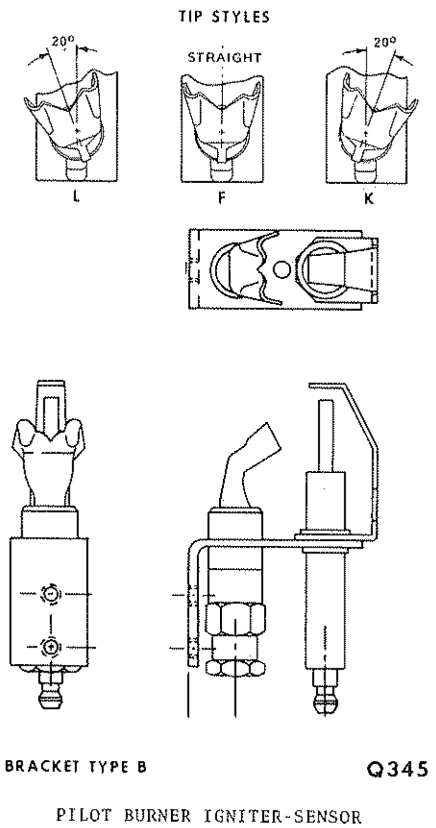
INTERMITTENT PILOT CONTROL MODULE

The control module contains the electronic components of the system, and also serves as a central wiring panel for the external controls. When powered by a 24V, 50/60 Hz transformer and controlled by a suitable thermostat or controller, it performs the following functions.

1. Performs a safe-start check by checking for a false flame condition on startup.
2. Generates a potential of 30,000 V (open circuit) for spark ignition of the pilot burner.
3. Opens the pilot valve.
4. Discontinues ignition spark when the pilot flame is established. The control module provides safety lockout if the pilot fails to ignite within the pilot flame-establishing period.
5. After proof-of-pilot flame, opens the main valve.
6. On a power loss, shuts down. When power is restored, it will begin a new startup.
7. On a loss of flame, the main gas is shut off and starts trial for pilot ignition.

PILOT BURNER IGNITER-SENSOR

The Pilot Burner Igniter-Sensors consist of a pilot burner, ceramic insulator, combination spark electrode/flame rod, and a ground strap. Flame sensing and pilot ignition functions use a single rod. The ground strap extends over the tip of the insulated rod, forming the spark gap. The end of the rod is positioned in the pilot flame, with the pilot burner target and ground strap serving as the ground area.



PILOT BURNER IGNITER-SENSOR

When the burner is lit, the flame is detected through the principle of flame rectification. Flame rectification is a process of converting alternating current (ac) into direct current (dc). A voltage is applied to the flame rod. When the burner ignites, the gas molecules between the flame rod and ground become ionized, and are able to conduct an electrical current.

Current through the flame flows mostly in one direction because of the size difference between the electrode and ground areas. The overall result is a pulsating direct current. The flame monitoring circuit in the module will only respond to this dc current to prove the presence of the flame.

FUNCTIONS AND OPERATION

The control module performs the following basic functions. Opening and closing the first (pilot) operator, providing a spark for igniting the pilot, sensing the pilot flame, shutting off the spark, and opening and closing the second (main) operator. These functions occur in 2 stages.

FIRST STAGE—TRIAL FOR PILOT IGNITION

On every call for heat (system start), the module performs an internal safe start check. A system start is prevented if the check shows that a flame simulating condition is present.

During a normal start, the module opens the first operator in the gas control. This allows gas to flow to the pilot burner. Simultaneously, the electronic spark generator in the module produces a 30,000 volt spark pulse output (open circuit). This voltage produces a spark at the pilot burner igniter-sensor rod, igniting the gas flowing around the electrode.

If the pilot flame is not detected during the trial for pilot ignition, the module will continue trying for pilot ignition until a flame is established. The module contains a safety lockout timer to limit the trial for pilot ignition period.

SECOND STAGE—MAIN BURNER OPERATION

When the pilot flame is established, a flame rectification circuit is completed to the burner ground. The module flame sensing circuit detects the flame current and shuts the spark generator off. At the same time the second operator (main) is opened in the gas control, allowing gas flow to the main burner. The pilot flame ignites the main burner conventionally. On the module, the flame current also holds the safety lockout timer in the reset, or normal, operating condition.

SAFETY LOCKOUT TIMER

The safety lockout timer circuit starts timing the moment the trial for pilot ignition starts. When the timing period runs out, the trial for pilot ignition ends, and the control module goes into lockout.

Before another attempt to start can be made, the module must be reset. Reset by adjusting the thermostat or controller below room temperature, or to its OFF position. An alternate method is to shut the system power OFF. Wait at least one minute, then turn the system ON. If normal ignition does not occur, use the troubleshooting table to determine the problem.

AUTOMATIC VENT DAMPER

The quick reacting means of electronically proving the pilot makes an automatic vent damper well suited to the heating system. The automatic vent damper is an energy conserving device designed to reduce the loss of heat up the vent. The damper automatically opens to expell combustible products when the furnace is on and closes to block heat loss when the furnace is off. The automatic damper is for application on AGA certified gas units only.

The automatic vent damper consists of a damper actuator unit and a damper assembly. The damper assembly is mounted in the furnace vent pipe. The actuator is attached to the damper assembly. An interlocking plug electrically connects the damper actuator to the electronic pilot control inside the furnace.

NOTE: If a common vent serves both the gas furnace and a gas water heater, the damper must be installed upstream from where the water heater vent connects to the common vent. The damper must never block the venting of the water heater.

FEATURES OF THE BARD AUTOMATIC VENT DAMPER

Construction is all stainless steel with extra large bearings for the shaft assembly.

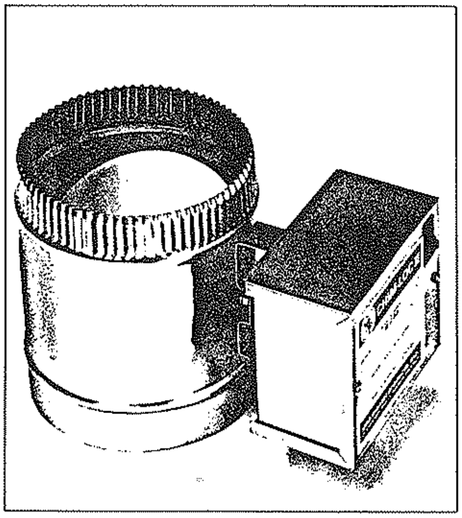
The motor assembly is rated at 1,000,000 cycles rather than 100,000 like many parts are. It is also easily replaceable should it ever be necessary.

The motor/gear train assembly are of a clutch type design and cannot be ruined if the damper blade is moved by hand—in either direction—fast or slow.

The motor operates in 90° segments, rotating in one direction only. The only time the gas valve circuit can be powered is when the damper blade is in the full open position. If the blade is more than 6° off of full open, the blade must travel to the next full open position before the gas valve can operate again.

There is also a proving circuit built into the motor assembly that requires the wiring to the gas valve be connected or the damper will not operate.

A lighted, two position rocker switch is mounted on the control box. With the switch in the "on" position, the switch is lighted (green in color) signifying that power is present and damper is ready to operate on command from the wall thermostat. A secondary feature of the switch is that in the "off" position, it serves as a standby device. Even if turned off when the damper blade is in the closed position, on the first call for heat from the thermostat, the damper will drive to the open position and stop, allowing the gas valve to operate. However, now the damper stays in the open position, allowing gas valve to cycle on demand from the wall stat. This could be utilized by the person who goes away for long periods of time during the heating season and is going to set his thermostat way low anyhow.



AUTOMATIC VENT DAMPER

The GMP damper is not spring loaded and does not automatically assume the open position in the event of a power outage. If there is an outage, the damper remains at whatever position it was at time of outage. There is no safety problem involved here since the furnace cannot operate with the power off and the damper has to assume the open position where power is restored before the gas valve can operate.

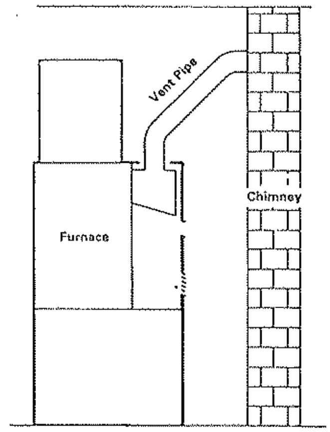
The 4 and 5 inch sizes have a solid blade, while the 6 inch has two one inch holes and the 7 inch has three one inch holes in it. Steel snap plugs are enclosed and can be inserted into the one inch holes for all dual solenoid (redundant) gas valves. It is important to understand here that the openings are not required for standing pilot applications.

To recap this item, all damper sizes (with holes plugged on 6 and 7 inch sizes) are suitable for use with current production electric ignition and standing pilot furnaces. There is sufficient leakage around the blade for venting of combustion products from a standing pilot.

ALL dampers are put through a ten cycle complete functional check at the manufacturers before shipment to Bard and we 100% test each damper upon receipt before placing in our finished goods inventory for shipment to our customers.

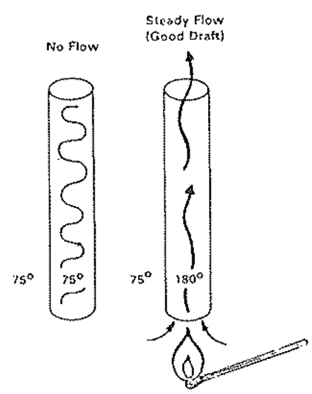
CHIMNEYS AND VENTS

Gas and oil fired furnaces rely on the combustion or burning of their fuels to generate usable heat. In the process they also produce wastes in the form of vent gases. The bulk of these waste gases are carbon dioxide (CO_2), water vapor, excess air and a small amount of other elements. In the case of improper or incomplete combustion these gases may also include carbon monoxide (CO), aldehydes and soot, which are very dangerous to the health of the homeowner.



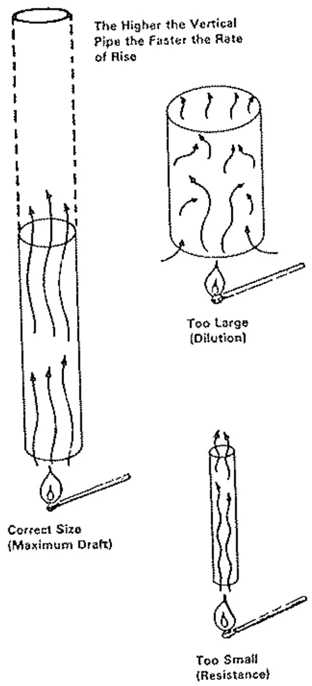
Proper venting of these gases to the outdoors is an extremely important part of a heating system. This venting is done through a chimney which leads from the furnace area vertically through the roof. A metal vent pipe is used to connect the furnace to the chimney (see drawing).

Vent gases are not "forced" out through the vent pipe and chimney but are "drawn" out. The chimney does this by producing a suction or drawing action called "draft."



The principle of creating draft is desired by the device illustrated. When no heat is applied to the air or gas the temperature both in and around the pipe are the same and no movement occurs. However, when a fire is lit it heats the air around it. This heated air expands in volume and becomes lighter in weight or less dense. By virtue of this lighter weight the warm air rises.

When confined within a vertical pipe the warm air cannot mix with the surrounding air and cool down. Within the pipe it retains its heat and therefore rises at a faster rate. In the process of rising it drags fresh air in behind it to replace it. As this new air is in turn heated the process is continued and a constant flow of air moves through the pipe as long as heat is applied.



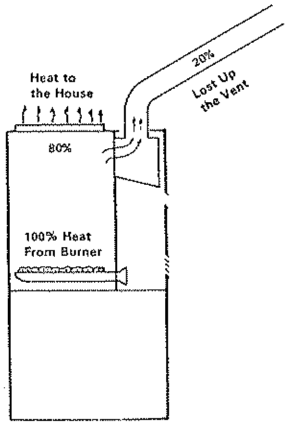
The volume of gas the chimney will move and the amount of draft it will create depends on two factors. One is the temperature of the vent gas. The second is the diameter and height of the chimney. A chimney which is too small or too short or vent gas temperatures which are too low result in poor draft. Increasing the temperature of the gas or the height of the chimney causes a higher draft. The diameter of the chimney or vent pipe is important because of friction. If they are too small, they will restrict the flow of gases by creating too much resistance to it.

The concept of draft is essential for the proper operation of an atmospheric burner. Draft allows the products of combustion to be removed safely, but more importantly, draft provides the availability of oxygen for combustion.

A residential gas furnace depends on its combustion air from the chimney effect created by its own heat exchanger. In effect, the heat exchanger is a small chimney in itself. It is factory designed to match the burner and to provide just the right amount of draft to draw the correct amount of combustion air into the burner.

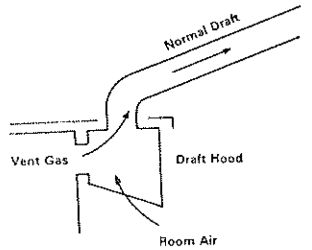
To prevent the chimney draft from upsetting the fine balance between the heat exchanger and gas burner a relief device is used between the furnace and the vent. It is usually designed and built in as a part of the furnace. It is called a "draft hood" or "diverter."

The draft hood is a form of box which is open at the bottom. Vent gases from the furnace pass into one side of this box. The vent pipe may be connected either to the opposite side or top of the box depending on its design. There also may be baffles designed into the box.

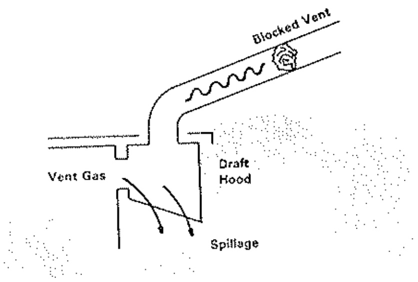


Not all of the heat produced by the furnace burner is used to heat the building. A part of it goes up the vent in the form of vent gas, which is necessary to maintain draft. Seventy-five to eighty percent of this heat is transferred by the heat exchanger to the indoor air. The other twenty to twenty-five percent is vented out through the vent and chimney along with the combustion gases. This amount of heat is referred to as the flue loss or stack loss.

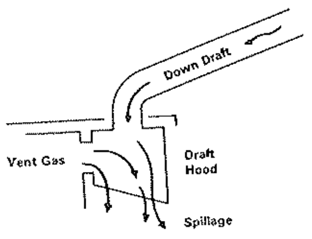
Normally the hot vent gases from the furnace pass into the draft hood and then into the vent pipe without any spilling out the bottom opening. This is because the hot gases stay toward the top of the draft hood and are removed by the draw from the vent pipe and chimney. Since the chimney draft is greater than required to remove the vent gases, additional air from the furnace room is drawn into the bottom opening and passes up the vent along with the gases.



Sometimes things will go wrong which upset the chimney draft. The result may be not enough draft to remove the vent gases due to a restriction, a downdraft in the chimney which reverses its flow or a blocked chimney which prevents any flow. When these things occur the draft hood acts as a relief valve.



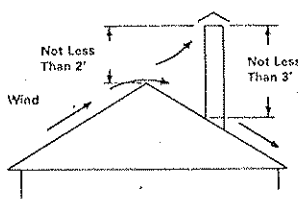
Since the vent gases are prevented from going up the chimney they have someplace else to go--out the bottom opening in the draft hood. This relief prevents combustion from being upset in the furnace. In the case of downdraft in the vent, the draft hood also provides a relief for air and gases coming down the chimney so that combustion at the burner isn't upset. Whenever gases are discharged from the bottom opening in the draft hood, it is referred to as "spillage."

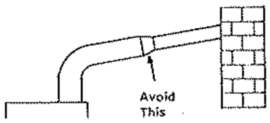


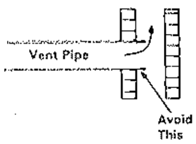
When spillage occurs then the vent gases are discharged in to the house. The result is that all of the water vapors from combustion pass into the house causing high humidity. If combustion is complete the relatively harmless CO_2 also passes into the house. However, if combustion is not complete, the vent gases will also contain carbon monoxide (CO). When these are introduced into the house an extremely dangerous condition is caused which can be fatal if not corrected. FOR THIS REASON THE CAUSE FOR SPILLAGE MUST BE FOUND AND IMMEDIATELY CORRECTED.

Good installation and maintenance are both important to proper operation of the vent system. The following points should be taken into consideration in the design and installation of a heating system:

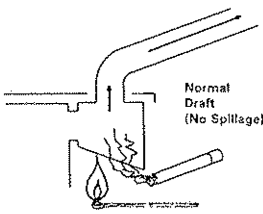
1. The top of the chimney must extend at least two feet above the highest point of the roof. This is to prevent downdrafts caused by wind moving across the roof.
2. The chimney top must also be at least three feet higher than the point at which it passes through the roof.
3. The connecting vent pipe between the furnace and chimney must not be smaller than the furnace vent collar at any point through its entire length.
4. Where the vent pipe enters the chimney it must not extend beyond the inner face or liner of the chimney.

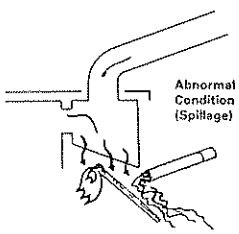






Detection of spillage from the draft hood is one of the quickest and easiest tests to make. The presence of vent gas odor and high humidity point toward spillage. It can be checked by putting smoke or a flame from a match or lighter near the bottom of the draft hood. If these are drawn upward into the draft hood, then no spillage is occurring. If the smoke or flame are forced downward away from the opening, then spillage is taking place.





It should be noted here that a momentary spillage is not cause for alarm. It usually happens when wind conditions outside cause a gust which momentarily reverses the chimney.

Sometimes the source of the problem in a vent system is created by a fault outside the system itself. One of the most common is low or negative air pressure in the furnace area. In this case the pressure is lower than atmospheric pressure outdoors. Negative pressure is a potential problem anytime a furnace is enclosed in a utility room or closet. Provisions must be made for combustion air in these areas. Combustion air considerations are explained in the points below. This lower pressure can cause a reverse suction which works against the chimney draft. It can be sufficient to cause draft hood spillage.

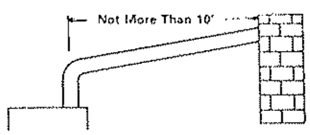
Possible causes for this low pressure and corrective actions are:

1. Door left off the furnace blower compartment. This causes a negative pressure from the suction side of the blower. In fact vent gases resulting from spillage are sucked into the blower, mixed with the circulating air and distributed throughout the house. KEEP THIS DOOR IN PLACE WHENEVER THE FURNACE IS IN OPERATION!!
2. Power vents and exhausts in the vicinity of the furnace. These may be an exhaust fan in a nearby window, a range hood exhaust or the exhaust from a clothes drier near the furnace. Normally these won't cause a problem in a large area but if the furnace room area is small and enclosed, they can. In this case, openings into the furnace room need to be added and be large enough for air to enter the room to equalize the pressure. These openings must be such that they cannot be accidentally blocked or closed. Even a sign to this effect is recommended.
3. The vent system itself draws air from the furnace room and can create a low pressure which can affect the draft and combustion. Therefore equalizing openings such as described above are essential for combustion and proper flue performance.

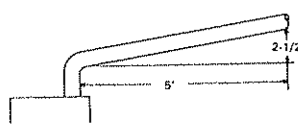
Most often normal infiltration of air into the furnace area is sufficient. However, if the vent is not drawing properly, then additional openings may be required from other areas within the building or even to the outdoors. Assuring adequate combustion air is of utmost importance for any installation.

NOTE: Whenever running checks and tests of the furnace and vent system, be sure that the conditions which might be creating the trouble and service complaint are there at the time. Shut the doors to the furnace room or furnace area, close all outside windows leading into the furnace room and turn on any exhaust fans which could affect the performance. Otherwise, the checking and testing may reveal no faults where in fact they do exist.

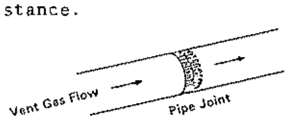
4. Horizontal vent pipe runs should be kept as short as possible but never more than ten feet. This is to avoid excessive friction losses and to keep from cooling the vent gases down to the temperature where condensation and poor draft results.



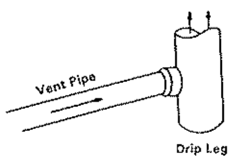
5. The pipe should have the least number of elbows and turns. These create friction losses.
6. In horizontal runs, the pipe must have an upward pitch of at least 1/2 inch per foot of length.



7. The vent pipe must be securely supported and joints must be tight and secure.
8. The joints should be made in the direction of the flow to reduce resistance.



9. A condensate drip leg must be provided in the vertical chimney below the point of connection by the vent pipe. This is to prevent condensate from running into the vent pipe and corroding it.

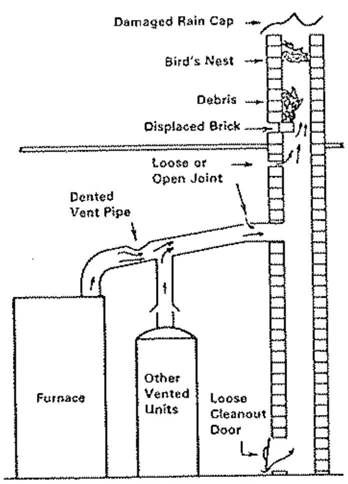


10. Where poor draft or condensation occurs in the vent pipe,insulating the pipe will often help to correct the condition.

11. Both the chimney and vent pipes must be clear of all obstructions at the time of installation and thereafter. Some sources of blockage are:

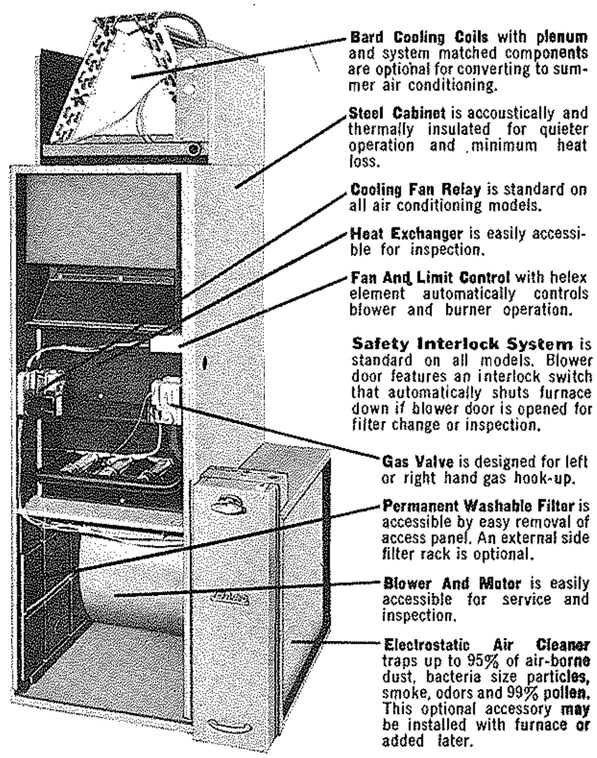
   a. Bird's nests.
   b. Debris which may have entered the chimney
   c. Damaged rain cap on the chimney
   d. Bent and damaged or displaced vent pipes
   e. Displaced bricks in masonry chimney

12. Occasionally other appliances which are vented into the same vent pipe or chimney will overload it and rob it of capacity to serve the furnace. If this is suspected, it can be checked by turning off the other appliances and temporarily blocking their connections into the vent system.



BASIC MAINTENANCE—GAS HEATING UNITS

In the preceding pages the service person has been exposed to the basic system components of typical gas fired heating units. In this section, basic maintenance procedures unique to gas fired heating units will be discussed. For those procedures common to all heating units, refer to the section on common systems and components in this manual.



TYPICAL HI-BOY GAS FURNACE

IN COMBUSTION VESTIBULE

☐ Check all electrical wiring for loose connections and and damaged insulation.

Check burners for lint, dust and scale.

1. Ignite burners by placing disconnect in "On" position.

2. Observe flame. It should be a fairly soft blue flame.

   a. If there is yellow in the flame, adjust primary air for best flame by loosening screw holding Primary Air adjustment Shutter. (NOTE: LP may have small orange tips and be properly adjusted)

   b. Slide shutter until yellow disappears.

   CAUTION - never close shutter completely.

NOTE: Shutters are standard equipment with the furnace. Sometimes shutters aid in achieving best flames and in avoiding noise problems.

☐ Clean if required.

If the flame will not clean up by adjustment, there might be an obstruction such as dust, lint or carbon deposits on burners or primary air shutters. This will cause the flame to be uneven and have yellow tips. If this is the case, clean the burners.

1. Remove burners from the furnace by "shutting off" Main Supply Gas Valve, loosening the Burner Manifold and removing the Burners.

MAINTENANCE CHECKSHEET

Dealer ______ Address ______
Customer ______ Address ______
Date ______ Person ______ Time In ______ Time Out ______
Equipment Make & Model ______
Notes ______

PRE-SERVICE CHECK

- ☐ Customer satisfied with system performance: ______
- ☐ Customer dissatisfied with system performance: ______

THERMOSTAT CHECKS

- ☐ Record thermostat settings: Temp: ______ °F. Mode: HEAT ☐OFF ☐COOL FAN: ☐ON ☐AUTO
- ☐ Check terminal connections for tightness
- ☐ Clean bimetal. Inspect mercury switch
- ☐ Check thermostat for level
- ☐ Check control circuit amperage: ______ A
- ☐ If customer dissatisfied with temperature control in heating season, adjust anticipator to match control circuit amp draw
- ☐ Initiate appropriate seasonal demand from thermostat

BLOWER COMPARTMENT CHECKS

- ☐ Check supply voltage at junction box: ______ vac ______ time
- ☐ Check blower motor amperage: ______ A ______ nameplate rating
- ☐ Turn power at unit main disconnect to OFF
- ☐ Check all wiring for loose connections and bad insulation
- ☐ Clean or change filter

Direct Drive Blower

- ☐ Check blower bearings
- ☐ Lubricate blower bearings
- ☐ Clean blower and compartment
- ☐ Check blower wheel for free and balanced rotation
- ☐ Check all blower housing mounts and setscrews for tightness
- ☐ Unused motor leads taped and out of way

Belt Drive Blower

- ☐ Remove blower belt and check for wear
- ☐ Check motor bearings for wear
- ☐ Lubricate motor bearings
- ☐ Check blower wheel bearings for wear
- ☐ Lubricate blower wheel bearings
- ☐ Clean blower and compartment
- ☐ Check blower wheel for free and balanced rotation
- ☐ Check pulley alignment
- ☐ Check motor and blower pulley setscrews for tightness
- ☐ Put belt back on blower and motor pulley and check belt tension
- ☐ Check all blower housing and motor mounts for tightness

HEATING SECTION CHECKS

ELECTRIC

- ☐ Check electrical wiring -- connections and insulation
- ☐ Check amperage draw of each element
- ☐ Check total amperage draw of elements ______ amps
- ☐ Check temperature rise ______ °F.
- ☐ Return outdoor thermostats to original settings if present

GAS

- ☐ Check all electrical wiring for loose connections and damaged insulation
- ☐ Check burners for lint, dust and scale
- ☐ Check for cracks in heat exchanger
- ☐ Check pilot flame
- ☐ Check for quiet, even burner ignition
- ☐ Check manifold gas pressure NAT. ______ in. wc. L.P. ______ in. wc.

Standing Pilot

- ☐ Check thermocouple open circuit ______ dcmv closed circuit ______ dcmv
- ☐ Check pilot valve safety drop-out time ______ min.
- ☐ Check automatic vent damper system
- ☐ Check electronic spark ignition control
- ☐ Check safety lockout
- ☐ Check limit safety
- ☐ Check temperature rise ______ °F.
- ☐ Check draft diverter
- ☐ Check furnace vent for rust
- ☐ Gas manifold hand valve is open before leaving

OIL

- ☐ Check electrical wiring -- connections and insulation
- ☐ Inspect combustion chamber
- ☐ Inspect for soot in heat exchanger
- ☐ Check fuel oil tank for sludge/water
- ☐ Change oil line filter
- ☐ Check oil lines
- ☐ Service oil burner
- ☐ Conduct combustion efficiency test ______ in wc. ______ smoke ______% CO_2 ______ °F. net
- ☐ Check limit safety
- ☐ Check temperature rise
- ☐ Check primary control
- ☐ Check furnace vent for rust

COOLING

- ☐ Check electrical wiring -connections and insulation (indoor)
- ☐ Check/clean evaporator coil
- ☐ Check/clean condensate drain
- ☐ Check static pressure drop ______ in. wc. ______ cfm (dry coil)
- ☐ Check wiring — connections and insulation (outdoor)
- ☐ Check/clean condenser coil
- ☐ Lubricate condenser fan motor
- ☐ Check line set and connections for evidence of leaks
- ☐ Check and record supply voltage
- ☐ Check refrigerant charge
- ☐ Check amperage draw on condenser fan motor
- ☐ Check amperage draw on compressor

HUMIDIFIER

- ☐ Check electrical wiring — connections and insulation
- ☐ Check transformer voltage ______ vac
- ☐ Check damper position

SPRAY TYPE

- ☐ Check solenoid valve
- ☐ Check nozzle spray pattern

DRUM TYPE

- ☐ Check for free rotation and scale
- ☐ Check water level adjustment
- ☐ Check overflow/drain line

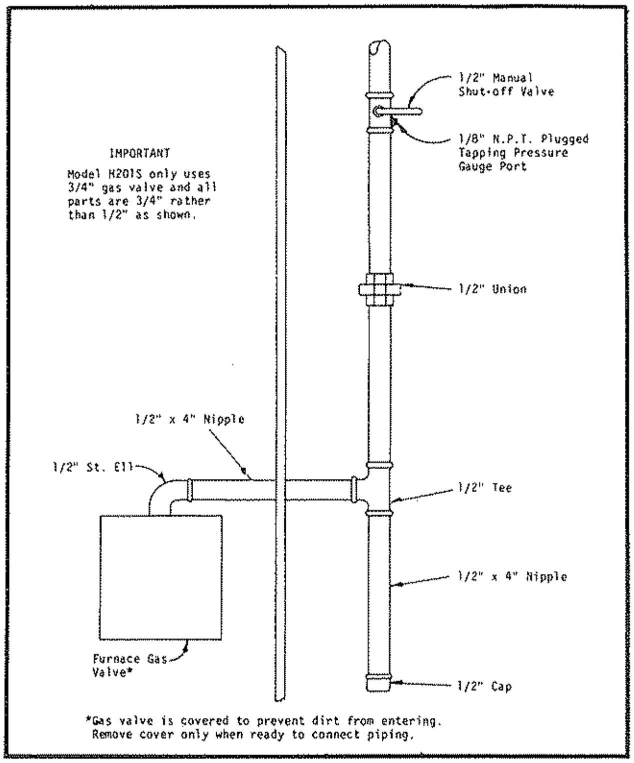
ELECTRONIC AIR CLEANER

- ☐ Check electrical wiring — connections and insulation
- ☐ Check sail switch or electrical blower interlock
- ☐ Check test button operation
- ☐ Check supply voltage ______ vac (120 vac)
- ☐ Check voltage to collecting plates ______ vdc (3500 vdc)
- ☐ Check voltage to ionization wires ______ vdc (8000 vdc)
- ☐ TURN POWER OFF
- ☐ Wash cells
- ☐ Wash prefilter screens

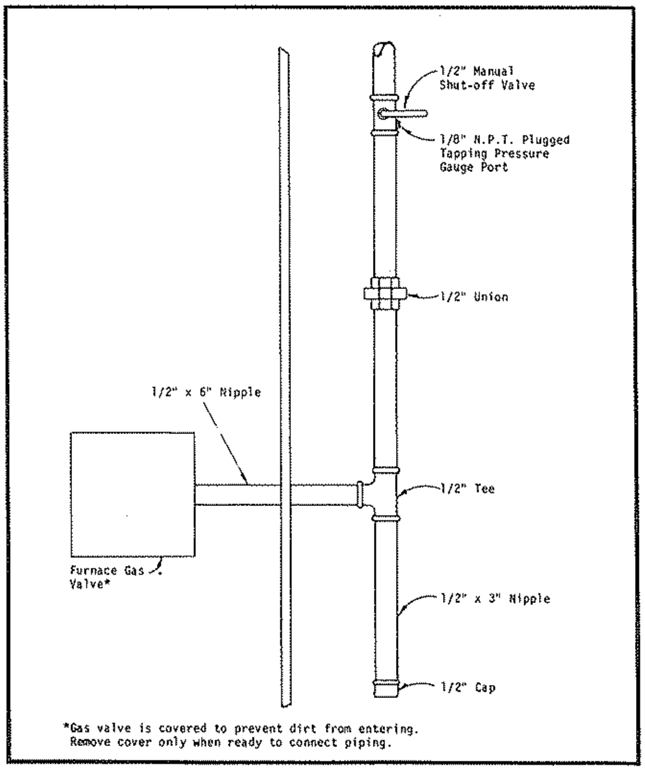
POST-SERVICE CHECKS

- ☐ Return thermostat to original settings recorded at beginning of service call
- ☐ Leave copy of completed checksheet with customer
- ☐ Power ON before leaving

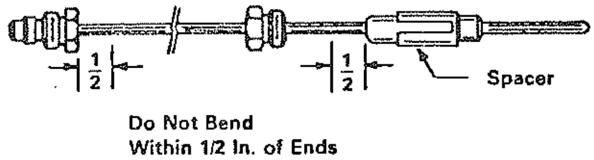
TYPICAL PIPING FOR H-SERIES AND C-SERIES



TYPICAL PIPING FOR G-SERIES



2. To take out the burner that has the Pilot Assembly mounted on it, remove Pilot Gas Line and Thermocouple leads from Gas Valve.



(Caution: Do not bend thermocouple within 1/2" of either end, and do NOT kink it any place).

3. Pull burners out of heat exchanger.
4. Place burners on cardboard or paper on floor.
5. To clean burners:
   a. Clean top of burner ports with a wire brush.
   b. Clean burner port by inserting a cleaning tool made from a piece of sheet metal cut to fit the burner ports and work tool in and out of each port.

      Clean "inside" of burner with a bottle cleaning brush.

SAFETY CAUTION: When replacing burners make sure ignition plates are even. Uneven plates could cause delayed ignition.

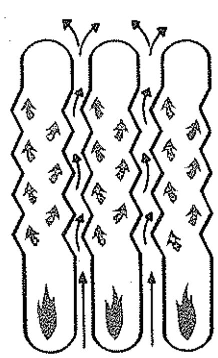
6. Inspect the combustion chamber and flue passages annually. Look for soot and any evidence of deterioration due to corrosion, cracking or other cause. Use a good light to look up into the section(s) above the burner(s). A small mirror is helpful.

   If "carbon" was found on the burner ports, it could mean that the heat exchanger also needs cleaning. It is most important to keep the heat exchanger clean. Soot acts like insulation on the inside surface of the heat exchanger. A build up of soot will decrease furnace efficiency by allowing more heat to be lost up the chimney.

   There are chemical soot removers on the market that have been used to clean heat exchangers. Servicemen are discouraged from using these sprays as they are prone to corroding the metal of the heat exchangers. Many manufacturers will void warranties of systems if the chemical sprays are used.

   Use the following procedure to clean heat exchanger (allow furnace to cool).

   a. Make sure gas and electric power supply is off.
   b. Break the gas pipe union. Remove gas manifold and burner assembly.
   c. Disconnect vent pipe from the top of the draft diverter.
   d. Remove the upper door, exposing the draft diverter.
   e. Remove the draft diverter.
   f. On multiple section furnaces, remove the restrictor plate and the flue baffles.

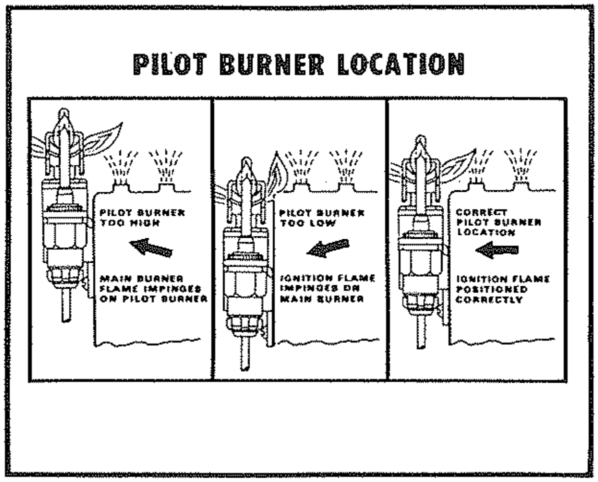


HEAT EXCHANGER CUTAWAY

g. Clean heat exchanger section(s) using long handled wire brush and vacuum cleaner. Clean the top section first, then clean upwards from the combustion chamber.*

h. Replace parts in reverse order. Check pilot burner or igniter/sensor for proper alignment.

*CAUTION: Do not use nylon brush, static electricity may cause carbon explosion.



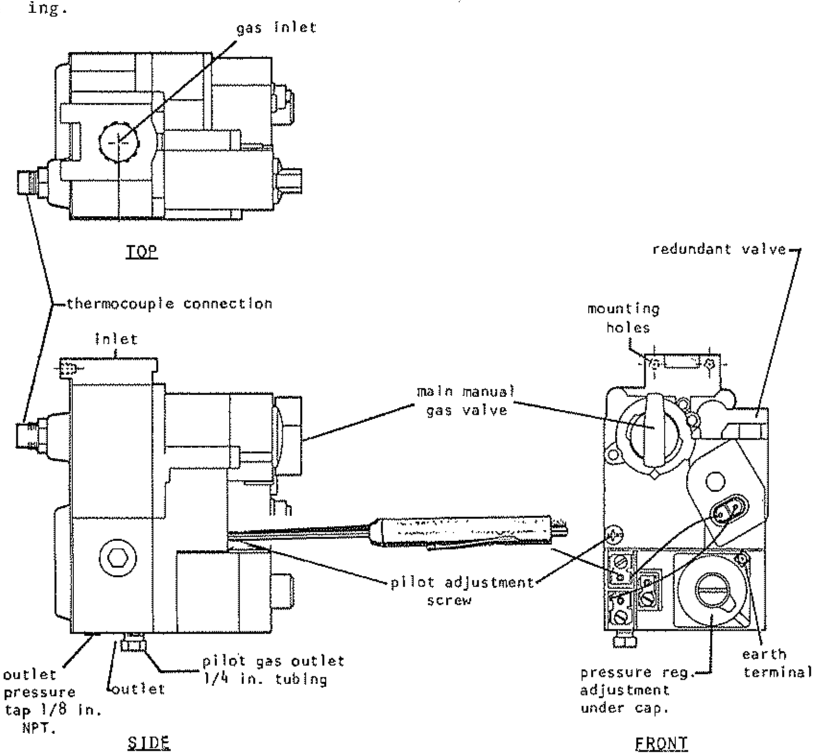
i. Reinstall burner manifold. Reconnect gas line and wiring.

j. Turn gas on. Check for leaks. Turn power on.

k. Refer to lighting instructions. Check for proper operation.

☐ Check for cracks in heat exchanger.

Occasionally a crack will occur in a heat exchanger from overfiring. It cannot be repaired and the entire heat exchanger must be replaced Do NOT just remove a faulty orifice. Do NOT attempt to weld the crack together. Excessive heat from welding will only fatigue the metal of the heat exchanger, making it more susceptible to cracking.



—VR800 DUAL AUTOMATIC VALVE COMBINATION GAS CONTROL—

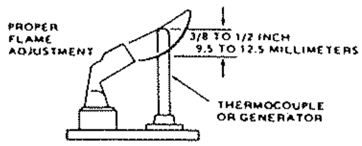
ADJUSTING PILOT FLAME.

There are several ways to check for cracks. The most clean, positive way is with a simple table salt and water solution. Sodium ions present in the atmosphere or an air stream turn a butane gas torch flame from blue to yellow. The test works by introducing sodium ions into a heat exchanger and then studying a butane torch flame.

1. While the furnace is operating, spray salt water solution into primary and/or secondary air supply to burners. Make sure blower compartment door is on and fastened.
2. Light a butane torch in air stream of nearest supply air register (approximately 8 to 12 inches from register face).
3. If flame turns yellow or streaked with orange, it is an indication sodium ions are present being released through crack or hole in heat exchanger.

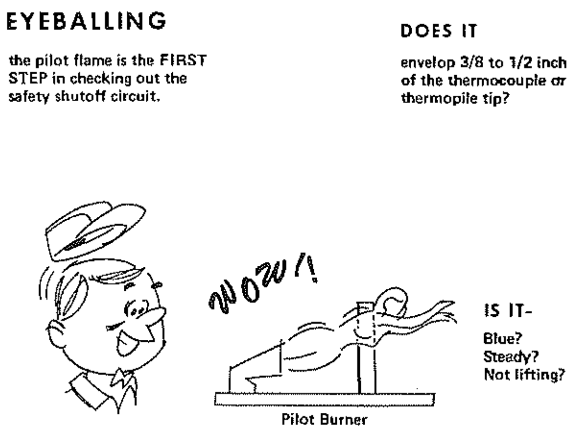
☐ Check pilot flame.

1. If pilot flame is out, relight. If pilot will not light, refer to instructions in this section.
2. With burner flame extinguished and pilot flame burning, observe pilot flame.
3. Pilot should have soft blue flame.



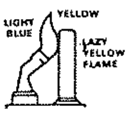
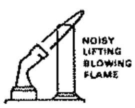
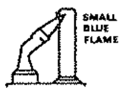
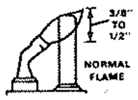
STANDING PILOT

4. Pilot flame should envelop the thermocouple "Hot Junction" from 3/8 to 1/2 inch.
5. Clean pilot assembly or adjust gas pressure to pilot if needed.



POOR PILOT FLAME CONDITIONS

If the pilot flame is not normal, a great deal can be learned about the nature of the pilot problem by inspecting its appearance. The causes of a number of abnormal flame conditions are summarized in the figure below. Also, refer to the pilot burner service analysis chart in the troubleshooting section of the student notebook for a more complete cause and effect analysis.

FLAME TYPES	POSSIBLE CAUSES	FLAME TYPES	POSSIBLE CAUSES
	1. Dirty lint screen or primary air opening. 2. Starving due to excessive input to main burner. 3. Orifice too large.		High gas pressure.
	1. Excessive draft at pilot location. 2. Recirculating products of combustion.		1. Characteristic of manufactured, butane-air and propane-air. 2. Orifice too small.
	1. Adjusting screw closed off. 2. Low gas supply pressure. 3. Clogged pilot burner orifice. 4. Improper orifice (too small). 5. Clogged pilot line filter.		Proper installation.

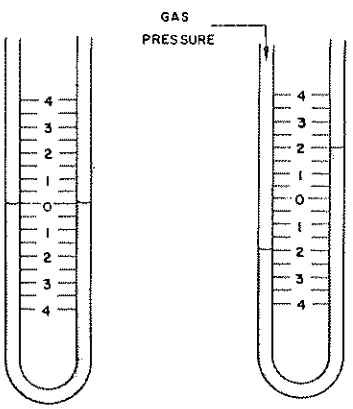
When checking the pilot flame, any air door included on the equipment should be in its final position so that the condition of the pilot flame will be completely normal. A small mirror may prove helpful in checking the pilot.

MAKE FOLLOWING CHECKS IF PILOT WILL NOT LIGHT

1. Check main gas valve to furnace to be sure it's on.
2. Turn main gas valve in furnace to "pilot" position.
3. Depress pilot reset button and hold match to pilot. If pilot does not hold when reset button is released, it indicates (a) loose thermocouple (b) bad thermocouple. To determine whether thermocouple is good or bad make following checks:

☐ Check for quiet even burner ignition.

1. Turn furnace on and off several times. Observe pilot pattern. Observe pilot bridges. Are they in straight? Do the burners ignite smoothly? If not, check gas pressure. Also check for dirty burners.



U-tube manometer.

CHECK MANIFOLD GAS PRESSURE

Gas pressure is critical for efficient unit operation. The recommended pressure for natural gas is 3.0 to 4.0 inches of water column and for LP is 10.5 to 11.5 inches of water column. Excess gas pressure will overfire a unit. Overfire means a Btu per hour input greater than on the unit nameplate. Overfiring means higher temperatures which cause additional expansion and contraction of the heat exchanger. Flames are larger which can cause "hot spots" on the heat exchanger. All reduce heat exchanger life. Too little gas pressure, underfire, is also harmful. It results in a lower combustion temperature. Condensation of water vapor, even above 100°F can occur. This will lead to rust and corrosion of the heat exchanger.

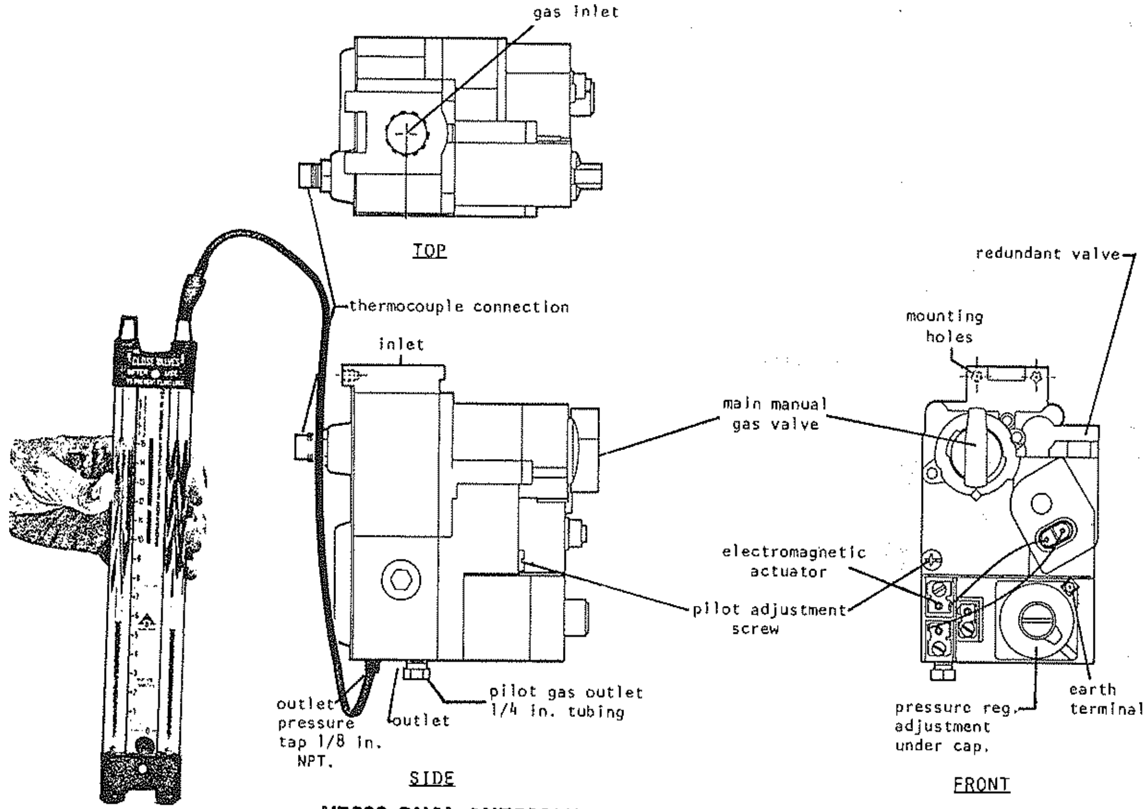
☐ Check manifold gas pressure. Adjust if required.

1. Turn "off" disconnect switch. (CAUTION: This must be done to prevent gas from coming out into the room when the plug is taken out).

NOTE: The following steps should be used on units which contain a Plug-Tap in the gas manifold (Bard low-boys). On other units which do not have a manifold plug-tag, see note in this section.

2. Take 1/8" pipe plug out of the plug-tap in gas manifold.
3. Insert B-valve into the plug-tap (with B-valve in "off" position).
4. Connect U-tube or pressure gauge hose to the B-valve. (Insert hose fitting into the plug-tap hole if B-valve isn't used. Caution: U-tube must be in upright position).
5. Turn thermostat to highest setting.
6. Turn "on" disconnect and "open" B-valve to take pressure reading. (CAUTION: Make sure hose does not come off of B-valve or gas manifold).
7. Reading should be approximately 3 to 4" of water column. If the pressure is under or over 3 to 4" adjust pressure regulator.
8. Turn "off" the disconnect.
9. Remove gauge or U-tube and B-valve.
10. Replace plug into gas manifold.
11. Turn on disconnect switch.
12. Check for leaks at plug.

NOTE: Most new equipment does not have a plug-tap in the gas manifold. On such equipment gas pressure is checked at the pressure tap located in the gas valve. An allen wrench is used to remove the pressure tap plug and the pressure gauge hose is plugged directly into the tap (see below).



VR800 DUAL AUTOMATIC VALVE COMBINATION GAS CONTROL

GAS PRESSURE MANOMETER

CHECKING GAS FURNACE OUTPUT.
PROCEDURE:

Check gas input at meter and check manifold pressure.

a. Low line pressure - less than required manifold pressure. (Notify gas company.)
   Low manifold pressure with (LP) gas. (Check for low level in fuel tank.)

b. Low manifold pressure. (Adjust pressure regulator for 3.0 - 4.0" w.g. for natural gas and 10.5 to 11.5" w.g. for (LP).

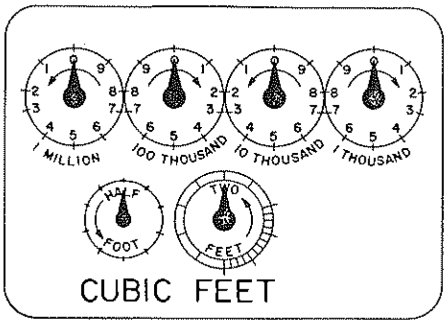
c. Orifice partially plugged. (Clean orifice).

d. Orifice too small. (Increase orifice size.)

HOW TO CHECK GAS FLOW AT METER (NATURAL GAS)

1. Make sure all gas appliances are turned off. Leave furnace running.

2. Using either the one, two, or five-foot dial on the meter, time one full revolution with a watch.



EXAMPLE:

One revolution on the two-foot dial = 68 seconds. Using the gas rate card shown you will note that 68 seconds = 106 cubic feet of gas per hour. There are 1,000 Btuh in each cubic foot of gas. Note: Make adjustments where gas heating value is other than 1,000 Btuh.

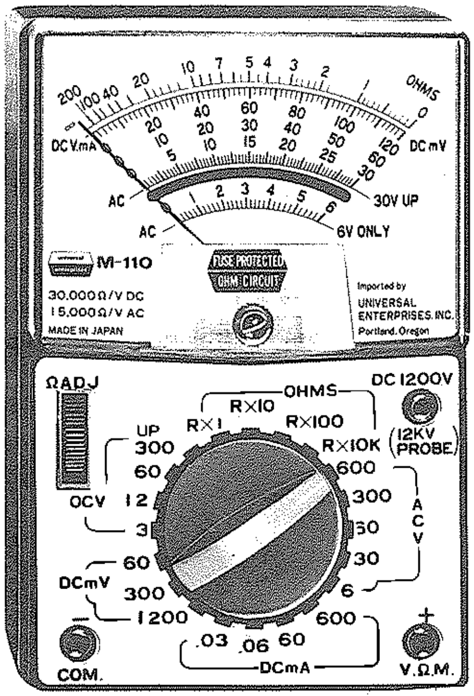
106 cubic feet of gas = 106,000 Btuh. Check Btuh gas flow against the Btuh listed on the AGA nameplate on the furnace.

Seconds for one Rev.	SIZE OF TEST DIAL ¼ cu.ft.	½ cu.ft.	1 cu.ft.	2 cu.ft.	5 cu.ft.
10	90	180	360	720	1800
11	82	164	327	655	1636
12	75	150	300	600	1500
13	69	138	277	555	1385
14	64	129	257	514	1286
15	60	120	240	480	1200
16	56	113	225	450	1125
17	53	106	212	424	1059
18	50	100	200	400	1000
19	47	95	189	379	947
20	45	90	180	360	900
21	43	86	171	343	857
22	41	82	164	327	818
23	39	78	157	313	783
24	37	75	150	300	750
25	36	72	144	288	720
26	34	69	138	277	692
27	33	67	133	267	667
28	32	64	129	257	643
29	31	62	124	248	621
30	30	60	120	240	600
31	–	–	116	232	581
32	28	56	113	225	563
33	–	–	109	218	545
34	26	53	106	212	529
35	–	–	103	206	514

Seconds for one Rev.	SIZE OF TEST DIAL ¼ cu.ft.	½ cu.ft.	1 cu.ft.	2 cu.ft.	5 cu.ft.
36	25	50	100	200	500
37	–	–	97	195	486
38	23	47	95	189	474
39	–	–	92	185	462
40	22	45	90	180	450
41	–	–	–	176	439
42	21	43	86	172	429
43	–	–	–	167	419
44	–	41	82	164	409
45	20	40	80	160	400
46	–	–	78	157	391
47	19	38	76	153	383
48	–	–	75	150	375
49	–	–	–	147	367
50	18	36	72	144	360
51	–	–	–	141	355
52	–	–	69	138	346
53	17	34	–	136	340
54	–	–	67	133	333
55	–	–	–	131	327
56	16	32	64	129	321
57	–	–	–	126	316
58	–	31	62	124	310
59	–	–	–	122	305
60	15	30	60	120	300

STANDING PILOT

Check thermocouple millivoltage, (record under load and open circuit).



CHECK THERMOCOUPLE MILLIVOLTAGE

There are several different meters which may be used to make a millivoltage check.
When taking readings on residential equipment be sure meters are set properly - see operating instructions for proper scale.

1. Open circuit millivoltage check to test thermocouple.
   a. Loosen thermocouple attaching nut.
   b. Place positive lead of multi-tester on the outside conductor of the thermocouple and the negative lead on the end of the inside conductor of the thermocouple.
   c. Follow instructions on AGA nameplate for relighting pilot. (Remember to hold down on gas valve knob for the remainder of this check. Also if meter moves below zero, reverse lead connections.)
   d. Read meter and record open circuit millivoltage. (Minimum acceptable voltage is 18 millivolts.)
   e. If voltage is below this, replace thermocouple or increase pilot gas flow.
2. Closed circuit millivoltage check to test pilot valve electrically.
   a. Remove from gas valve and screw General Controls Adapter No. 103050G (green in color) into the gas valves threaded connection for the thermocouples' attaching nut (finger tight). This test is used to determine whether or not the pilot safety solenoid is strong enough to adequately hold in the open position when current is applied.
   b. Screw attaching nut of thermocouple into the adapter (thermocouple finger tight plus 1/4 turn with wrench).
   c. Place positive lead of multi-tester on the outside conductor of the thermocouple and the negative lead on the tab of the adapter.
   d. Re-light according to pilot lighting instructions on AGA nameplate. (If meter goes below zero, reverse the meter leads.)
   e. Read and record the closed circuit, (minimum 7 millivolts). If reading drops below minimum, solenoid is very likely going bad.
   f. Leave meter leads connected for next check.

CHECK SAFETY DROP-OUT TIME

☐ Check safety drop-out time (maximum 3 minutes).

This is a mechanical check on pilot valve and could indicate a sticking valve.

1. A stop watch or wrist watch with a secondhand is needed for this check.
2. Turn pilot "out" and start timing.
3. Listen for a "click" from the gas valve.
4. When this "click" is heard, record the time and millivoltage. (Maximum time allowed is 2-1/2 minutes (180 seconds) for safety drop-out. Normally the millivoltage reading should be below 4 millivolts). Hold lighted match at pilot to be sure valve is completely seated and not leaking gas.
5. Remove meter leads.
6. Unscrew thermocouple attaching screw and remove from adapter.
7. Unscrew and remove adapter from gas valve.
8. Replace attaching nut of thermocouple in gas valve. (Caution: Tighten finger tight plus 1/4 turn with wrench. If too tight, it will mash insulator).
9. Light pilot according to AGA nameplate instructions.
10. Turn gas valve knob to the "on" position.

SPARK IGNITION/VENT DAMPER

CHECK AUTOMATIC VENT DAMPER SYSTEM

☐ Check automatic vent damper system.

Damper must be fully open before ignition control lights pilot gas.

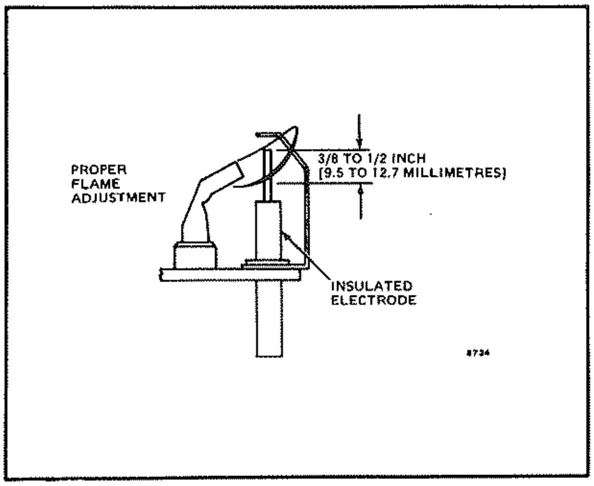
NOTE: Field repairs cannot be made. Call vendor for service or replace.

1. Turn room temperature to high setting so contacts close (call for heat). Damper operator opens damper. Damper position can be determined by slot indicator on shaft.
2. When damper is fully open, ignition control lights pilot gas which in turn lights main gas burner.
3. Test for air spillage at draft hood relief opening after 5 minutes of main burner operation. (See draft diverter test).
4. Turn thermostat to low setting to open contacts. Pilot and main burner flames will extinguish. Damper operator closes damper.
5. Return thermostat to normal setting.

CHECK ELECTRONIC SPARK IGNITION CONTROL

☐ Check electronic spark ignition control.

1. Check all connections for proper pilot burner ignition. CAUTION: Be sure power is OFF when checking high voltage connections.
2. Observe presence of spark. If not present, determine if power is available to control.
3. Check for proper spark gap. Should be set at 7/64". If spark does not occur with power applied and gap properly set, replace spark ignition control.
4. Check for pilot gas ignition. If it doesn't light even with spark present, gas is not available at pilot burner. This could also mean either gas pressure is too high or low, or the electronic assembly is not in the flame.
5. Check burner ignition. If it does not ignite but pilot gas does, check ignition cable connections to sensing probe and control. Turn off power, disconnect ignition cable and check resistance with VOM for 0 resistance.



-PROPER FLAME ADJUSTMENT.

☐ Check safety lockout.

1. Shut off gas. The unit will then proceed through the automatic ignition cycle once. The system will then lockout.

☐ Check limit safety.

1. Eliminate blower operation.
   NOTE: On a belt drive blower, simply remove the belt. On a direct drive blower, disconnect the common lead (white wire).
2. Initiate a call for heat at the thermostat.
3. Use a thermometer in the plenum to measure temperature rise.
4. The limit should shut down the furnace operation at 200°F or between 2-1/2 to 3 minutes.
5. If the furnace continues to operate, shut it off immediately. The limit is faulty and must be replaced.

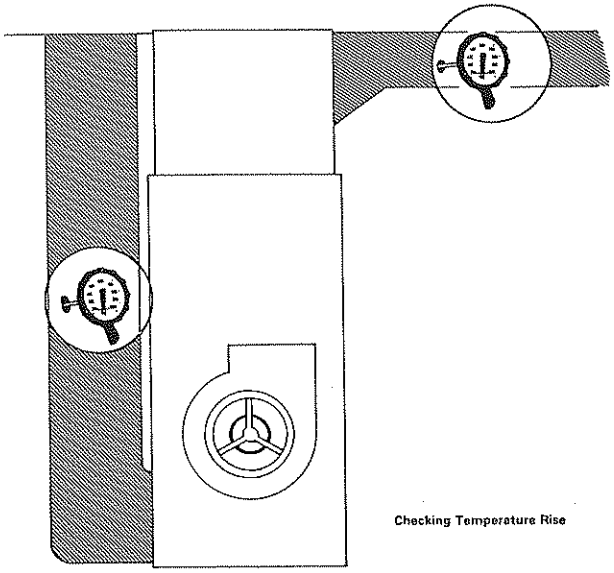
☐ Check temperature rise.

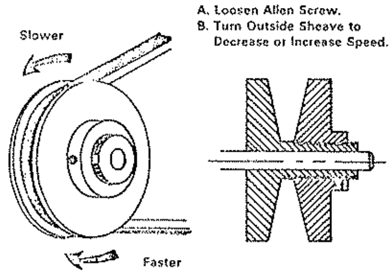
If the homeowner is satisfied with the comfort level in the home, this check could be skipped.

1. Make sure all doors are on furnace.
2. Place thermometer in supply plenum, positioned out of direct line of the heat exchanger.
3. Place thermometer in return air plenum close to the furnace.
4. There should be about 85°-95° difference between the thermometer in the return air duct and the thermometer in the supply duct.
5. If the temperature difference is less than 85°-95° the blower is running too fast. Slow blower down.*
6. If the temperature difference is more than 85°-95° the blower is running too slow. Speed it up.*

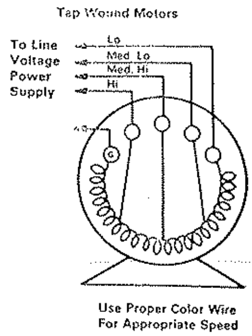
NOTE: Systems with less Btu output have lower temperature rise. It may be as low as 20°F on some gas units.

*On furnaces that have add-on heat pumps or air conditioning, the temperature difference will be lower.





BELT DRIVE BLOWER



DIRECT DRIVE BLOWER

CHECK DRAFT DIVERTER

☐ Check draft diverter

1. After furnace has been on for approximately three minutes, hold a match next to the top lip of the draft diverter on the upflow and reverse-flow, next to the outside bottom lip on horizontal and move back and forth.
2. If vent-draft is okay, the flame should be drawn into the diverter.

☐ Check furnace vent for possible rustout.

1. Vent should have a solid ring. If rust spots are suspect, take a screwdriver and push the point into the center of the rust spot.

☐ Be sure gas manifold hand valve is open before leaving job.

MAINTENANCE CHECKSHEET

Dealer ______________________________ Address ______________________________
Customer ______________________________ Address ______________________________
Date ____________ Person ____________ Time In ____________ Time Out ____________
Equipment Make & Model ______________________________
Notes ______________________________

PRE-SERVICE CHECK

- ☐ Customer satisfied with system performance: __________
- ☐ Customer dissatisfied with system performance: __________

THERMOSTAT CHECKS

- ☐ Record thermostat settings: Temp: ______ °F. Mode: ☐HEAT ☐OFF ☐COOL FAN: ☐ON ☐AUTO
- ☐ Check terminal connections for tightness
- ☐ Clean bimetal. Inspect mercury switch
- ☐ Check thermostat for level
- ☐ Check control circuit amperage: __________ A
- ☐ If customer dissatisfied with temperature control in heating season, adjust anticipator to match control circuit amp draw
- ☐ Initiate appropriate seasonal demand from thermostat

BLOWER COMPARTMENT CHECKS

- ☐ Check supply voltage at junction box: __________ vac __________ time
- ☐ Check blower motor amperage: __________ A __________ nameplate rating
- ☐ Turn power at unit main disconnect to OFF
- ☐ Check all wiring for loose connections and bad insulation
- ☐ Clean or change filter

Direct Drive Blower

- ☐ Check blower bearings
- ☐ Lubricate blower bearings
- ☐ Clean blower and compartment
- ☐ Check blower wheel for free and balanced rotation
- ☐ Check all blower housing mounts and setscrews for tightness
- ☐ Unused motor leads taped and out of way

Belt Drive Blower

- ☐ Remove blower belt and check for wear
- ☐ Check motor bearings for wear
- ☐ Lubricate motor bearings
- ☐ Check blower wheel bearings for wear
- ☐ Lubricate blower wheel bearings
- ☐ Clean blower and compartment
- ☐ Check blower wheel for free and balanced rotation
- ☐ Check pulley alignment
- ☐ Check motor and blower pulley setscrews for tightness
- ☐ Put belt back on blower and motor pulley and check belt tension
- ☐ Check all blower housing and motor mounts for tightness

HEATING SECTION CHECKS

ELECTRIC

- ☐ Check electrical wiring -- connections and insulation
- ☐ Check amperage draw of each element
- ☐ Check total amperage draw of elements __________ amps
- ☐ Check temperature rise __________ °F.
- ☐ Return outdoor thermostats to original settings if present

GAS

- ☐ Check all electrical wiring for loose connections and damaged insulation
- ☐ Check burners for lint, dust and scale
- ☐ Check for cracks in heat exchanger
- ☐ Check pilot flame
- ☐ Check for quiet, even burner ignition
- ☐ Check manifold gas pressure NAT. ______ in. wc. L.P. ______ in. wc.

Standing Pilot

- ☐ Check thermocouple open circuit ______ dcmv closed circuit ______ dcmv
- ☐ Check pilot valve safety drop-out time __________ min.
- ☐ Check automatic vent damper system
- ☐ Check electronic spark ignition control
- ☐ Check safety lockout
- ☐ Check limit safety
- ☐ Check temperature rise ____ °F.
- ☐ Check draft diverter
- ☐ Check furnace vent for rust
- ☐ Gas manifold hand valve is open before leaving

OIL

- ☐ Check electrical wiring -- connections and insulation
- ☐ Inspect combustion chamber
- ☐ Inspect for soot in heat exchanger
- ☐ Check fuel oil tank for sludge/water
- ☐ Change oil line filter
- ☐ Check oil lines
- ☐ Service oil burner
- ☐ Conduct combustion efficiency test ____ in wc. ____ smoke ____% CO_2 ____ °F. net
- ☐ Check limit safety
- ☐ Check temperature rise
- ☐ Check primary control
- ☐ Check furnace vent for rust

COOLING

- ☐ Check electrical wiring -connections and insulation (indoor)
- ☐ Check/clean evaporator coil
- ☐ Check/clean condensate drain
- ☐ Check static pressure drop ____ in. wc. ____ cfm (dry coil)
- ☐ Check wiring — connections and insulation (outdoor)
- ☐ Check/clean condenser coil
- ☐ Lubricate condenser fan motor
- ☐ Check line set and connections for evidence of leaks
- ☐ Check and record supply voltage
- ☐ Check refrigerant charge
- ☐ Check amperage draw on condenser fan motor
- ☐ Check amperage draw on compressor

HUMIDIFIER

- ☐ Check electrical wiring — connections and insulation
- ☐ Check transformer voltage __________ vac
- ☐ Check damper position

SPRAY TYPE

- ☐ Check solenoid valve
- ☐ Check nozzle spray pattern

DRUM TYPE

- ☐ Check for free rotation and scale
- ☐ Check water level adjustment
- ☐ Check overflow/drain line

ELECTRONIC AIR CLEANER

- ☐ Check electrical wiring — connections and insulation
- ☐ Check sail switch or electrical blower interlock
- ☐ Check test button operation
- ☐ Check supply voltage __________ vac (120 vac)
- ☐ Check voltage to collecting plates __________ vdc (3500 vdc)
- ☐ Check voltage to ionization wires __________ vdc (8000 vdc)
- ☐ TURN POWER OFF
- ☐ Wash cells
- ☐ Wash prefilter screens

POST-SERVICE CHECKS

- ☐ Return thermostat to original settings recorded at beginning of service call
- ☐ Leave copy of completed checksheet with customer
- ☐ Power ON before leaving