HOW TO GET
THE BEST
FROM
ONE-PIPE STEAM

A PRACTICAL MANUAL
FOR

HEATING SYSTEM AND BOILER
OPTIMIZATION,
MAINTENANCE, LOSS PREVENTION,
REPLACEMENT, AND INSTALLATION

BY

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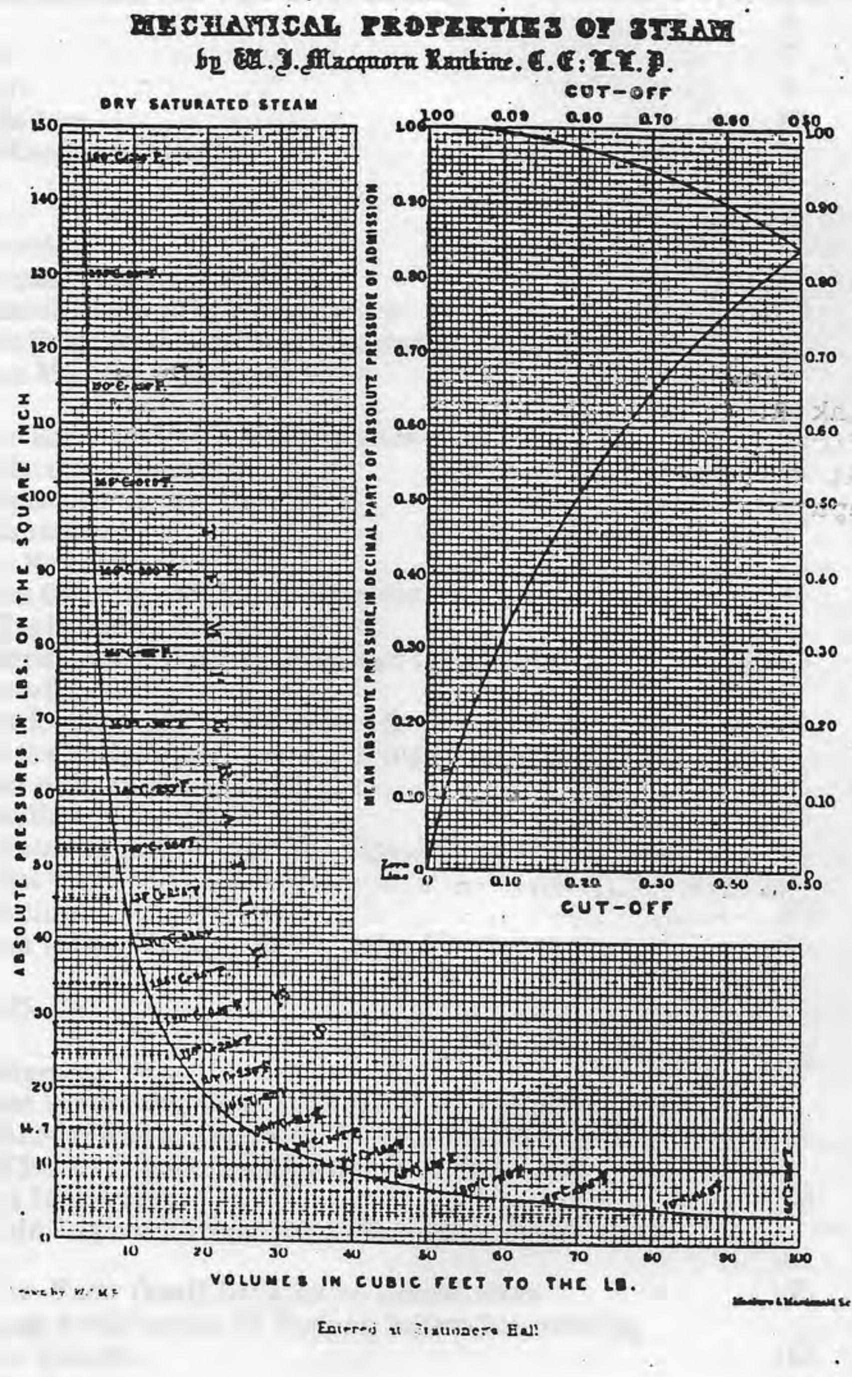
PREPARED FOR

THE

THE NEW YORK CITY DEPARTMENT

OF

HOUSING PRESERVATION AND DEVELOPMENT



This early steam chart was taken from W.J.M. Rankine's 1873 book A Manual for the Steam Engine and Other Prime Movers.

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INTRODUCTION

This manual will describe how to bring the practice of one-pipe steam heating into the last quarter of the twentieth century. Surprisingly, one-pipe steam heating remains a practical and economical method of heating many buildings where building height makes hot water heating difficult and the various forms of two-pipe steam heating too expensive and complex to be practical.

This will be an expansion of the Gospel of Dry Steam, published and distributed by the New York City Department of Housing Preservation and Development last year. The Gospel dealt with a few specific problems encountered in steam heating in the typical pre-1920 New York multi-family apartment house whose one-pipe heating system was in basically good condition but in need of specific improvements to increase performance and efficiency.

The Gospel was written for the reader who had already had a fair amount of experience with one-pipe heating systems but was confronted with operational problems that then-available literature did not adequately address. This manual will address one-pipe steam heating in considerably greater detail.

I intend to provide the reader with a practical guide to optimizing heating system performance and preventing the loss of the boiler. This manual should be useful as a training guide to those who have had little experience; it also establishes guidelines and checklists helpful to experienced heating practitioners and building managers.

The first objective for any owner or building manager is to maintain the heating plant so as to reduce the cost of operation, reduce or eliminate down time (costly in terms of tenant complaints and potential heat violations) and to extend the life of the system. It is all too easy to consider an old boiler a "clunker" and replace it at great cost. Many boilers today, with care and a modest investment can give service for years to come and do not need to be replaced.

There comes a time when boilers and other parts of a heating system must be replaced. This manual includes a discussion of the considerations that go into replacement of heating system components, including size and type of boiler, fuel, domestic hot water supply, piping, controls, etc. All too often an installation falls short of what it should be for effective,economical, and consistent heating system performance. I have included a checklist of items for owners and managers to use as they oversee and inspect the work of the installers to insure that the system is installed and brought into service correctly. The key to successful installation is first to have a good design and then to follow the manufacturer's instructions. This may seem elementary, but well thought-out engineering and proper implementation of instructions are frequently missing from the typical heating job. This manual will illustrate typical examples of today's best practice.

This manual was developed under contract to the Division of Energy Conservation and Owners' Assistance of the New York City Department of Housing Preservation and Development. The contract also included on-site inspections of existing heating plants and of new boiler installations in City-owned residential buildings. The observations made in the course of the inspections provide the basis for citing here the most common mistakes made in installations and for the suggestions as to solutions to enhance the performance and longevity of the heating systems.

Although this text is written in terms of a steam heating system in a multi-family apartment house, the lessons here are also applicable to single-family houses and to a wide variety of commercial and industrial structures. In particular, the principles governing the prevention of boiler-caused water hammer is applicable to any steam application from apartment houses to power plants.

In this book I will assume that the reader may have limited experience with steam heating but has a practical bent and wants to have a real effect on a steam heating plant, either because his own comfort depends on it, or his income as an owner depends on it, or his heating business could profit from what I think is some of the latest and best thinking on this subject.

Be aware that I offer many suggestions in this book which are based on my experience. Sometimes they differ significantly from what some manufacturers recommend; generally they are more conservative. I always recommended that the manufacturer's instructions be thoroughly understood before undertaking any engineering or construction work. However, since manufacturers' instructions are necessarily general, the person using them must make adjustments where necessary. This book will give you many examples of this.

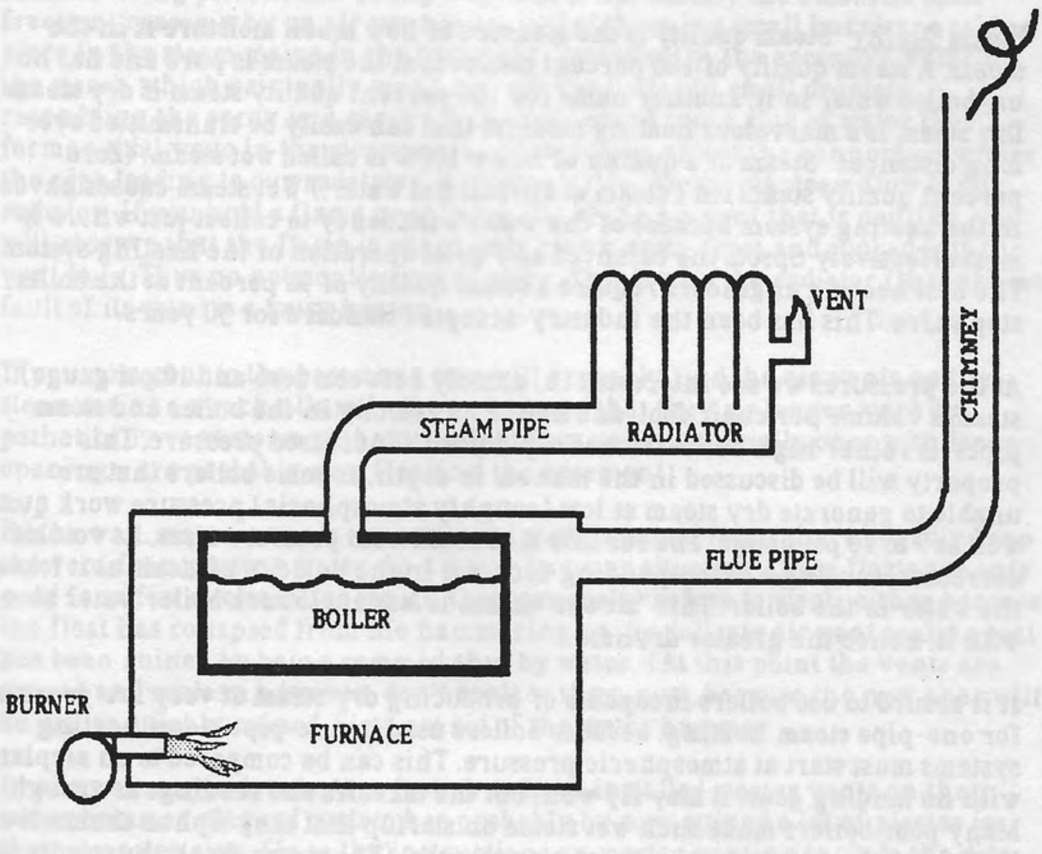
I would like to thank Assistant Commissioner Peter H. Judd of HPD's Energy Conservation and Owner's Assistance for his help in reviewing this manual. His knowledge and humor were invaluable.

Frank R. Gerety
New York, March 1987

THE BASIC ELEMENTS OF ONE-PIPE STEAM HEATING

In the first chapters, a few basic terms and concepts will be discussed and defined. It is important that the reader understand the material here, because everything following depends on it. This warning is especially relevant to the experienced practitioner because he frequently does a lot of his work by rote, and in doing so, technical misconceptions and bad practices gradually creep into an otherwise good practice.

The following crude illustration shows the most basic elements of a one-pipe steam heating system.



BASIC ELEMENTS OF A ONE-PIPE STEAM HEATING SYSTEM

STEAM

Steam is the stuff we use as the conveyor of heat from the place where the fuel is burnt to where the heat is needed.

The Advantages of Steam Steam is a remarkable heat-conveyor, because it releases an enormous amount of heat when it condenses back into water. This makes steam capable of conveying heat over considerable distances and up considerable heights at reasonable cost. Steam condenses at 212° when it is at atmospheric pressure: this is hot enough to permit reasonably sized radiators while not so hot as to cause serious injury when a radiator is touched.

Steam Quality Steam quality is the measure of how much moisture is in the steam. A steam quality of 100 percent means that the steam is pure and has no un-boiled water in it; another name for 100 percent quality steam is dry steam. Dry steam is a marvelous heating medium that can easily be transmitted over long distances. Steam of a quality of below 100% is called wet steam. (Zero percent quality steam isn't steam at all, just hot water.) Wet steam causes havoc in the heating system because of the water's tendency to collect just where it most effectively upsets the balanced and quiet operation of the heating system. The best heating engineers require a steam quality of 98 percent at the boiler stop valve. This has been the industry-accepted standard for 50 years.

At the pressures we are interested in, namely between zero and 10 psi gauge) steam's volume per cubic foot, and hence its velocity in the boiler and steam pipes, is rather high but decreases rapidly with increased pressure. This property will be discussed in the manual in depth, as some boilers that are unable to generate dry steam at low (roughly atmospheric) pressure work quite well at 7 to 10 psi gauge. The for this is that as steam pressure rises, its volume decreases, causing a corresponding decrease in the velocity of steam as it leaves the water in the boiler. This "slower" steam is less apt to suck boiler water along with it, hence the greater dryness.

It is absurd to use boilers incapable of producing dry steam at very low pressure for one-pipe steam heating, because boilers used in one-pipe steam heating systems must start at atmospheric pressure. This can be compared to an airplane with no landing gear: it may fly well, but the takeoffs and landings are rough. Many poor boilers make such wet steam on startup that they siphon themselves half-dry before they reach operating pressure. (The water that so hurriedly left the boiler frequently winds up on someone's rug or in a salad bowl or bucket shrewdly positioned beneath the radiator's air valve.)

How to Determine Whether Your Steam Is Dry Enough Steam quality or dryness is measurable, but the instrumentation required to do the job is not practical for use in apartment houses. A steam calorimeter directly measures steam quality in the pipe, but a calorimeter and its attendant equipment will cost as much as a small boiler, thus defeating our aim of silent and economical heat. Instead of determining how dry the steam is, we will rather determine how dry it isn't by rather devious methods. Basically there are a few symptoms that indicate the presence of excessive moisture in the steam that you should learn to recognize, and all the instrumentation you will need is a lighted match or candle and a good pair of eyes and ears. Here are the specifics:

1. Panting and Squirting Radiator and Steam-Main Air Vents This can happen

quite quietly, although it is frequently accompanied by the famous knocking pipes most people think is a standard affliction of steam heat. Most people learn that the steam in their radiators is not all it's cracked up to be when the air vent starts squirting water. If the air vent does indeed squirt water, first make sure the radiator is reasonably level and that the radiator valve is fully open. If all hell (noise and lots of water issuing from the vent) breaks loose when the partially open valve is opened, close it and wait for the heating cycle to end. When the steam is off, the valve can then be opened. When the steam is back on, the air vent should release air smoothly; if it pants like a dog in the hot sun, this is s sure sign that water somewhere is keeping steam from entering the radiator. Although this can be caused by the pipe leading to this particular radiator being pitched the wrong way, this is not usually the case. The most frequent reason why an air vent pants is that there is a small hurricane taking place in the steam mains in the basement. Specifically, the excessive water in the steam, which originally may have left the boiler in small droplets resembling the spray in a car-wash, has coalesced into a slug of water that forms a tidal wave in the steam main. As this wave passes the connection where the pipe leading to our radaiator, it momentarily interrupts steam flow to our radiator. If you hold a flame near the outlet of the air vent that is panting, you will observe that the flame is alternately blown away from and <u>sucked into the vent hole</u>. Thus no net venting takes place. This is why the radiator (through no fault of its own) is a lousy heater.

If you now go into the basement, you will probably find the air vents on the steam mains a wreck. (Usually they are so old that they no longer work or pathetically vent steam without closing. New vents, especially ones with large openings, are probably now flooding the basement.

By the way, most air vents are equipped with internal floats that allegedly keep the vent from passing water. In a water hammer situation, these floats are only good for a few cycles, after which they generally refuse to work, either because the float has collapsed from the hammering or the delicate air vent sealing seat has been ruined by being rammed shut by water. (At this point the vents are ruined and useless; however, don't replace them now, because the new ones will be just as quickly ruined. First get rid of the water hammer.

By the way, anybody who was foolish to have installed master vents on their water hammer plagued system has probably by now ruined a lot of plaster in the rooms upstairs. Since the instructions on master venting include the dire warning <u>not to install master vents until all water hammer is eliminated</u>, they deserve the mess they caused

<u>2. Knocking Pipes and Sloshing Sounds in Radiators and Pipes</u> Knocking pipes are caused by water in them being flung into a fitting. This is in most situations with one-pipe steam caused by wet steam leaving the boiler. In rare cases a steam main has sagged, allowing a water pocket to form, but the boiler us generally the culprit. Sloshing sounds are just a milder indicator of water hammer.

<u>3. Boiler Water line Too High for the Steam Mains</u> Sometimes a new boiler is installed with its water level higher than it was in the old boiler. because the pit the old boiler was installed in has been filled in. Generally the boiler water line should be at least 28" below the lowest point in the steam main to prevent water from backing up into the main. If the new boiler has been installed too high,

the cure isn't cheap. Either lower the boiler or install a condensate pump and steam trap or water seal at the end of the steam mains.

4. Check Valves on Return Lines Check valves on return lines cause the end of the steam mains to be flooded because the steam pressure in the boiler keeps the check valve shut until the water on top of the check valve rises high enough to force it open. If you see check valves on return lines, have their guts removed.

5. Zooming water line in the Boiler Gauge Glass This is caused by unstable boiling occurring in the boiler. This is frequently caused by dirty water in the boiler or by water slugs in the steam mains rapidly varying steam pressure, causing sudden pulsations of flash steam. To remedy a dirty water condition, clean the boiler in accordance with the boiler manufacturer's instructions. Avoid snake-oil and other magic potions in the boiler. Just use the materials prescribed by the boiler manufacturer.

Another common cause of a zooming water line is the wrong steam piping on the boiler causing wet steam to leave the boiler. Tests conducted by the author have shown that even boilers with certified I=B=R ratings must be derated by 50 percent if the steam piping on the boiler is wrong. The remedy is to reinstall the boiler steam piping in scrupulous accordance with the boiler manufacturer's instructions. The cost of this can be hideous, but there's no other way out.

Operating Steam Pressure The best steam pressure for a one-pipe heating system is usually under 1 psi. This allows the best control of the output of steam radiators. (Other steam heating systems use steam at pressures ranging from a high vacuum to several hundred psi; these systems are outside the scope of this manual.)

The Disadvantages of Steam Steam and water sometimes have a Jekyll & Hyde relationship that can make a fool of the unwary. Unlike Dr. Jekyll and Mr Hyde, luckily, steam and water if managed correctly both have a positive part to play in steam heating. The trick is to keep each in its place. This book will show you how. This book will also show you how critical it is to have dry steam, and how to insure that your boiler produces it.

THE BOILER

The boiler is a glorified tea-kettle, nothing more. It converts the heat from the fuel burnt in the furnace (the stove) first to hot water and then to steam. Our kettle does something else that's very important: it separates the steam from the water. This is essential because a boiler that boils over is about as useful as a pot or kettle that does the same: both make a mess and waste a lot of fuel in the process.

Steam boilers are made of two principal materials: steel and cast iron, whose relative advantages will be discussed later.

The Furnace and Burner

The furnace is where the fuel is burnt. Think of it as a fancy stove. In the modern boiler the furnace is an integral part of it, with the boiler surrounding part of if not most of the furnace. It is the furnace's job to allow the fuel to burn as completely as possible so that the boiler can extract as much heat as possible. The burner atomizes the fuel into a fine spray and mixes it with the air the fan has blown into the furnace This mixture is ignited and the resulting combustion provides the heat to make the steam.

Boiler Efficiency

Boiler efficiency is measured in three basic ways, combustion efficiency, steady-state boiler efficiency, and seasonal boiler efficiency.

Combustion Efficiency: Combustion efficiency is a measure of how well the fuel is burnt and how well the boiler has absorbed the heat from this combustion. It is the most easily measured of the three efficiencies because the only measurements are flue gas temperature and carbon dioxide concentration. However, combustion efficiency plays only a partial role in real heating system efficiency, because it ignores the heat lost through the boiler's walls into the air. It also ignores the heat lost by the boiler when the burner is off and steam is not being produced. Lastly, and most significantly it ignores the terrible losses to efficiency due to wet steam.

Steady-State Boiler Efficiency: This is fuel-to-steam efficiency and is inevitably a few points lower than combustion efficiency. This efficiency is rarely measured in the field because it requires a device called a calorimeter, which is a device that measures steam quality. The I=B=R Gross Output on boilers carrying the I-B-R nameplate yields steady state efficience when divided by the heat input. Steady state efficiency does not account for losses from the boiler when the burner is off and steam is not being produced.

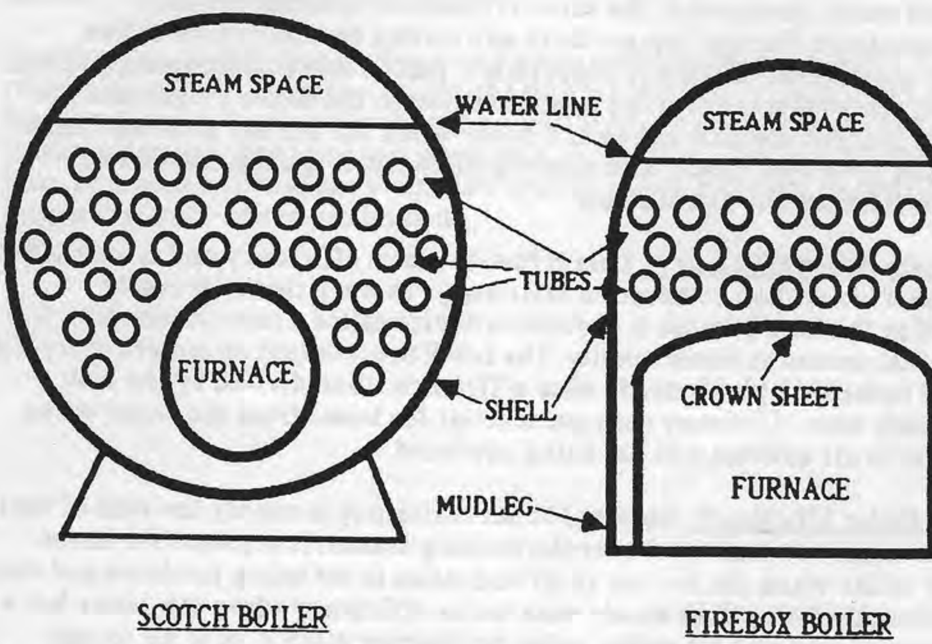
Seasonal Boiler Efficiency: Seasonal boiler efficiency is simply the ratio of fuel heat in to steam out, measured over the heating season. It accounts for losses from the boiler when the burner is off and steam is not being produced and can be significantly lower than steady state boiler efficiency when the boiler has a large thermal mass and when the boiler and burner allow a lot of air to pass through the boiler when the burner is off.

STEEL BOILERS

Steel boilers currently made fall into three basic types: scotch, firebox, and watertube. Scotch and firebox boilers are classified as firetube boilers because the combustion gases pass through the tubes, and the water surrounds the tubes. In watertube boilers the situation is reversed; the water is inside the tubes, and the combustion gases pass around the outside of the tubes. The illustrations show the major features of each type.

Scotch Boilers In the scotch boiler fuel is burnt in a cylindrical furnace surrounded by water. The combustion gases travel to the rear of the furnace where they enter a chamber where they reverse direction and enter the firetubes. The gases pass forward through these tubes and may reverse direction once or twice more before they enter the chimney. The scotch boiler has the advantages of low first cost and ease of installation. However, many scotch boilers made today are overfired and thus produce wet steam. Scotch boilers tend to be noisy, and most designs require very tight control of the water level to prevent priming (the discharge of steam containing excessive quantities of water due to violent boiling and insufficient steam space in the boiler). This usually requires the use of a condensate tank and feed pump, which negates part of the scotch boiler's cost advantage. The scotch boiler usually requires a large-diameter steam header for proper steaming performance. In specifying a scotch boiler, the engineer should insist on a written guarantee of the rated output with 98 percent quality steam at a pressure no higher than 2 psi. This will put all boilers on an equal rating basis meeting the accepted rating criteria for the heating industry.

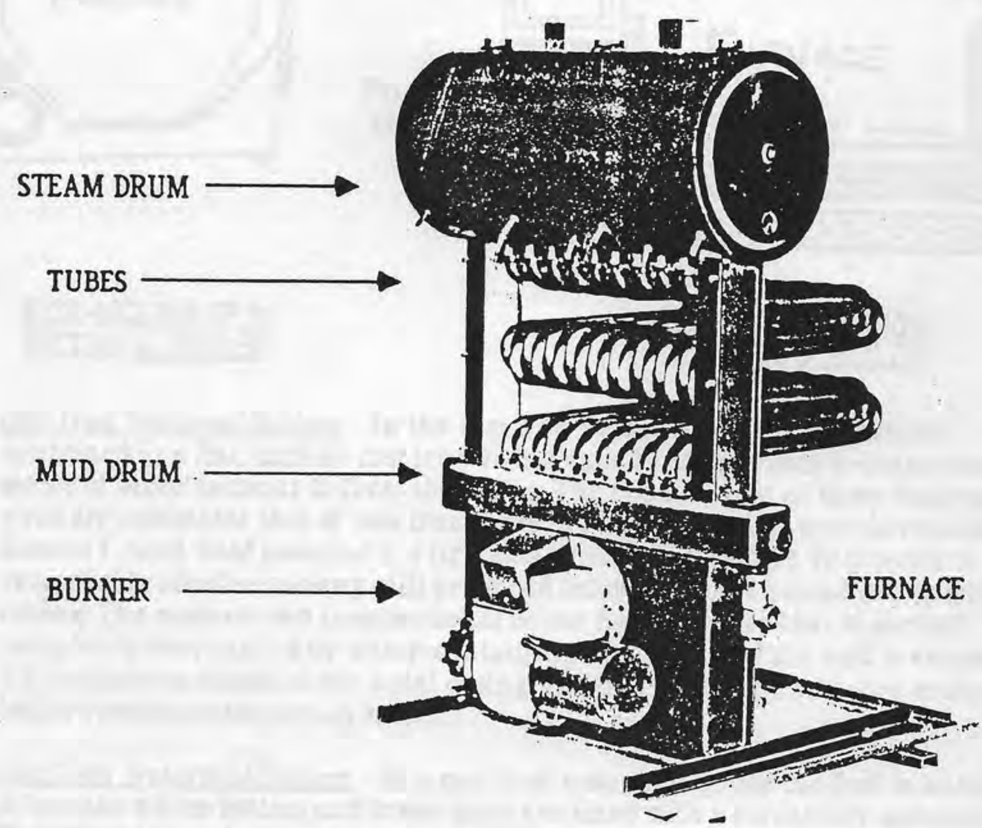
MAJOR TYPES OF STEEL FIRETUBE HEATING BOILERS



SCOTCH BOILER FIREBOX BOILER

Firebox Boilers In the firebox boiler fuel is burnt in a squarish furnace whose roof (crownsheet) is curved. The combustion gases travel to the rear of the furnace where they enter a chamber where they reverse direction and enter the firetubes. The gases pass forward through these tubes and reverse direction and pass through another set of tubes before they enter the chimney. Firebox boilers are rated somewhat more conservatively than scotch boilers are, and thus are more expensive than scotch boilers. Like scotch boilers, firebox boilers require very tight control of the water level to prevent priming and resultant wet steam. This usually requires the use of a condensate tank and feed pump. Unless it is supplied with a drypipe, the firebox boiler usually requires a large-diameter steam header for proper steaming performance. In specifying a firebox boiler, the engineer should insist on a written guarantee of the rated output with 98 percent quality steam at a pressure no higher than 2 psi. This will put all boilers on an equal rating basis meeting the accepted rating criteria for the heating industry.

Watertube Boilers In a watertube boiler the fuel is burnt in a furnace, and the combustion gases pass around the outside of the tubes rather through the inside of the tubes. Water is fed into a watertube boiler through a header called a mud drum. The bottom ends of the tubes are connected to the mud drum; at the top end of the tubes is a header called the steam drum. The mud drum and tubes are filled with water, and the steam is generated within the tubes. The steam-water mixture rises into the steam drum where the steam is separated from the water.



BRYAN D-SERIES WATERTUBE STEAM BOILER

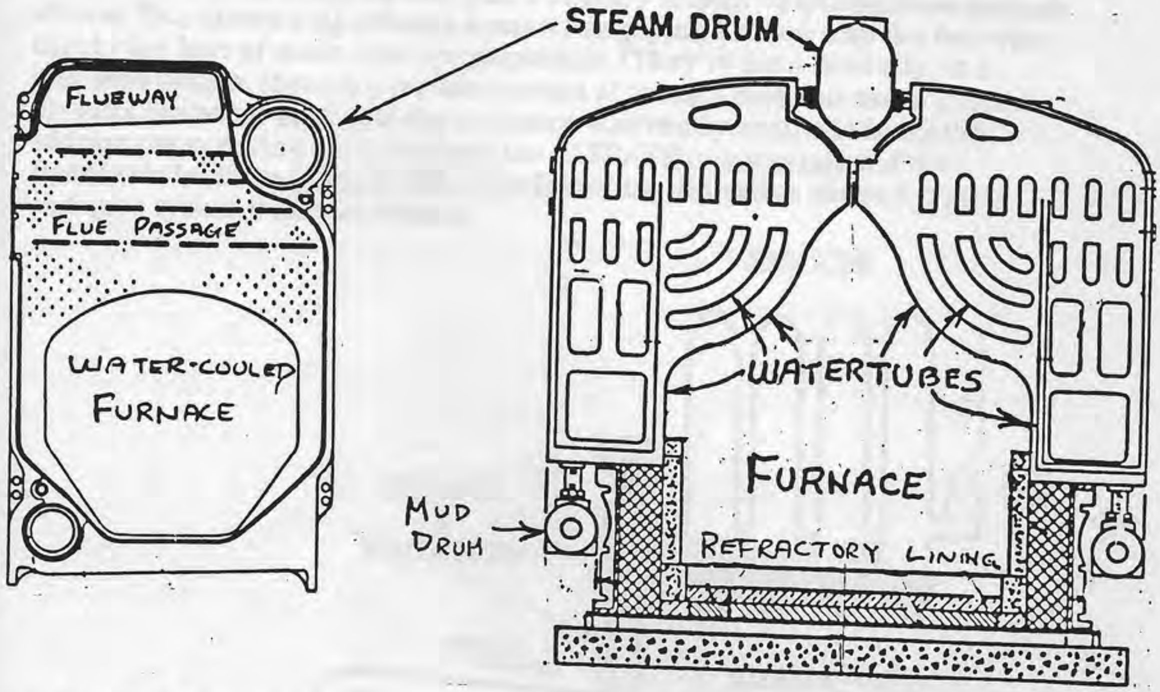
Watertube boilers come in many varieties. The Bryan Model D boiler is typical of a watertube boiler used for heating purposes. In this boiler the mud drum is box-shaped, the tubes are bent in a multiple hairpin pattern, and the steam drum is a large cylindrical vessel. The above illustration shows this boiler

without the casing that contains the combustion gases. This illustration shows an oil burner, but gas firing is also used in this boiler. Although watertube boilers are sometimes more expensive than scotch or firebox boilers, they require considerably less boiler room space than scotch or firebox boilers do. Watertube boilers have far less water than firetube boilers and are thus less vulnerable to flash steam accidents. (Flash steam is analagous to what happens to a bottle of champagne when opened: bubbles suddenly appear and a lot of champagne goes everywhere but in the glass where it belongs. In a boiler flash steam is created when a steam heating system undergoes pressure changes which are sometimes the result of wave action in the steam pipes between the steam and the condensate. As the pressure falls, the boiler suddenly produces a lot more steam that it is rated for; as the steam pressure rises, the opposite happens. This is the cause of rapid, sweeping changes in the water level in the boiler's gauge glass.)

CAST IRON BOILERS

Cast iron boilers are available in two basic types: sectional and watertube. The illustration shows these boilers in cross-section.

CAST IRON BOILER TYPES



WEIL-MCLAIN Nº 88
SECTIONAL BOILER

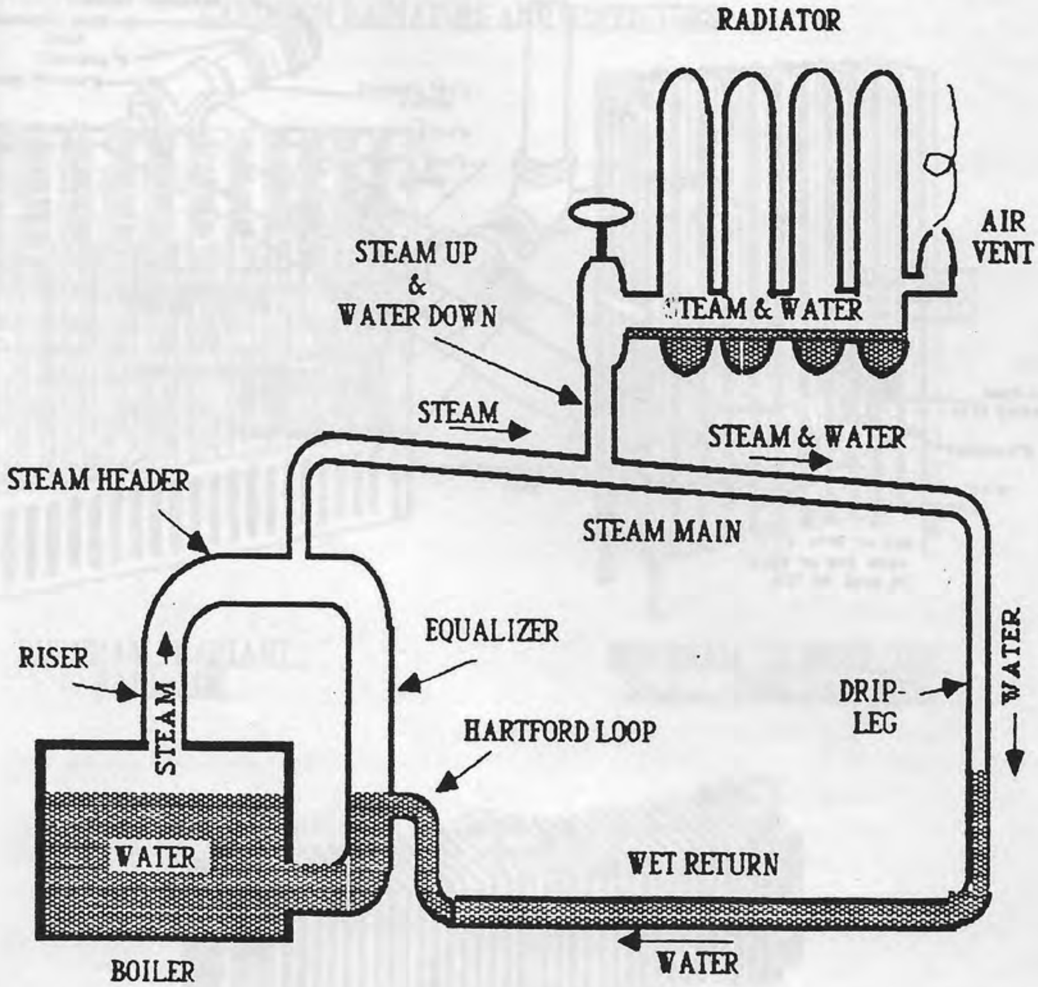
H.B.SMITH MILLS 6500
WATERTUBE BOILER

Cast Iron Sectional Boilers In the cast iron sectional boiler the water is contained in a flat, boxlike cast iron vessel called a section that is connected to a series of other sections to form the boiler. The construction of these boilers strongly resembles that of cast iron radiators, both of which were invented by Samuel F. Gold. Gold patented his first sectional boiler in 1859. This boiler is remarkably similar to many still produced today, but was encased in a brick casing. The modern cast iron sectional boiler has a furnace that is partially or completely surrounded by water-containing cast iron, and the unit is encased in a fiberglass-insulated sheet metal casing. (In this aspect the cast iron sectional boiler resembles the scotch boiler.)

Cast Iron Watertube Boilers In a cast iron watertube boiler the fuel is burnt in a furnace whose bottom and lower sides are lined with a refractory material. This allows these boilers to use heavy oil. The combustion gases pass around the outside of the tubes rather through the inside of the tubes. Water is fed into this watertube boiler through two mud drums, one at each side of the furnace. The bottom ends of the tubes are connected to the mud drums by screw nipples; at the top end of the tubes is a header called the steam drum, which is connected to the top of the tubes by screw nipples. The mud drum is filled with water, and the tubes are partially filled with water. When steam is generated in the tubes, the steam-water mixture rises into the tops of the tubes and into the steam drum where the steam is separated from the water. Although somewhat more expensive than most other boilers, the cast iron watertube boilers have an extraordinarily long life expectancy. Cast iron watertube boilers have far less water than most other boilers and are thus less vulnerable to flash steam upsets. The design of the cast iron watertube boiler allows cracked tubes to be isolated from the rest of the boiler with a short interruption in steaming. This makes this type of boiler desirable in buildings which can not afford anything but the shortest interruption of heat.

STEAM AND CONDENSATE PIPING

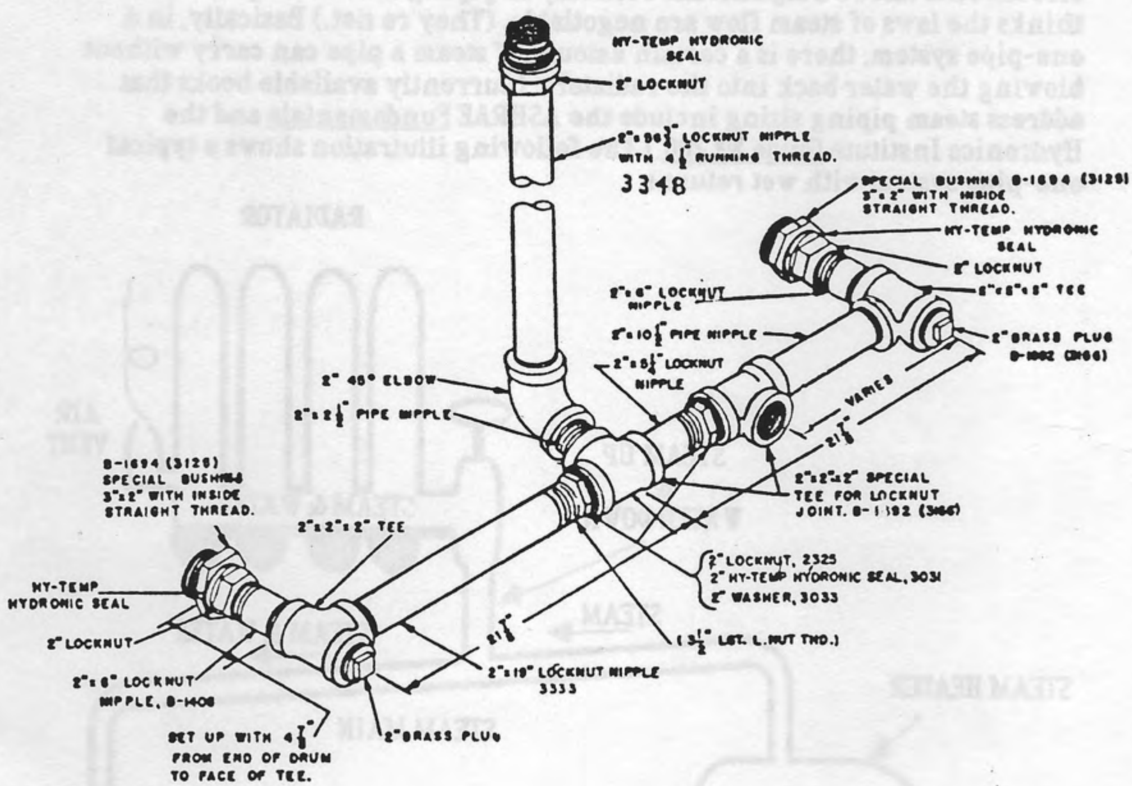
Steam piping conveys the steam from the boiler (where it is made) to the radiators (where it is used). On a one-pipe system part of the steam piping also returns the condensed steam (water) from the radiators back to the boiler. One of the facinating aspects of one-pipe steam heating is that steam and water not only coexist in the pipes; they often flow in opposite directions. This unlikely situation has been going on well past a century in many pipes with no undue effects. This allows a significant economy in piping but can trap the fool who thinks the laws of steam flow are negotiable. (They're not.) Basically, in a one-pipe system, there is a certain amount of steam a pipe can carry without blowing the water back into the radiators. (Currently available books that address steam piping sizing include the ASHRAE Fundamentals and the Hydronics Institute Guide Nº 200.) The following illutration shows a typical one-pipe system with wet returns.



STEAM AND CONDENSATE (WATER) FLOW PATHS IN A ONE-PIPE STEAM SYSTEM

RETURN YOKE FOR AN H.B. SMITH 3500 MILLS BOILER

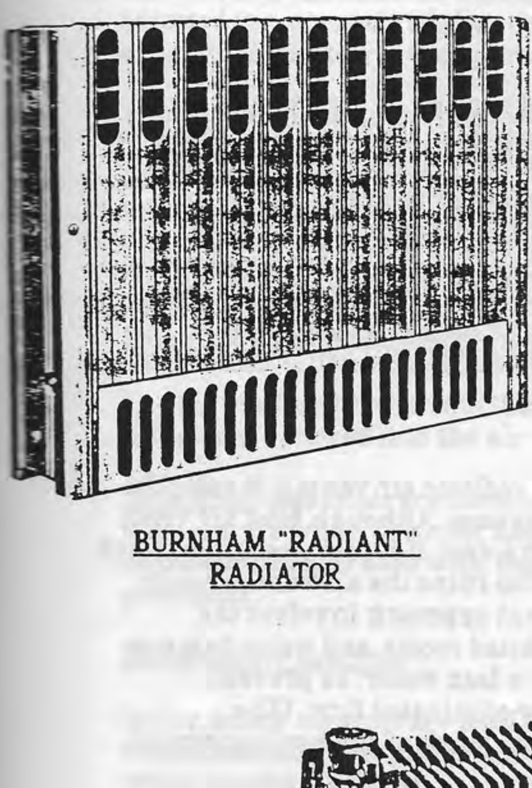
This return yoke is shipped with the boiler and makes it easier for the installer to do the job right than it is to do the job wrong. This boiler requires no particular steam piping because it produces bone-dry steam at the boiler outlet.



RADIATORS

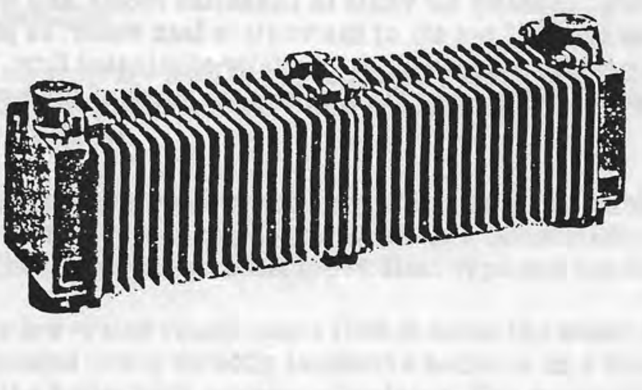
Radiators are what heat the rooms and occupants of a building. Steam condenses in the radiators and returns to the boiler through the piping. "Radiators" as used in this manual refers to traditional cast iron radiators as well as to any other heaters, such as steel convectors, that use steam for heating. The various types of radiators deliver their heat in surprisingly different manners, and this can significantly affect human comfort. The two forms of heat delivered by radiators are radiant heat and convective heat. Radiant heat warms people directly, whereas convective heat warms the room air, which subsequently warms the people in the room. Cast iron radiators and steel convectors should not be mixed within one-pipe steam heating because of their vastly different heating characteristics. The cast iron radiators retain their heat while the boiler is off; steel convectors go cold almost immediately.

CAST IRON RADIATORS AND CONVECTORS



BURNHAM "RADIANT" RADIATOR

BURNHAM "SLENDERIZED" SMALL-TUBE RADIATOR



GOVERNALE CAST IRON CONVECTOR

AIR VENTS

Air vents are used to allow air to be automatically expelled from the piping and radiators in a one-pipe steam heating system. This is necessary because when the boiler is not in operation, the radiators and piping are filled with air, and this air must be vented to allow steam to enter the piping and radiators. Air vents when properly applied can have a significant effect on the balance of the heating system and thereby on its fuel consumption. Air vents are divided in two categories: radiator air vents and steam pipe air vents.

Steam Main and Riser Air Vents

Steam line air vents are large capacity air vents used to rapidly remove large quantities of air from the steam mains and risers. Usually in the past these vents have been located at the end of the steam mains in the basement. A new approach, Master Venting, provides a calibrated rapid air removal from all steam pipes so that the steam enters all radiators simultaneously. See the chapter titled Master Venting in this manual.

Radiator Air Vents

Radiator air vents should provide only localized venting of the radiator if the steam main and riser air vents are in proper operation. Radiator air vents come in many configurations and venting capacities. Most radiator air vents have one venting rate and provide little if any control over the radiator's output; others have adjustable venting rates that allow the radiator's output to be varied. However, no air vents themselves respond to the room air temperature so as to maintain the air temperature at a preset level. This requires the use of thermostatic actuators, which are discussed under Automatic Control of Individual Radiators in the chapter called Heating System (Comfort) Controls.

Water Hammer Damage Avoidance

Before undertaking any work on steam line or radiator air vents it is essential that all water hammer be eliminated from the system. Although most air vents are supplied with floats that supposedly close the vent if it becomes waterlogged, the water hammer that causes this to happen also ruins the air vent through incessant hammering. The use of the master vent approach involves the installation of large capacity air vents in inhabited rooms, and water hammer inevitably causes many, if not all, of the vents to leak water. To prevent property damage, water hammer must be totally eliminated first. (The elimination of water will inncidentally eliminate much of the heating system imbalance.)

BOILER CONTROLS

Boiler controls have two functions: safety and comfort. Boiler safety controls prevent the boiler from destroying itself either by excessive pressure or from overheating because of inadequate water in the boiler; boiler operating controls tailor the steam pressure to the operating characteristics of the heating system thermostats.

Boiler Operating Controls

Boiler operating controls are used to maintain proper steam pressure (pressure controls) and proper boiler water temperature when domestic hot water is provided (aquastats).

Pressure Controls: **Pressure controls on steam heating boilers usually maintain system steam pressure at a few psi. The most commonly used control is the Honeywell PA-404A "Pressuretrol", which uses a diaphragm-operated microswitch to control the burner. A second PA404A control is fitted with a microswitch that must be manually reset when it is tripped. This control is adjusted to a pressure higher than the normal operating pressure and serves as a last-ditch backup to the operating pressuretrol.**

The PA404A pressuretrol has one deficiency when applied to one-pipe steam heating systems. That is the minimum pressure it can maintain steam pressure at is about 1.5 psi, and the differential between burner cut-in and cut-off is at least one psi. A more appropriate control to use is the Honeywell L408A1132. This unit allows system steam pressure to be controlled to a high degree of accuracy, around 1/2 psi, which is best for one-pipe steam. This unit uses a mercury switch in place of the microswitch and consequently is more reliable in the frequently humid atmosphere of a boiler room.

The air vent is screwed into the thermostatic actuator, and the thermostatic actuator is screwed into the air vent tapping in the radiator.

Aquastats: **Aquastats are used to maintain the boiler water at a preset minimum temperature when domestic hot water is provided by heat from the boiler water. Aquastats are also used with heavy oil burning boilers to provide heat to the oil preheater.**

Boiler Safety Controls

Boiler safety controls are used to prevent boiler loss when the water level in the boiler is unsafe (low-water cutoffs), and to automatically add water to the boiler when needed (feeders).

Low-Water Cutoffs **Low water cutoffs are boiler safety controls that shut off the burner if the water level in the boiler falls below the minimum safe operating water level. They come in two basic types: float-type and conductivity-type.**

The float-type low-water cutoff uses a float to sense the water level in the boiler. This float is located either directly inside the boiler or in a chamber that is connected to the boiler with appropriate piping. The conductivity-type low-water cutoff uses the dfference in conductivity between that of water and that of steam or air.

ASME Boiler and Pressure Vessel Code Requirements for Low-Water Cutoffs. The installation of a low-water cutoff on low-pressure staem boilers is required by Section IV Heating Boilers of the ASME Boiler and Pressure Vessel Code. Paragraphs HG-602 and HG-605 specify the exact manner and location in which the low-water cutoff is to be installed. (A copy of these rules is in the appendix.) Basically, the fuel flow must cease immediately when the surface of the water falls to the lowest visible part of the water gauge glass.

Time Delays on Low-Water Cutoffs. Some manufacturers of low-water cutoffs are offering models with time delays to prevent so-called nuisance burner trips caused by surging and momentary lack of condensate return. These low-water cutoffs are installed above the usual location for a low-water cutoff so that the time delay will not interfere with the burner being shut off before the water falls to the lowest visible part of the gauge glass.

Care must be exercised in installing a low-water cutoff with a time delay on a boiler not specifically equipped for it, because a properly located tapping may not exist. An improperly installed device of this type may be in violation of the ASME Code.

Reasons for Time Delays on Low-Water Cutoffs. Ironically, the reasons for installing time-delay low-water cutoffs are traceable in most cast iron boilers to improper installation. For example, most cast iron boilers have enough water between the normal operating level and the cut-off level to allow the boiler to steam for a good ten minutes. This is usually adequate time for the system to start to return adequate condensate to the boiler without the need for additional water. However, several mistakes in installation can upset this balance:

1. An improper steam header on the boiler will cause wet steam rather than dry steam, and the excess water in the steam will cause the boiler water level to fall prematurely.

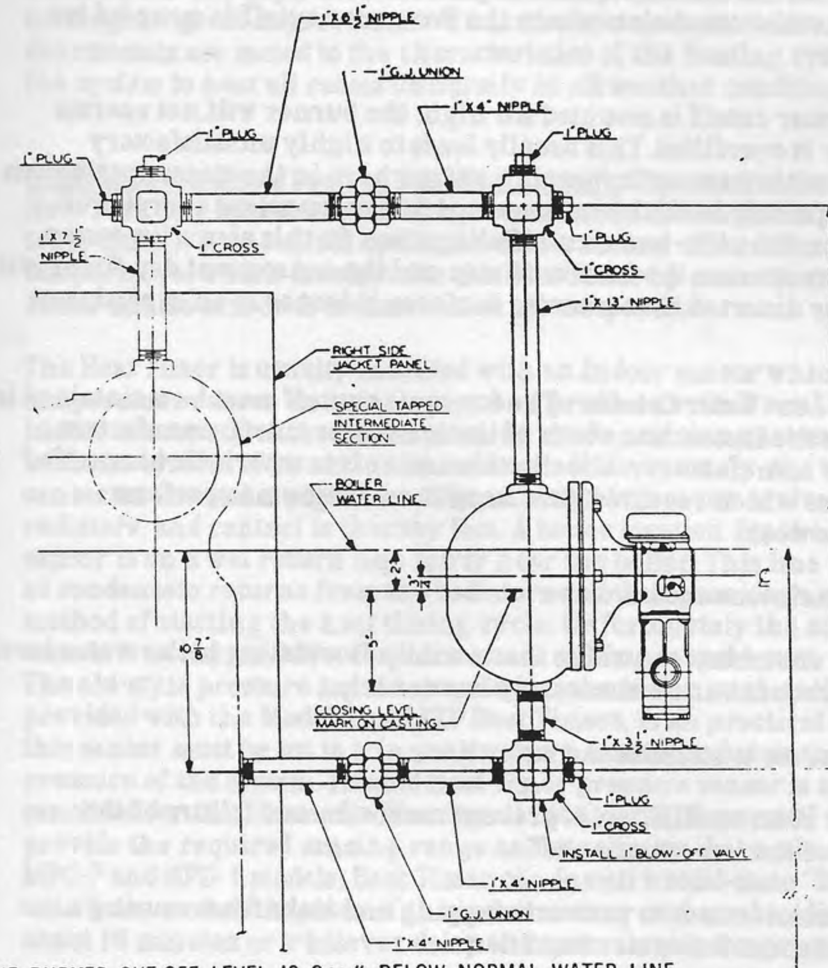
2. Poor boiler water quality will cause wet steam rather than dry steam, and the excess water in the steam will cause the boiler water level to fall prematurely.

3. Clogged wet return lines will retard the flow of condensate to the boiler.

Sometimes on larger installations the installer responds to a situation like this by installing a boiler feed pump at considerable expense, not knowing that his poor installation practices are the real culprit.

Proper and Improper Installation of Low-Water Cutoffs. The manufacturers of low-water cutoffs and the responsible boiler manufacturers provide specific instructions as to where and how the low water cutoff is to be mounted on each boiler. The illustration below shows a proper low-water cutoff application to Peerless 0711 through 0724 FDA boilers.

TYPICAL INSTALLATION OF A FEEDER/LOW-WATER CUTOFF



THE BURNER CUT-OFF LEVEL IS 2 3/4" BELOW NORMAL WATER LINE.

Note that this illustration establishes the exact cut-off and normal water levels for the boiler as well as the proper pipes and fittings required to achieve these operating levels.

Nothing is left to chance.

Some additional examples of installation instructions from H.B. Smith and McDonnell & Miller are in the appendix.

Unfortunately, a field survey of many boiler installations has revealed that these instructions are frequently disregarded. Typically, low-water cutoffs are mounted a few inches too high or too low; each mis-installation causes its own problems.

When the low-water cutoff is mounted too low, the burner will continue to operate even if the water level in the boiler is below the manufacturer's lowest recommended safe operating water level. In extreme cases this can lead to

recommended safe operating water level. In extreme cases this can lead to overheating and loss of the uppermost heat transfer surfaces of the boiler. However, as most manufacturers establish their lowest recommended safe operating water level with some conservatism, the damage here is usually limited. This is not the case below where the low-water cutoff is mounted too high!

When the low-water cutoff is mounted too high, the burner will not operate unless the boiler is overfilled. This usually leads to highly unsatisfactory operation, with water hammer appearing everywhere in the steam distribution system. This frequently leads the incompetent or unscrupulous operator or mechanic to bypass the low-water cutoff altogether. In this case a low water condition will never cause the burner to stop and the consequent dry firing will lead to cracked or distorted heat transfer surfaces at best or to an explosion at worst.

Maintenance of Low-Water Cutoffs. The low-water cutoff must be maintained in accordance with the instructions both of the low-water cutoff manufacturer and of the boiler manufacturer. Usually this amounts to a periodic blow-off of the float chamber which requires little more than a minute to perform, generally once a week.

Other, indirect maintenance involves:

1) Proper water chemistry control so that a wildly fluctuating boiler water level does not cause frequent and unnecessary burner trips,

2) Proper firing rate to stabilize the water line,

3) Proper boiler room ventilation to prevent corrosion and failure of the electrical parts of the low-water cutoff.

4) Return line maintenance to prevent clogging and leaks from causing a periodic or permanent low-water condition

5) The correct steam piping so that the boiler does not produce wet steam and thereby run out of water prematurely.

Automatic Water Feeders Automatic water feeders are intended to maintain minimum water level in the boiler when the superintendant is not doing his or her job. It is essential that the quantity of makeup water in a boiler be monitored, as excessive makeup water is a sign of leakage in the boiler or in the heating system.

Do not use automatic water feeders on boilers unless the makeup system is equipped with a water meter. Otherwise, unattended automatic water feeders mask boiler and heating system leaks and should not be used.

(Unfortunately few boilers are fitted with a water meter and consequently many boilers only a few years old are lost because the oxygen in the raw makeup water east away at the boiler around the water line.)

A steam boiler should have its water level checked at least weekly when it has been off for at least one-half hour so that leaks can be found and eliminated.

HEATING SYSTEM (COMFORT) CONTROLS

Comfort controls consist of a central thermostat and localized thermostats. Controls for one-pipe steam heating are simple, and in the last few years have undergone great improvement. When the best modern room and radiator thermostats are mated to the characteristics of the heating system, they make the system to heat all rooms uniformly in all weather conditions.

Central Thermostats Such as the "Heat Timer" The central thermostat in most New York City apartment buildings consists of a device called a Heat Timer (a trade name). This control cycles the boiler on and off as a function of outside temperature, which is relayed to the Heat Timer by an outdoor sensor. The Heat Timer has no sensor to measure room air temperature.

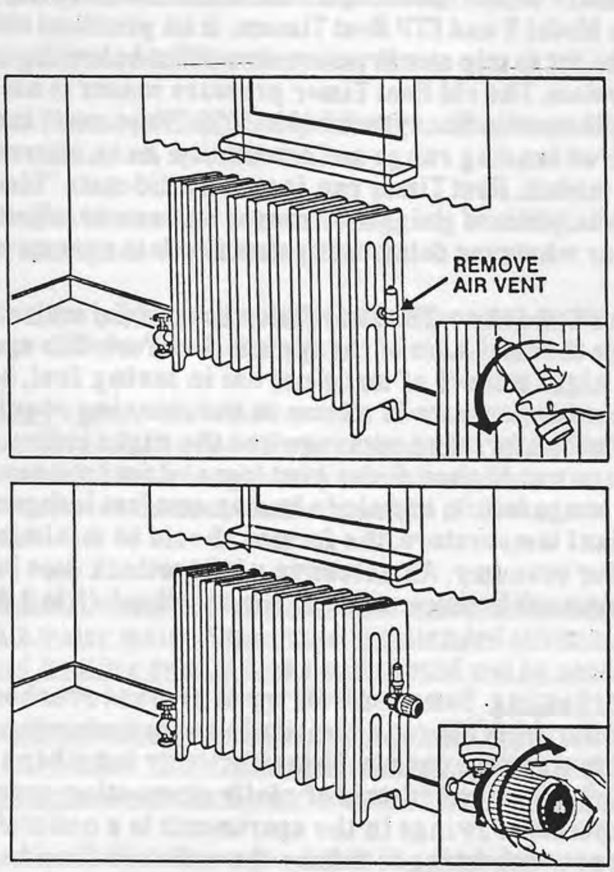
The Heat Timer is usually installed with an indoor sensor which is either a temperature sensor on a steam pipe or a pressure switch on the boiler. The indoor sensor starts the heating timing cycle, and this start should coincide with the arrival of steam in the radiators. Unfortunately, the temperature sensor on the steam pipe is usually activated before the arrival of steam in the radiators, and control is thereby lost. A better location for the temperature sensor is on a wet return line fairly near the boiler. This line warms up slowly as condensate returns from the radiators and thus provides a sensitive and valid method of starting the heat timing cycle. Unfortunately the adjustment of this sensor is tricky, and few contractors are willing to make such a fine adjustment. The old-style pressure sensor mounted on the boiler, such as that usually provided with the Model E and ETP Heat Timers, is an practical alternative, but this sensor must be set to trip at a pressure somewhat below the operating pressure of the system. The old Heat Timer pressure sensor is not sufficiently sensitive for this; instead, a Honeywell L608A1053 "Vaporstat" is recommended to provide the required sensing range and sensitivity. As an alternative on the MPC-7 and HPD-1 models, Heat Timer can install a solid-state "District Steam" time delay module in place of the indoor sensor and can be adjusted to a delay of about 10 minutes or whatever delay the system needs to operate consistently.

Night Temperature Setbacks. The Heat Timer is provided with a night setback. However, the large thermal mass of the typical New York City apartment building makes a night setback of marginal use in saving fuel, because the lower mean radiant temperature in a room in the morning requires a higher air temperature for comfort than was required the night before when the mean radiant temperature was higher. Since heat loss and fuel consumption are dependent on air temperature, and since human comfort is dependent on the proper mean radiant temperature, the former should be minimized and the latter maximized for economy. An excessive night setback does just the opposite. In the typical apartment house, a minimal night setback (2 to 3 degrees) is recommended.

Prevention of Overheating Some controls try to prevent overheating by preventing the boiler from operating until the condensate returning from the system has cooled to a certain degree. This effectively lengthens the time between boiler "on" cycles and instead of really preventing overheating increases the temperature swings in the apartments to a noticeable degree. The only way to prevent overheating is to keep the radiators from becoming fully filled with steam. This is one of the purposes of Master Venting.

Automatic Control of Individual Radiators Thermostatic actuators are available that automatically vary the venting rate depending on the room air temperature and thus provide thermostatic control on each radiator. The air vent is screwed into the thermostatic actuator, and the thermostatic actuator is screwed into the air vent tapping in the radiator. These actuators are available from various manufacturers and are available with room air temperature sensors and control knobs that allow these thermostatic actuators to be used with both enclosed and free-standing radiators. One problem with early models of these thermostatic actuators was that they tended to waterlog and thereby cause small amounts of water to gurgle out of the air vent. (This kept the author himself awake on many nights.) The best new designs, such as the new Danfoss 1-PS, incorporate a condensate return passage with a ball check to allow condensate to return to the radiator without having to pass through the main valve opening. These have been tested by the author and are dead silent when installed on systems whose steam pressure is limited to about 1/2 psi.

In using such thermostats the choice of the air vent is critical, because if the vent is too large, the radiator will fill with steam before the thermostatic actuator has time to reduce the venting rate. Preferably a vent with the smallest possible opening, such as a Hoffman Nº 41 (the straight-shank version of the well-known Hoffman Nº 40) or the Hoffman Nº 500 hygroscopic disc air vent. With this arrangement it is possible to prevent overheating even after the boiler has been off all night. The following illustration shows a Danfoss 1-PS radiator thermostat.



BOILER MAINTENANCE AND LOSS PREVENTION

Although there have been great improvements in the efficiency of steam boilers in the last few years, a boiler should not be replaced unless it is economical to do so. Too many boilers are replaced for the wrong reasons. The worst reason of all is that the owner allowed the old boiler to destroy itself through poor maintenance. This results in a helter-skelter replacement job in the middle of winter. In the haste to replace the boiler, the causes of the old boiler's demise are still usually unattended to, so the new boiler frequently falls victim to the same trap as the old one did. The quality of a mid-winter replacement is usually well below that done when there's time to do it right, and the price is usually higher in view of the urgency. New asbestos regulations can be expected to make replacement of some boilers financially ruinous.

What's so tragic about boiler loss is that it is so easily and economically prevented. The most common causes of boiler loss are also sources of excessive fuel consumption, so the reasons in favor of loss prevention are double.

Boilers are lost usually through a sequence of preventable accidents. Perhaps the most comon cause of loss of heating boilers in the combination of a leaky underground return line with a defective low-water cutoff and feeder. In the typical New York apartment house the return lines are run above the basement floor but are routed under doorsills. The purpose of this was to allow the building superintendant and his family (who used to live in the basement) to move about their quarters without having to step over pipes. Since most of these buried pipes have been underground for the better part of a century, they have been subject to corrosion both from inside and outside. Since they are buried, their leakage is invisible, especially if the boiler is equipped with the usual automatic feeder. As water is lost to the ground, the raw makeup water that is automatically fed into the boiler causes accelerated rusting, and some of this rust inevitably is deposited in the float chamber of the low water cutoff and automatic feeder. With the floats in these devices comfortably supported by a growing pile of rust, rarely flushed out by the careless or ignorant superintendant, the boiler eventually runs out of water and overheats. This frequently results in one or more cracked cast iron sections or severly distorted steel furnace surfaces. The result is that the boiler is a total loss.

Too many manuals on the subject of boiler operation and maintenance assume that the average owner has a shed full of tools and instruments and that he or she has a large amount of technical knowledge and experience. For the average owner or superintendant these manuals are useless and may even scare them away from performing those tasks that can and must be performed to make the boiler last.

The next pages contain a suggested program for the typical owner or superintendant to follow. It covers those tasks that a non technically qualified person can <u>and must</u> perform between visits by the mechanic.

AN OWNER'S GUIDE FOR BOILER MAINTENANCE AND LOSS PREVENTION

This guide is intended for the owner or operator of a boiler who is not technically trained. Consequently, everything in this guide is simple to perform and requires no judgement on the part of the owner. A checklist follows this Guide.

<u>1. OBTAIN AND FOLLOW MANUFACTURER'S INSTRUCTIONS.</u> First and foremost obtain the instructions for operating and maintaining your boiler and burner from the boiler manufacturer. Most reputable boiler manufacturers offer this information for free. It's worth a long distance telephone call to the manufacturer's home office. Get this information in advance. Don't assume that that your mechanic possesses or has ever read these instructions.

<u>Note:</u> Most unsatisfactory boiler and burner performance is caused by a failure to read, understand, and follow the manufacturer's instructions. With the wide variety of equipment in New York, no technician or repair person can be expected to know your unit perfectly. If the mechanic doesn't have the correct information, in a pinch he or she will have to "wing it", usually with bad results.

<u>2. VERIFY THAT THE LOW-WATER CUTOFF IS INSTALLED AT THE CORRECT HEIGHT FOR YOUR BOILER.</u> Most low-water cutoffs are not only poorly maintained; worse, they are usually installed wrong. They are required to shut the burner off once the water level in the boiler drops to the lowest visible part of the gauge glass. The exact cutoff point for your boiler is shown in the boiler manufacturer's instructions.

<u>Note:</u> The gauge mark cast on the body of various low water cutoffs models does not always indicate the cutoff point. In some cases where the low water cutoff also includes a boiler feeder, this mark represents the feeder shutoff point, which is sometimes a few inches above the low water point.

<u>3. KEEP THE LOW-WATER CUTOFF FLOAT CHAMBER FREE OF SEDIMENT.</u> Most low water cutoffs must be blown off (drained) weekly to keep the water level sensing float from hanging up. Obtain and follow the manufacturer's instructions for your low-water cutoff to determine how often this should be done. Yearly, replace the blow-off valve at the bottom of the low-water cutoff's body. To make sure the electrical part of the low-water cutoff remains in good condition, replace the microswitch assembly yearly.

<u>4. VERIFY THAT THE LOW-WATER CUTOFF IS INSTALLED CORRECTLY.</u> Verify that the feeder is not connected to hot water, as hot water ruins the feed valve. The feeder must be connected only to cold water and it must be piped to feed into the heating system's return pipe, never directly into the boiler.

<u>5. KEEP THE AUTOMATIC WATER FEEDER FLOAT CHAMBER FREE OF SEDIMENT.</u> Automatic water feeders are similar in principle to the device that refills your toilet when it is flushed. Just as toilets leak, so do feeders. A periodic check of the water level in the gauge glass may reveal a leaking feeder. (Specifically, if the water level keeps rising, there may be a leak in the feeder.) To verify, operate the boiler with the feeder turned off for a few days. If the water level remains stable, the feeder is probably the culprit.

6. DON'T LOOK AT THE BURNER FLAME - IT WON'T TELL YOU ANYTHING! Burner flames range from blue to white to orange, and color has little to do with proper operation. The only way to verify proper combustion is to perform a combustion efficiency test. This involves analyzing the flue gases by measuring carbon dioxide, temperature, draught, and smoke density. Test kits for doing this, such as the Bacharach "Fyrite" are available for a few hundred dollars and will pay for themselves in a few months.

7. CHECK THE BOILER WATER LEVEL DAILY. The gauge glass tells you whether there is enough water in the boiler for proper steaming and safe operation. Too much water causes knocking radiators; too little can destroy the boiler. Make sure the water level in the boiler is at the level recommended in the manufacturer's instructions. Sometimes this level is marked on the boiler itself. If the gauge glass becomes dirty and the water level hard to read, have it cleaned or replaced. If the water level in the gauge glass zooms up and down, the boiler is generating wet steam because of dirt in the water or improper steam piping.

8. KEEP THE BURNER AND FUEL SYSTEM PARTS CLEAN. Keep the burner, fuel oil lines, pump, and strainer outwardly clean so that an oil leak will be visible. An oil leak is messy and a fire hazard. (Note that air can also leak into the oil lines. This inward leakage is dangerous. It will usually cause the burner to shut down (if you are lucky) or cause a furnace explosion (if you're not). Unfortunately, air leaks are not easily detected except by a vacuum test. This should be performed yearly by a qualified mechanic.) For burners using heavy (Nº 4 or 6) oil, clean the filter weekly. (If the filter needs cleaning more often than this, the fuel tank needs cleaning, or the oil is dirty.)

9. DON'T LET THE BOILER WATER GO TO POT! Follow the boiler manufacturer's instructions for Boiler draining and cleaning. Each boiler has areas that can burn out if they become clogged with junk that can enter the boiler through the return line. In cast iron boilers this can cause cracked sections; in steel boilers this can cause burnt out furnaces, combustion chambers, and mudlegs, All are expensive to repair.

10. DON'T DRAIN THE BOILER TOO MUCH. Avoid excessive draining; this introduces unwanted oxygen and minerals via the fresh makeup water. Do not drain the boiler in the summer unless it is necessary for repairs.

Note: Many boilers are installed with their drain tappings plugged (to save a few bucks). Have full-size drain valves installed in all of these openings. When you have these valves installed, you can make sure these areas are clean.

11. OPERATE THE SAFETY VALVE MONTHLY; VERIFY ITS CAPACITY ON THE NAMEPLATE. A safety valve is a boiler's ultimate protection against explosion. A safety valve must never be plugged or valved off from the boiler (even if it is leaking). Have a leaking safety valve replaced immediately. Your safety valve's relieving capacity (stamped on the safety valve nameplate) must equal or exceed the "Minimum Relief Valve Capacity" on the boiler nameplate. Safety valves for steam heating boilers must open at 15 pounds per square inch and so state on the safety valve's nameplate.

Monthly Check: With the boiler in operation and under steam pressure, pull the safety valve lanyard to allow steam to escape. When the lanyard is released,

steam flow should stop immediately. If the safety valve leaks, have it replaced, making sure that the minimum relieving capacity is maintained. If you must operate the boiler before the safety valve is replaced, DO NOT PLUG THE VALVE; YOU'LL HAVE TO PUT UP WITH A BIT OF LEAKAGE. A BOILER EXPLOSION CAN OTHERWISE OCCUR!!!

12. TAKE A LOOK AT BOILER DOORS, BREECHING, AND CHIMNEY; THEY SHOULD CLOSE TIGHTLY. (The breeching is another name for the smoke pipe that connects the boiler to the chimney.) The joints in boiler doors, breeching, and chimney should for checked for leakage with a lighted candle when the boiler is operating. If the flame is sucked into a joint, this reveals a leak which should be eliminated. The boiler doors allow the boiler flue passages to be inspected and cleaned. They should close tightly. Use a candle to verify their tightness after you close them.

13. MAKE SURE THE DRAUGHT REGULATOR SWINGS FREELY. The draught regulator is the round swinging plate on the breeching. It maintains the proper draught in the boiler. Do not attempt to adjust it; just touch it gently to make sure that it swings freely. If it doesn't replace it. (Danger: a stuck draught regulator can cause smoke and deadly carbon monoxide.

14. LISTEN FOR NOISES THAT DIDN'T EXIST BEFORE. Noisy operation (e.g. knocking radiators, pipes, hissing radiator air vents, etc.) reveal the existence of serious problems in the steam boiler or piping and should receive the attention of an expert. Noise is not only annoying, it wastes monumental amounts of fuel.

BOILER ROOM MAINTENANCE CHECK LIST

BUILDING ADDRESS: ___________________

SIGNATURE: ___________________

DAILY BOILER-ROOM MAINTENANCE CHECKLIST
WEEK OF ______, 198_

	Sun.	Mon.	Tues.	Wed.	Thu.	Fri.	Sat.
Oil storage tank gauge reading:							
Water level in gauge glass:							

WEEKLY BOILER-ROOM MAINTENANCE CHECKLIST
WEEK OF ____, 198_

Flush the low-water cutoff(s) in accordance with manufacturer's instructions. __ (done)

Wipe down all equipment. ___(done)

Check for oil leaks around fuel lines, transfer pumps, strainers, & burner. ___ (done)

Clean oil strainer(s) (for No. 6 oil). ___ (done)

MONTHLY BOILER-ROOM MAINTENANCE CHECKLIST
MONTH OF ____, 198_

Look at top of chimney for visible smoke when burner is operating. ___ (done)

Clean all equipment & the boiler room. ___ (done)

Inspect entire system for steam, water, fuel, & smoke leakage. ___ (done)

Operate safety valve to clear debris from its opening. ___ (done)

Open all boiler drains to remove a quart of water from each. ___ (done)

Test the (red) burner emergency switch when the burner is operating. ___ (done)

Clean oil strainer(s) (for No. 4 & 6 oil). ___ (done)

Open boiler doors & inspect for soot buildup. Clean if needed. ___ (done)

LEAKS IN ONE-PIPE STEAM HEATING SYSTEMS

Leaks are in three principal types:

1) Boiler leaks,

2) Steam leaks,

3) Return line leaks.

Boiler leaks occur most frequently in steel boilers that are either very old or are being overfired.

In very old boilers, chronic leaks are usually as sign that the boiler has come to the end of its useful service life.

Leaks Caused by Overfiring. In new and many older steel boilers overfiring is the real cause of tube leaks. The reason for this is that in order to lower the price on a boiler, some manufacturers are now specifying a firing rate far beyond that which is appropriate for the design and geometry of the boiler. This results in firetubes near the furnace becoming steam blanketed. This condition results in overheating, with the inevitable result of thermal cycling and accelerated oxygen pitting.

Boiler Leaks Caused by Excessive Raw Makeup Water. Many relatively new steel and cast iron boilers corrode because leaks in the return lines cause inordinate amounts of raw makeup water to be introduced into the boiler. Steel boiler manufacturers usually recommend the use of an anticorrosion water treatment to protect the rather thin and vulnerable steel firetubes from corrosion. Although in steam heating system service, cast iron is naturally considerably more resistant to corrosion than is steel, large amounts of raw makeup water can corrode, even the relatively heavy cast iron sections. This usually occurs at the waterline. (Ironically, cast iron boilers are more vulnerable than steel boilers here because the manufacturers of cast iron boilers usually do not recommend any form of anticorrosion water treatment.)

Steam Leaks are ignored by only the most incompetent operators, as they usually cause property damage where they occur. A steam leak consequently is not a frequent cause of low water, although is it an insidious waster of fuel. It also accelerates boiler and system corrosion by requiring raw makeup water.

Wet Return Line Leaks are the the subtle killers of boilers. Wet returns can be expected to corrode and leak in most buildings that are over fifty years old. A buried wet return is attacked is especially vulnerable because is is also subject to ground water attack.

Wet Return Line Maintenance It is economical to embark on a program of wet return line maintenance in all buildings, to include the following:

Flush wet returns. The responsible boiler Manufacturers recommend that return lines be fitted with a block valve upstream of the Hartford loop and a blowoff valve upstream of the block valve. A new boiler should be operated for a day with the return line block valve shut and the condensate wasted. In this manner, the loose crud that has collected in the return system can be blown out with steam pressure. This procedure should be retroactively implemented on all boilers, as malfunctioning return lines cause severe system imbalance as well as a low-water condition. If an excessive amount of crud comes out of the pipes, the line can be assumed to be severely corroded and in need of replacement.

Owners will find it advantageous to consider replacing all wet returns that have been in service since before World War II because the steel in these pipes is well shy of a quarter of an inch thick when new and in the last half century or so has lost most of that original thickness.

Replace all buried wet returns, irrespective of their age. As wet returns that are buried are subject to corrosion on both sides and since leaks in them can not be easily seen, such lines should be replaced, preferably with un-buried (above-the-floor) wet returns.

Note: Buried wet return lines are very common under door sills in the basement in New York City apartments. This is because the superintendant usually used to live in the basement, and he didn't want to step over pipes each time he went from room to room. Since few basements are used today for more than storage, the reason for most buried wet returns is obsolete, and in view of the trouble buried wet returns can cause, they should be replaced with above-the-floor wet returns wherever possible.

Keep all wet returns visible. This will allow them to be easily monitored for leakage.

Although most wet return lines have traditionally been steel, an excellent alternative material to use in secure buildings is Type L copper tube soldered with 95-5 solder, which is 95 percent tin and 5 percent antimony. Although copper material is usually more expensive to buy than steel, the installed cost of each is usually about equal because the steel is harder to work with.

The size of the replacement horizontal lines should be the same as the size of the old lines, but never be less than 2-inch. The purpose of this is to prevent them from becoming clogged. (In some cases this means that the new lines will be larger than the old ones. So be it.)

WHEN TO REPLACE A BOILER OR A BURNER

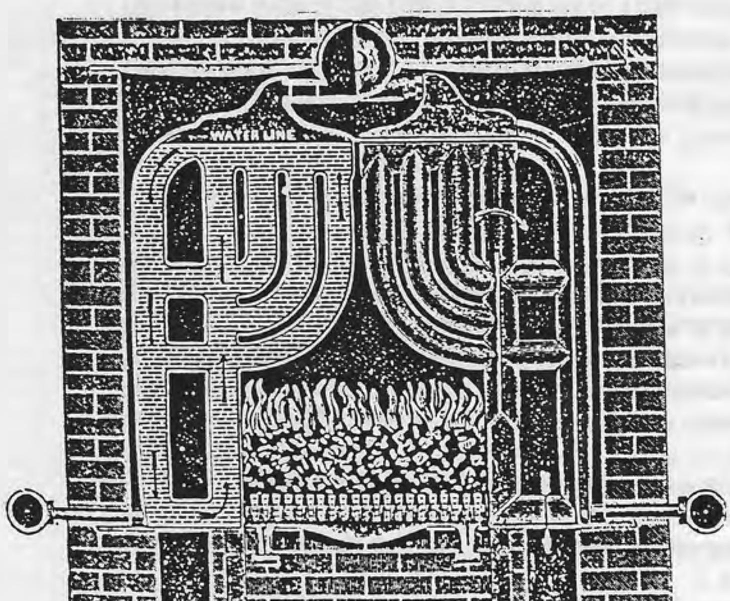
Certain boilers should be replaced even if they appear to be on good operating condition. This is because they are uneconomical to operate or irreparably unreliable.

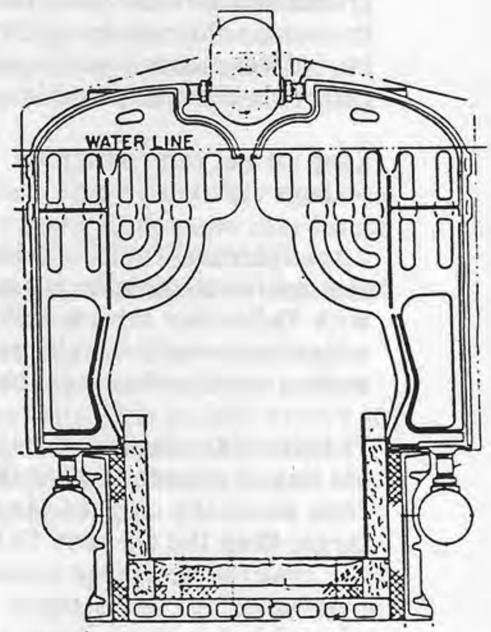
The terms "uneconomical" and "unreliable" must be applied within the context of the building being heated.

"Not All Old Boilers Are Over the Hill."

The age of a boiler has little to do with its efficiency. For example, a properly fired 1915-vintage Mills water-tube boiler can offer both steady-state and seasonal efficiencies as high as some of the best current designs.

THE MILLS BOILER OVER A CENTURY





MILLS Nº 4-1/2

C. 1890

MILLS 4500

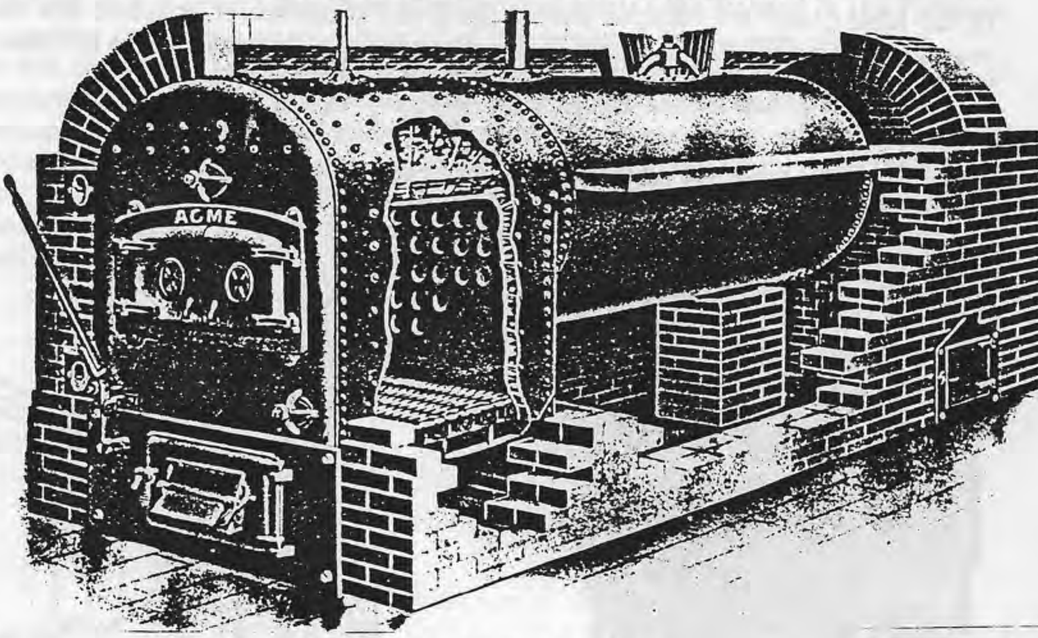
1987

H.B. SMITH COMPANY

The above illustration shows how little a first-class design, such as the Mills boiler, has had to change in a century. The primary changes between the 1890 Nº 4-1/2 and the 1987 4500 are in the replacement of the brick setting with a low thermal mass jacket and furnace lining, a larger steam-drum, and rearranged mud-drums. The boiler's steam output has been increased enormously from the coal-fired Nº 4-1/2 at about 25 Hp. to 90 Hp. for the oil or gas-fired 4500. (The current coal-fired Mills boiler of this type, the Nº 451, is rated at about 50 Hp.) Incidentally, the fuel-to-steam efficiency of the 1890 and 1987 coal-fired boilers is about 80%; the efficiency for the oil or gas-fired boiler is about the same. All three make steam at a bone-dry 99%+ quality.

Thermal Seives

On the other hand, most brick-set steel boilers, commonly installed up to about 1930, have such enormous thermal mass that such boilers are generally highly inefficient in the cyclic service common to most one-pipe steam heating systems. Consider the following illustration of an Acme firebox boiler with a brick setting (American Radiator Company, circa 1915). A brickset boiler has bricks covering both the furnace and the boiler shell. This boiler was designed for coal and was not intended to cycle on and off as is required with gas or oil firing. With coal firing the thermal mass of the brick setting was not detrimental to efficiency because it was rarely allowed to cool down. By comparison, with cyclic firing, an unacceptable amount of the heat stored in the bricks is essentially lost when the boiler is not making steam.



ACME BRICKSET FIREBOX BOILER
CA. 1915
AMERICAN RADIATOR CO.

Oversized Boilers

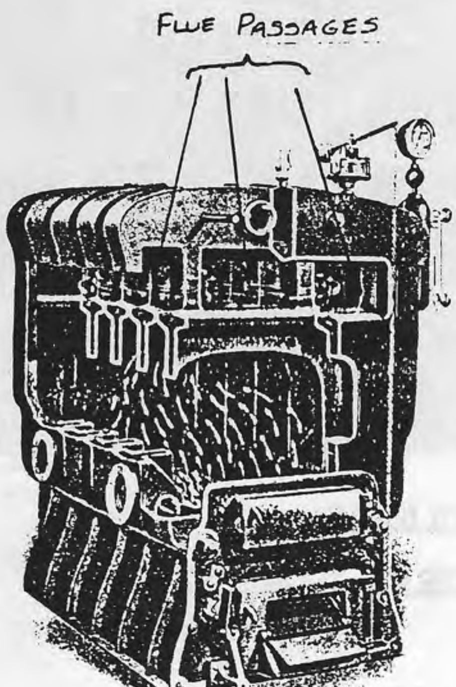
Oversized boilers are frequently considered good candidates for replacement, but truly oversized boilers are rare, and the steady-state efficiency of a boiler varies little over a large range of outputs. What matters is not so much the excess capacity but the excessive thermal mass that sometimes characterizes an oversized boiler. In general, an inefficient boiler generally should be replaced in an apartment house where it is used on a daily basis; however, replacement of the same boiler in a church, presumably used only a few hours on Sunday, is rarely economical.

Reliability Considerations

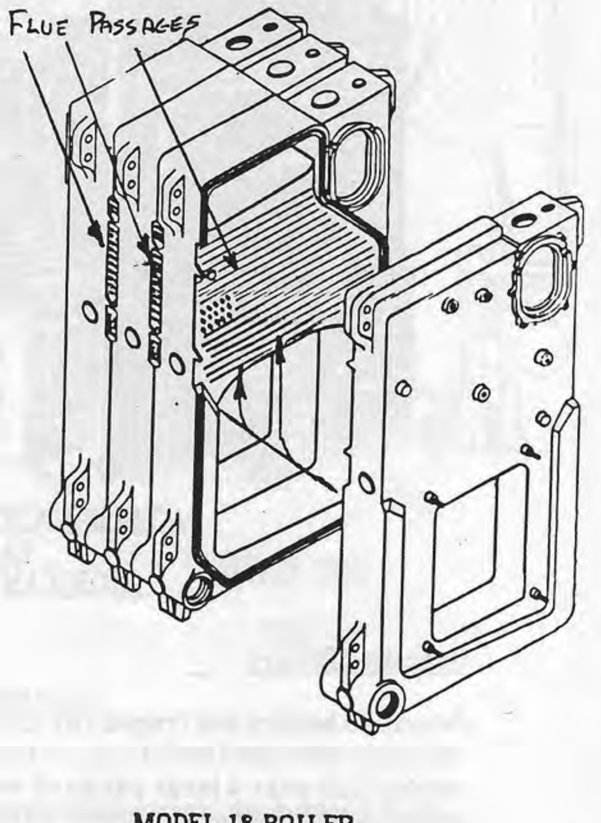
Reliability must also be considered within the context of the nature of boiler's intended use. Some buildings can not tolerate the lack of steam for more than a few hours, while other buildings are more tolerant in this regard.

Why a New Boiler, Then?

The design of boilers and burners has undergone a revolutionary improvement in the last decade or so. The new oil and gas burners allow such tight control over the combustion process that the real boiler efficiency has improved by one-quarter. A major part of this improvement is due to the greatly increased pressure the burner's fan can produce. This has allowed boiler flue passages to narrowed to the point where a rather narrow (1-inch) brush is required to clean the flue passages. By comparison, the older boilers originally designed for coal firing or for firing by low fan pressure oil burners, have flue passages that will easily accept the human arm. The following illustration compares a 1915 Ideal Sectional boiler with an H.B. Smith model 18. (Note that flue passages in the Ideal boiler are cleaned out via the front of the boiler, whereas the flue passages in the H.B. Smith model 18 are cleaned from accesses in the left side of the boiler.)



IDEAL Nº S-15-6 BOILER
C. 1915
AMERICAN RADIATOR CO.



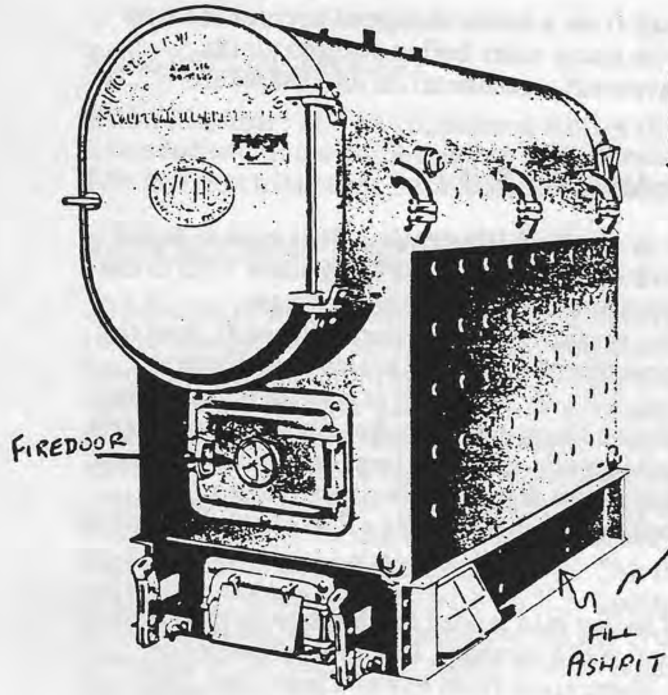
MODEL 18 BOILER
1987
H.B. SMITH CO.

Although the best efficiencies result from a boiler designed around the new burner technology, a new burner in many older boiler designs yields efficiencies that make boiler replacement uneconomical and therefore unnecessary.

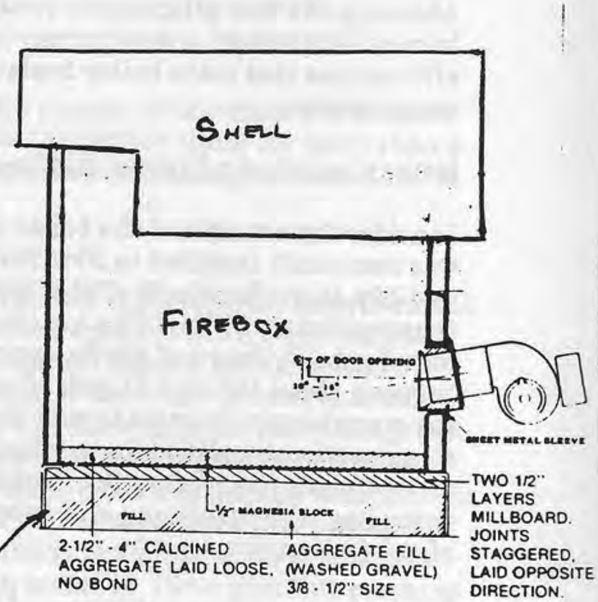
Modernization of a Typical, Middle-Aged Steel Boiler

Consider the example of the boiler in the next illustration. This type of boiler was commonly installed in New York apartment houses from about 1930 to the mid-50s. It is a Pacific Nº 4782 boiler SBI rated at 10330 sq. ft. steam (approximately 98 Hp.). The heating surface of this boiler is 608 sq.ft., and the New York City Board of Air Resources would allow this boiler to be fired at between about 19.5 and 33 gph of oil. With this boiler it is unwise to fire it past the manufacturer's rated input (30 gph) because steam quality may suffer and steam-water circulation in the firebox walls would be impared. (Note the three curved pipes connecting the firebox to the drum. These pipes act as a flow restrictor, and overfiring will result in steam blanketing and eventual burnout of the firebox.)

The best way of firing this type of boiler is to mount the burner in the firedoor. To protect the crown sheet (the roof of the firebox), the burner should be cocked downward as shown in the illustration from Power Flame, Inc. This illustration also shows the proper way to fill in the ashpit and to cover the bottom 3 to 4 inches of the mudlegs. Typical oil burners applicable for this boiler would be a Power Flame C-3 or Carlin 1150 FFD, firing no more than 30 gph. The boiler should be fired with natural draught as close to neutral as possible. This will prevent flame impingement on the water cooled steel surfaces.



PACIFIC Nº 4782
BOILER



SECTION THROUGH
FURNACE

Before attempting to re-burner an aging steel boiler such as this Pacific, it is essential to perform a thorough inspection of the waterside surfaces of the boiler. This is necessary even if the boiler is not currently leaking. With a firebox boiler like a Pacific whose firebox is attached to the shell with external riser and downcomer pipes, the restricted circulation in these areas makes such boilers vulnerable to early mudleg burnout. The boiler trim should essentially be the same as for the field erected boiler example later in this manual.

Fuel Considerations

Nº 2 Oil vs Heavier Grades of Oil There are many boilers fired by old rotary cup burners in the 10 to 30 gallon per hour range using Nº 4 or 6 fuel oil. Although these burners are rarely in the best operating condition, frequently because of poor maintenance and an I-don't-care mechanic, the replacement with this type of burner with a state-of-the-art burner using Nº 4 or 6 oil is terribly expensive. Although a first-class Nº 2 oil burner is much less expensive, the use of considerably more expensive Nº 2 oil negates a lot of the economy due to increased efficiency. However, many owners choose Nº 2 oil because of the relatively simple maintenance on a burner using this fuel (compared to the considerable complexity of a heavy oil burner).

Because of the difference in fuel costs for the various grades of oil, the owner contemplating a burner replacement is in a bind. This can be further complicated by the fact that the old burner has arrived at its present wretched state through poor maintenance, and all new burners, being considerably more complex than the old burners, are likely to fall victim to the same poor

maintenance. To make matters worse, the installation of a new burner requires a considerable amount of engineering expertise, which many burner mechanics (and many engineers) lack.

<u>Natural Gas</u> If natural gas is available, it should be considered as an alternative to oil. Traditionally, it has been priced somewhere between Nº 4 and Nº 6 oil. The cost of a good gas burner is usually close to that for a first-class Nº 2 oil burner. The services of the local gas utility are usually available to make reasonably sure that the installation is proper, and the adjustment and maintenance of a gas burner is far less difficult than for any oil burner. Lastly, gas prices are usually regulated whereas oil prices aren't, and gas meters and gas billing are highly accurate.

A Boiler/burner replacement checklist in on the next page.

BOILER REPLACEMENT CHECKLIST

1. Does the boiler spring leaks other than tube leaks at least once per heating season?

2. Is the boiler a brickset boiler? (Remember that a true brickset boiler has the entire shell covered with bricks. This is to be distinguished from other types of boiler whose brickwork is limited to the furnace.)

3. Is the boiler grossly oversize, compared to its load?

If the answer to any of the above questions is yes, the boiler is a good candidate for replacement.

BURNER REPLACEMENT CHECKLIST

1. Is the burner a natural draught rotary cup burner?

2. Is the burner a non-flame-retention head type high pressure atomizing burner for Nº 2 oil?

3. Does the burner have only on-off firing (compared to low-high-low or modulating firing), or is the low-high-low or modulating firing equipment in deteriorated condition? (This applies only to burners firing over about 5 to 7 gallons per hour; smaller burners usually have only on-off firing.)

If the answer to any of the above questions is yes, the burner is a good candidate for replacement.

ASBESTOS CONSIDERATIONS

Asbestos was a constituent in the insulation applied to boilers and piping until the early 1970s. Asbestos rope was used until recently to seal furnace and flue doors and the gaps between the sections in cast iron boilers. New regulations governing the management of friable asbestos in boilers and piping are coming into effect New York City in 1987, and the effect of these regulations in the short term will be to make boiler removal and replacement considerably more expensive than before. This will upset the economic equation governing replacement versus renovation of boilers in favor of retaining usable existing boilers. (Burner replacement is not so affected, as burner replacement does not usually involve disturbing friable asbestos.)

Some asbestos experts caution that some currently required friable asbestos removal techniques involving vacuum cleaning may disturb those tiny particles that are most harmful to human health.

As the science of friable asbestos management is in its infancy, it is this writer's opinion that friable asbestos should be left in place wherever its particles are unlikely to become airborne on a frequent basis. (This applies to most friable asbestos containing covering on old boilers and steam piping in boiler rooms and uninhabited basements. In these areas, the friable asbestos-containing covering can be encapsulated.)

In all cases the owner should keep abreast of local regulations.

New York City Regulations In New York City all Building Notices (BNs) and Plumbing Repair Notices (PRNs) submitted to the Department of Buildings must be accompanied by a filed statement covering the absence or presence of asbestos. All construction or repairs involving asbestos must be done in accordance with specific regulations. In New York City call the Bureau of Air Resources, Asbestos Abatement, at 212-323-8641, for regulations and procedures.

SELECTING A REPLACEMENT BOILER

If a new boiler is required, the range of boiler designs facing the owner or the engineer is varied and the quality and performance are equally varied. Boilers are offered in steel and cast iron with gas, oil, and combination gas-oil firing. Boilers are offered both bare and in boiler-burner packages.

The most important point to remember here is that as emphasized previously, dry steam is the beginning and end of quiet and economical steam heating system performance.

Boiler Efficiency and Steam Quality All boilers offered today have a combustion efficiency of 80 to 90 percent, with fuel-to-steam efficiencies a little below to considerably below the combustion efficiency. The reason for the wide variation in fuel-to-steam efficiencies is that while the best boilers produce bone-dry steam (98 percent quality (i.e. dryness) and better), the steam produced by some current boilers is more akin to a scalding monsoon. A minimum required steam quality of 98 percent was established by the manufacturers of both steel and cast iron boilers about 50 years ago. This is considered necessary by responsible heating engineers for the proper and noiseless operation of steam heating plants. (The knocking in steam heating systems can most frequently be attributed to wet steam.) This manual discusses how to select a boiler that has a guaranteed 98 percent steam quality at the very low steam pressure essential to the proper operation and control of one-pipe steam heating.

Certified Boiler Steam Output Ratings Unless the heating engineer is an expert on boiler design and can evaluate the design of a boiler to determine if it will deliver its rated capacity with the requisite 98 percent steam quality, he or she is well advised to choose a boiler having is rating certified by an organization following generally accepted standards and using generally accepted test procedures.

The standard test for boilers is in ASME Performance Test Code PTC-4.1. This has been the standard for over 100 years. The heating industry has used PTC-4.1 and has required a minimum steam quality of 98 percent for the last 50 years.

Boilers carrying the Hydronics Institute (I=B=R) nameplate meet these criteria, and their ratings are published periodically by The Hydronics Institute (35 Russo Place, Berkeley Heights, N.J. 07922; Telephone: 201-464-8200).

Other manufacturers have tested their boilers in accordance with PTC-4.1 and meet the 98 percent steam quality criterion but have not listed their boiler with the Hydronics Institute. In this case the heating engineer can and should obtain the manufacturer's written certification of his ratings.

Packaged Boilers Compared to Bare Boilers Boilers are offered both as boiler-burner packages or as bare boilers to which a burner must be added. Although a bit of money can be saved by buying the boiler and burner separately (as compared with the cost of a package), the owner shouldn't do so unless he or she has the technical expertise to mate the characteristics of the burner with the characteristics of the boiler. Needless to say, this demands a level of engineering expertise that few mechanics or installers have, and the large number of botched jobs are a sad witness to this. The use of packaged

boilers is thus strongly recommended. However, some reputable manufacturers do not offer such a package, so in this case the owner's engineer must design one himself. This writer has prepared a suggested boiler burner combination using a typical field-erected steel scotch boiler and a Carlin oil burner (as this combination is frequently used). It is in the appendix. To contrast this approach and to illustrate the degree of detailed engineering that a packaged boiler includes, the boiler and burner instructions supplied with an H.B. Smith Series 18 boiler and a Carlin oil burner are in the appendix.

STEEL BOILERS COMPARED TO CAST IRON BOILERS

The merits of steel vs cast iron boilers have been discussed many times; the relevant arguments are worth repeating here:

First Cost: Steel boilers are no less expensive than cast iron boilers if they are of equal quality and performance.

Maintenance Cost: Assuming a reasonably leak-free heating system, a cast iron boiler can be expected to last the greater part of a century with no repairs required on the boiler. However, the tubes of steel boiler, generally being much thinner than the thinnest part of a cast iron boiler, are vulnerable to corrosion and will generally require replacement several times in the life of a boiler in spite of water treatment. (This is a significant disadvantage for steel boilers.)

Efficiency: Neither boiler is inherently more efficient, although the efficiencies of both steel and cast iron boilers vary widely.

Ability to Survive an Accident: This is not dependent on the material used but rather on the design of the particular boiler.

If the above arguments sound a bit mushy and inconclusive, you've got the point. More specifically, neither material by itself is inherently superior; it's what the manufacturer does with it that counts!

SIZING OF REPLACEMENT BOILERS

One of the most lively topics among engineers and contractors in the heating field is how much a boiler can be undersized to take credit for new windows, insulation, &c. The answer is that a steam boiler's required output is independent of the type of building the boiler is installed in. It is totally dependent on the amount of installed radiation and on the domestic hot water load. The boiler must be capable of meeting the largest simultaneous space heating and domestic hot water load.

Installed Radiation Load The best way to determine the installed radiation is to perform a thorough survey of it. This may seem like a pain in the neck, but an undersized boiler is far worse. The appendix contains ratings of the radiators most commonly found in apartment houses. However, the ratings should be taken with the following in mind: The ratings established by the manufacturers and certified today by the Hydronics Institute are considered to be on the conservative side, so it is a good idea to boost the ratings by 10 percent to be safe.

Piping and Pickup Factor. The space heating load is multiplied by a piping and pickup factor, which accounts for the extra steam required to heat up the radiation and steam piping to operating temperature. This factor is unique to each building and usually varies from around 1.33 to 1.7 for typical buildings. (This writer prefers to use 1.6 as a minimum in apartment houses.) The exact factor is best determined by an experienced heating engineer or by a representative of the boiler manufacturer. When in doubt it's best to be on the high side here. To determine the appropriate piping and pickup factor the following factors must be considered:

1. Intermittent vs continual operation affects the piping and pickup factor.

2. Type of radiation (e.g. cast iron column radiators, cast iron tube radiators, cast iron small tube radiators, steel or copper convectors, mitre coils, cast iron convectors, etc.) The ratio of output to the weight of each type of radiation affects the piping and pickup factor.

3. The type of steam piping and the compactness or dispersion of the piping arrangement affects the piping and pickup factor.

Domestic Hot Water Load In comparison with the (easily determined) heating load, the domestic hot water load is subject to human whim and is therefore highly unpredictable. Through the years manufacturers and professional organizations (such as ASHRAE) have published methods for predicting the amount of hot water that will be used in various types of buildings. It is this writer's opinion that none of these methods are applicable to the type of occupancy typical to inner-city apartment houses. The reason for this is twofold:

(1) The unusually large number of occupants per apartment, and

(2) The growing use of dishwashers and clothes washers (in spite of a building owner's attempts to control same).

Because of this, it is likely the peak hot water load is twice that predicted by the usual methods. If the domestic hot water is produced by the same boiler that heats the building, it is critical to make sure that the boiler can satisfy the largest combined simultaneous heating and domestic hot water demand. Otherwise, the heating system will become unbalanced.

It is critical that this heating load, piping and pickup factor, and domestic hot water load be determined conservatively, because the consequences of an undersized boiler can be disastrous. Specifically, if the boiler can not produce adequate steam for the installed load, some radiators will heat up rapidly while others will remain cold for an hour or so. This unbalanced system then must be operated long enough for the coldest rooms to be adequately heated, and by this time the rest of the building is grossly overheated (and the owner bankrupt). By comparison, a properly fired system will heat up rapidly and evenly, and therefore operate economically.

In terms of efficiency, the consequences of a somewhat oversized boiler are today not half so onerous as they were 15 years ago. This is because the best designs available today combine a reduced thermal mass with very restrictive passageways for combustion air and flue gases. The result of this is that the standby losses have been cut in half compared to 15 years ago.

Feed Pumps, Condensate Storage Tanks, and Automatic Feeders

It has been the author's experience that few normal heating systems using cast iron boilers properly installed need condensate tanks and feed pumps because the boilers themselves have enough water between the normal operating level and the cut-off level. Steel scotch and firebox boilers, however, generally require a condensate tank and feed pump because their water level must be very tightly controlled for proper steaming.

If the heating system's piping is very extensive, the boiler itself may not contain enough water between its recommended operating level and the lowest safe level; in this case some form of feedwater storage must be provided. (If the boiler is overfilled in the hope of providing adequate water, the steam will siphon a lot of this excess into the steam pipes where it will cause havoc. The boiler may even end up with less water than it would have if it had been filled properly.) A properly sized condensate storage tank and feed pump will allow the water line to be controlled to a high degree of precision and prevent noisy operation and nuisance low-water burner trips.

A water level that is too high is frequently caused by the use of the wrong automatic water feeder or by an automatic water feeder that is right for the boiler but incorrectly installed. In both cases the feeder maintains a boiler water level too high for proper steaming, and the boiler water level can drop rapidly because of this. The manufacturers of automatic feeders and the responsible boiler manufacturers provide specific instructions as to where and how the low water cutoff is to be mounted on each boiler. Some excellent examples of installation instructions from Peerless, H.B. Smith, and McDonnell & Miller are in the appendix.

Do not use automatic feeders on boilers unless the makeup system is equipped with a dedicated, low-flow water meter. Otherwise, automatic feeders mask leaks and should not be used. A steam boiler in a multiple dwelling should have its water level checked at least weekly when it has been off for at least one-half hour. In this manner leaks can be readily discovered and remedied.

HOW TO DETERMINE THE PROPER FIRING RATE FOR A BOILER

The most important principle in firing boilers in one-pipe steam heating systems is that the installed radiation and piping loads (not the building envelope's heat requirements) determine the boiler size and firing rate. No credit can be taken for reduced heating loads because of new windows, insulation, &c., unless the installed radiation load is reduced accordingly.

Specifically, the boiler size and firing rate are based on the sum of the maximum loads simultaneously imposed on the boiler by the installed radiation and by the domestic hot water generating system (if served by the boiler).

Heating Load In an existing steam heating system the "heating load" is the sum of the installed radiation that is operated simultaneously. This load is multiplied by a piping and pickup factor, which accounts for the extra steam required to heat up the radiation and steam piping to operating temperature. This factor is unique to each building and usually varies from around 1.33 to 1.7 for typical buildings. The exact factor is best determined by an experienced heating engineer or by a representative of the boiler manufacturer. When in doubt it's best to be on the high side here.

Consider the following.

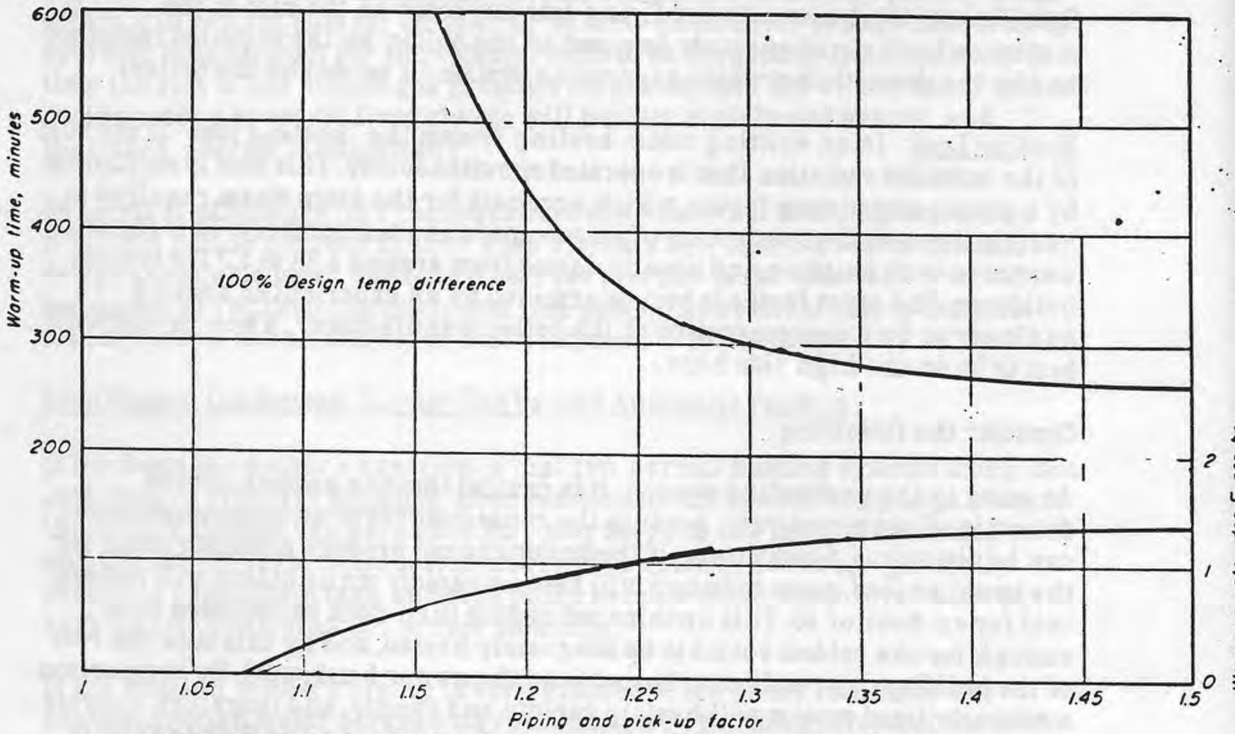
As noted in the preceeding section, it is critical that the heating load be determined conservatively, because the consequences of an undersized boiler can be disastrous. Specifically, if the boiler cannot produce adequate steam for the installed load, some radiators will heat up rapidly while others will remain cold for an hour or so. This unbalanced system then must be operated long enough for the coldest rooms to be adequately heated, and by this time the rest of the building is grossly overheated (and the owner bankrupt). By comparison, a properly fired system will heat up rapidly and evenly, and therefore operate economically. Consider the following graph from "Piping and Pickup Factors for Automatically Fired One-Pipe Hot Water and Steam Systems" (by Warren S. Harris and Chien Fan of the University of Illinois, published in 1959 as Engineering Experiment Station Bulletin Nº 455). This shows how the building's warmup time increases astronomically with a piping and pickup factor below about 1.3, while a factor above 1.3 has little effect on reducing the warmup time. Note that the building the tests were performed on was a single-family house with small-tube cast iron radiation. As stated above, the use of different types of radiation and piping would shift the warmup curve horizontally. For typical apartment houses a minimum pickup factor of 1.6 is highly recommended. Because of off-cycle loss considerations, gross oversizing is not recommended.

The Effect of Domestic Hot Water Load on the Firing Rate In comparison with the (easily determined) heating load, the domestic hot water load is subject to human whim and is therefore highly unpredictable. Through the years manufacturers and professional organizations (such as ASHRAE) have published methods for predicting the amount of hot water that will be used in various types of buildings. It is this writer's opinion that none of these methods are applicable to the type of occupancy typical to inner-city apartment houses. As noted above the reason for this is twofold:

(1) The unusually large number of occupants per apartment, and

(2) The growing use of dishwashers and clothes washers (in spite of a building owner's attempts to control same).

Because of this, it is likely the peak hot water load is twice that predicted by the usual methods. If the domestic hot water is produced by the same boiler that heats the building, it is critical to make sure that the boiler can satisfy the largest combined simultaneous heating and domestic hot water demand. Otherwise, the heating system will become unbalanced.



EFFECT OF PIPING AND PICKUP FACTOR ON THE WARMUP RATE

How to Determine Specific Boiler Firing Rates **The following describes how to determine the appropriate firing rate for various classes of boilers, once the required output is known.**

Firing Rates for I=B=R and SBI Rated Boilers. New boilers carrying an I=B=R nameplate may be used at that rating provided the boiler has been installed in accordance with the manufacturer's instructions. (The SBI nameplate is no longer applied.)

In fitting new burners to I=B=R or SBI-rated boilers, the maximum firing rate should be limited to that on the nameplate. In extreme cases this may be increased by 10 percent. The minimum firing rate is limited by the flue gas dewpoint temperature. Note that with some of the latest high efficiency cast iron designs, the manufacturers do not recommend underfiring these boilers by more than about 15 percent. This is necessary because these boilers produce their rated output with very low stack temperatures, and underfiring them can lower the stack temperature to below the flue gas dewpoint and lead to corrosion in the breeching and stack.

Firing Rates for Non I=B=R and SBI Boilers (Old and New). Many boilers

manufactured today are not rated in accordance with any generally accepted standard, such as the I-B-R or SBI standard discussed above. Instead, they carry a manufacturer's rating. A manufacturer's rating may not guarantee the high (98 percent) quality steam that the I-B-R and SBI ratings require. Lower steam qualities are not always acceptable in one-pipe steam heating systems and frequently result in water hammer and unbalanced system performance. Consequently the use of such boilers at their manufacturer's rating is not recommended unless the manufacturer can certify that the boiler's rating is at 98 percent (or higher) quality steam. If such information is not available, it is the responsibility of the heating engineer, not the oil burner mechanic, to establish an appropriate firing rate for the boiler that will meet the system's loads and will also take into consideration the following points.

Fireside Considerations for Determining the Proper Firing Rate

"Square Feet per Horsepower". Many boilers are proudly advertised as having a certain magic ratio of heating surface per unit of steam output (and that boilers not having this amount are implicitely inferior). This is silly. Different boilers need different ratios of heating surface per unit of output, based on the type of boiler and fuel, the geometry of the boiler, the gas, water and steam circulation patterns, and other considerations. Also, the heat transfer in the furnace is many times more intense than in the convective heat transfer areas, so the addition of extra heat transfer surface in the final gas pass areas will yield little increased output and may in fact adversely affect the water and steam circulation patterns.

Heat Release in the Furnace. A furnace is limited by its volume and geometry in its ability to permit the combustion of fuel. Various burner designs permit different heat release rates. For example, the natural draught rotary burners installed in the 1930s yield a rather bulky and diffuse flame and consequently heat release rates well below 80,000 BTU/cu.ft. were then generally recommended. By comparison, the air atomizing and flame retention type pressure atomizing burners can perform well at over 175,000 BTU/cu.ft. (This improvement in burner performance has unfortunately permitted older boilers to be (over)fired to the extent that the steam quality becomes unacceptable, while the combustion efficiency is better than ever.) Heating engineers should be wary of older boiler designs whose ratings have been greatly increased because unless the rest of the boiler has been modified where necessary to maintain steam quality, this increased output is of little use.

Another effect of the higher heat releases now available is that some older scotch designs have a combustion chamber that is too shallow to evenly distribute the combustion gases into the direct tubes. This results in rapid tube wastage and unacceptably high stack temperatures.

Standby Losses. In many installations the existing boiler may be larger than necessary for the heating load. Many of these boilers deliver an acceptably high steady-state efficiency at reduced firing rates; however, severely underfired boilers can suffer from large standby losses, compared to smaller boilers with the same output. Extreme underfiring can lower the stack temperature to the point where flue gas condensation occurs. This must be avoided to protect the breeching and chimney.

Waterside Considerations for Determining the Proper Firing Rate

A boiler's firing rate is limited by the boiler's ability to separate steam from water to provide the required steam quality. Many cast iron boilers were designed primarily as hot water boilers, and may not have the generous passages necessary for orderly steam and water circulation. In some current steel designs the direct tubes are so close to the furnace that the steam leaving the furnace's surface blankets the direct tubes. This causes these tubes to overheat and this makes them vulnerable to oxygen attack. Steam blanketed surfaces also transfer little heat, so the boiler efficiency suffers. The only remedy one can apply to such badly conceived boilers is to underfire them to the point where they behave, hoping all the while that the new, reduced steam output is adequate for the heating system. If it is not, the boiler must be replaced.

BOILER STEAM PIPING

Introduction Boiler steam piping is the piping that runs between the steam outlet(s) on the boiler and the building's steam mains. It also includes an equalizer pipe that is connected to the boiler below the boiler water line. This chapter shows typical steam piping instructions by a reputable boiler manufacturer. The appendix contains a newsletter recently published by a manufacturer on boiler steam piping. It points out many of the mistakes that are commonly made and why they must be avoided. Most manufacturers now recommend the use of a boiler steam piping header that serves as a centrifugal steam separator. This is essential because most current boilers do not produce 98 percent quality steam at their outlet and rely on the header to finish the steam separation. This arrangement is hardly new and appeared in the 1937 ASHVE American Society of Heating and Ventilating Engineers) Guide.

Steam Piping for I=B=R Rated Boilers An I=B=R rated boiler must be piped as shown in the boiler manufacturer's installation instructions. This applies to both pipe size and arrangement. The reason for this is that the boilers were generally tested with this recommended piping under carefully controlled and monitored conditions and have been shown to produce 98 percent quality steam at the I=B=R rating. Deviations from the manufacturer's recommended piping may result in a significant decrease in boiler output. This chapter contains an example of the recommended steam piping for a typical I=B=R rated boiler.

Note that in most cases the manufacturers require the connection to the building steam mains to be located beyond the point where all boiler steam outlet pipes connect to the header. The reason for this is that it is desirable to have all steam running in the same direction before it is delivered to the building steam mains. In this way, when the steam is forced to make a sudden turn into the branch connection leading to the building steam mains, the water that is in the steam is flung into the equalizer pipe and is thereby returned to the boiler.

Some boilers, however do not require this type of header. Most notable in this class are the H.B. Smith Mills header-type watertube boilers. The reason for this is that these boilers incorporate an extremely effective steam separation system within the boiler proper . With these boilers the piping arrangement is not critical so long as all available steam outlet connections are used. This can be of significant advantage in boiler rooms where the ceiling height or other constraints make the construction of elaborate header piping difficult if not impossible.

Steam Piping for Other Boilers Boilers other than those with an I-B-R or SBI rating may be rated by other reputable organizations and may carry AGA (American Gas Association), UL (Underwriters Laboratories) or other nameplates. Some boilers may have nothing more than a manufacturer's rating, which may not be based on any generally accepted criteria. It is important to note that such ratings may or may not have a required minimum steam quality. Consequently it is good practice to be quite conservative in the design of the steam piping for these boilers.

With most large cast iron boilers the boiler manufacturers do provide recommended steam piping arrangements, and these should be followed, although an increase in riser and header size is usually beneficial.

With most steel boilers, however, the manufacturer simply indicates a steam outlet size without any specific recommendation as to its arrangement. In these cases the procedure on the next page is recommended as a minimum.

Steam Piping for Steel Boilers Without Certified Ratings

Pipe Sizes The pipe sizes herein are based on a conservative application of the ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) "Steam Pipe Capacities for Low-Pressure Systems", which appears in Table 14 in the ASHRAE's 1985 Fundamentals. Column B is used.

Determination of Steam Output The first step is to determine the total steam generating capacity of the boiler. The manufacturer's nameplate rating is considered to be sufficiently accurate. Note that this "rating" may likely be based on combustion efficiency, which is always higher than fuel-to-steam efficiency. No allowance is to be made for the portion of boiler output used in generating domestic hot water, because the boiler will frequently be producing steam when little if any hot water is needed.

Risers Two risers should be used to minimize the horizontal distance the steam has to travel within the boiler. (This should minimize wave formation on the water surface.) The risers should be located approximately one-quarter the boiler shell length from each end of the shell. These risers are to be sized as follows: Half the nameplate boiler horsepower, and choose the pipe size from the table below whose capacity is equal to or greater than this amount.

TABLE TO DETERMINE THE SIZE OF EACH RISER

Pipe Size, in.	Capacity, Hp.
3	8
3-1/2	10
4	12
5	25
6	40
8	75
10	150
12	250
16	500

Example For a 60 Hp. boiler, take half of 60, i.e. 30. Each riser is sized for 30 Hp. The smallest pipe that is rated for 30 Hp. on the table above is 6-inch. Thus two 6-inch risers will be used.

Header. The header should be one pipe size larger than the risers. In our example, the 6-inch risers will require an 8-inch header. Note that the header comprises the following (from front-to-back or vice-versa):

a) A reducing el that connects the front riser to the header
b) A straight piece of pipe
c) A reduced-bull tee to whose bull the other riser is attached
d) A piece of pipe, two header diameters long

e) A full size tee, bull upward, whose bull connects to building steam mains (This tee may have its bull arranged up to 45° either side of vertical if necessary.)

f) A reducing el, which connects to the equalizer (described below)(This el may angle its reduced outlet up to 45° either side of vertical if necessary.)

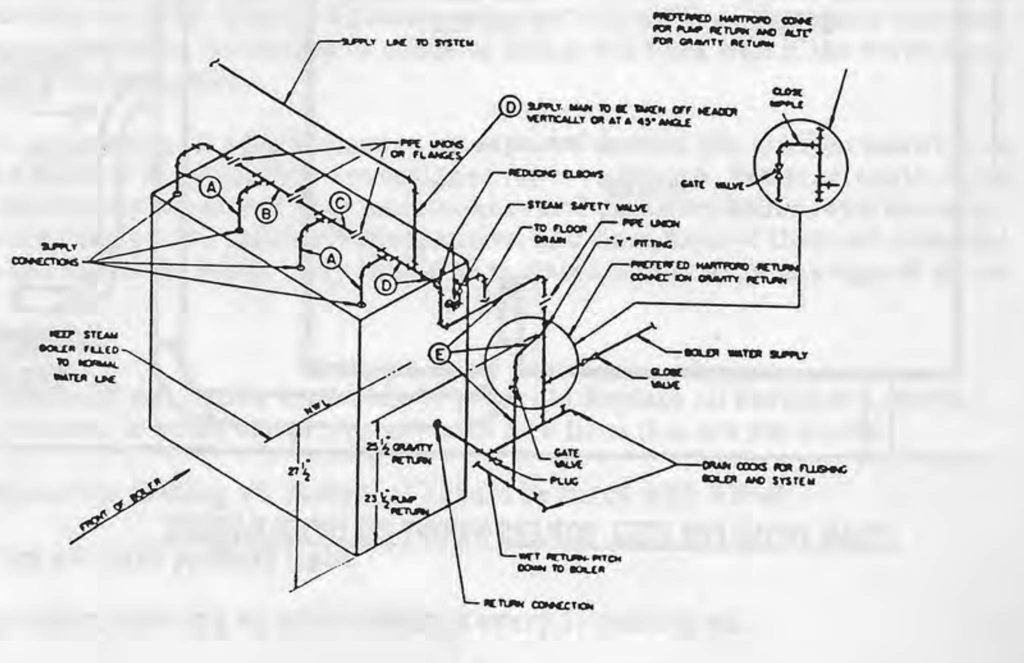
Equalizer. The equalizer should be sized in accordance with the following table:

TABLE TO DETERMINE EQUALIZER SIZE

Nameplate Output, Hp.	Equalizer Pipe Size, in.
under 25	2
25-40	3
40-200	4
above 200	6

Connection to Building Steam Mains. To the bull of the upward-facing tee the building steam mains are connected. As the building mains are probably smaller than the header, it will be necessary to reduce the pipe size somewhere. It is best to avoid a pipe size reduction in a horizontal run of pipe because this requires the use of an eccentric reducer or a drip. Instead, a reducing el should be attached to the bull of the upward-facing tee. This allows the size reduction to be made without trapping any water. A shut-off valve should be installed here.

The following illustration shows piping for a Burnham Series 5 gas fired boiler, which has an I=B=R certified rating. This illustration shows all of the elements of the typical properly installed cast iron steam boiler. Note the use of all supply connections, the specific riser, header, and equalizer pipe sizes, the exact Hartford loop configuration, and the inclusion of return line block and drain valves. The only improvements that are recommended for this excellent figure would be the inclusion of the minimum height of the header above the boiler, the minimum horizontal distance between the supply risers and the header, and the addition of a steam stop valve

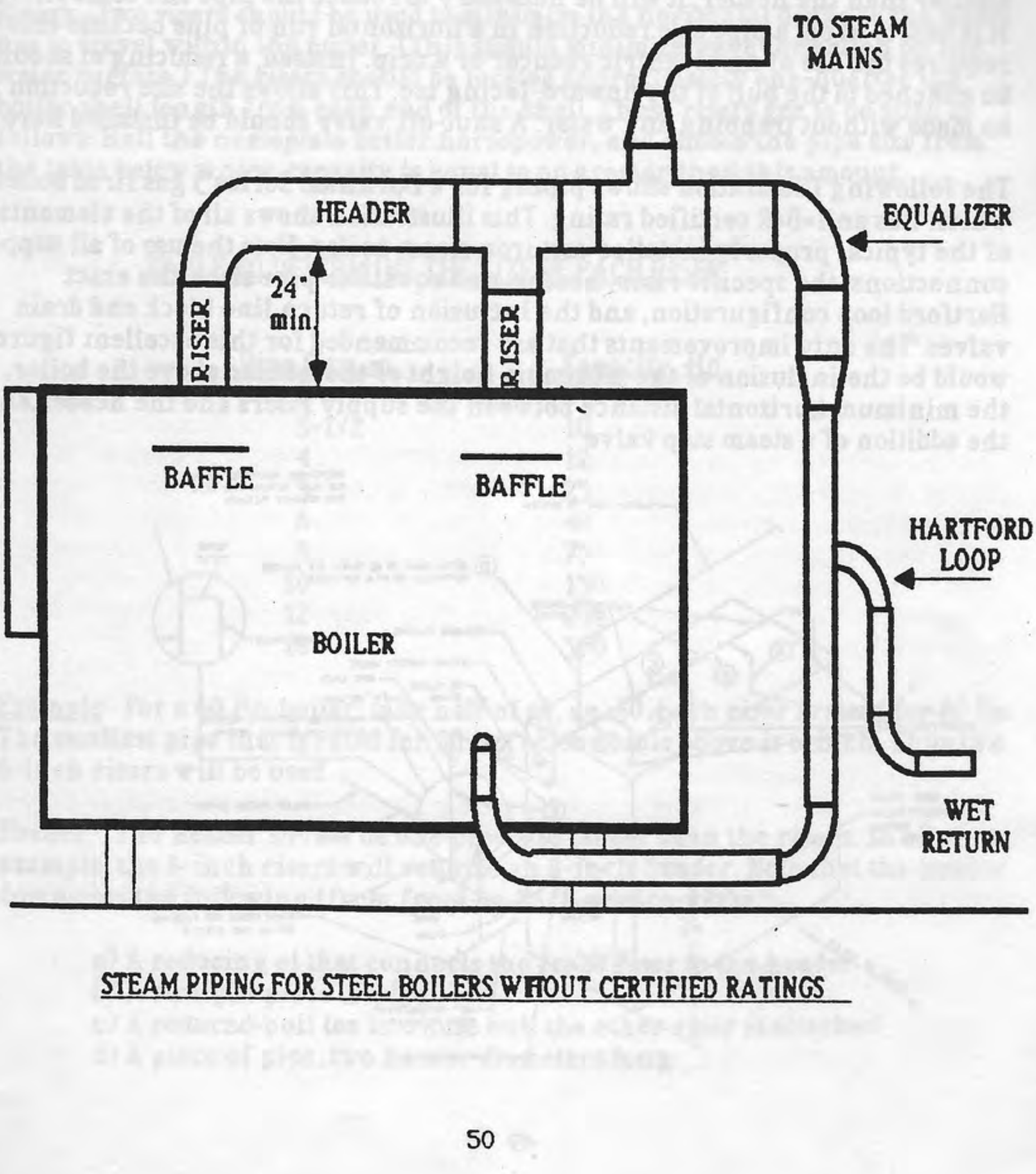


Boiler Size		5021	5022	5024	5026
Riser	A	(4) 3"	(4) 3"	(4) 3"	(4) 3"
HEADER	B	4"	4"	5"	5"
	C	5"	5"	5"	5"
	D	6"	6"	6"	6"
Equalizer E°		2½"	2½"	2½"	3"

° Use these sizes only when return pipe is smaller. If return pipe is larger, increase size of E to size of return main.

PIPING SIZES FOR THE BURNHAM SERIES 5 BOILERS SIZES 5021 - 5026

The following illustration shows an example of the steam piping recommended for boilers that do not have certified ratings. Note that the pipe sizes here must be a lot larger than those required for boilers with certified ratings. This is necessary because the risers, header, and equalizer must act as the principal steam separator because the boilers themselves usually have minimal steam space and only the most rudimentary steam separation systems.



STEAM PIPING FOR STEEL BOILERS WHOUT CERTIFIED RATINGS

CRITERIA FOR REPLACING OTHER PARTS IN A HEATING SYSTEM

Although most elements in a steam heating system can be expected to last over a century, certain parts don't, e.g. wet return lines, air vents, valve packing, boiler controls, burners, &c. The timely replacement of these elements is necessary so that the system will continue to operate properly and economically.

Wet Return Lines Wet return lines are usually made of standard weight steel pipe with a wall thickness of about 1/8 inch. Generally about 40 years is all one can reasonably expect from steel pipe in this type of service. Consequently, as noted earlier, it is strongly recommended that all wet return lines in place since before World War II be replaced. Furthermore, many buildings have wet return lines that run underground to clear doorways and other obstructions. These are subject to external corrosion in addition to internal corrosion and consequently have a far shorter life expectancy. It is usually safe to assume that they are leaking even after a few years of service. (To make matters worse, underground return lines are excellent places for crud to settle in.) If possible, underground lines should be replaced with above-ground lines. Copper is an excellent material for wet return lines and can be run underground if truly necessary. A 2-inch minimum pipe size is recommended by most authorities to prevent plugging.

Air Vents Air vents generally fail for two reasons: water hammer and contamination. Both tend to occur together, as water hammer tears up a lot of crud in the steam pipes that is then hurled into the air vent's hole. If a system has been plagued with water hammer, the air vents are probably beyond repair, as their seating surfaces have probably been ruined by repeated hammering. Before throwing the air vents out, however, squirt a bit of WD-40 in to the air vent's hole. This frequently removes the dirt and allows the vent to operate properly.

Valve Packing Valve packing is available at most hardware stores. A steam valve whose packing is leaking should be have its packing nut tightened or its packing replaced. Usually tightening the nut will suffice. If packing is needed but unavailable, teflon tape or common string will work well if the valve is not operated frequently.

Boiler Controls It's hard to assign an expected service life to boiler controls, as the number of cycles they are designed for is very high. However, controls fail prematurely because of poor maintenance and excessive boiler room humidity. Since controls are relatively inexpensive, and since some of them are essential to the life of the boiler, they should be replaced if they show any sign of abuse.

Summary

Replace all wet return lines over 40 years old. Replace all buried wet return lines over 10 years old, preferably with new lines that are not buried.

Replace all leaking air vents that cannot be cured with WD-40.

Keep all valve packing tight.

Consider replacing all boiler controls every 10 years or so.

HOW TO GET THE BEST SERVICE FROM A HEATING CONTRACTOR WHEN A NEW BOILER OR BURNER IS INSTALLED

Although the heating contractor is in most localities required to have either a plumbing license or an oil burner mechanic's license if he is to work on the boiler or burner, he is not required to demonstrate any engineering ability or have any engineering credentials. Generally the mechanic's knowledge of the burner is adequate, but his or her knowledge of the boiler and the rest of the heating system leaves much to be desired. The details of one-pipe steam heat usually are equally foreign to most HVAC (heating, ventilating, and air conditioning) engineers. However, most manufacturers of heating system equipment furnish exhaustive installation and maintenance instructions for their equipment, and so long as the contractor or engineer reads and follows these instructions, reasonably good work will be done. Most heating system problems result from the engineer's or contractor's failure to follow the manufacturer's written instructions. The owner should obtain a set of the instructions so that some quality control can be exercised. As the instructions are written in plain English and are also well illustrated, a reasonably literate owner, manager, or engineer should be able to exercise enough control to see that the work is reasonably well done. The book will discuss certain details common to all good steam heating work that must be properly done of the system is to work. The following page contains a suggested checklist for new boiler and burner installations.

BOILER INSTALLATION CHECKLIST

1. Is the boiler room floor properly prepared in accordance with the boiler manufacturer's instructions? Is the boiler waterline height at least 28 inches below the lowest end of the steam mains? Has a sump pump been installed where needed?

2. On a cast iron boiler with rubber sealing rings, were the boiler sections assembled using the approved lubricant. IF ANY OIL OR OTHER PETROLEUM HAS BEEN USED, THE SEALING RINGS MUST BE REPLACED AND ALL SEALING SURFACES MUST BE THOROUGHLY CLEANED BEFORE REASSEMBLY.

3. On a cast iron boiler, are the boiler sections in-line and vertical?

4. On a steel boiler, is the shell level?

5. On a steel boiler have you received the appropriate ASME Data Reports for the boiler assembly and steam pipe installation?

6. On all boilers, is all piping, and in particular the steam piping, in accordance with the manufacturer's instructions?

7. On all boilers are all controls and trim installed in accordance with the manufacturer's instructions?

8. On all boilers with low-high-low firing, does the burner go to low fire at the appropriate pressure (1/2 to 1 psi)?

9. On all boilers with modulating firing, does the burner start to modulate at the appropriate pressure (1/2 to 1 psi)?

10. On all boilers has the boiler been cleaned in accordance with the manufacturer's instructions or in accordance with ASME Section VI?

11. On all installations, have all wet returns been cleaned out or replaced if leaky?

12. Is the water level in the gauge glass at the level recommended by the boiler manufacturer? Is it steady?

13. On all installations, has the burner been adjusted in accordance with the boiler and burner manufacturer's instructions? Have you seen the installer perform the combustion efficiency test? Are the results in accordance with the boiler and burner manufacturer's instructions?

14. Have all permits been obtained and inspections made in accordance with local law?

Note: See the start-up report on the next page. This was prepared by the Bryan Steam Corporation and is an excellent checklist. It demonstrates the dedication of many manufacturers to excellence on boiler installation and operation. This type of form can be adapted to most installations.

BRYAN STEAM CORPORATION
PERU, INDIANA

DATE________
OWNER'S COPY____
ENGINEER'S COPY____
AGENT'S COPY____
OTHERS____

BOILER START-UP REPORT

(FILL IN COMPLETELY)

LOCATION DATA

Job Name ________
Address________
City________
Phone________
Contractor's Jobsite Phone________
Describe how to get there________

PERSONNEL DATA

Name of Owner________
Architect________
Engineer________
Contractor________
Address________
City________ Phone________
Contractor's Job Foreman________
Address________
City________ Phone________
Name of Day Custodian________
Address________
City________ Phone________
Night Custodian________
Address________
City________ Phone________
Name of Gas Company________
Phone________
Name of Gas Co. Service Engineer:________
Time of Service Engineer's Arrival:________
Name of Electrician:________
External Controls by Whom________
Name of their service man:________

BOILER AND BURNER DATA

Boiler Model No.________
Serial No.________ Assembly A___ B___ C___
Pressure Rating: Steam________ Water________
Rated Input - BTUs________
Boiler Tubes: Copper________ Steel________
Gas Burner Type:
Barber Jet________ Ribbon________
Raised Port________ Power________
Oil Burner Type:
Bryan________ Other________
Forced Draft________ Dual Fuel Model________
Low Water Cutoff:
No.________ Type________

BOILER AND BURNER DATA (continued)

Relief Valve: Make________
Model________ Size________
Pressure Setting________ Relief Capacity________
ID Fan:
Make________ Model________
Draft Fan Air Switch Control:
Make and Type________
Size and Location of Combustion Air Inlet________
Breeching: Size________ Approximate Length________
Stack: Height________ Inside Dimension________
Draft Control:
Vertical Diverter________ Barometric________
Describe Air Elimination System on Boiler________
FIA. FM or Other Control System________
Additional Safety Controls________

FUEL AND OPERATIONAL DATA

Grade of Oil________ Oil Pressure on Burner Nozzles________
Gas: Type________ BTU________ Sp. Gr.________
Gas Pressure: Gas Train Inlet________
Manifold________
Burner Input BTUs: High Fire________
Low Fire________
CO_2 Reading in Flue Gas:
Low Fire________ High Fire________
Stack Temperature: High Fire________
Low Fire________
Draft Reading at Flue Outlet________ in. H_2O
Combustion Efficiency:________
Pilot Thermocouple Output - Millivolts
No. 1________ No. 2________
Pilot Flame Rod Output - Micro-amps________
Control Settings: Low Fire Operator________
High Fire Operator________ High Fire Cut-In________ High Limit________
Others________
Low Water Cutoff Checked for Safety________
High Limit Checked for Safety________
Burner Checked out for Sequencing________
Boiler Room Housekeeping:
Good________ Fair________ Bad________
Comments:________
Time and Travel: Miles________ Hours________
Accepted by:________
Report by:________
Charge Service: Yes________ No________

2M MG 2/81

BRYAN STEAM CORPORATION • PERU, INDIANA

FORM NO. 1184

This "Boiler Start-Up Report is typical of the concern a responsible manufacturer has in insuring that a new boiler is operating properly. An owner or specifying engineer might adopt a similar type of form.

A checklist, however, is only as effective as the people implementing it. The person who inspects the boiler installation must already understand the boiler manufacturer's instructions and all other information pertaining to the installation. Do not rely on the heating contractor's knowledge.

WHY HAS WATER HAMMER (KNOCKING PIPES) BECOME SO COMMON?

What is water hammer?

In steam heating systems water hammer is what happens when water is somewhere it doesn't belong (such as in steam pipes or radiators) and is flung at high speeds into a radiator, a valve, or pipe fitting. The ensuing noise presents an esthetic problem - and more seriously - an economic problem.

Water hammer prevents the balanced distribution of steam to all radiators and thus results in overheating and underheating in the same building. This inevitably wastes fuel.

Misconceptions About Water Hammer

Water hammer is incorrectly blamed on bad air vents, old pipes, and worn-out radiators. Water hammer can be caused by poorly pitched radiators and pipes and by partially shut radiator valves. However, the most frequent culprit is the boiler and steam and return piping.

The boiler is like a pot. If it is overfilled, it boils over; if it is overfired, it boils over; if it is filled with dirty water, it boils over. This applies equally to the best and worst boilers. Consider these details:

Water Level **Each boiler has a certain water level at which it steams best. Usually this is a bit above the minimum water level required for safe operation. Many manufacturers indicate on the boiler jacket the correct water line. This should be verified and maintained carefully.**

Firing Rate **A boiler must be sized and fired in accordance with the heating system it serves. The boiler must also be fired at a rate appropriate to its fireside and waterside properties.**

DOMESTIC HOT WATER

Stored, Steam-Heated Domestic Hot Water with a Coal-Fired Boiler

Traditionally, the boiler has been the source of domestic hot water for most apartment houses. In the days of coal firing, the most common way to make hot water was by the use of a hot water storage tank heated by steam from the boiler. This required the boiler to maintain a head of steam summer and winter. Control of the hot water temperature was simple, even with a hand-fired boiler. (An automatic valve admitted steam to the coil when the hot water temperature was inadequate; the boiler steam pressure was maintained by a mechanical device that used steam pressure to operate the boiler's combustion air dampers. To prevent heat from being delivered to the radiators in summer, the valve between the boiler and the heating steam mains was closed.)

Stored, Steam-Heated Domestic Hot Water with a Oil-Fired Boiler

With the advent of oil or gas firing, the tank was retained, and the only control change was the substitution of an electric pressure controller on the oil or gas burner for the mechanical damper operator.

Tankless Coil with an Oil- or Gas-Fired Boiler

Sooner or later the storage tanks started to leak, and the cost to replace the tanks was daunting. The oil-or gas-fired boiler was however capable of providing domestic hot water on a real-time basis through the use of a tankless coil. This is a coil that is submerged in boiler water and makes domestic hot water as needed. The primary advantage of the tankless coil system is that it is the least expensive system to install.

The controls for the tankless coil system are considerably more complex than for the tank-type water heater. An aquastat (which operates the burner based on the boiler water temperature) maintains boiler water temperature at a preset level, so that the boiler water itself is a source of stored heat energy. The temperature of the domestic hot water leaving the coil can vary widely, however, depending on the boiler water temperature and the demand for domestic hot water. This requires the use of a tempering valve to maintain the temperature of the domestic hot water delivered to the apartments at a constant level. A circulating pump, operating continually, is required to bathe the tempering valve's sensor with water at a representative temperature. This system is the one most commonly used today in apartment houses.

Unfortunately, the tankless coil system tends to be unstable in operation, with hot water temperatures subject to wide and sudden variations if the equipment is not properly maintained on a regular basis. The primary disadvantage of this system, however, is the fact that the boiler must be capable of satisfying the total coincident maximum heat and hot water load. (This is necessary to prevent uneven space heating.) This can result in a large boiler, and if this boiler is subject to high standby losses, it will be uneconomical.

Gas-Fired Separate Storage Water Heaters

The typical oil- or gas-fired boiler in use fifteen years ago was subject to considerable standby losses, especially in the summer when it was not required to fire frequently. With the rising oil costs of the 1970s, there was a trend toward the installation of gas-fired storage water heaters that operate independent of the boiler, allowing the boiler to be shut down entirely during the summer. This system took advantage of the low, regulated cost of natural gas and allowed the boiler to be sized for the steam heating system alone. This system has the advantage of temperature stability. This system should be considered for those buildings that have a very small domestic hot water load compared to the space heating load (rarely occurring in apartment houses). However, this system has several disadvantages, including high initial cost, high standby losses, and relatively short tank life (requiring the replacement of the entire water heater).

Stored, Domestic Hot Water Heated by Circulating Water from a Oil-or Gas-Fired Boiler

Domestic hot water storage tanks use the boiler water to heat the domestic water through a heat exchanger. This heat exchanger may be a tankless coil in the boiler, a boiler water coil in the storage tank, or a separate heat exchanger between the boiler and the storage tank. This system uses pumps to circulate water in the coil. This system offers the advantage of thermal stability, low tank standby losses, long storage tank life (the tank being unfired), and low boiler standby losses (if the boiler is a modern, low thermal mass boiler). This system also takes advantage of the very high boiler efficiencies available with modern boilers. The use of storage tanks also allows the boiler to be sized considerably below the highest coincident heating and hot water load, so the cost of the boiler may be considerably lower than that required when a tankless coil is used alone. This system also allows for future increases in hot water demand through the use of additional storage capacity.

The choice of which storage system to use can be affected by the type of boiler used. Some boilers have no provision for a tankless coil. Some boilers have a tankless coil that encroaches on the steam space because this arrangement this requires the boiler water level into the steam space, thereby preventing proper steaming. (This is the case with many existing boilers which were not properly designed to accommodate a tankless coil but nevertheless were fitted with one to the disastrous detriment of the boiler's steam quality. In these cases the tankless coil should be removed, and a storage system, not requiring a tankless coil, should be substituted.)

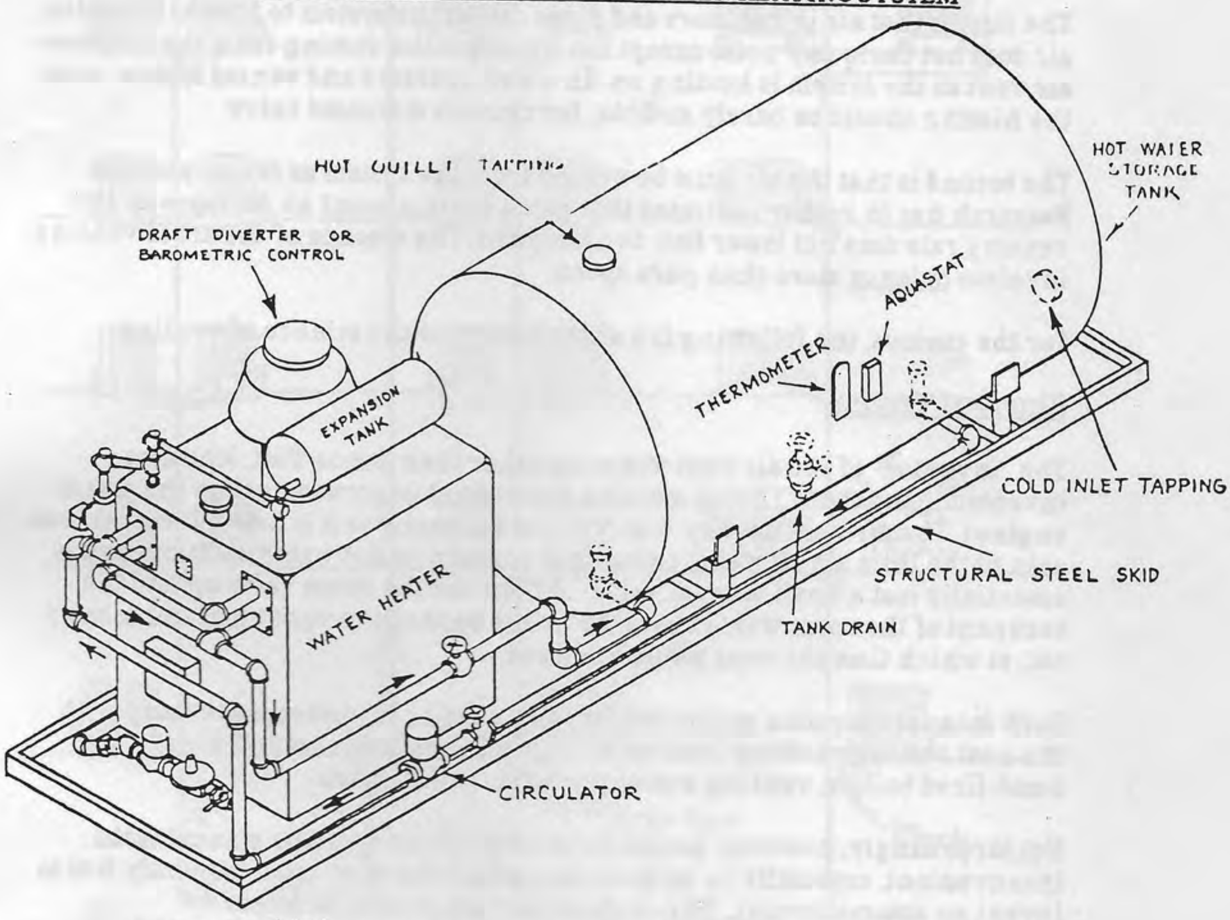
Use of a Separate Boiler to Make Stored Domestic Hot Water

With the exception of the gas-fired storage water heaters described earlier the systems described use the steam heating boiler to provide the heat source for both building steam heat and domestic hot water. In some buildings where the domestic hot water load is a relatively small part of the total load, the use of a single boiler may not be economical because the single boiler is forced to operate on extremely short cycles. This can be especially true in buildings with boilers whose obsolete, asbestos-covered boilers have relatively large off-cycle losses but can't be replaced because of ruinous asbestos removal costs. In this case, the off-cycle losses can be minimized with a separate domestic hot water generator, such as the Bryan "Water-Pak" indirect storage water heating system. The steam boiler's firing rate can then be adjusted for the steam heating load exclusively.

Recommendations

In general, since most apartment houses have a domestic hot water load that is a significant part of the total heating load, the use of stored, domestic hot water heated by circulating water from the boiler is recommended if the boiler has resonably low standby losses. The separate boiler alternative offers the same efficiency and thermal stability as the "one-boiler" alternative where the domestic hot water load is small or where the steam boiler is a poor hot water maker because of high off-cycle losses.

BRYAN "WATER-PAK"
INDIRECT STORAGE DOMESTIC WATER HEATING SYSTEM



This illustration shows the essential elements of a packaged indirect domestic hot water generator and storage tank. The word "indirect" means that the domestic hot water is heated by a water-to-water heat exchanger so the minerals in the domestic water are not rapidly precipitated by boiler surfaces heated directly by hot furnace gases. The use of a unit like this is preferable to the use of a separate boiler with a tankless coil because of the lower off-cycle losses inherent in an insulated storage tank with no flue passages.

MASTER VENTING

Venting is often misunderstood, but its principle is quite simple. When a steam heating system is not in operation, parts of the boiler and piping are filled with air; the rest is filled with water. For the steam system to operate, the steam must replace the air in those areas where heating is to take place: radiators and piping. This must be done every time the system starts up.

There are a few common misconceptions that should be corrected before the specifics of venting are discussed.

The first is that air in radiators and pipes causes the system to knock. In reality, air does not cause any noise except the hissing noise coming from the radiator air vent as the system is heating up. In a well operated and vented system, even the hissing should be barely audible, for reasons discussed below.

The second is that the air must be vented from the system as fast as possible. Research has in reality indicated that past a certain point an increase in the venting rate does not lower fuel consumption. The essence of the art of venting involves balance more than pure speed.

For the curious, the following is a short history of the science of venting.

History of Venting

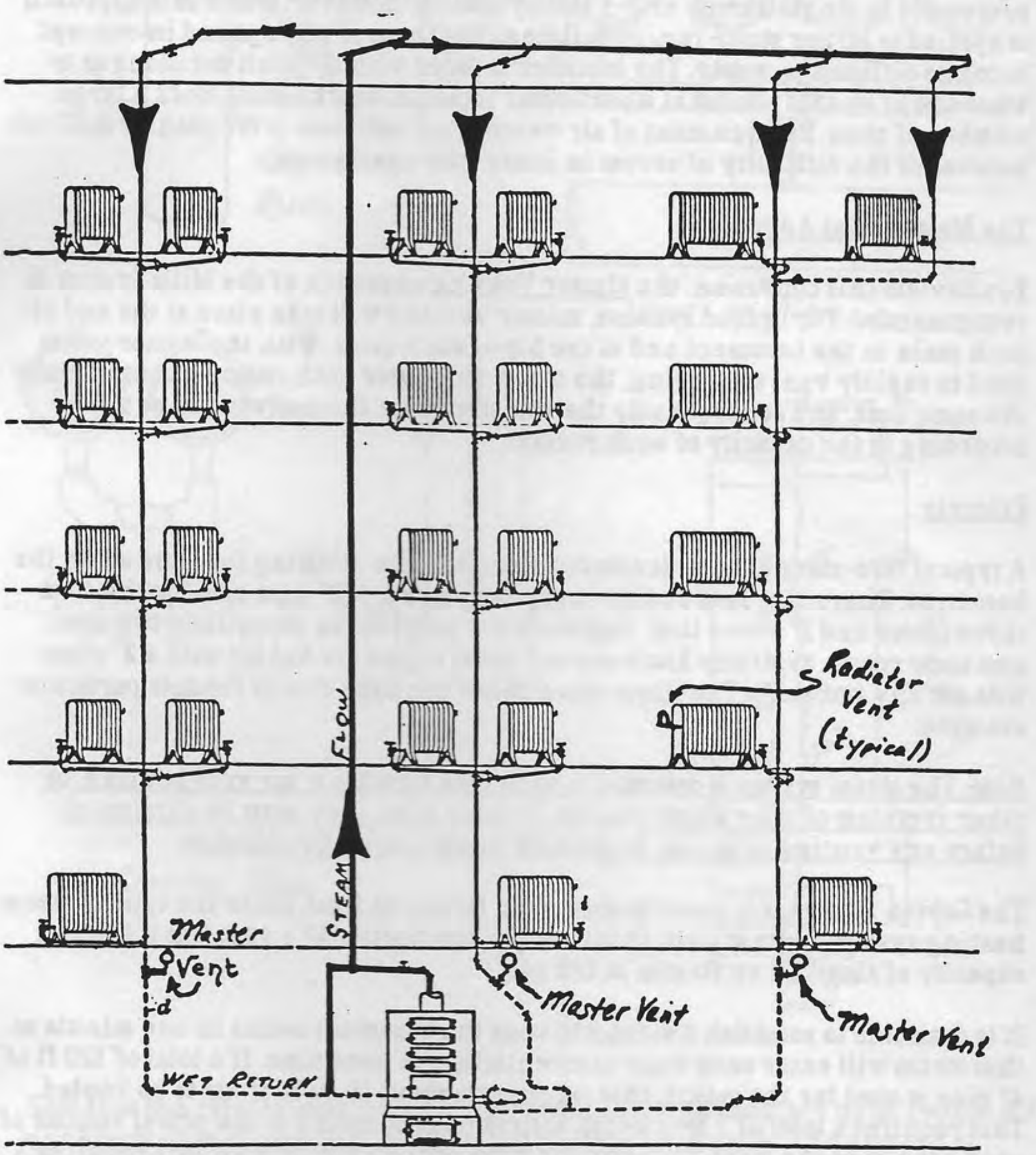
The "inventor" of the air vent was none other than James Watt, who also invented the radiator (not to mention substantial improvements on the steam engine). The air vent used by Watt was not automatic as it is today. It rather was akin to the little air cock that commonly appears on hot water radiators and is essentially just a small manual valve. Whenever the steam came up and the occupant of the room wanted heat, he or she opened the vent until steam came out, at which time the vent would be closed.

Such manual operation might appear to be a major inconvenience today with the heat coming on every hour or so, but in the days of coal and wood hand-fired boilers, venting was required much less often.

Not surprisingly, however, people found even these sporadic manual tasks inconvenient, especially in large buildings, so sooner or later somebody had to invent an automatic vent. This is generally believed to be Moses P. Breckenridge, shop foreman of H.B. Smith & Co., who patented "Breck's" Automatic Air Valve in 1868.

The next major advance in venting was patented in 1873 by John H. Mills whose system of steam piping allowed the vast majority of air to be rapidly vented at a single point in the cellar. Mills described the system as "the combination of one or more pipes, conveying the steam without distribution to a point above the radiators, with branch piping conveying the steam downward, and serving at one and the same time to supply steam to and conduct the water of condensation from the radiators, the steam, air and water moving together in one direction towards the boiler:" The significance of Mills' invention is that of the master vent on the main steam lines, whose capacity is far greater than that of the vent on any individual radiator. With the Mills system it was possible to have the steam enter each radiator, irrespective of location, at essentially the same time. The air vent on a radiator then was required to vent only that radiator.

The following illustration shows a Mills downfeed steam distribution for one-pipe steam heating with the master vents in the basement.



MILLS DOWNFEED STEAM DISTRIBUTION SYSTEM
WITH MASTER VENTS IN THE BASEMENT

Unfortunately, the Mills system is rarely found in residences, tenements, or moderately-sized new-law (post-1901) apartment houses.

The typical steam distribution system in these buildings is an upfeed system, whose venting is provided by one so-called "quick vent" at the end of each main and by air vents on each radiator. The combination of a "quick vent" whose capacity is little more than that of a single radiator air vent and a variety of radiator air vents (installed through the years from whatever the corner hardware store had in stock) results in a gross imbalance in system performance, as measured by room temperature.

The Gorton Corporation has for years recommended the use of graduated venting in houses to balance the system, and this approach has been quite successful in single-family or 2-3 family houses. However, when this approach is applied to larger multi-family buildings the theory, while sound in concept, becomes difficult to apply. The installer is faced with difficult decisions as to what size of vent is needed at a particular location, and he must stock a large number of sizes. Readjustment of air venting on radiators is frequently difficult because of the difficulty of access in inner-city apartments.

The Master Vent Approach

To alleviate this confusion, the Master Venting approach of the Mills System is recommended. For upfeed systems, master venting will take place at the end of each main in the basement and at the top of each riser. With the master vents sized to rapidly vent the piping, the steam will enter each radiator at essentially the same time, and consequently the radiator vents themselves can be sized according to the capacity of each radiator.

Example

A typical five-story old-law tenement has a 4" main running fore and aft in the basement. Risers that feed radiators typically are 2-1/2" pipe size for the first three floors and 2" above that. Radiators are provided in essentially two sizes, and some rooms, typically kitchens and toilet rooms are heated with a 2" riser without any radiators. The illustration below contains details for this particular example.

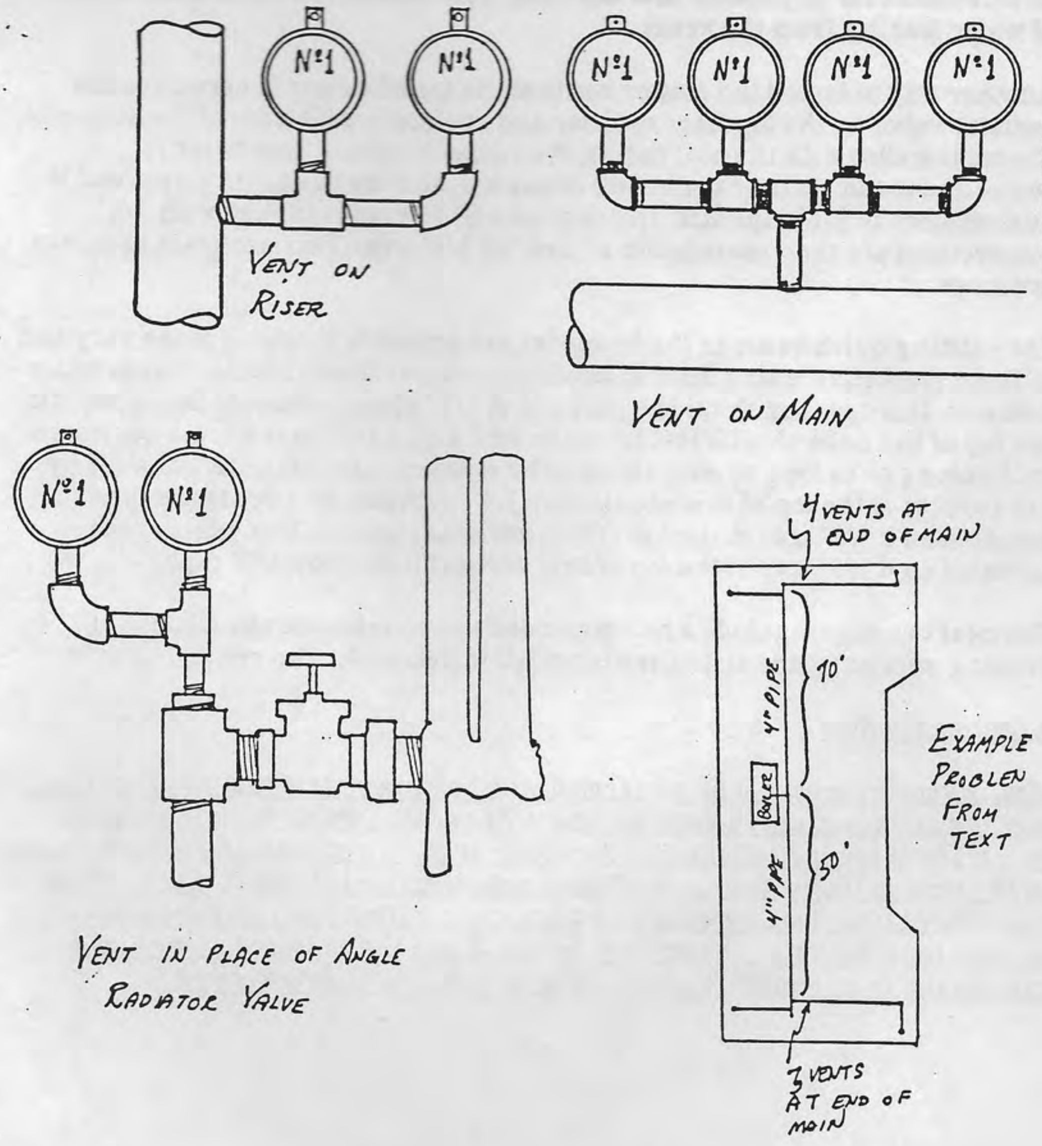
Note: The steam system is assumed to suffer no knocking, air vent panting, or other symptom of poor steam quality. If these exist, they must be eliminated before any venting is begun, as the new vents can leak profusely.

The Gorton Nº 1 vent is rated at about 4 cu ft/min at 1 psi. Since the typical steam heating system vents at only about 1/8 psi, the Gorton Nº 1 vent has a venting capacity of about 1.4 cu ft/min at 1/8 psi.

It is desirable to establish a system to vent the basement mains in one minute so that steam will enter each riser at essentially the same time. If a total of 120 ft of 4" pipe is used for the mains, this represents about 10 cu ft of air to be vented. This requires a total of 7 Nº 1 vents, distributed according to the actual volume of each branch of the main. If the boiler room is centrally located, this requires 3 or 4 vents at each end. (If the mains have sub-branches the venting required for those trunks common to two or more sub-branches is added to the capacity required for those sub-branches served.)

It is likewise desirable to establish a system to vent the top of each riser in one minute to allow steam to enter each radiator at essentially the same time. The volume of the risers that feed radiators as described above have a volume of about 1.5 cu ft, so one Nº 1 vent is required at the top of each riser. The radiator-less 2" risers also have a volume of about 1 cu ft and thus also require one Nº 1 vent at the top of each riser.

MASTER VENTING DETAILS



Note that the calculations for riser and steam main venting are quite rough: it is unnecessary to calculate pipe volume to the last cubic inch. The number of vents should be rounded up to the next whole number. The basic idea in this venting approach is to use the boiler's entire steam production to fill the piping before any radiator is heated.

As the radiators were assumed to be in two sizes, one typically having twice the capacity of the other, A Hoffman Nº 40 is used on the smaller radiator while a Gorton Nº 6 vent is used on the larger radiators. Since the Hoffman Nº 40 vent is roughly equal in capacity to the vents usually installed on radiators, the existing vent may be retained if it is in good condition.

If the risers are exposed on the next-to-the-highest floor, the required vents may be mounted on a tree of 3/8" pipe tapped into the riser. Note that in tapping into the riser it is advisable to tap the pipe a bit deep so that the 3/8" nipple can be screwed as far as possible into the riser. This should minimize the possibility of water leaking from the vents.

Another way to install the master vents at the top of a riser is to remove the radiator valve on the top floor radiator and replace it with a tee of the same size, the tee installed with the bull facing the radiator inlet. A gate valve is connected to the radiator to the bull of the tee, and the remaining run-end is bushed down to 3/8" pipe size. The required Nº 1 vents (supplied with 3/8" connections are then mounted on a "tree" of 3/8" pipe. This promotes excellent drainage.

The existing quick vents in the basement are probably installed at the very end of their respective mains. As this location is vulnerable to leakage due to water hammer, this opening should be plugged. A 1/2" opening should be tapped into the top of the main about 2 feet from the end, and a 1/2" pipe nipple (at least 6 inches long or as long as possible) is to be screwed into this hole. Put a 1/2 by 3/8 reducer at the top of this nipple. The 3/8" pipe size Nº 1 vents are then mounted on a 3/8" tree at the top of this vertical pipe.size Nº 1 vents are then mounted on a 3/8" tree at the top of this vertical pipe.and a 1/2' pipe

The next two pages include a recommended way to calculate the amount of venting necessary and also other installation details for the vents.

<u>A Cautionary Note</u>

<u>Master venting must not be performed on a heating system that has knocking, panting and squirting radiator air vents, or existing quick vents that squirt water. These are indications that the boiler or piping are causing water hammer in the system. Unless the cause of these symptoms is eliminated, master vents will likely cause flooding wherever they are installed. The resultant property damage could outweigh the savings in fuel. Since the causes of water hammer can usually be eliminated economically, it is foolish to do otherwise.</u>

SPECIFICS ON MASTER VENTING AND RADIATOR MAINTENENCE

Steam Main Vents: Vents should be installed at the end of each steam main in the basement.

The number of vents to be installed at the end of each steam main in the basement is determined as follows:

1. Make a simple layout diagram of the steam mains showing their location, length, and pipe size. (The pipe size can be determined by measuring the pipe's outside diameter and comparing it to the PIPE OUTSIDE DIAMETER in the table below.)

PIPE DIMENSIONS AND VOLUMES

PIPE SIZE	PIPE OUTSIDE DIAMETER	PIPE VOLUME PER RUNNING FOOT
1-1/4 in.	1.66 in.	0.010 cu.ft.
1-1/2 in.	1.90 in.	0.014 cu.ft.
2 in.	2.38 in.	0.023 cu.ft.
2-1/2 in.	2.88 in.	0.030 cu.ft.
3 in.	3.50 in.	0.053 cu.ft.
3-1/2 in.	4.00 in.	0.07 cu.ft.
4 in.	4.50 in.	0.09 cu.ft.
4-1/2 in.	5.00 in.	0.11 cu.ft.
5 in.	5.56 in.	0.14 cu.ft.
6 in.	6.63 in.	0.20 cu.ft.
7 in.	7.63 in.	0.27 cu.ft.
8 in.	8.63 in.	0.36 cu.ft.

2. Starting with each branch, determine its volume by multiplying its length (in feet) by the PIPE VOLUME PER RUNNING FOOT for the size of the particular branch. If a particular branch starts at one size and ends at another, calculate each volume separately, and add up the separate volumes.

3. Calculate the volume of each trunk (that is a steam main leading to more than one branch). Divide this volume by the number of branches connected to this trunk, and add this volume to the volume of each of the branches connected to this trunk. This is the TOTAL VENTING VOLUME for each branch.

4. Take each TOTAL VENTING VOLUME and divide it by 1.4. This is the number if Gorton Nº 1 vents required at the end of each main. (If the number is not a whole number round it up to the next whole number.) Use the Gorton Nº 1 vent with the 3/8 inch shank.

5. To install these vents, a 1/2" opening should be tapped into the top of the main about 2 feet from the end, and a 1/2" pipe nipple (at least 6 inches long or as long as possible) is to be screwed into this hole. Put a 1/2 by 3/8 reducer at the top of this nipple. The 3/8" pipe size Nº 1 vents are then mounted on a 3/8" tree at the top of this vertical pipe.

Riser Vents: Two Gorton Nº 1 vents with 3/8 inch shanks are required at the top of each riser.

If the risers are exposed on the next-to-the-highest floor, the vents may be mounted on a tree of 3/8" pipe tapped into the riser. Note that in tapping into the riser it is advisable to tap the pipe a bit deep so that the 3/8" nipple can be screwed as far as possible into the riser. This should minimize the possibility of water leaking from the vents.

If the risers are inaccessible, the master vents must be installed at the top of a riser as follows. Remove the radiator angle valve on each top floor radiator and replace it with a tee of the same size. The tee must be installed with the bull facing the radiator inlet. An American-made gate valve is then to be connected to the radiator to the bull of the tee, and the remaining run-end is to be bushed down to 3/8" pipe size. The required Nº 1 vents are then to be mounted on a "tree" of 3/8" pipe.

Note: Although this example used a combination od Gorton and Hoffman vents, other vents may be used provided their venting capacity can be established. The principle remains the same: rapid venting of the pipes and leisurely venting of the radiators.

Radiator Vents: A Hoffman Nº 40 is to be installed on the each radiator.

Vent and Vent Piping Installation Details:

1. Clear all existing tappings before installing vents.

2. Use only teflon tape.

3. A squirt of WD-40 in the outlet of each vent will greatly improve its sealing ability.

Radiator Shutoff Valves: Repack all shutoff valves with graphited fibre valve packing. Replace loose or broken valve handles.

Radiator Pitch: Check radiator pitch with a carpenter's level to verify that the radiator is either dead upright or pitched slightly toward the shutoff valve. Correct the pitch if necessary using appropriate wood blocks under the radiator legs.

Acknowledgments

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A SUGGESTED INSTALLATION GUIDE
FOR TYPICAL FIELD-ERECTED STEEL SCOTCH BOILERS
FIRED BY CARLIN 701 & 801CRD & 1050 FFD OIL BURNERS

INTRODUCTION This manual is intended to guide the installer of a scotch boiler so that the boiler will perform adequately and economically. The boiler models covered here are nominally rated from 40 to 100 Hp. The oil burner for these units is the Carlin Models 701 CRD, 801 CRD, and 1050 FFD.

It is also intended that installation be acceptable under the rules of:

1. The New York City Department of Housing Preservation and Development

2. The New York City Board of Air Resources

3. The ASME Boiler and Pressure Vessel Code.

In reviewing many scotch boiler installations the writer has become aware of a pattern of errors in the installations that make the boilers perform uneconomically and with great upsets in the steam heating system. In general these errors are the result of a failure to follow the instructions supplied by the boiler manufacturer, the oil burner manufacturer, and the manufacturer of the boiler accessories. The most common errors are:

1. The misinstallation of the steam supply and equalizer lines

2. The mis-location of the low water cutoff

3. The use of the wrong automatic feeder

4. The use of the wrong type of tankless coil

5. The introduction of makeup water directly into the boiler

6. A failure to properly clean the boiler's waterside surfaces at startup

7. A failure to properly adjust the burner.

DETAILED INSTRUCTIONS

Boiler Sizing Boilers should be sized and specified at no more than 80 percent of their nominal rating. For example, if an 80 HP boiler output is required, an 100 Hp. boiler should be used, but it should be fired for a maximum output of 80 HP.

Boiler Assembly The boiler should be assembled in accordance with the instructions and drawings supplied by the boiler manufacturer. All openings (such as washouts and surface blowoffs) should be provided with full-size gate valves.

Boiler Trim Boiler trim should be installed as shown on the drawing in this manual. In locating the water column and low water cutoff, particular care should be exercised to assure that they are located at the precise height required. All measurements should be taken from the firetubes themselves as shown on the drawing. The installer should verify that the "lowest Permissible Water Level" tag is attached in the boiler 2 inches above the top of the firetubes..

NOTE : The McDonnell & Miller Nº 51 combination low water cutoff & feeder should not be used to perform both low-water cutoff and automatic feed functions on scotch boilers of this size range. (This is because the Nº 51has an excessive height difference between the low water cutoff water level and the normal operating water level.). If an combination low-water cutoff and automatic feeder is desired, a Nº 47 combination low water cutoff & feeder should be used (This automatically establishes the minimum operating water level 1 inch above the burner cutoff level.) However, for increased reliability, the low-water cutoff should be of the mercury-switch type, such as a Nº 150.

Safety Valves Safety valves should be installed in the openings provided by the boiler manufacturer. Discharge piping shall be the same size as the discharge opening on the safety valve and should lead to a safe discharge point. This piping should be adequately supported.

Steam Supply Line and Equalizer The 8-inch steam supply header and 4-inch equalizer should be sized and installed as shown in the illustration on the following pages. No reduction in pipe size should be made if this arrangement is used. However, the use of double steam risers is strongly recommended for optimum steam quality. See Boiler Steam Piping in this manual.

Connection to Building Steam Mains A reducing coupling should be installed at or beyond the outlet of the tee on the steam header. The small end of this reducer should be no smaller than the size of the building mains. A gate valve should be installed downstream of this reducer and upstream of all mains. It should be the same size as the small end of the reducer.

The equalizer and Hartford return loop should be exactly as shown on the illustration. No reduction in pipe size should be made.

The steam pipe from the boiler is to welded into the boiler shell with an inward projection of the steam pipe into the boiler shell of no more than 1 inch.

Note: Since this welded joint between the boiler shell and the steam pipe is within the scope of Section IV of the ASME Boiler and Pressure Vessel Code, it must be be welded by an installer having as ASME "H" Certificate of Authorization for welded steel boilers. The installer is required to complete an H-4 Manufacturer's Partial Data Report and have it signed by the installer's Authorized Inspector who inspected the welding and witnessed the hydrostatic test. (This is required by most state Boiler Laws.)

Connection to Building Return Lines A reducer should be installed upstream of the Hartford loop to mate with the building returns. A full-size return line gate valve should be installed in this line and a 2-inch drain connection and valve should be installed upstream of the return line gate valve. (These valves will be used to blow the return lines out under steam pressure.)

Boiler Makeup Water Boiler makeup water, either through a manual feed valve or an automatic feeder, should be piped into the condensate return piping at least 3 feet beyond (that is upstream of) the block valve on the return line. (This is to prevent thermal shock in the boiler). Boiler makeup water must be cold water only to avoid damage to the feeder.

Tankless Coils Tankless coils must be of the offset type and installed such that they will provide full rated hot water output with the boiler water level no higher than 3 inches above the top of the firetubes.

Firing Rates For optimum steam quality, boilers should be fired at no more than 80 percent of their rated maximum input. For 80 percent firing, use the following oil firing rates:

40 Nominal Hp.: Carlin 701 CRD (4.80 gpm low fire; 9.60 gpm high fire)
50 Nominal Hp.: Carlin 701 CRD (6.00 gpm low fire; 12.00 gpm high fire)
60 Nominal Hp.: Carlin 801 CRD (7.20 gpm low fire; 14.40 gpm high fire)
70 Nominal Hp.: Carlin 801 CRD (7.80 gpm low fire; 16.80 gpm high fire)
90 Nominal Hp.: Carlin 1050 FFD (9.00 gpm low fire; 22.00 gpm high fire)
100 Nominal Hp.: Carlin 1050 FFD (9.00 gpm low fire; 24.00 gpm high fire)

Note: The above table refers to firing rates, not nozzle sizes. For the proper nozzle size and type, refer to the Carlin instructions.

Draught Settings All boilers should be fired with a -.05" w.c. draught at high fire measured in the smokehood.

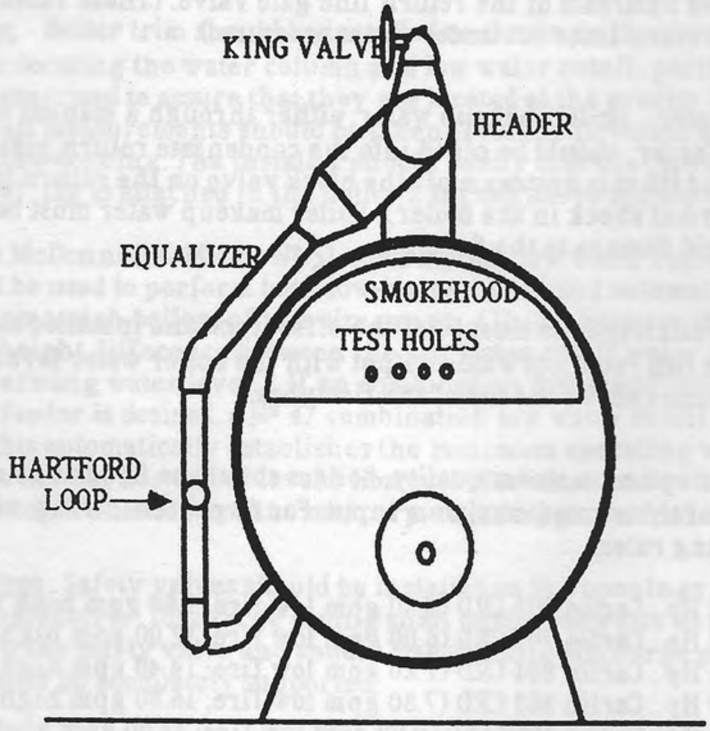
Carbon Dioxide Level All burners should be adjusted for 12.5 percent carbon dioxide with zero smoke. The carbon dioxide reading must be taken in the smokehood.

Oil Burner Installation Oil burners should be installed and adjusted in accordance with the instructions supplied by The Carlin Company. Examples of these instructions are in the appendix. However, to maintain currency, the actual instructions shipped with the burner should be used in the particular installation.

Initial Boiler Cleaning and Return System Flushing Prior to startup, the boiler should be cleaned in accordance with article 7 of Section VI of the ASME Boiler and Pressure Vessel Code.

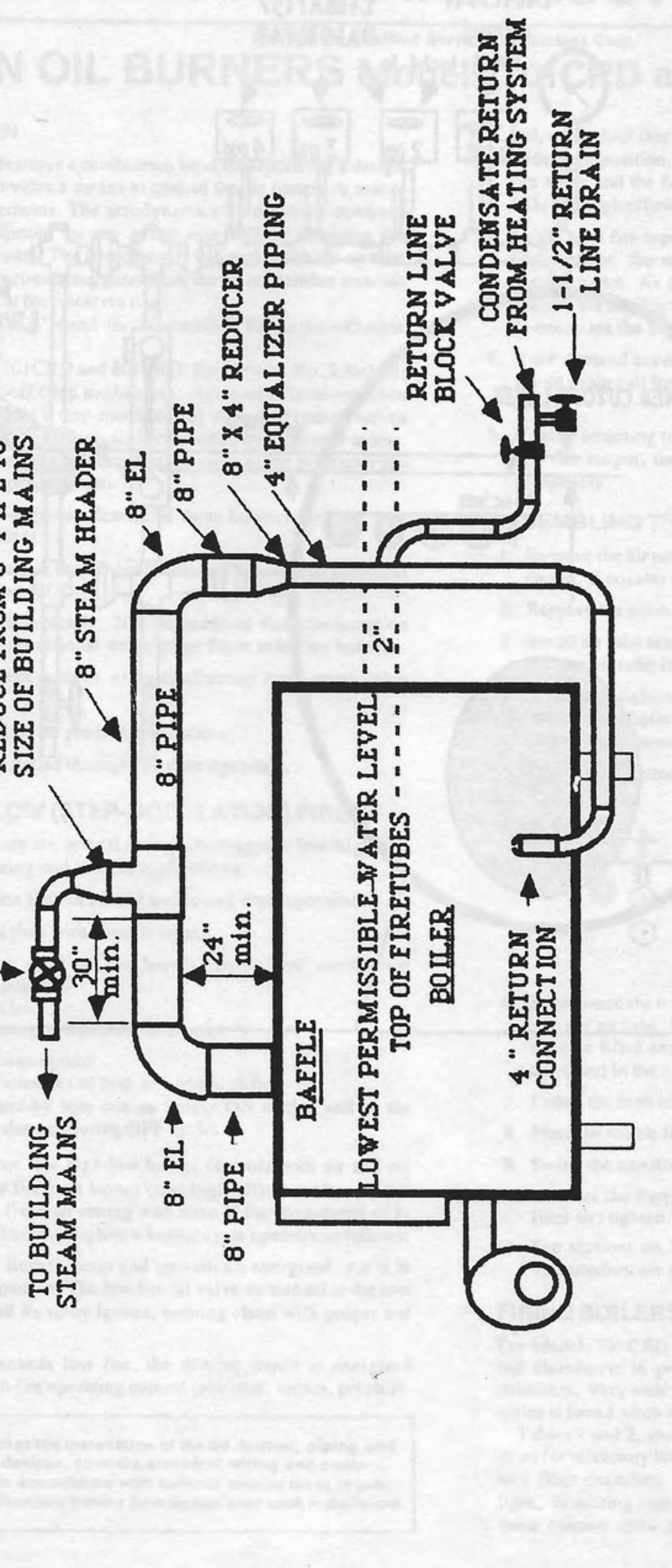
After this initial boiler cleaning is performed, the boiler should be operated with the block valve on the return line shut and the condensate wasted to drain for the first day of operation. This will prevent sludge in the return lines from entering the boiler.

Boiler Water Treatment Boiler water should be treated in accordance with Article 9 of Section VI of the ASME Boiler and Pressure Vessel Code and in accordance with the boiler manufacturer's instructions.

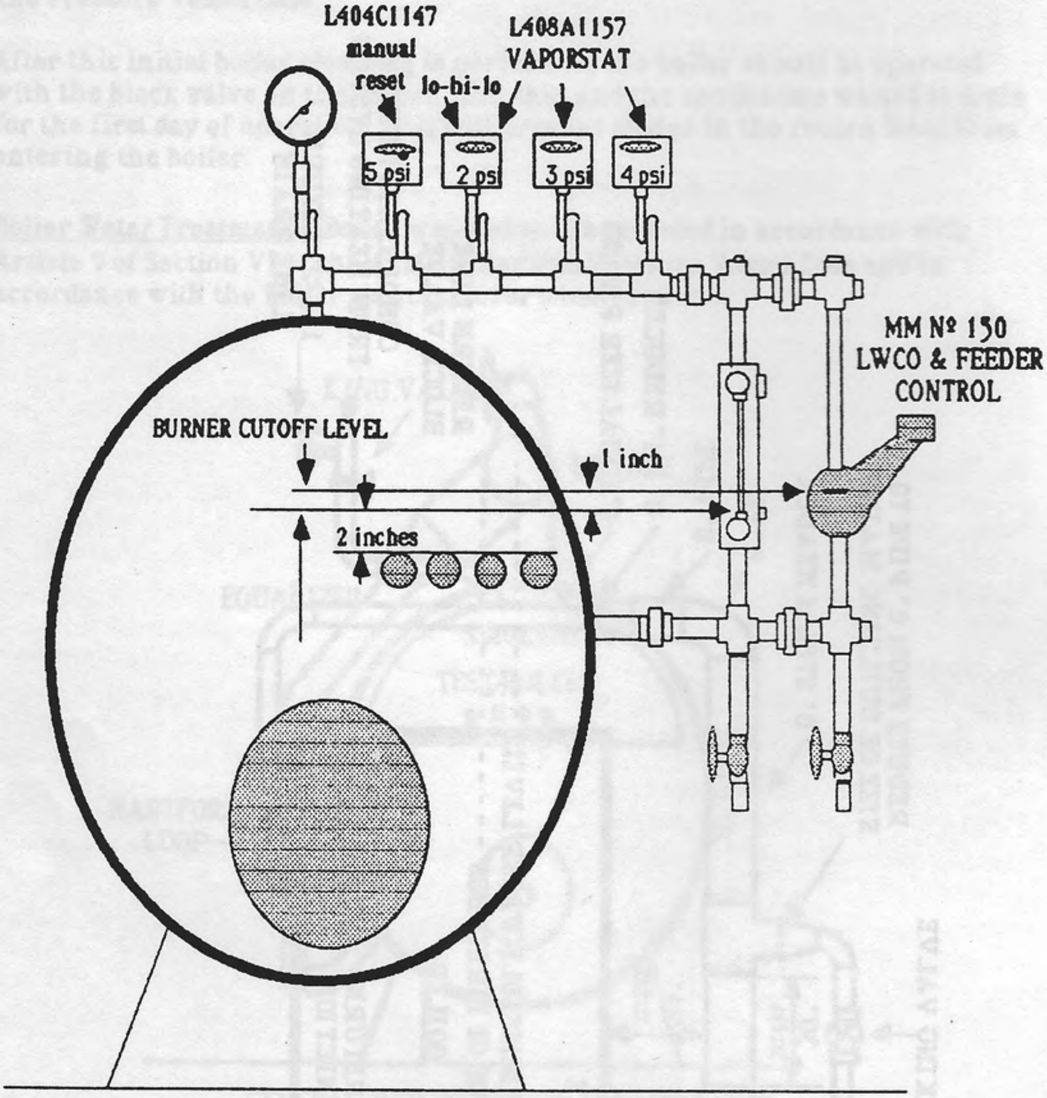


GENERAL BOILER PIPING ARRANGEMENT
AND
LOCATION OF COMBUSTION TEST HOLES
REAR VIEW

GENERAL BOILER PIPING ARRANGEMENT
SIDE VIEW



CONTROL TRIM



INSTALLATION and OPERATING INSTRUCTIONS

For Use By Qualified Service Technicians Only

CARLIN OIL BURNERS Models 701CRD and 801CRD (60-Hz)

DESCRIPTION

"CRD" burners features a combustion head incorporating a design concept which provides a means to control the air pattern to match the nozzle requirements. The aerodynamics for optimum combustion are easily adjusted for any nozzle size without changing the air-handling hardware. The flame front is initiated inside the air tube so that no erratic recirculating gases from the main chamber area can quench the flame at the retention ring.

The letters "CRD" stand for "Controlled Retention—Double Speed."

Carlin Models 701CRD and 801CRD, for use with No. 2 fuel oil, are low-high-low-off (step modulating) high speed flame retention burners. Oil flow-rate is step-modulated by the use of two oil valves and two nozzles. Combustion air is controlled by a damper motor. Its end-switch energizes the second stage valve as the air shutter approaches a wide open position.

Due to the low-high-low feature of these burners they are very versatile and efficient:

1. They can operate in forced draft boilers or furnaces at pressures up to 0.50 inches W.C.
2. They will save typically, 20% in seasonal fuel consumption compared to conventional single-stage flame retention burners.
3. They can operate with or without refractory lined combustion chambers.
4. They are superior for process applications.
5. They can be installed through fire door openings.

LOW-HIGH-LOW (STEP-MODULATION) FIRING

Advantages: There are several strong advantages to low-high-low firing in both heating and process applications:

1. Smooth ignition both in natural and forced draft operations.
2. Closer control than with a single input.
3. Less strain or wear on the burner, boiler and combustion chamber components:
   a. Longer cycles.
   b. Gradual changes; less thermal shock.
4. Lower fuel consumption:
   a. Higher efficiencies of both low and high fire.
   b. Lower stand-by loss due to longer ON cycles and to the closed air damper during OFF cycles.

Operation: A true low-high-low burner controls both air and oil flow rates. A low fire start burner (low-high-off) controls only the oil rate and has a fixed air setting with none of the advantages of 1, 2, 3, or 4 above. The low-high-low burner cycle operates as follows:

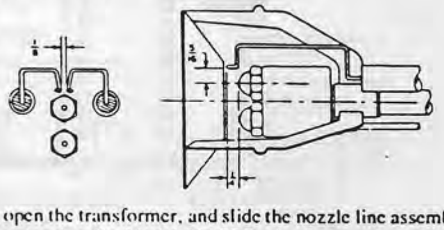
1. Call for heat. Burner motor and ignition are energized. Air is in the low fire position. The low fire oil valve admits oil to the low fire nozzle and its spray ignites, burning clean with proper air/fuel ratio.
2. If demand exceeds low fire, the damper motor is energized through a high fire operating control (aquastat, airstat, pressuretrol, or outdoor thermostat). As the damper motor approaches a wide open position, the auxiliary end switch energizes the high fire valve and the full fire with open air, burns clean with high CO_2 and high efficiency.
3. As the high fire input begins to exceed the demand of the high fire operator, the operating control opens to de-energize the damper motor. As the damper motor returns the air shutter to low fire the auxiliary end switch in the damper motor opens and de-energizes the high fire valve.
4. If the demand exceeds low fire, the high fire operating control would again call for more heat as in Step 2 and then followed by Step 3.
5. If, after returning to low fire, the load should drop to below the low fire output, the operating limit would shut off the burner completely.

It is important that the installation of the oil burner, piping and fittings, safety devices, controls, electrical wiring and equipment be done in accordance with national and/or local regulations of the authorities having jurisdiction over such installation.

ASSEMBLING THE BURNER (TWO-PAK)

1. Remove the air tube and nozzle line assembly from the smaller carton. If nozzles are not installed, see instructions under (4).
2. Remove the main housing assembly from the larger carton.
3. Install air tube assembly in housing using set screws provided. Be sure air tube is fully seated against step in housing.
4. Install and tighten the proper nozzles (see Tables 5 & 6, Page 4) in the adapter. Be careful not to damage the electrode insulators or to bend the wires.
5. Check the electrode settings.

FIG. 1



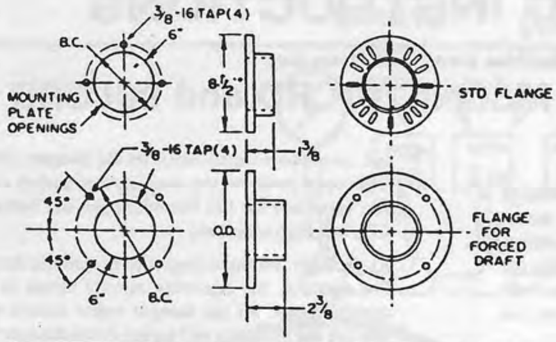
6. Swing open the transformer, and slide the nozzle line assembly into the air tube. On Model 801CRD, the flame retention ring must be lifted and guided through the throttle ring (a reduced diameter) in the end of the air tube. DO NOT FORCE IT.
7. Fasten the high tension leads to the transformer terminals.
8. Place the nozzle line yoke in the groove in the adjusting screw.
9. Swing the transformer to the closed position.
10. Connect the flared fitting on the copper oil lines to the nozzle lines and tighten.
11. See sections on Page 3 for adjustments of combustion head and combustion air.

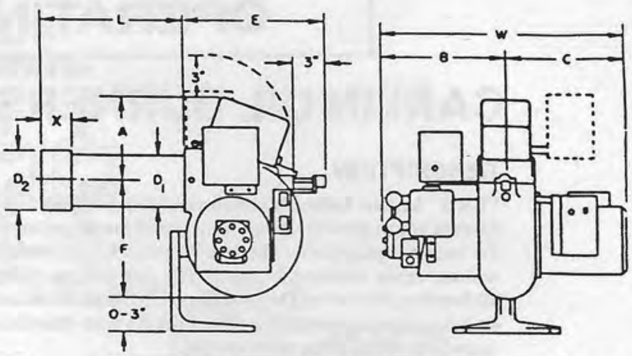
FIRING BOILERS WITH COMBUSTION CHAMBERS

The Models 701CRD and 801CRD operate with superior efficiency and cleanliness in properly designed refractory-type combustion chambers. Very wide tolerance to burner adjustments and other variables is found when these chambers are used.

Tables 1 and 2, show the recommended minimum inside dimensions for refractory brick, refractory pre-cast and pre-formed refractory fiber chambers. Due to their quick warm-up properties, the light, insulating-type materials are slightly preferable although these burners show less dependence upon refractory temperature

DIMENSIONS





MODEL	STD. FLANGE	B.C.	FORCED DRAFT FLANGE	B.C.	O.D.
701CRD	240	6¾-7⅛	240FF4	9"	10"
801CRD	840CRD	6⅞-7⅛	240FF5	10"	11"

MODEL	A	B	C	D_1	D_2	E	F	L	W	X
701CRD	7½	9½	10	4⅛	5⅞	13	9	10 11/16-14 11/16	19½	2½
801CRD	8	12	11	5¼	5⅞	14½	10½	10-12	23	3

TABLE 1 701CRD
MINIMUM DIMENSIONS RECOMMENDED IN REFRACTORY COMBUSTION CHAMBERS—(Inches)

1 High Fire Oil Delivery Rate GPH @ 150 PSI	2 Length L	3 Width W	4 Dimens. C	5 Suggested Height H	6 Minimum Dia. Verticle Cyl.
6.00	19	13.5	7.0	13	17
6.60	22	14.0	7.0	14	20
7.20	24	14.5	7.5	14	24
7.80	27	15.0	7.5	15	25
8.40	30	15.5	8.0	15	28
9.00	33	15.5	8.0	15	31
9.60	34	16.0	8.0	16	32
10.20	35	16.0	8.0	16	33
10.80	36	16.0	8.0	16	34
11.40	37	16.5	8.5	16	35
12.00	48	16.5	8.5	16	46
12.60	52	16.5	8.5	16	50
13.20	55	16.5	8.5	16	53

Note: These are MINIMUM dimensions and each may be exceeded without much effect.

TABLE 2 801CRD
MINIMUM DIMENSIONS RECOMMENDED IN REFRACTORY COMBUSTION CHAMBERS—(Inches)

1 High Fire Oil Delivery Rate GPH @ 150 PSI	2 Length L	3 Width W	4 Dimens. C	5 Suggested Height H	6 Minimum Dia. Vertical Cyl.
11.4	33	15	7.5	15	31
12.0	34	16	8	16	32
12.6	35	16	8	16	33
13.2	36	17	8.5	17	34
13.8	38	17	8.5	17	36
14.4	39	18	9	18	37
15.0	40	18	9	18	38
15.6	41	19	9.5	19	39
16.2	43	19	9.5	19	41
16.8	44	20	10	20	42
17.4	46	20	10	20	44
18.0	47	21	10.5	21	45
18.6	49	21	10.5	21	47
19.2	51	22	11	22	49
19.8	52	22	11	22	50

Note: These are MINIMUM dimensions and each may be exceeded without much effect.
Refer to Fig 2 for details showing L, C, & H.

TABLE 3 701CRD
MINIMUM DIMENSIONS RECOMMENDED IN BOILERS FIRED WITHOUT COMBUSTION CHAMBERS—(Inches)

1 High Fire Oil Delivery Rate GPH @ 150 PSI	2 L With Target	3 L Without Target	4 Width W	5 Dimens. C	6 Dimens. D
6.00	19	23	15.5	8.0	10.0
6.60	22	26	16.0	2.0	10.0
7.20	24	28	16.5	8.5	10.5
7.80	27	32	17.0	8.5	10.5
8.40	30	35	17.5	9.0	11.0
9.00	33	38	17.5	9.0	11.0
9.60	34	40	18.0	9.0	11.0
10.20	35	41	18.0	9.0	11.0
10.80	36	42	18.0	9.0	11.0
11.40	37	43	18.5	9.5	11.5
12.00	48	54	18.5	9.5	11.5
12.60	52	58	18.5	9.5	11.5
13.20	55	60	18.5	9.5	11.5

TABLE 4 801CRD
MINIMUM DIMENSIONS RECOMMENDED IN BOILERS FIRED WITHOUT COMBUSTION CHAMBERS—(Inches)

1 High Fire Oil Delivery Rate GPH @ 150 PSI	2 L With Target	3 L Without Target	4 Width W	5 Dimens. C	6 Dimens. D
11.4	33	38	17	7.5	9.5
12.0	34	39	18	8	10
12.6	35	40	18	8	10
13.2	36	41	19	8.5	10.5
13.8	38	43	19	8.5	10.5
14.4	39	44	20	9	11
15.0	40	46	20	9	11
15.6	41	47	21	9.5	11.5
16.2	43	49	21	9.5	11.5
16.8	44	50	22	10	12
17.4	46	52	22	10	12
18.0	47	54	23	10.5	12.5
18.6	49	56	23	10.5	12.5
19.2	51	58	24	11	13
19.8	52	59	24	11	13

Refer to Figs 3 and 4 for details showing L, C, & D.

than previous models. Refractory materials in boilers and furnaces should be capable of withstanding 2600°F (1427°C) or higher.

The notes accompanying Table 1 and 2 provide further details relative to variations in dimensions and geometry.

FIRING BOILERS WITHOUT REFRACTORY CHAMBERS

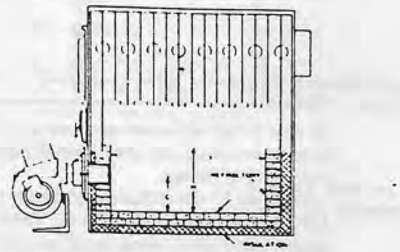
Depending upon the geometry of the combustion space some units perform better than others without refractory. When the back wall of the unit coincides approximately with the end of the flame, a target of refractory material is usually required.

Tables 3 and 4 show MINIMUM dimensions required for good combustion. They may be exceeded without much effect.

INSTALLING THE BURNER: FLANGE MOUNTED

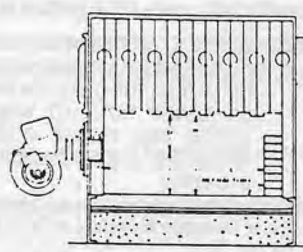
1. Measure, in the burner opening, the distance from the inside of the combustion chamber to the outside of the mounting plate to find the insertion length of air tube needed. Position flange with sleeve inside on air tube at a point from end of burner corresponding to this measurement. Tighten set screws to anchor flange. The flange is now located so that the end of the burner will be flush, or almost flush, with the inside of the combustion chamber.
2. Slide the end of the air tube into the opening and secure the flange to the front plate.

FIG. 2



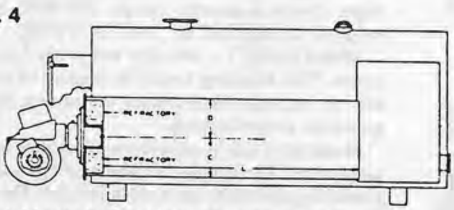
Brick combustion chamber, side view.

FIG. 3



Wet leg boiler. No combustion chamber, side view.

FIG. 4



Scotch Marine boiler. No combustion chamber.

INSTALLING THE BURNER: PEDESTAL MOUNTED

1. Adjust the pedestal so that the height of the air tube matches the location of the burner opening.
2. Slide the end of the air tube into the opening so that it is flush or nearly flush with the inside of the combustion chamber.
3. From the outside of the unit, seal the space around the air tube with asbestos cement or equivalent.

FIG. 5

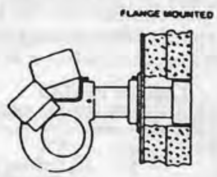
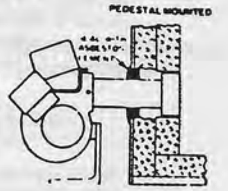


FIG. 6



HOW TO ADJUST THE COMBUSTION HEAD

The retention ring position ahead of the throttle ring is adjustable from zero (flush) to 1¼ inches (Dimension "A," Figs. 7 and 8). Turning the adjusting screw in (clockwise) increases the distance "A" ahead. This distance is indicated by lifting the housing cover and reading the scale on the nozzle line across the corners on sides of the channel guiding the nozzle line. Each division is 1/16 inch.

Refer to "A" dimension given in Table 5 and 6 for corresponding nozzle selection. (If alternate nozzle sizes are used select "A" dimension from the high fire oil delivery rate, Column 5). EXAMPLE: 701CRD firing at 11.40 GPH high fire. "A" column setting reads ¾".

1. Turn adjusting screw counterclockwise until zero on scale is aligned with rear of housing. ("A" equals zero see Fig. 8).
2. Now turn adjusting screw clockwise until the ¾" graduation on the scale coincides with rear of housing. Each mark (or line) is 1/16 inch. (See Fig. 8.)
3. The retention ring will now be exactly ¾" ahead of the throttle ring. (See "A" dimension, Fig. 7.)

CAUTION: Housing cover should be raised slightly when attempting to change retention ring setting ("A" dimension) otherwise scale will be torn or distorted. This can be done by backing out the two hold-down screws 2 to 3 turns, and then lifting cover slightly while adjusting. Be sure to tighten screws after adjusting.

FIG. 7

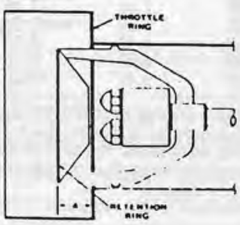
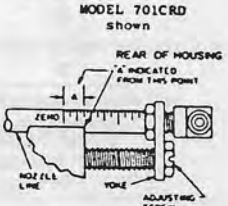


FIG. 8



COMBUSTION HEAD ADJUSTMENT FOR COMBUSTION AIR

When adjusting the combustion head forward or back, the space around the rim of the retention ring is increased or decreased which increases or decreases the amount of combustion air to correspond with the nozzle sizes used.

Also, by using the specified nozzle combinations for low and high fire (Tables 5 and 6), the air fuel ratio for both low and high fire are optimized by the automatic damper motor and its associated linkage. THIS LINKAGE HAS BEEN PRE-SET AT THE FACTORY AND SHOULD NOT BE ADJUSTED. It is set to be in the fully open position when the burner is in high fire.

By adjusting the combustion head according to Tables 5 and 6, (last column), for the firing rate delivered by the particular nozzles, the burner should deliver very close to the proper amount of combustion air and CO_2. Slight increases or decreases will usually be required depending upon the draft. Normally a draft of 0.02 to 0.04 inches W.C. (negative pressure) is recommended over the fire for natural draft applications.

Model 701CRD is provided with a low fire air shutter adjusting screw. This adjustment limits the amount of shutter closure which thereby increases or decreases the amount of combustion air required for proper burning.

Model 801CRD is supplied with separate low fire and high fire air shutters. The low fire air shutter has an adjusting screw which should be adjusted to get a clean, low fire. The high fire air shutter is not adjustable and moves with the linkage that is preset at the factory.

TABLE 5 701CRD
NOZZLE DATA AND COMBUSTION HEAD SETTINGS

Nozzle specifications Hago Products Corp. 1st Stage*	2nd Stage*	Spray	Oil Delivery Rate GPH @ 150 PSI Low Fire	High Fire	"A"** Approximate Retention Ring Setting On Scale
3.00	2.00	60°H	3.60	6.00	1/16"
3.25	2.25	60°H	3.90	6.60	3/16"
3.25	2.75	60°H	3.90	7.20	1/4"
3.50	3.00	60°H	4.20	7.80	5/16"
3.50	3.50	60°H	4.20	8.40	3/8"
3.75	3.75	60°H	4.50	9.00	7/16"
4.00	4.00	60°H	4.80	9.60	1/2"
4.00	4.50	60°H	4.80	10.20	9/16"
4.50	4.50	60°H	5.40	10.80	5/8"
4.50	5.00	60°H	5.40	11.40	3/4"
5.00	5.00	45°H	6.00	12.00	7/8"
5.00	5.50	45°H	6.00	12.60	1 1/16"
5.00	6.00	45°H	6.00	13.20	1 1/4"

TABLE 6 801CRD
NOZZLE DATA AND COMBUSTION HEAD SETTINGS

Nozzle Specifications Hago Products 45° H 1st Stage*	2nd Stage*	Oil Delivery Rate GPH @ 150 PSI Low Fire	High Fire	"A"** Approximate Retention Ring Setting on Scale
5.50	4.00	6.60	11.40	1/16"
5.50	4.50	6.60	12.00	1/16"
5.50	5.00	6.60	12.60	1/8"
5.50	5.50	6.60	13.20	3/16"
6.00	5.50	7.20	13.80	1/4"
6.00	6.00	7.20	14.40	5/16"
6.00	6.50	7.20	15.00	3/8"
6.50	6.50	7.80	15.60	7/16"
6.50	7.00	7.80	16.20	1/2"
6.50	7.50	7.80	16.80	5/8"
6.50	8.00	7.80	17.40	3/4"
6.50	8.50	7.80	18.00	7/8"
7.00	8.50	8.40	18.60	1"
7.00	9.00	8.40	19.20	1 1/8"
7.00	9.50	8.40	19.80	1 1/4"

*When field conditions are unusual or if the load requires it, the low fire and high fire may be altered such that the low fire is increased and the high fire decreased as needed. The low fire air shutter adjusting screw will require turning to the revised nozzle sizes.

**"A"—See Figs. 7 and 8, Page 3.

NOZZLE SPECIFICATIONS:

The nozzles shown in Tables 5 and 6 are standard and usually provide the best fire. Substitutions are not normally recommended.

Other makes of nozzles may or may not prove satisfactory.

For special applications, other specifications might provide a more desirable pattern.

FORCED DRAFT FIRING:

Due to the back pressure in forced draft units the maximum firing rate of a burner is reduced. The greater the pressure, the lower the maximum GPH capability becomes. Table 7 shows this. Note that the Table stops at 0.50 inches W.C.; the maximum recommended back pressure for these models.

TABLE 7
MAXIMUM FIRING RATES (GPH)—FORCED DRAFT

Burner Model	Combustion Chamber Pressure 0.00	0.10	0.20	0.30	0.40	0.50 INS. W.C.
701CRD	13.20	12.70	12.30	11.80	11.30	10.90
801CRD	19.80	19.40	19.00	18.60	18.20	17.80

The combustion head settings for forced draft firing would be somewhat greater than those shown in Tables 5 and 6 which are for zero pressure or natural draft.

FUEL UNITS AND OIL LINES

Standard burners are provided with a two-stage 3450 rpm fuel unit set at 150 PSI.

A single-pipe system is recommended whenever the bottom of the fuel tank is above the burner or is at the same level as the burner. This includes outdoor fuel tanks that are at such levels. The length of run should not exceed 100 ft. and the vacuum should not exceed 12" mercury. Be sure the by-pass plug has been removed for single-pipe systems.

A two-pipe system is recommended when the fuel tank is below the level of the burner, and the fuel unit must pull (lift) the fuel up to the burner. The vacuum reading should not exceed 12" mercury. For two-pipe installations the by-pass plug must be installed.

Table 8 shows, for the standard two-stage fuel unit, the allowable lift and lengths of ½" and ⅝" OD tubing for both suction and return lines in two-pipe systems.

TABLE 8 MODEL 701CRD & MODEL 801CRD
TWO-STAGE UNITS—TWO-PIPE SYSTEMS
(150 PSI)

Lift (feet)	Length of Tubing (Feet) ½" OD	⅝" OD
0	100	100
2	88	100
4	78	100
6	69	100
8	59	100
10	49	100
12	39	100
14	29	82
15	24	68

Be sure that all oil line connections are absolutely air tight. Check all connections and joints. Flared fittings are recommended. Do not use compression fittings.

Open the air-bleed valve and start the burner. For clean bleed, slip a 3/16" ID hose over the end of the bleed valve and bleed into a container. Continue to bleed for 15 seconds after oil is free of air bubbles. Stop the burner and close the bleed valve.

LIGHT-OFF AND ADJUSTMENT

NOTE: WHEN STARTING THIS BURNER THE FIRST TIME OR AFTER CHANGING NOZZLES THE FLAME MAY GO OUT DURING THE SWING FROM LOW TO HIGH. BE READY TO SHUT THE BURNER DOWN JUST AFTER THE FLAME GOES OUT. REPEAT THIS UNTIL THE AIR IS PURGED OUT OF THE HIGH FIRE OIL LINE.

Before starting the burner, pre-set the retention ring position for the particular firing rate according to Table 5 for the 701CRD or Table 6 for the 801CRD.

If the fire is a little too rich, move the combustion head forward by increasing dimension "A." Fig. 8 and 9. At the lower inputs, a very slight change is usually enough. DO NOT ALTER THE LINKAGE. IT IS PRE-SET AT THE FACTORY.

Model 701CRD is provided with a low fire air shutter adjusting screw. This adjusting limits the amount of shutter closure which thereby increases or decreases the amount of combustion air required for proper burning.

Model 801CRD is supplied with separate low fire and high fire air shutters. The low fire air shutter has an adjusting screw which should be adjusted to get a clean, low fire. The high fire air shutter is not adjustable and moves with the linkage that is preset at the factory.

Adjust draft to 0.02 to 0.04 inches W.C. over the fire for natural draft units.

Run a smoke test. Strive for zero or a trace. Each time further adjustment of retention ring is made, reset the draft to 0.02 to 0.04 inches W.C. over the fire.

Check CO_2. This should be 12 to 12½ percent, and will often be over 13 percent, in a well-sealed unit.

Check for good ignition and clean cut-off. If cut-off continues to be poor, look for air leaks in the suction line and correct them.

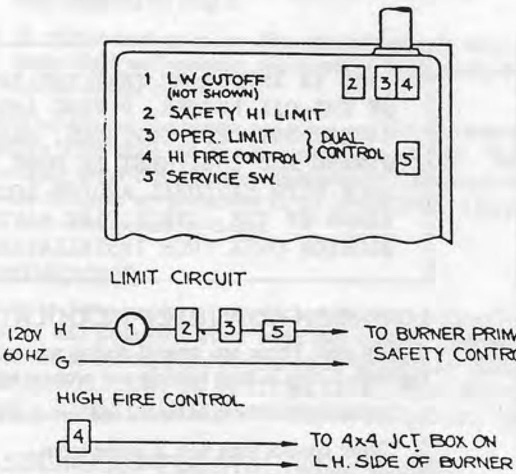
WIRING FOR LOW-HIGH-LOW STEP MODULATION

In order to take full advantage of the energy savings potential of these burners they should be wired to operate with low-high-low cycles. Hence the firing cycle would be much longer by going from low to high to low once or several times before shutting off.

In the following illustrations are two examples: 1. Water Boiler. 2. Steam Boiler. In each case we have a limit circuit which starts and stops the burner and a high fire control which brings the high fire on and off.

Also, prewired and built into the burner is a manual high fire switch which enables the installer or operator to hold the burner on low fire if so desired.

Refer to the appropriate example for your installation.



Example: Water Boiler

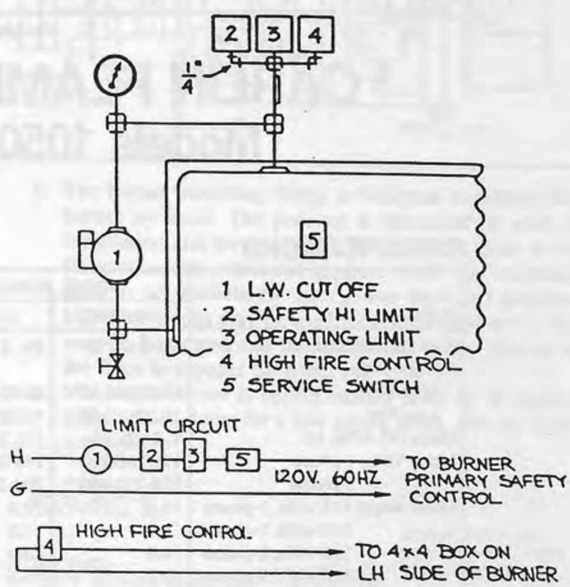
Operating Range 170°–190°F

2. Set Safety Hi Limit: Cut in 200—Cut out 210
3. Set Operating Limit: Cut in 180—Cut out 190
4. Set Hi Fire Control: Cut in 170—Cut out 180

Operation:

1. Call for heat; cold start. Burner starts on low and goes to high fire.
2. When the temperature rises to 180°F the burner goes to low fire.
3. If temperature drops to 170° burner returns to high fire.
4. If temperature rises to 190° burner shuts off.

NOTE: Since the calibrations on the limit controls are seldom exact, it will be necessary to readjust the settings during operation.



Example: Steam Boiler

Operating Range 3 to 6 PSI

2. Set Safety Hi Limit: Cut in 8 PSI—Cut out 10 PSI
3. Set Operating Limit: Cut in 5 PSI—Cut out 6 PSI
4. Set Hi Fire Control: Cut in 3 PSI—Cut out 4 PSI

Operation:

1. Call for heat; cold start. Burner starts on low and goes to high fire.
2. When pressure rises to 4 PSI the burner goes to low fire.
3. If pressure drops to 3 PSI burner returns to high fire.
4. If pressure rises to 6 PSI burner shuts off.

NOTE: Since the calibrations on the limit controls are seldom exact, it will be necessary to readjust the settings during operation.

THE CARLIN COMPANY

A subsidiary of Ford Products Corporation

601 MARSHALL PHELPS ROAD • P. O. BOX 750 • WINDSOR, CT 06095

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INSTALLATION and OPERATING INSTRUCTIONS

For Use By Qualified Service Technicians Only

CARLIN FLAME FUNNEL® OIL BURNERS

Models 1050FFD and 1150FFD (60-Hz)

SPECIFICATIONS

ITEM	MODEL NUMBER	
	1050FFD	1150FFD
Fuel Specification	No. 2 CS12	No. 2 CS12
Firing Range		
High-Fire*	15.00–25.00*	20.00–35.00*
Low-Fire	9.00–12.00	12.00–15.00
Motor HP, RPM, Hz	1, 3450, 60	1½, 3450, 60
Motor Volts; 1-phase	115/208-230**	115/208-230**
3-phase	208-230/460**	208-230/460**
Motor amps; 115 volts, 1-phase	16.4	22.0
230 volts, 1-phase	8.2	11.0
230 volts, 3-phase	4.0	5.0
460 volts, 3-phase	2.0	2.5
Control Volts, Hz	120, 60	120, 60
Ignition Transformer, volts	120/12,000	120/12,000
Burner Housing	Rugged casting	Rugged casting
Blower Wheel, Dia. × W.	7" × 5"	7⅜" × 5"
Flame Retention Ring, O.D.	3¹³⁄₁₆"	4¼"
2-Stage Fuel Unit Pressure	100	100
Low and High-Fire Oil Valve	120V, 60-Hz	120V, 60-Hz
Damper Motor with End Switch	120V, 60-Hz	120V, 60-Hz
Oil Nozzle Specs.	(3) 45° SS	(3) 45° SS
Approximate Shipping Weight	135 lbs.	145 lbs.

*Gph ratings are based on sea level to 2,000 ft. elevation. For every 1,000 ft. rise over 2,000 ft., reduce the maximum gph rating by 4%.
**Motor volts and phase must be specified when ordering.

DESCRIPTION

Model 1050FFD and Model 1150FFD Flame-Funnel oil burners for use with No. 2 fuel oil are low-high-low-off (step modulating) high speed flame retention burners. Oil flow rate is step-modulated by the use of two oil valves and three nozzles, low-fire from the first nozzle and high-fire added by the second and third nozzles firing simultaneously. Combustion air is controlled by a damper motor. Its end-switch energizes the second-stage valve as the air shutter opens.

Due to the low-high-low feature of these burners they are very versatile and efficient.

1. They can operate in forced draft boilers or furnaces at pressures up to 0.50 inches W.C.
2. They will save typically, 20% in seasonal fuel consumption compared to conventional single-stage flame retention burners.
3. They can operate with or without refractory lined combustion chambers.
4. They are superior for process applications.
5. They can be installed through fire door openings.

IT IS IMPORTANT THAT THE INSTALLATION OF THE OIL BURNER, PIPING AND FITTINGS, SAFETY DEVICES, CONTROLS, ELECTRICAL WIRING AND EQUIPMENT BE DONE IN ACCORDANCE WITH NATIONAL AND/OR LOCAL REGULATIONS OF THE AUTHORITIES HAVING JURISDICTION OVER SUCH INSTALLATION.

LOW-HIGH-LOW (STEP-MODULATION) FIRING

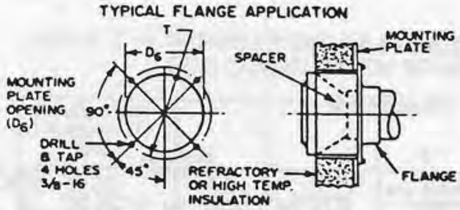
Advantages: There are several strong advantages to low-high-low firing in both heating and process applications:

1. Smooth ignition both in natural and forced draft operations.
2. Closer control than with a single input.
3. Less strain or wear on the burner, boiler and combustion chamber components:
   a. Longer cycles.
   b. Gradual changes; less thermal shock.
4. Lower fuel consumption:
   a. Higher efficiencies of both low and high-fire.
   b. Lower stand-by loss due to longer ON cycles and to the closed air damper during OFF cycles.

Operation: A true low-high-low burner controls both air and oil flow rates. A low-fire start burner (low-high-off) controls only the oil rate and has a fixed air setting with none of the preceding advantages. The low-high-low burner cycle operates as follows:

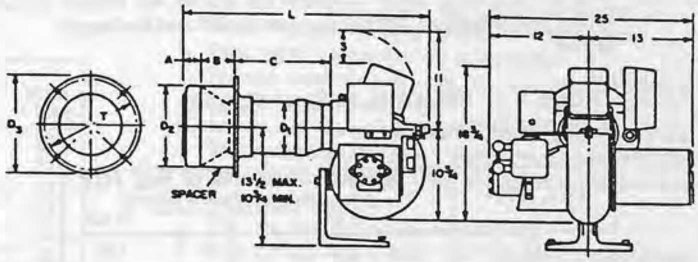
1. Call for heat. Burner motor and ignition are energized. Air is in the low-fire position. The low-fire oil valve admits oil to the low-fire nozzle and its spray ignites, burning clean with proper air/fuel ratio.
2. If demand exceeds low-fire, the damper motor is energized through a high-fire operating control (aquastat, airstat, pressuretrol, or outdoor thermostat). As the damper motor approaches a wide open position, the auxiliary end switch energizes the high-fire valve and the full fire with open air, burns clean with high CO_2 and high efficiency.
3. As the high-fire input begins to exceed the demand of the high-fire operator, the operating control opens to de-energize the damper motor. As the damper motor returns the air shutter to low-fire the auxiliary end switch in the damper motor opens and de-energizes the high-fire valve.

TYPICAL FLANGE APPLICATION



DIMENSIONS – MODELS 1050FFD & 1150FFD

MODEL NO.	A	B	C	D_1	D_2	D_3	D_6	T	L
1050 FFD	1⅝	4-8	11½-7½	5¼	8⅝	11	9	10	31¼
1150 FFD	2⅛	4-8	11⅞-7⅞	6¼	9⅞	12	10¼	11	32



4. If the demand exceeds low-fire, the high-fire operating control would again call for more heat as in Step 2 and then followed by Step 3.
5. If, after returning to low-fire, the load should drop to below the low-fire output, the operating limit would shut off the burner completely.

Both models are completely pre-wired and fire-tested at the factory. Photocells are factory-mounted in air tube. Self-checking ultraviolet detectors, miniature UV and lead sulphide detectors are assembled to the factory-located nipple on the burner-mounting flange.

UNPACKING

Remove form-in place top which will expose assembled burner and pedestal carton. Note that primary control is mounted to burner. Carefully lift entire burner from carton. BE CAREFUL NOT TO BEND OIL LINES AND DO NOT PULL WIRING HARNESS WHEN LIFTING BURNER.

ASSEMBLE PEDESTAL (when used)

1. Carefully tip burner back on housing to expose pedestal mounting hole.
2. Fasten pedestal to mounting block. The pedestal height is adjustable from 10¾" minimum to 13½" maximum to centerline of air tube.
3. Tighten at desired height.

INSTALLING THE BURNER

Before installing, check the following items:

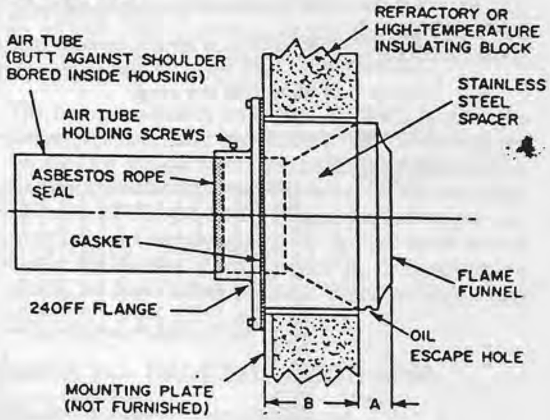
1. The combustion space can be larger, but not smaller than indicated by the dimensions in Table 3, page 4. An exception is as follows: When a refractory chamber is used, the length can be reduced by 10 percent, only if necessary.
2. The mounting plate opening and tappings must be according to the dimensions shown above. (See Typical Flange Application.)
3. The diameter of the opening in the refractory or front insulating block should equal the diameter of the opening in the mounting plate.
4. Dimension "B," the length of the stainless steel spacer, should be approximately equal to the distance from the outside of the front plate to the inside of the insulation or refractory. See Fig. 1. When the above requirements are met, proceed as follows:

a. Insert end of burner into opening and fasten flange to mounting plate using four ⅜-16 × ¾ cap screws provided.

b. The burner mounting flange is designed to support the burner by itself. The pedestal is furnished for ease of installation and service where the burner is close to the floor, also for additional support when the mounting plate is not sufficiently strong. For the latter purpose, blocks or bricks may be used, or a steel shelf or the like may be fabricated and fastened to the boiler front or to the floor to support the pedestal.

c. Make sure burner is approximately level or, if deliberately pitched down for a low crown sheet, that the angle is correct.

FIGURE 1



OIL SUPPLY PIPING

GENERAL: In systems where the bottom of the tank is higher than, or about equal to, the level of the fuel unit, a one-pipe system may be used. In systems requiring lift, a two-pipe installation is required. It is essential that all air leaks be eliminated before starting the burner. Overhead systems should be avoided. In no case should the top of the tank be more than 12 feet above the fuel unit. Flexible copper tubing with flared end-fittings is strongly recommended.

If a system is being converted from heavy oil, the oil storage tank must be clean. Install properly sized copper oil lines all the way to the tank if possible. If not, replace as much of the old piping as possible with copper lines. Also replace old filters and fire-protective valves with new ones properly sized.

VALVES AND FILTERS: Domestic-type fire-protective valves, check valves, and oil filters are too small and too restrictive for the 40 gph pumping rate of the fuel unit. Use fittings which are equal or greater in size than the oil line on both suction and return.

OIL LINE SIZES: Table I shows the OD of the copper tubing recommended, depending upon the lift and the length of run.

TABLE 1 — OIL LINE SIZING GUIDE (Copper Tubing)

LIFT, FEET	MAXIMUM LENGTH OF RUN, FEET (Both Suction and Return) ½ OD	⅝ OD
0	81	100
2	73	100
4	64	100
6	56	100
8	48	100
10	40	100
12	32	90
14	24	67
15	20	56

NOTES:

1. If lift exceeds 15 feet or if the length of run exceeds the above, use a booster pump and system.
2. Sizes shown apply to both suction and return line for a two-pipe system for one burner only.
3. For a multiple burner installation, use a separate suction line for each burner. If a common return is used, it must be increased by one size for each additional burner.
4. For one-pipe (gravity or no-lift) installations, use ½-inch OD tubing for runs up to 94 feet long, and ⅝-inch OD for runs of 95 to 150 feet long.

FIGURE 2

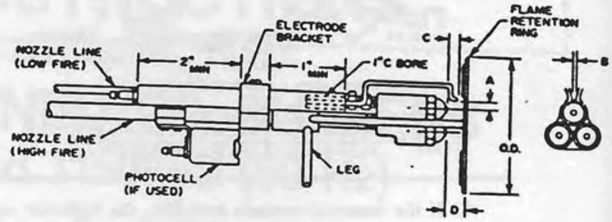
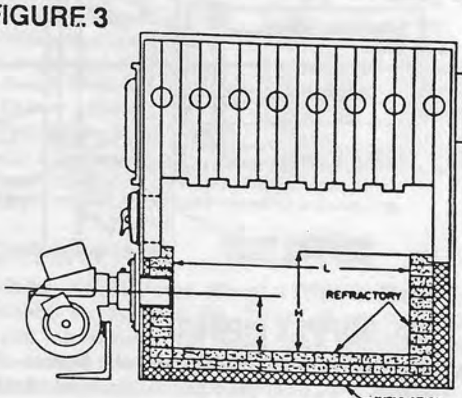


TABLE 2 — ELECTRODE AND FLAME RETENTION RING SETTINGS (Inches)

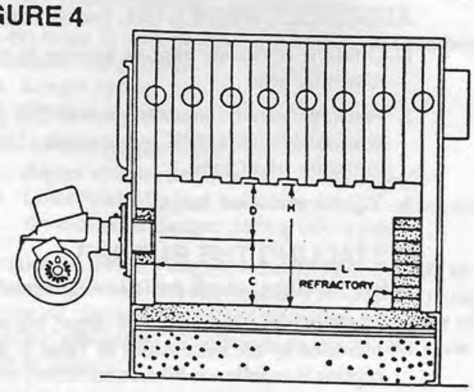
MODEL	A Bottom of electrode wires to center of top nozzle	B Spark gap	C Electrode tips to face of nozzles	D Face of nozzles to outside rim of retention ring	O.D.
1050FFD	5/16-3/8	⅛	¼	⅝	3 11/16
1150FFD	5/16-3/8	⅛	¼	⅝	4¼

FIGURE 3



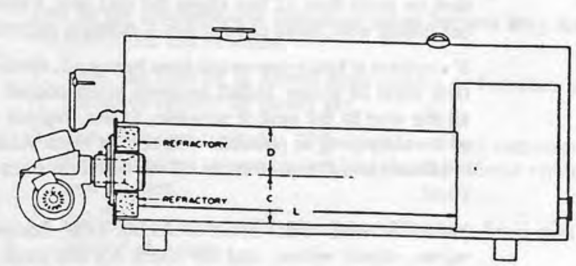
Brick combustion chamber, side view.

FIGURE 4



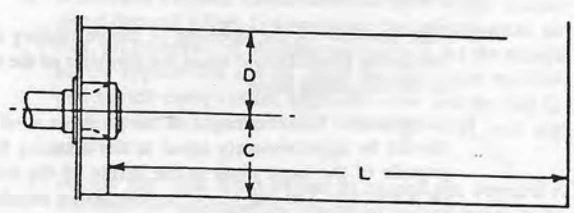
Wet leg boiler. No combustion chamber, side view.

FIGURE 5



Scotch Marine boiler. No combustion chamber.

FIGURE 6



An increase in dimension "D" over those listed in Table 3 is preferred for better heat distribution. (Does not apply to Scotch Marine boiler, Fig. 5.)

TABLE 3 — MINIMUM INSIDE DIMENSIONS FOR COMBUSTION SPACE

FIRING RATE (3 Nozzles Firing) GPH	C	D	L*	Width or Diam.
15.00	10	10	44	20
16.00	10.5	10.5	46	21
17.00	10.5	10.5	48	21
18.00	11	11	50	22
19.00	11	11	52	22
20.00	11	11	54	22
21.00	11	11	56	22
22.00	11.5	11.5	57	23
23.00	11.5	11.5	59	23
24.00	11.5	11.5	60	23
25.00	11.5	11.5	62	23
26.00	12	12	63	24
27.00	12	12	65	24
28.00	12	12	66	24
29.00	12	12	68	24
30.00	12.5	12.5	69	25
31.00	12.5	12.5	71	25
32.00	12.5	12.5	73	25
33.00	12.5	12.5	74	25
34.00	13	13	76	26
35.00	13	13	77	26

* If refractory chamber or target wall is used, these lengths may be reduced by 10 percent if necessary.

Note: Refractory chambers with abnormally high walls are not recommended. As a general guide, the height of the walls should not exceed the inside width of the chamber. Side walls of refractory combustion chamber need only be high enough to protect the base and about 3 inches of the mud leg of the boiler.

ELECTRICAL WIRING

1. Bring the 110–120V power supply to the control circuit through a fused disconnect switch as shown in the diagram shipped with the burner.
2. Wire the burner motor power supply through a fused disconnect switch. Refer to the diagram shipped with the burner. For single-phase motors, wire the power supply to the L1 and L2 terminals of the motor contactor. For three-phase motors, wire two (2) legs to L1 and L2. Wire the third leg directly to the motor lead that is in the motor contactor enclosure. This third leg is shipped from the factory, tagged, and capped with instructions.
3. Refer to the specification table on page 1 for motor current ratings.

Be sure that the supply voltage corresponds to the voltage as labeled on the top of the motor contactor, because the motor winding connections are installed at the factory for that voltage.

LIGHT-OFF AND ADJUSTMENT

1. The following equipment is needed to make the necessary tests for a proper adjustment and safety check:
   a. Smoke tester (Shell scale).
   b. CO_2 tester (0–20%).
   c. Draft gauge.
   d. Stack thermometer.
   e. Microammeter.
   f. Voltmeter and ammeter.
   g. Oil pressure gauge (0–200 PSI).
   h. Oil vacuum gauge (0–30 inches Hg).
2. Check the following before light-off is attempted:
   a. Boiler water level (or pressure for water boiler).
   b. Feed water valves and oil valves open.
   c. Primary control relays are free and safety switch is not locked out on safety.
   d. Limits and operating controls are set properly. Note: The operating limit No. 1 should be set a little higher than No. 2. The high limit should be set higher than both Nos. 1 and 2.
   e. Turn the burner service switch "off."
   f. Turn the low-fire switch "off" (down). This will prevent high-fire operation during low-fire adjustment.
   g. Close the main disconnect switches (both the control circuit and motor circuit).
   h. Check the motor rotation. Turn the service switch on and off briefly. The top of the fan should rotate toward the air tube. If it does not, interchange connections at T1 and T2 of the motor contactor.
   i. Open the bleed port on the fuel unit and run the motor to purge the air from the oil system. When the oil flows clear, close the bleed port. The burner should now be ready to start.

NOTE: WHEN STARTING THIS BURNER THE FIRST TIME OR AFTER CHANGING NOZZLES THE FLAME MAY GO OUT DURING THE SWING FROM LOW TO HIGH. BE READY TO SHUT THE BURNER DOWN JUST AFTER THE FLAME GOES OUT. REPEAT THIS UNTIL THE AIR IS PURGED OUT OF THE HIGH-FIRE OIL LINE.

3. The linkage assembly on Model 1150FFD is set at the factory for maximum high-fire air. The connecting rod between the damper motor arm and the high-fire air shutter should not be adjusted. However, for the low range of the 1150FFD (20.00–25.00 gph) the swivel joint position must be adjusted along the damper motor arm to reduce the amount of the high-fire air. This adjustment should be done before light-off. Refer to Table 4 and Fig. 7.

FIGURE 7— DAMPER MOTOR ARM

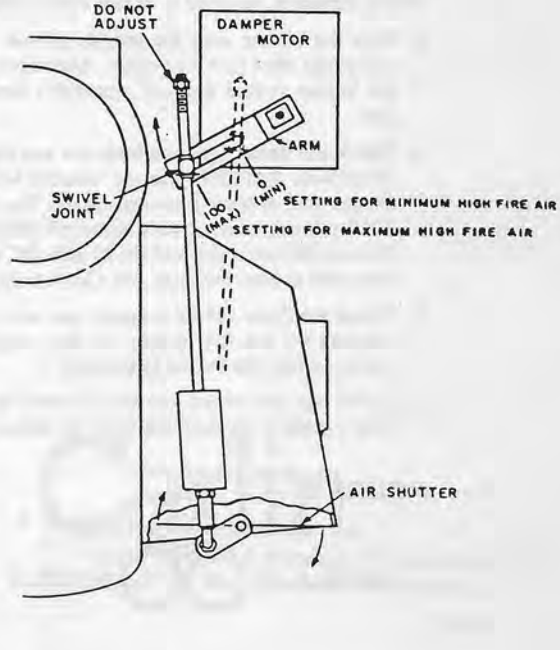


TABLE 4 — 1150FFD DAMPER MOTOR ARM SETTINGS (SEE FIG. 7)

FIRING RATE GPH	APPROX. SETTING ON ARM
20	20
21	25
22	30
23	35
24	45
25–35	100(MAX)

DO NOT ALTER ANY OF THE LINKAGE ASSEMBLY ON MODEL 1050FFD. It is preset at the factory with the damper motor arm set for maximum air for the entire firing range of the burner regardless of the nozzle sizes.

4. Set the head assembly and low-fire air shutter according to Tables 5 or 6. Start the burner with the low-fire switch OFF (switch down).

5. Switch to high-fire by turning the low-fire switch to "on" (up). If the high-fire lacks air, adjust the combustion head until the fire burns clean and sharp. Turning the combustion heard adjusting screw clockwise will give more air, counterclockwise, less air. DO NOT ALTER THE LOW-FIRE (TOP) SHUTTER FOR THE HIGH-FIRE COMBUSTION AIR.

6. When the high-fire looks clear and sharp, turn the burner to low-fire and readjust the air if necessary. Switch from low to high and back several times. Adjust until both fires look good and clean.

7. Check draft, smoke number, CO_2 and stack temperature. Typical readings are as follows for natural draft:

Fire	Draft	Smoke	CO_2
Low-fire	(higher)	Trace	11–13%
High-fire	.03/.05 W.C.	Zero	12–14%

Adjust burner as required to obtain these readings.

8. Stop the burner with the service switch. Wait for the postpurge, then turn it on again. After a prepurge period, the burner should light-off smoothly; then go to high-fire.

9. Check the flame signal on both low and high-fire. The Honeywell R4140M primary control with photocell should read at least 2 microamperes. The Fireye D30-5010 primary control with photocell should read near 20 volts DC normally, and 16–20 volts DC at saturation. For other control readings, see Carlin wiring diagrams.

10. Check the flame failure response and safety lockout by shutting off the fuel supply (or de-energizing the oil valves) while the burner is running.

11. Check the low water cut-off (if used) by depressing float switch or by draining water to reduce the level.

FIGURE 8

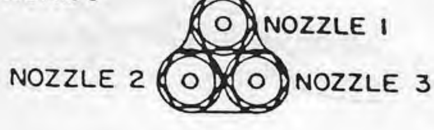


TABLE 5 — NOZZLE GUIDE AND AIR SETTINGS FOR MODEL 1050FFD

Firing Rate, GPH	Nozzles: Low Fire 1*	Nozzles: High Fire 2	Nozzles: High Fire 3	Head Setting	Low Fire Air Shutter Opening
15.00	9.00	3.00	3.00	1/16	1
16.00	9.00	3.50	3.50	3/16	7/8
17.00	9.00	4.00	4.00	5/16	3/4
18.00	9.00	4.50	4.50	7/16	11/16
19.00	9.00	5.00	5.00	9/16	5/8
20.00	9.00	5.50	5.50	11/16	9/16
21.00	9.00	6.00	6.00	13/16	1/2
22.00	9.00	6.50	6.50	1	7/16
23.00	9.00	7.00	7.00	1 1/4	3/8
24.00	9.00	7.50	7.50	1 1/4	3/8
25.00	9.00	8.00	8.00	1 1/4	3/8

USE 45° SS NOZZLES

* Note: Nozzle No. 1 may be increased to 10.00, 11.00, or 12.00 gph. If this is done, Nozzles No. 2 and 3 must be decreased so that the same total firing rate is maintained.

DO NOT DECREASE Nozzle No. 1 below 9.00 gph.

TABLE 6 — NOZZLE GUIDE AND AIR SETTINGS FOR MODEL 1150FFD

Firing Rate, GPH	Nozzles: Low Fire 1**	Nozzles: High Fire 2	Nozzles: High Fire 3	Head Setting	Low Fire Air Shutter Opening
20.00	12.00	4.00	4.00	0	5/8
21.00	12.00	4.50	4.50	0	5/8
22.00	12.00	5.00	5.00	0	5/8
23.00	12.00	5.50	5.50	0	5/8
24.00	12.00	6.00	6.00	0	5/8
25.00	12.00	6.50	6.50	0	5/8
26.00	12.00	7.00	7.00	1/8	5/8
27.00	12.00	7.50	7.50	1/4	5/8
28.00	12.00	8.00	8.00	7/16	9/16
29.00	12.00	8.50	8.50	9/16	1/2
30.00	12.00	9.00	9.00	11/16	7/16
31.00	12.00	10.00	9.00	13/16	3/8
32.00	12.00	10.00	10.00	1	5/16
33.00	12.00	11.00	10.00	1 1/4	1/8
34.00	12.00	11.00	11.00	1 1/4	1/8
35.00	12.00	12.00	11.00	1 1/4	1/8

USE 45° SS NOZZLES

** Note: Nozzle No. 1 may be increased to 13.0C, 14.00, or 15.00 gph. If this is done, Nozzles No. 2 and 3 must be decreased so that the same total firing rate is maintained.

DO NOT DECREASE Nozzle No. 1 below 12.00 gph.

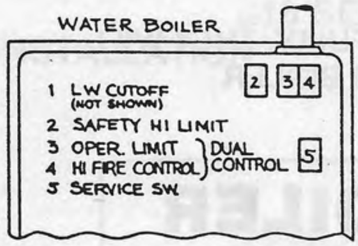
WIRING FOR LOW-HIGH-LOW STEP-MODULATION

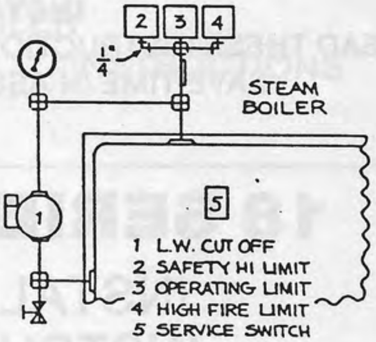
In order to take full advantage of the energy savings potential of these burners they should be wired to operate with low-high-low cycles. Hence the firing cycle would be much longer by going from low to high to low once or several times before shutting off.

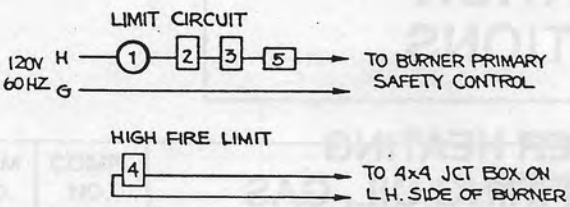
In the following illustrations are two examples: 1. Water Boiler. 2. Steam Boiler. In each case we have a limit circuit which starts and stops the burner and a high-fire control which brings the high-fire on and off.

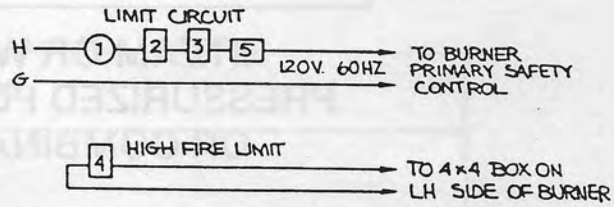
Also, pre-wired and built into the burner is a manual high-fire switch which enables the installer or operator to hold the burner on low-fire if so desired.

Refer to the appropriate example for your installation.









Example: Water Boiler Operating Range 170°–190°F
2. Set Safety Hi Limit: Cut in 200-Cut out 210
3. Set Operating Limit: Cut in 180-Cut out 190
4. Set Hi Fire Control: Cut in 170-Cut out 180

Operation:

1. Call for heat; cold start. Burner starts on low and goes to high-fire.
2. When the temperature rises to 180°F the burner goes to low-fire.
3. If temperature drops to 170°F burner returns to high-fire.
4. If temperature rises to 190°F burner shuts off.

NOTE: Since the calibrations on the limit controls are seldom exact, it will be necessary to readjust the settings during operation.

Example: Steam Boiler Operating Range 3 to 6 PSI
2. Set Safety Hi Limit: Cut in 8 PSI-Cut out 10 PSI
3. Set Operating Limit: Cut in 5 PSI-Cut out 6 PSI
4. Set Hi Fire Control: Cut in 3 PSI-Cut out 4 PSI

Operation:

1. Call for heat; cold start. Burner starts on low and goes to high-fire.
2. When pressure rises to 4 PSI the burner goes to low-fire.
3. If pressure drops to 3 PSI burner returns to high-fire.
4. If pressure rises to 6 PSI burner shuts off.

NOTE: Since the calibrations on the limit controls are seldom exact, it will be necessary to readjust the settings during operation.

Carlin

The Carlin Company, Windsor, Connecticut 06095
A subsidiary of Ford Products Corporation

Form No. IO-193(5M) Rev. 9/86

Printed in U.S.A.

INSTALLER

READ THESE INSTRUCTIONS CAREFULLY. THEY WILL SAVE TIME IN ASSEMBLING BOILER

18 SERIES BOILER

INSTALLATION INSTRUCTIONS

STEAM OR WATER HEATING
PRESSURIZED FOR FIRING OIL, GAS OR COMBINATION GAS/OIL

DESIGNED AND TESTED ACCORDING TO THE A.S.M.E. BOILER AND PRESSURE VESSEL CODE, SECTION IV FOR MAXIMUM ALLOWABLE WORKING PRESSURE.
STEAM - 15 PSIG, WATER - 80 PSIG

CAUTION

DO NOT USE AUTOMOTIVE ANTI-FREEZE IN BOILER WATERWAYS. IF NECESSARY TO USE ANTI-FREEZE, BE SURE TO EMPLOY A PREPARATION DESIGNED FOR HYDRONIC HEATING SYSTEMS AND OF ETHYLENE OR PROPYLENE GLYCOL BASE *WITHOUT* CORROSION INHIBITORS FOR PROTECTION OF ALUMINUM.

HBSmith
CAST IRON BOILERS
Warming America since 1853
WESTFIELD, MASSACHUSETTS 01086

THESE INSTRUCTIONS TO BE LEFT WITH THE BOILER FOR REFERENCE PURPOSES

18 SERIES BOILER
INSTALLATION INSTRUCTIONS

ITEM NO.	COMP. NO.	DESCRIPTION
1	3562	FRONT SECTION
2	3563	INTERMEDIATE SECTION, PLAIN
3	3585	INTERMEDIATE SECTION, HEATER (OPTIONAL--NOT SHOWN)
4	3564	BACK SECTION
5	----	SMOKEHOOD (7", 8", 9" OR 10")
6	3567	SLIDE DAMPER
7	----	TANKLESS HEATER (AS ORDERED)
8	3572	HEATER COVER PLATE, BLANK
9	60333	HEATER COVER PLATE GASKET
10	3569	FRONT UPPER PORT COVER PLATE, BLANK----STANDARD - STEAM
11	3571	FRONT UPPER PORT COVER PLATE, 3" TAP----STANDARD - WATER
12	3584	BACK UPPER PORT COVER PLATE, BLANK----STANDARD - STEAM & WATER
13	3570	BACK UPPER PORT COVER PLATE, 4" TAP----OPTIONAL - WATER
14	3546	CLEANOUT COVER PLATE W/CARRAIGE BOLTS AND WING NUTS
15	3565	BURNER MOUNTING PLATE, CARLIN--6⅛" OPENING
16	3566	BURNER MOUNTING PLATE, POWERFLAME--7¾" OPENING
17	60023	BURNER MOUNTING PLATE ROPE, ¼"
18	60434	BURNER MOUNTING PLATE INSULATING BLOCK
19	60331	UPPER PORT HYDRONIC SEAL
20	60332	LOWER PORT HYDRONIC SEAL
21	60025	INSULATING CERAMIC ROPE
22	----	TIE ROD & HARDWARE
23	----	FRONT OBSERVATION PORT ASSEMBLY
24	70614	REAR OBSERVATION PORT ASSEMBLY

HB Smith
18 Series Boiler

TABLE OF CONTENTS

18 SERIES BOILER INSTALLATION INSTRUCTIONS

1. GENERAL

18 Series boilers are wet-base, extended surface, vertical flue design with integral cast flue gas collector for pressurized firing with oil, gas or combination power burners. Upper and lower port hydronic seals are of a special material resistant to petroleum products and compatible with ethylene and propylene based anti-freeze (non-automotive type) which *does not* contain corrosion inhibitors to protect aluminum. The flue gas joints between sections, etc. are sealed using high temperature (2300° F) ceramic fiber rope. Access to the heating surface for cleaning is provided from the left hand side of the boiler through large cast iron cover plates. A slide damper is provided in the flue gas outlet for back pressure adjustment.

The boilers are supplied completely knocked down for field assembly, as factory assembled blocks of sections or completely assembled boiler-burner units. All items should be inspected for damage upon receipt, and any damage reported to the wholesaler and trucker. All components should be stored in a clean, dry area.

The boilers are conservatively rated for high efficiency performance with capability for down-firing to match connected load. The large OBROUND upper port provides transfer area above the water surface for dry steaming at full load.

2. BOILER LOCATION

The boiler must be installed on a smooth, level, non-combustible floor or pad as close to the chimney or vent location as possible to minimize breeching length. Allow clearance around the boiler for piping service, maintenance, cleaning and tankless coil removal. Approximately 30 inches on the sides is a minimum. (Check local code requirements)

Do not install electrical conductors in floor or pad under boilers.

See FIG. NO. 1 for boiler floor pad requirements, and TABLE NO. 1 for minimum required pad length.

Boiler No.	Min. Recommended Pad Length
18-*- 4	36"
18-*- 5	42"
18-*- 6	48"
18-*- 7	54"
18-*- 8	60"
18-*- 9	66"
18-*-10	72"
18-*-11	78"
18-*-12	84"

TABLE NO. 1

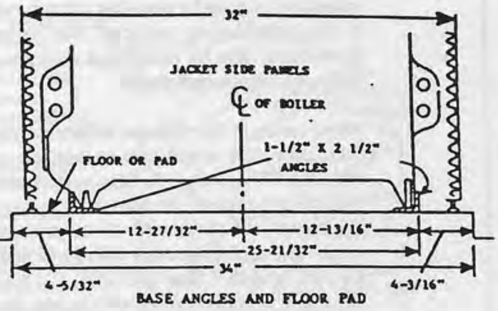


FIGURE NO. 1

3. CODES AND REGULATIONS

All work in connection with the boiler, burner and controls must be performed in strict accordance with requirements of state and local authorities having jurisdiction over boiler installations. In the absence of such local requirements the following should govern:

A.S.M.E. Section IV - "Heating Boilers"
A.S.M.E. Section VI - "Care and Operation of Boilers"
ANSI/NFPA 31 - "Installation of Oil Burning Equipment"
ANSI/Z223.1 - "National Fuel Gas Code"
ANSI/NFPA 70 - "National Electrical Code"

4. CHIMNEY AND BREECHING

The breeching connection between boiler and chimney should be as direct as possible with the minimum number of elbows or bends. It should pitch upwards to the chimney at a rate of ¼ inch per foot of horizontal run. Generally, the breeching and chimney should be the same diameter as the boiler outlet connection.

For fuel conservation and stable burner performance, the vent connection from the boiler should not include a barometric draft control or other opening unless the venting system can develop an excessive draft, or is required by code.

5. COMBUSTION AND VENTILATION AIR

An adequate supply of air for the boiler room must be provided to allow complete combustion of fuel and ventilation of the room to avoid excessively high ambient temperature. Air inlet by natural ventilation directly from the outside shall have total free area of not less than one sq. in. per 14,000 BTU per hour of input of all fuel burning appliances in the boiler room.

Where combustion air must be obtained through ducts, see ANSI/NFPA 31 or ANSI Z223.1 for requirements.

If mechanical combustion air supply is required, the system must be approved by the local authorities, and should provide at least 30 CFM per gallon of oil and 0.25 CFM per MBH of gas input to the boilers.

Ventilation air, if required, must be in addition to the combustion air quantities called for above.

18 SERIES BOILER INSTALLATION INSTRUCTIONS

6. ASSEMBLY OF SECTIONS

When boilers are delivered to the job site, each item should be inspected closely for possible shipping damage. Scars or nicks in the port sealing surfaces may allow leakage. Notify the trucker and sign for equipment as damaged or refuse to accept delivery of damaged goods.

When ready to commence assembly, recommended on a level pad, place the angle rails in position parallel with each other with the 2" legs on the floor and measuring 25-21/32 inches outside dimension. Be sure to align the center of the boiler with the center line of the pad. If no pad provided, shim and grout under the angles to make then level and provide support along the full length. See FIGURE 1. Clean hydronic gasket recesses and rope groove with a wire brush, taking care not to damage machine surface.

See TABLE 2 for proper alignment of sections.

TABLE 2

4 SECT	F	P	P	B								
5 SECT	F	P	H	P	B							
6 SECT	F	P	P	H	P	B						
7 SECT	F	P	P	P	H	P	B					
8 SECT	F	P	P	P	P	H	P	B				
9 SECT	F	P	P	P	P	P	H	P	B			
10 SECT	F	P	P	P	P	H	P	H	P	B		
11 SECT	F	P	P	P	P	P	H	P	H	P	B	
12 SECT	F	P	P	P	P	P	P	H	P	H	P	B

F=Front Section
P=Plain intermediate section
H=Heater intermediate section-Optional, must be ordered.
B=Back Section

CAUTION

Due to the fact that the sections are top heavy, it is absolutely necessary that the back section be supported in such a manner as to prevent its falling and causing potential serious bodily injury while preparing to add the next section. One such way would be to insert a piece of 3" x 36" piping in the lower port.

Stand the back section in place with the feet on and in the angle iron rails. Support the section as required to prevent it from falling forward or rearward. Insert the ceramic fiber rope in the groove around the outer part of the section using adhesive to hold it in place during the positioning of the next section. (SEE FIGURE 2) Place the upper and lower hydronic seals in the recessed in the section at the ports. Slide the next section carefully up to the back section taking care not to dislodge the ceramic rope or the hydronic seals. Inspect the alignment of the sections through the open ports and, if properly aligned, install the draw rods with nuts drawn hand-tight. (SEE FIGURE 3) Plumb the sections before applying torque to the upper right and lower left draw rods. Maintain finger-tight torque on upper left and lower right draw rods.

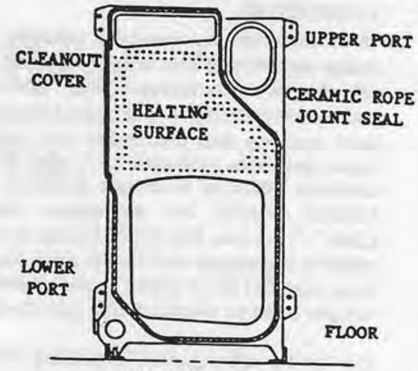


FIGURE 2

IMPORTANT

The upper and lower ports should be drawn up metal to metal around the outside of the hydronic seal. It is not necessary to be metal to metal at the bottom pad or at the top of the cleanout opening. Avoid excessive torque on upper left and lower right draw rods, which may warp the section. See FIGURE 3 for correct alignment of the seal.

Assemble additional sections as described above.

After draw rods are hand tight, torque as shown in TABLE 3.

TABLE 3

STEP 1	UPPER RIGHT	5 FT. LBS.
STEP 2	LOWER LEFT	5 FT. LBS.
STEP 3	UPPER LEFT	5 FT. LBS.
STEP 4	LOWER RIGHT	5 FT. LBS.
STEP 5	UPPER RIGHT	25 FT. LBS.
STEP 6	LOWER LEFT	25 FT. LBS.
STEP 7	UPPER RIGHT	50 FT. LBS.
STEP 8	LOWER LEFT	50 FT. LBS.
STEP 9	UPPER LEFT	10 FT. LBS.
STEP 10	LOWER RIGHT	10 FT. LBS.

Prepare additional intermediate sections and install in the same manner described above. Be sure each section is properly sealed against water leakage and flue gas exfiltration. Be certain the angle rails remain level and provide support for each section as it is assembled. Check each section for vertical position.

When all sections, including the front section or back are in place, check all draw rods to insure iron-to-iron contact at ports. *DO NOT APPLY EXCESSIVE TORQUE.* See TABLE 3 for recommended torques.

Install upper port cover plates on front and rear sections, using hydronic seals, studs and nuts. Refer to exploded view on page 3, Item Nos. 10-13 & 19.

18 SERIES BOILER INSTALLATION INSTRUCTIONS

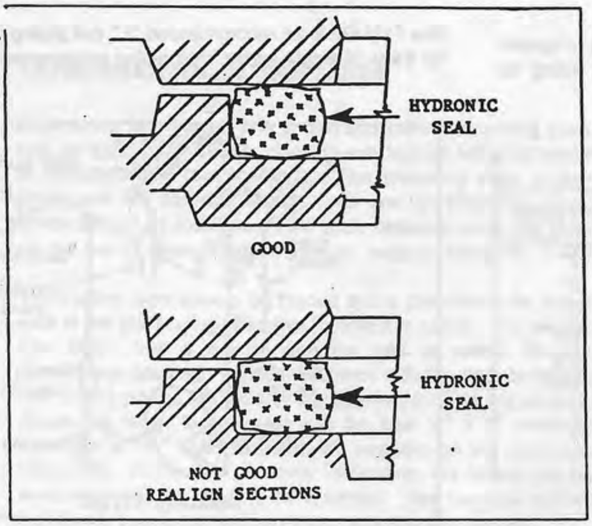


FIGURE 3

7. HYDROSTATIC TEST

Plug tappings, fill boiler with water and vent air from top of boiler. Apply pressure not to exceed 1½ times the maximum boiler working pressure marked on the sections. Check for leaks. Leakage at seals may be due to misalignment of hydronic seals. Loosen draw rods, reposition seals and retest as above.

Excessive torque on draw rods may damage castings. Do not exceed the torque shown in TABLE 3.

In a cold environment, hydronic seals may not quickly conform to sealing surfaces when properly compressed. Under such conditions, hydrostatic testing with cold water might show weeping or leaking at the seals. To avoid this possibility, delay filling the boiler with cold water for a few hours after assembly, or use warm water, if available, for the tests.

If there is seepage about chapelets or minor leakage, consult the H. B. Smith Company representative for advice regarding A.S.M.E. Code approved repairs by peening or plugging.

8. STEAM PIPING

A steam piping schedule is shown in TABLE 4. Pitch piping to allow condensate to flow in the same direction as steam. Makeup water connections must be made to the return piping, not directly to the boiler. Install blow-down valves as required.

See FIGURE 4 for recommended acceptable steam piping arrangement.

TABLE 4

BOILER SIZE	NO. OF 3" RISERS	HEADER	EQUALIZER
4 THRU 6 SECTION	1	3"	1½"
7 THRU 12 SECTION	2	4"	2"

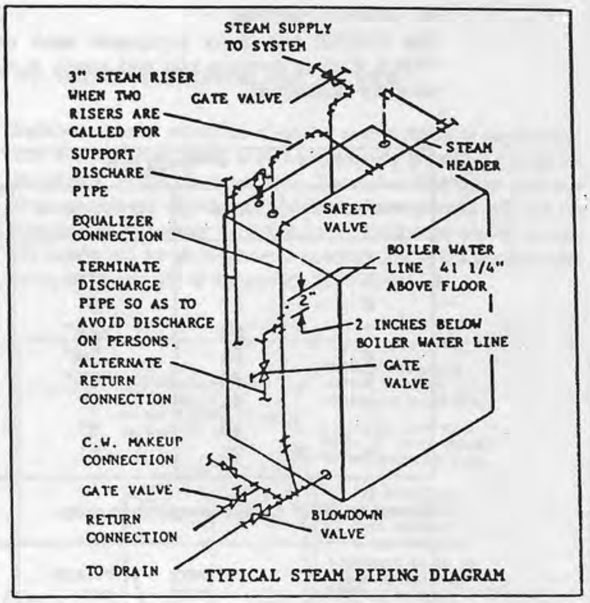


FIGURE 4

TABLE 5

NUMBER OF SECTIONS	EVAPORATION RATE GPM	WATER 1" BELOW WATER LEVEL GAL	MIN. FEED WATER PUMP RATE-GPM	CONDENSATE RECIEVER CAP.-GAL
4	.59	1.9	1.18	11
5	.76	2.4	1.52	15
6	.94	2.9	1.88	18
7	1.10	3.3	2.20	20
8	1.28	3.8	2.56	24
9	1.45	4.3	2.90	27
10	1.62	4.8	3.24	30
11	1.78	5.2	3.56	34
12	1.96	5.7	3.92	37

Feed water makeup requirements.

NOTE

These recommendations are considered normal for compact buildings on the basis of 80% receiver use. Where buildings are spread out, additional receiver capacity may be necessary because of the extended time required for condensation to return to the receiver.

18 SERIES BOILER INSTALLATION INSTRUCTIONS

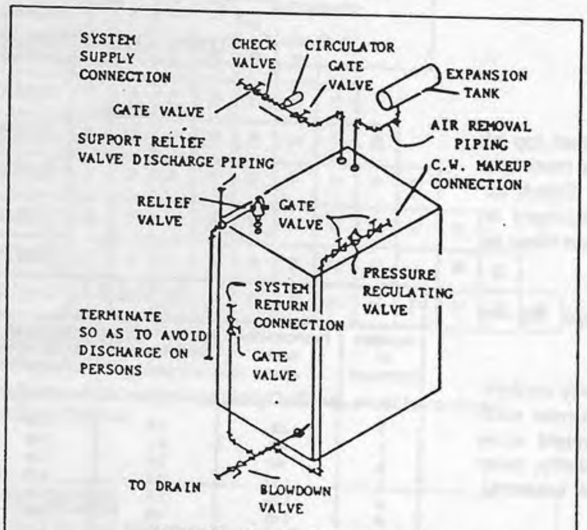
9. WATER PIPING

See FIGURE NO. 5 for acceptable water piping diagram. TABLE 6 gives pumping rate and supply & return sizing for standard installations.

TABLE 6

BOILER SIZE	GPM	RETURN CONN.	SUPPLY CONN.
4	30	2"	2"
5	38	2"	2"
6	47	2"	2"
7	56	2½"	2½"
8	64	2½"	2½"
9	73	2½"	2½"
10	81	3"	3"
11	90	3"	3"
12	98	3"	3"

Based on 20° F system temperature drop.



TYPICAL WATER PIPING DIAGRAM

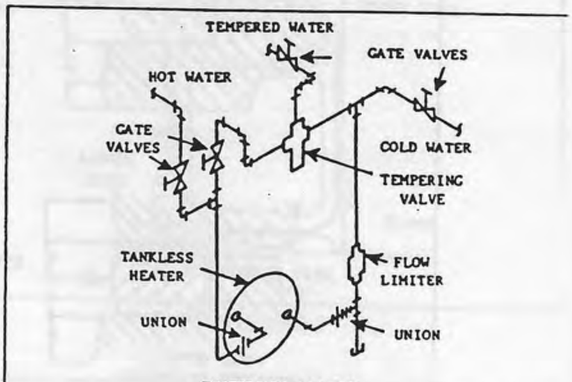
FIGURE 5

10. TANKLESS HEATERS

Heater openings are provided for below-the-water-line tankless heater coils in all back sections and in special intermediate scetions when ordered. See TABLE 2 for the correct placement of these heater sections. For water boiler applications the rear upperport cover plate can be furnished with an optional 4" tap in order to accommodate a type "L" screw in tankless heater. Install the low limit temperature control in the ¾" tap located in the center of the coil.

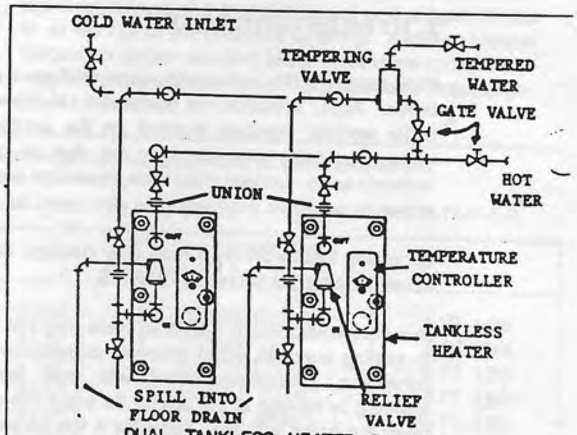
If heater sections are installed in an order other than in TABLE 2 the jacket panels will not match.

See FIGURE 6 for recommended "L" coil piping and FIGUR for SM9-18 single and/or dual piping arrangements.



TANKLESS PIPING

FIGURE 6



DUAL TANKLESS HEATER PIPING

FIGURE 7

11. SMOKEHOOD

Install smokehood with the correct size smokepipe connectin collar using the 5/16" x 1½" studs and hex nuts furnished i screw seats in the back section. Apply a thin, even layer of fur nace cement on the raised surface of the back section to pro vide a tight joint at the boiler. Fasten the slide damper in th open position for starting the burner adjustment process.

18 SERIES BOILER INSTALLATION INSTRUCTIONS

12. BURNER MOUNTING PLATE

Each boiler is provided with a cast iron burner mounting plate with an appropriate burner opening and tapped holes for studs to accommodate burner flange. The mounting plate is furished with ¼" diameter sealing rope and an insulation block which should be installed on the plate before placing the plate on the boiler. (See exploded view on page 2, items no.15-18)

The sealing rope should be placed in the groove on the boiler side of the plate using adhesive to hold it in place. The insulation block has a burner opening and a cutout for the observation opening. Locate the block with the high temperature facing on the fire side in the opening in the front section. Attach the block to the plate with the four ¼" x 5" machine screws and 1½" O.D. washers, the washers on the insulation block side. At the time of burner installation, the hole in the insulation block may have to be enlarged. See separate burner installation booklet for further assistance and dimensions.

13. CLEANOUT COVERS

Be sure the rope seals are in place around the groove in the cleanout cover plate. Install the plates on the boiler sections carefully to insure proper sealing all around, using the 5/16" x 2" carraige bolt and 5/16" wing nuts.

14. REAR OBSERVATION PORTS

Install 5/16" x 1½" studs in the three screw seats for the observation opening in the back section. Apply a thin layer of furnace cement on the observation port mounting flange and set the port assembly over the studs. Fasten with washers and nuts drawn tight to seal between the back section and the port assembly.

15. CONTROL LOCATIONS

NOTE
Jacket front panel should be in place before controls on front of front section are installed.

Refer to FIGURE 9 showing locations recommended for steam and water boiler limit and operating controls. Note the requirement for an operating temperature control whenever a tankless heater is called for. This is in addition to pressure limit controls and other operating controls on steam boilers.

NOTE
On steam boilers the 1" close nipple and 1" x ¼" reducing coupling for operating control should be installed prior to jacket top panels.

16. JACKET

Jacket assembly details are contained in a separate instruction booklet.

17. SAFETY AND RELIEF VALVES

Safety and relief valves sized on the output rating of each boiler size are furnished along with the necessary pipe and fittings for installation in the back section. The valve discharge connections should be piped to a location where people will not be exposed to hot vapor or liquid. Any discharge piping should be supported so as to prevent exerting any strain on the valve body by the weight of the piping. See FIGURE 8.

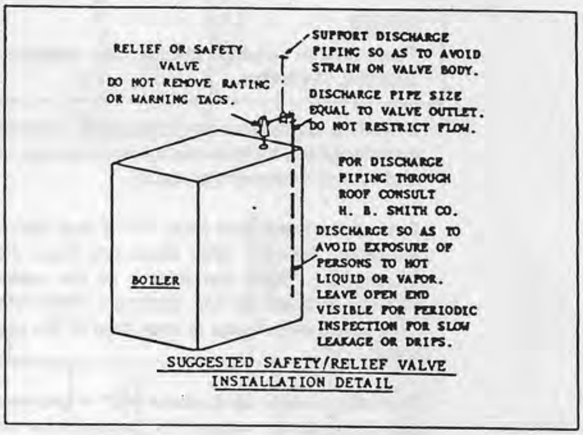


FIGURE 8

Some state and local codes require steam safety valves be piped to the atmosphere outside the building.

18. CLEANING BOILER WATERWAYS

A. STEAM BOILERS

NOTE
The boiler should be cleaned before connecting system piping and installing steam trim.

1. Plug unused openings all around the boiler leaving a valved overflow pipe connected to the safety valve tapping. Also provide a valved blow-down connection to one of the bottom tappings.

2. The fuel burning equipment should be installed and made ready to operate in accordance with the burner instructions.

3. Fill the boiler with water to the middle of the upper port, addng a boiler cleaning compound, as recommended in A.S.M.E. Section VI.

4. Fire the boiler for at least one hour at a low rate to circulate the cleaning compound through the boiler.

5. Blow off surface of boiler water through skimmer connection or through safety valve opening by feeding clean water into the boiler through a bottom fill connection.

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INSTALLATION INSTRUCTIONS

6. When the water coming off the surface runs clear, shut off the burner, close the top valves and open the bottom blow-down valve. If there is a slight steam pressure in the boiler, it will assist the blow-down.

7. When the sections have cooled after blow-down, flush the interior of the boiler from the top by introducing water from a hose through the top port. When the water runs clear, complete the system piping, install the steam trim and controls. Fill the boiler with clean water. Heat the boiler water to at least 180° F to release corrosive gases.

B. WATER BOILERS

> **NOTE**
> The system piping should be completed before cleaning the boiler.

1. Add an approved boiler compound. Follow the compound manufacturer's instructions for best results. Fill the system and vent air wherever necessary.

2. Heat the water to at least 180° F and circulate through all the piping system. After about one hour, drain the system thoroughly. Wash the interior of the boiler with a hose inserted through the top tapping. When blow-down water runs clean, allow boiler to cool, then fill the system with clean water.

3. Heat the water up to about 180° F and vent air as necessary to purge the system. The boiler is now ready to operate.

19. OWNERS INSTRUCTIONS

A. For best performance of the boiler, the following suggestions should be performed by a qualified boiler room technician, through a regular program of maintenance and adjustment to obtain the following.

1. Oil burner combustion: 12 to 12½+ % CO_2, zero smoke, smooth lightoff and operation.

Gas burner combustion: 10 to 10½ % CO_2, 0.02% CO, smooth lightoff and operation.

2. Keep boiler fireside surfaces clean. Flue gas temperature reading above 400° F over boiler room temperature signals the start of soot accumulation. Inspect at least twice each year.

3. Steam boiler water condition should be observed. Unstable water line, system steam hammer indicate dirty water. Blow-down is recommended. However, the introduction of excess raw water to a steam boiler can result in the deposit of scale and inefficient operation or physical damage to the boiler.

4. Float operated and probe type low water cutoff devices should be maintained according to the instructions of the the manufacturer.

5. Limit control function should be checked on a regular basis.

6. Flame safeguard controls should be checked regularly.

B. The products of combustion must be conducted to the outdoors by means of a metal connector of at least the same size as the boiler smokehood outlet and a chimney or stub-stack. The boiler is constructed for pressurized operation and the burners are selected for operation against a back pressure of 0.10 ins. w. c. at the boiler outlet. If the actual conditions cause a back pressure in excess of 0.10 ins. w. c. at the boiler outlet, consult the H. B. Smith Co. for verification of burner size. If the chimney has the ability to develop excess draft, a barometric draft control should be installed in the chimney. Check with the H. B. Smith representative for assistance.

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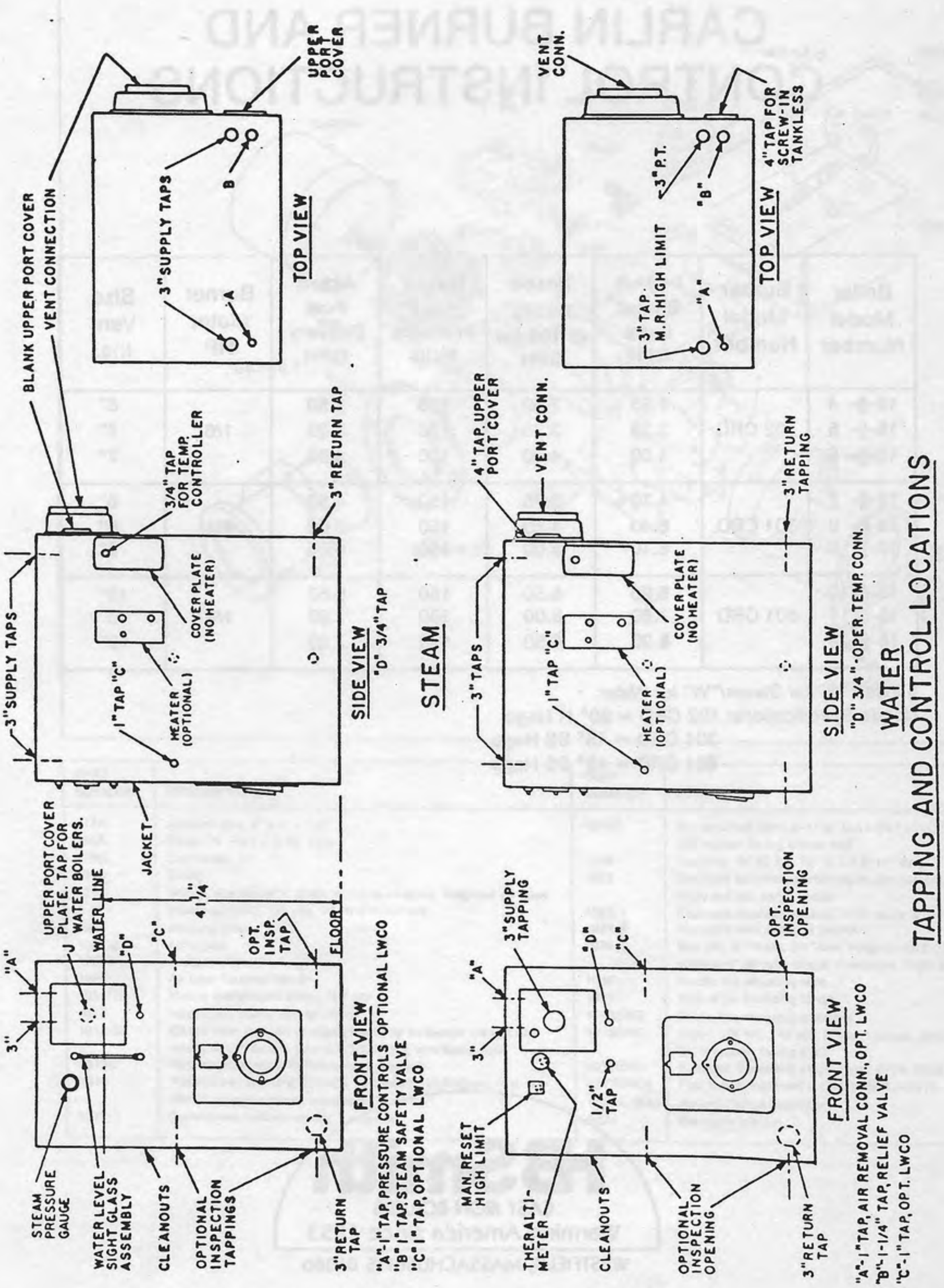
INSTALLATION INSTRUCTIONS



TAPPING AND CONTROL LOCATIONS

FIGURE 9

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CARLIN BURNER AND CONTROL INSTRUCTIONS

Boiler Model Number	Burner Model Number	I=B=R Burner Input GPH	Nozzle Rating @ 100 psi GPH	Nozzle Line Pressure PSIG	Actual Fuel Delivery GPH	Burner Motor HP	Size Vent Ins.
18-§- 4	102 CRD	2.55	2.50	100	2.50	1/6	6"
18-§- 5		3.25	3.25	100	3.25		7"
18-§- 6		4.00	4.00	100	4.00		7"
18-§- 7	301 CRD	4.70	3.75	150	4.50	1/4	8"
18-§- 8		5.40	4.50	150	5.00		8"
18-§- 9		6.10	5.00	150	6.00		9"
18-§-10	601 CRD	6.90	5.50	150	6.60	1/2	10"
18-§-11		7.60	6.00	150	7.20		10"
18-§-12		8.30	6.50	150	7.80		10"

§ Insert "S" for Steam/"W" for Water.

Nozzle Specifications: 102 CRD = 60° H Hago
301 CRD = 45° SS Hago
601 CRD = 45° SS Hago

HBSmith
CAST IRON BOILERS
Warming America since 1853
WESTFIELD, MASSACHUSETTS 01086

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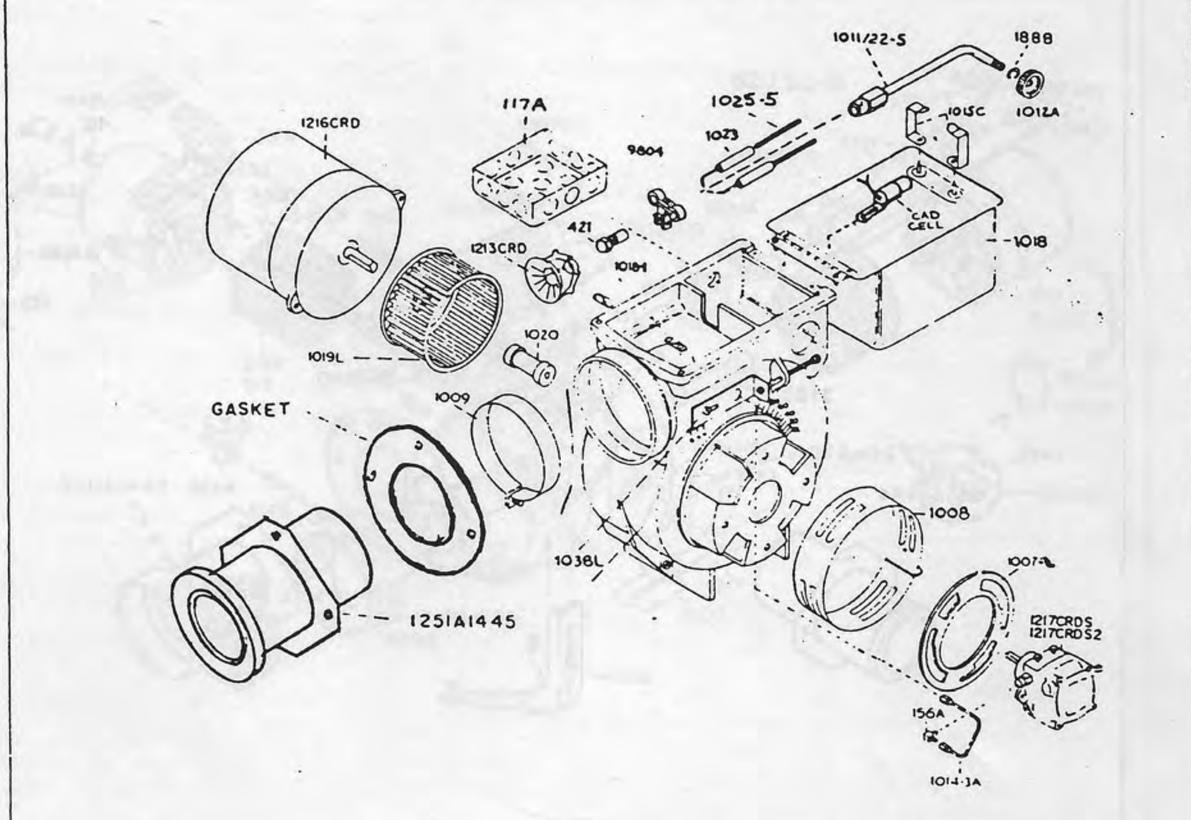
CARLIN BURNER AND CONTROL INSTRUCTIONS

CARLIN OIL BURNER PARTS LIST

Model 102 CRD—60 Hz, 3450 RPM



PART NUMBER	DESCRIPTION	PART NUMBER	DESCRIPTION
117A	Junction box, 4" x 4" x 1½"	1019D	Blower wheel (fan), 5-1/16" OD x 2¼" wide, 7/16" hub, ½" bore, CW rotation facing closed end
156A	Elbow, ⅛" NPT x 3/16" flare	1020	Coupling, ½" ID x 5/16" ID x 2-5/16" long
178B	Connector, ½"	1023	Electrode assembly consisting of part numbers 1023-1 and 1023-2. Right and left, same design
188B	E-ring	1023-1	Electrode insulator, glazed, 7/16" diam. x 3¼" long
421	Nozzle, specify GPH, angle and type of spray. Magnetic oil valve, instant-opening, 120 volt, 60 Hz (Peter Paul)	1023-2	Electrode wire with lock washer
1001	Housing only	1025-9	Bus bar, ⅛" brass, 6¾" long integral with #-32 hex locknut for nominal 9" air tube model, 2 required. Right and left, same design
1007-2	Air shutter	1038L	Nozzle line adjusting slide
1008	Air control band	1041	Gasket for mounting flange
1009	Air tube-housing clamp	1213CRD	Flame retention ring assembly
1011/22-9	Nozzle line/adaptor assy., 10Y oal	1216CRD	Motor, 1/6 HP, 115 volt, 60 Hz, 1-phase, 3450 RPM, ½" shaft, CCW rotation facing shaft
1012	Nozzle line thumb nut, ⅜"-24 NF	1217CRD	Fuel unit, Sunstrand single-stage A2YA-7916
1014-3A	Oil line from fuel unit to nozzle line (only for burner without oil valve), 3/16" copper tube x 7-3/16" long with flared nuts	1217CRD2	Fuel unit, Sundstrand two-stage B2YA-8916
1015C	Terminal for ignition transformer, 2 required	1251A-1445	Air tube/flange assembly
1018	Transformer; primary, 120 volt; secondary, 10,000 volt. (No. 1015C spring terminals included)	9804	Electrode bracket
1018-1	Transformer hold-down tab, 2 required		

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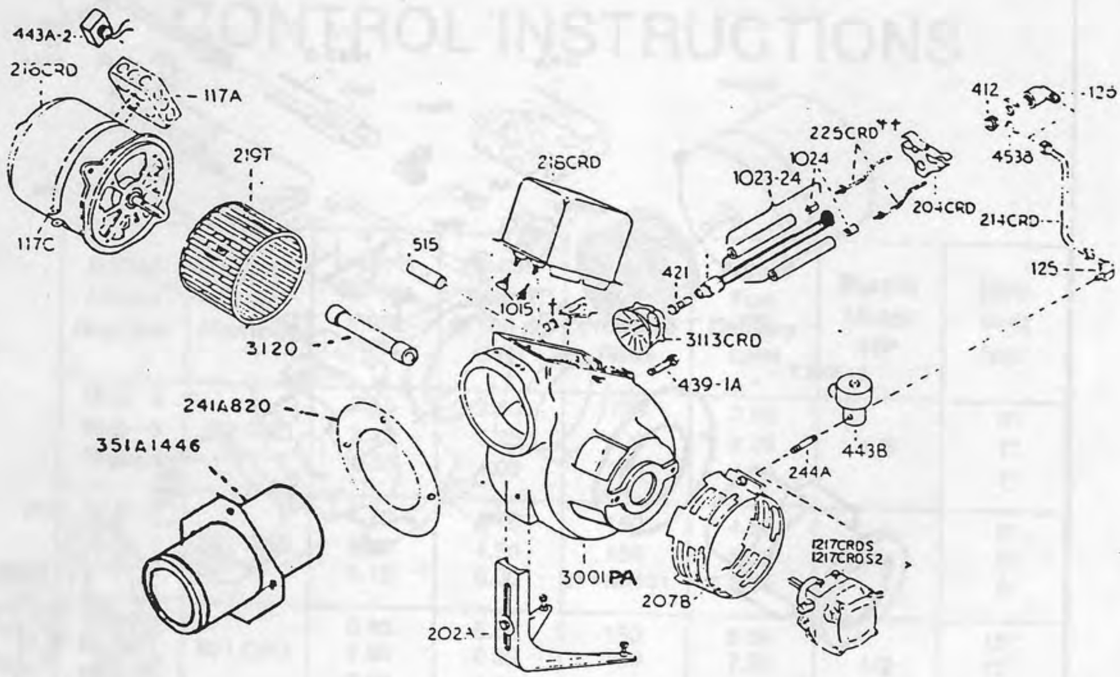
CARLIN BURNER AND CONTROL INSTRUCTIONS

CARLIN OIL BURNER PARTS LIST

Model 301 CRD—60 Hz, 3450 RPM



PART NUMBER	DESCRIPTION
117A	Junction box, 4" x 4" x 1½"
117C	Clamp for mounting junction box to motor. ¾" wide x 18¾" long
125	Male elbow, ⅛" PT x ¼" tube
126	Female elbow, ⅛" PT x ¼" tube
202A	Pedestal
204CRD	Electrod bracket assembly
207B	Air shutter only
211/22-9	Nozzle line/adaptor assy., 16¾" long, for nominal 8" air tube model
214CRD	Oil line from oil valve to nozzle line, ¼" copper tube x 9½" long with flared nuts
216CRD	Motor, ¼ HP, 3450 RPM, 115 volt, 60 Hz, 1-phase, ½" shaft, CCW rotation facing shaft
218CRD	Transformor. Primary, 120 volt, 60 Hz; secondary 10,000 volt. No. 1015 spring terminal included
219T	Blower wheel (fan), 5¾" OD x 4" wide, 9/16" hub, ½" bore, CW rotation facing closed end
220	Coupling, ½" ID x 7/16" ID x 3/316" long, neoprene with nylon flanged ends
225CRD-9	Bus bar, 6⅝" long, with hex locknut, for nominal 8" air tube model. ⅛" brass rod, 2 required. Right and left, same design
241A820	Gasket for mounting flange
244A	Brass nipple, ⅛" PT x 2" long
351A-1446	Air tube/flange assembly 4¾ utl
412	Nozzle line locknut
421	Nozzle, specify GPH, angle and type of spray
439-1A	Screw for adjusting combustion head. ⅜"-16 x 1¾" long
443A-2	2 sec. electronic time delay
443B	Magnetic oil valve, instant-opening, 120 volt, 60 Hz
515	Carrying tube, 9/16" OD x 7/16" ID x 2¼" long
1015	Spring terminal for ignition transformer, 2 required
1023-24	Electrode assembly with insulator, 7/16" odiam. x 3¼" long and 1024 bus-bar extension nut
1024	Bus-bar extension nut
1217CRD	Fuel unit, Sundstrand single-stage JA2BB-100, CW rotation facing shaft Fuel unit, Webster single-stage 21R15OD-1A5, CW rotation facing shaft
1217CRD2	Fuel unit, Sundstrand two-stage HA2BB-100 CW rotation facing shaft Fuel unit, Webster two-stage 22R15OD-1A5, CW rotation facing shaft
3001PA	Housing with scroll extension and pressure augmentor
3113CRD	Flame retention ring assembly
4538	Yoke for adjusting combustion head

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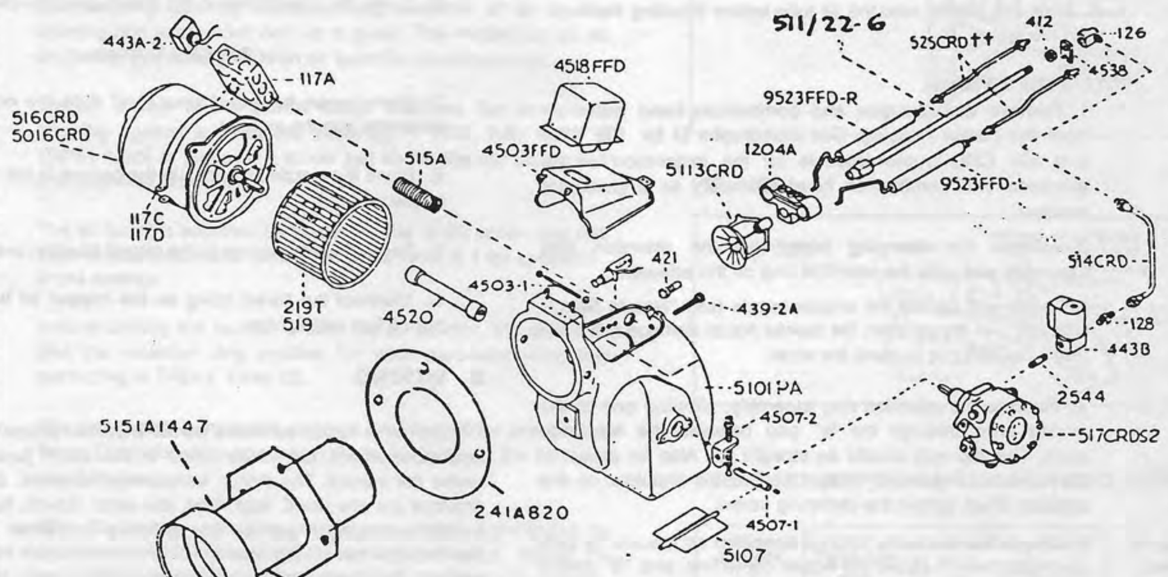
CARLIN BURNER AND CONTROL INSTRUCTIONS

CARLIN OIL BURNER PARTS LIST

Model 601 CRD—Hz, 3450 RPM



PART NUMBER	DESCRIPTION
117A	Junction box, 4" x 4" x 1½"
117C	Clamp for mounting junction box to motor, ¾" wide x 18¾" long For Model 601 CRD
126	Female elbow, ⅛" PT x ¼" tube
128	Male connector, ⅛" PT x ¼" tube
240FF4	Mounting flange, for forced draft
412	Nozzle line locknut
421	Nozzle, specify GPH, angle and type of spray
439-2A	Screw for adjusting combustion head assembly ⅜"-16 x 2½" long
443A-2	Solid-state 2 second time delay relay; 120 volt, 60 Hz
443B	Magnetic oil valve, instant-opening, 120 volt, 60 Hz
511/22-6	Nozzle line/adaptor assembly, ⅛" brass pipe 18¾" long, for normal 10" air tube model
514CRD	Oil line from oil valve to nozzle line, ¼" copper tube x 10½" with flared nuts
515A	Scanner armor, 2¼" long
516CRD	Motor, ⅓ HP, 3450 RPM, 115 volt, 60 Hz, 1-phase, ½" shaft CCW rotation facing shaft.
517CRDS2	Fuel unit, Sundstrand two-stage H3PB-B100, CW rotation facing shaft. Pressure set at 150 psi
519	Blower wheel (fan), 6-5/16" OD x 4" wide, ⅝" hub length ½" bore, CW rotation facing closed end.
525CRD-6	Ignition wire, 6⅜" overall, for nominal 10" air tube model
1204A	Electrode bracket
2544	Brass nipple, ⅛" PT x 2½" long
4503-1	Hinge for transformer mounting and cover, with 2 retaining washers
4503FFD	Transformer mounting and cover
4507-1	Air shutter lever assembly
4507-2	Air shutter adjustment assembly
4518FFD	Transformer. Primary, 120 volt, 60 Hz; secondary, 12,000 volt
4520	Coupling, ½" ID x 7/16" ID x 4⅞" long, neoprene with nylon flanged ends
4538	Yoke for adjusting combustion head
5101PA	Housing with air shutter and shutter adjustment assembly with pressure augmentor
5107	Air shutter assembly 3⅜" x 5⅛" shutter with center rod
5113CRD	Flame retention ring assembly, 3¾" diam. with centering stubs
5151A-1447	Air tube/flange assembly, 11-11/16" overall length, 4¾" od
9523FFD-L	Electrode assembly, left, with 6" insulator
9523FFD-R	Electrode assembly, right, with 6" insulator

18 SERIES BOILER
CARLIN BURNER AND CONTROL INSTRUCTIONS

Model 102 CRD & 301 CRD

1. ASSEMBLING THE BURNER

A. Remove the burner assembly from the carton. If nozzle is not installed, see instructions under (C).

B. Slide the gasket onto the air tube before installing the burner in the boiler.

C. Install the nozzle.

1. Remove the electrode and combustion head assembly from the burner housing. See paragraphs D for 102 CRD and 301 CRD burner models for the installation of the electrode and combustion head assembly as a guide for removal.

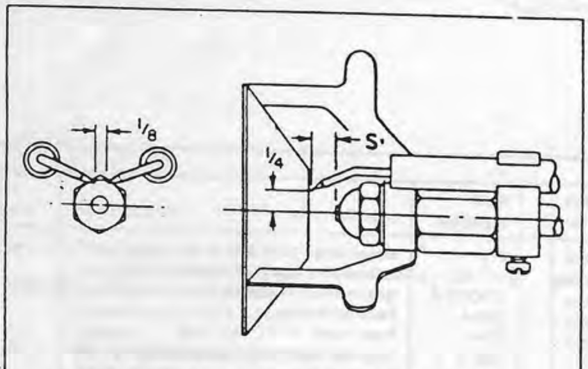
2. Loosen the clamping screw on the retention ring assembly and slide the retention ring off the adapter.

3. Install and tighten the proper nozzle (see "Nozzle Specifications") in the adapter. Be careful not to damage the electrode insulators or to bend the wires.

4. Replace the retention ring assembly, slipping one of the riveted arms through the ⅛" gap between the electrode ends. This top arm should be straight up. Also be sure that the retention ring clamp is tight against the shoulder on the adapter. Then tighten the clamping screw.

5. Check the electrode settings specified as follows: ⅛ inch plus gap, ¼ inch above the nozzle centerline, and "S" ahead of the nozzle tip. See FIG. NO. 1.

FIG. NO. 1



102 CRD - S = 3/16" 301 CRD - S = ¼"5

For 102 CRD Burners

D. Swing open the transformer, and slide the nozzle line assembly into the air tube. It may be necessary to turn nozzle line assembly upside down to ease insertion into the air tube. Then the threaded adapter on the end of the nozzle line is passed through the opening in the left side of the housing.

E. Run the aluminum (knurled) thumb-nut onto the nozzle line and tighten hand-tight.

F. Connect the flared fitting on the copper oil line to the nozzle line and tighten.

G. Swing the transformer to the closed position and fasten.

For 301 CRD Burners

D. Swing open the transformer, and slide the nozzle line assembly into the air tube.

E. Place the nozzle line yoke in the groove in the adjusting screw.

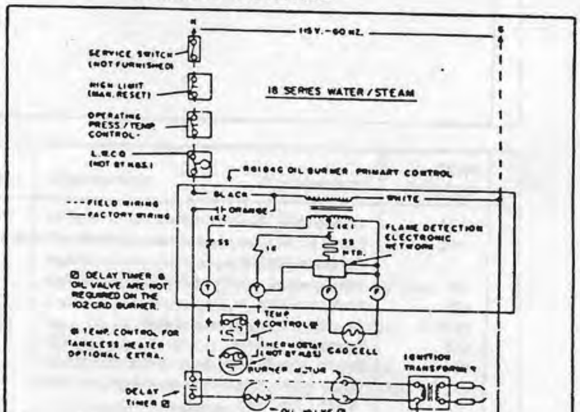
F. Swing the transformer to the closed position and fasten.

G. Connect the flared fitting on the copper oil line to the nozzle line and tighten.

2. WIRING

The burner is furnished with a burner-mounted primary control, field connections are to be made in the 4"x4" junction box under the control. The motor, transformer, oil valve, and flame detector are pre-wired. High limit, low water cut-off, fusible link switch, emergency and service switches are wired in series between the hot supply lead and the unwired black lead in the control. The thermostat or operating control, if used, is wired to "T" and "T".

FIG. NO. 2 HONEYWELL TYPE R8184G PRIMARY CONTROL



3. LIGHT-OFF AND ADJUSTMENT

By moving the electrode and combustion head assembly forward or backward the location of the flame retention ring relative to the air cone can be controlled. See FIG. NO. 3.

It is important that the installation of the oil burner, piping and fittings, safety devices, controls, electrical wiring and equipment be done in accordance with national and/or local regulations of the authorities having jurisdiction over such installation.

18 SERIES BOILER - CARLIN BURNER
INSTALLATION AND OPERATING INSTRUCTIONS

The scale on the nozzle line slide plate is calibrated in 1/16 inch divisions. See FIG. NO. 4. By loosening the locking screw and the thumb-nut and pushing on the thumb-nut, the assembly can be moved to the required position. To lock in place, first tighten the thumb-nut and then the locking screw. TABLE 1 shows for each firing rate the recommended positions of the flame retention ring with the corresponding amounts of air shutter opening and is provided only as a guide. This model has an air shutter for fine control plus an air band for coarse control.

The air shutter has a pointer which indicates the percent of opening against a calibrated scale (9 = 90%, fully open = 100%). Lock in place by a screw just above the ear on the fuel unit after final adjustment.

The air band is adjusted by loosening the ¼-20 screw and nut. Lock in place after final adjustment. See TABLE 1 for appproximate settings.

Before starting the burner, preset the air shutter, the air band, and the retention ring position for your particular firing rate according to TABLE 1A or 1B.

The boiler and burner are selected and tested for pressurized firing. Open the slide damper in the boiler outlet to the full open position.

Start the burner and, using instruments, check combustion for approximately 12 percent CO_2 and zero smoke. Adjust the combustion head forward for more air or backward for less air, see dimension "A" in FIG. NO'S. 3, 4, 5, and 6. Close the slide damper in boiler outlet to produce positive draft on the boiler side of the damper of 0.10 ins. w.c. Recheck CO_2 and smoke and adjust combustion head as necessary. Check for smooth lightoff and clean cut-off. Be sure there are no air leaks in oil suction connections before making adjustments to improve light off or cut-off.

TABLE 1A APPROXIMATE AIR & HEAD SETTINGS
102 CRD

Air Cone I.D.	Firing Rate GPH	Air Control Settings: Retention Ring Setting Inches on Scale Dimension "A"	Percent Opening Air Shutter	Percent Opening Air Band
2⅝	2.00	⅛	100	25
2⅝	2.25	¼	100	100
2⅝	2.50	5/16	100	100
2⅝	2.75	7/16	100	100
2⅝	3.00	9/16	100	100
2⅝	3.25	⅝	100	100
2⅝	3.50	11/16	100	100
3"	3.00	0	100	50
3"	3.25	1/16	100	65
3"	3.50	⅛	100	80
3"	3.75	¼	100	90
3"	4.00	⅜	100	100
3"	4.25	9/16	100	100
3"	4.50	11/16	100	100

FIG. NO. 3

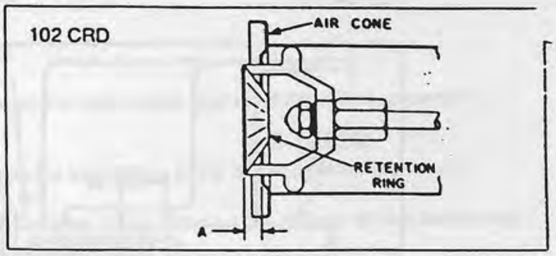


FIG. NO. 4

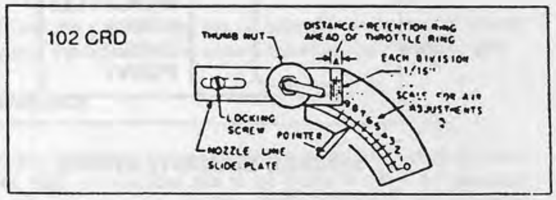
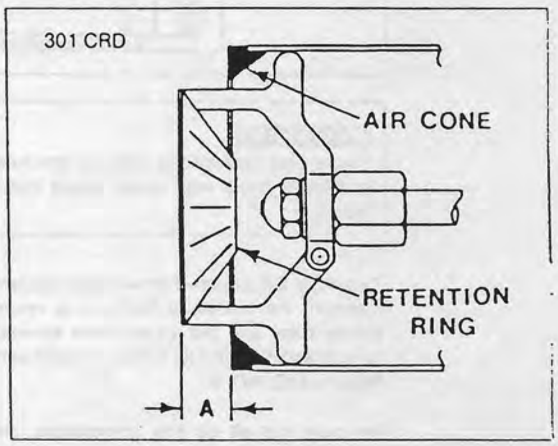


TABLE 1B APPROXIMATE AIR & HEAD SETTINGS
301 CRD

Air Cone I. D.	Firing Rate GPH	Retention Ring Setting Inches on Scale, Dimension "A"	Air Shutter Opening (Percent)
3¼	3.00	3/16	15
3¼	3.50	¼	40
3¼	4.00	⅜	50
3¼	4.50	7/16	70
3¼	5.00	½	80
3¼	5.50	⅝	90
3¼	6.00	13/16	100
3½	4.00	0	40
3½	4.50	⅛	65
3½	5.00	3/16	80
3½	5.50	5/16	95
3½	6.00	7/16	100
3½	6.50	9/16	100
3½	7.00	¾	100

FIG. NO. 5



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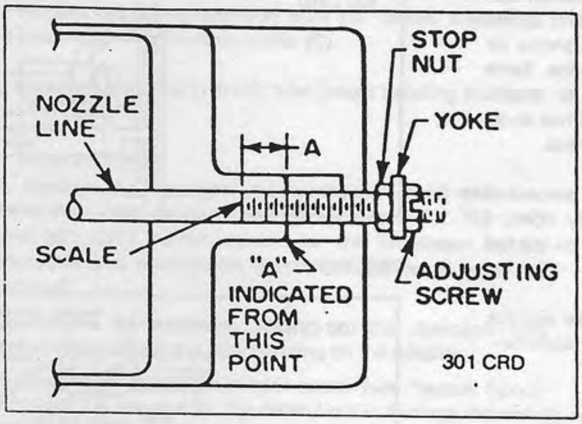
CARLIN BURNER AND CONTROL INSTRUCTIONS

FIG. NO. 6



4. NOZZLE SPECIFICATIONS

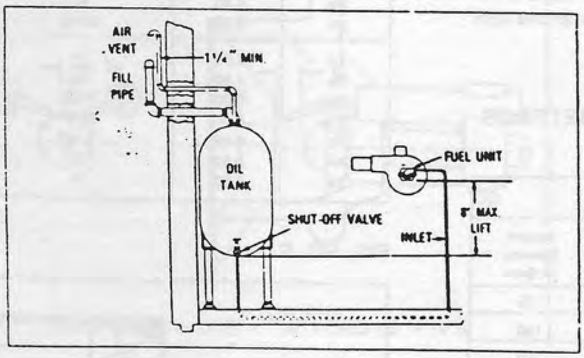
See cover page.

5. FUEL UNITS AND OIL LINES

Single-Pipe Oil Lines—Standard 102 CRD burners are provided with single-stage 3450 rpm fuel units with the by-pass plus removed for single-pipe installations.

The single-stage fuel unit may be installed single-pipe with gravity feed or lift. Maximum allowable lift is 8 feet. See FIG. NO. 7.

FIG. NO. 7



IMPORTANT

Single-pipe installations must be absolutely air-tight or leaks or loss of prime may result. Bleed line and fuel unit completely.

Two-Pipe Oil Lines—For two-pipe systems where more lift is required, the two-stage fuel unit is recommended. TABLE 2 (single-stage and two-stage) show allowable lift and lengths of ⅜ inch and ½ inch OD tubing for both suction and return lines. Refer to FIG. NO. 8.

Be sure that all oil line connections are absolutely airtight.

Check all connections and joints. Flared fittings are recommended. ***Do not use compression fittings.***

Open the air-bleed valve and start the burner. For clean bleed, slip a 3/16" I.D. hose over the end of the bleed valve and bleed into a container. Continue to bleed for 15 seconds after oil is free of air bubbles. Stop burner and close valve.

FIG. NO. 8

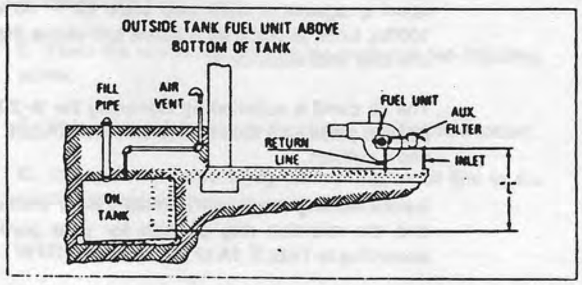


TABLE 2 OIL PIPING TABLE
MAXIMUM HORIZONTAL AND VERTICAL
LENGTHS OF RUN — TWO PIPE SYSTEMS

Lift (Feet)	Single Stage		Two Stage			
	102 or 301 CRD		102 or 301 CRD		601 CRD	
	⅜"	½"	⅜"	½"	½"	⅜"
0	53	100	68	100	100	100
2	45	100	63	100	88	100
4	37	100	58	100	78	100
6	29	100	53	100	69	100
8	21	83	48	100	59	100
10	13	52	42	100	49	100
12	—	—	37	100	39	100
14	—	—	32	100	29	82
16	—	—	27	100	24	68

18 SERIES BOILER
CARLIN BURNER AND CONTROL INSTRUCTIONS

Model 601 CRD

6. ASSEMBLING THE BURNER

A. Remove the burner from the carton. If nozzles are not installed, see instructions under (D).

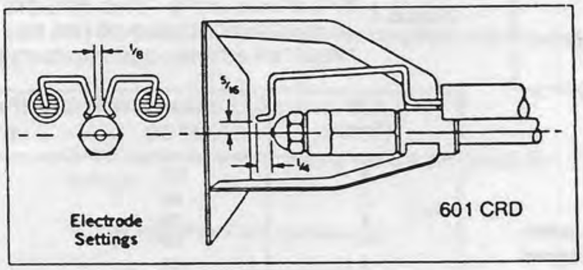
B. Remove the electrode and combustion head assembly from the burner housing.

C. Remove the flame retention ring assembly.

D. Install and tighten the proper nozzle (45° SS Hago) in the adapter. Be careful not to damage the electrode insulators or to bend the wires.

E. Check the electrode settings specified as follows: ⅛ inch to 3/16 inch gap, 5/16 inch above the nozzle centerline and ¼ inch ahead of the nozzle tips. See FIG. NO. 9.

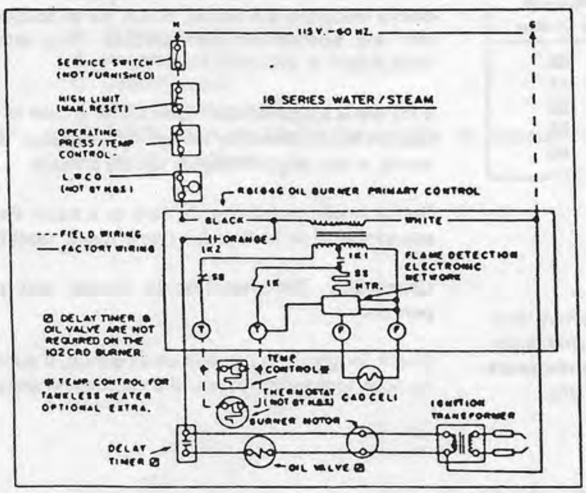
FIG. NO. 9



F. Replace the retention ring assembly. Swing open the transformer, and slide the nozzle line assembly into the air tube.

G. Place the nozzle line yoke in the groove in the adjusting screw.

FIG. NO. 10



H. Fasten the high tension leads to the transformer terminals.

I. Swing the transformer to the closed position and fasten.

J. Connect the flared fitting on the copper oil line to the nozzle line and tighten.

7. INSTALLING THE BURNER: FLANGE MOUNTED

A. Place the gasket over the air tube. Slide the end of the air tube into the opening and secure the flange to the front plate.

8. WIRING

When the burner is furnished with a burner-mounted primary control, field connections are to be made in the 4"x4" junction box under the control. All CSA labeled burners are supplied with a primary control as certified by CSA. The motor, transformer, oil valve, and flame detector are pre-wired. High limit, low water cut-off, fusible link switch, emergency and service switches are wired in series between the hot supply lead and the unwired black lead in the control. The thermostat or operating control, if used, is wired to "T" and "T". Otherwise, jumper "T" and "T".

When the primary control is mounted on the boiler or furnace, the motor, transformer, and oil valve connections are joined in the junction box mounted on the motor.

9. HOW TO ADJUST THE COMBUSTION HEAD

The retention ring position ahead of the throttle ring is adjustable from zero (flush) to 1⅛ inches (Dimension "A", FIG. NO'S. 11 and 12). Turning the adjustable screw in (clockwise) increases the diatance "A" ahead. This distance is indicated by reading the scale on the nozzle line across the corners on sides of the channel guiding the nozzle line. Each division is 1/16 inch.

18 SERIES BOILER
CARLIN BURNER AND CONTROL INSTRUCTIONS

FIG. NO. 11

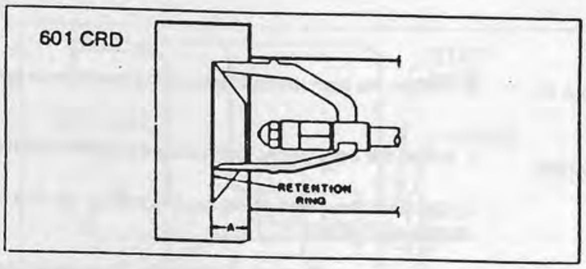
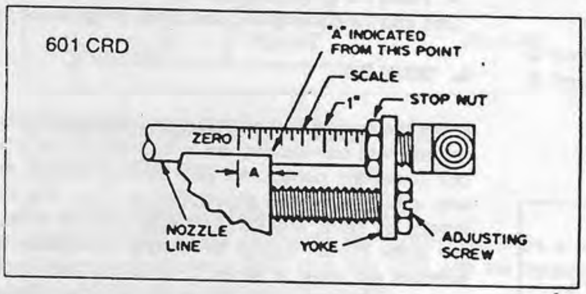


FIG. NO. 12



10. RETENTION RING AND AIR SHUTTER ADJUSTMENTS

TABLE 3 shows for each firing rate the approximate recommended positions of the flame retention ring with the corresponding amounts of air shutter opening. TABLE 3 is provided as a guide only. Final adjustments must be made to suit the conditions of the installation.

TABLE 3 APPROXIMATE SETTINGS FOR MODEL 601 CRD

Nozzle GPH	Delivery @ 150 PSI	Retention Ring "A"	Percent Air Shutter
5.00	6.00	3/16	35
5.50	6.60	¼	45
6.00	7.20	5/16	50
6,50	7.80	⅜	55
7.00	8.30 *	7/16	60

* 146 PSI pump press

11. NOZZLE SPECIFICATIONS

Other mades of nozzles may or may not prove satisfactory. Sufficient test data is not available to make other recommendations. The correlation of nozzle sprays between different manufacturers ; not consistent. See cover page for nozzle specifications.

12. FUEL UNITS AND OIL LINES

Standard burners are provided with a two-stage 3450 rpm fuel unit *set at 150 psi.*

A ***single-pipe system*** is recommended whenever the bottom of the fuel tank is above the burner or is at the same level as the burner. This includes outdoor fuel tanks that are at such levels.

A ***two-pipe system*** is recommended when the fuel tank is below the level of the burner, and the fuel unit must pull (lift) the fuel up to the burner. For two-pipe installations the by-pass plug must be installed. Maximum recommended vacuum is 12 inches of mercury.

TABLE 4 shows, for the standard two-stage fuel unit, the allowable lift and lengths of ½" and ⅝" OD tubing for both suction and return lines in two-pipe systems.

Be sure that all oil line connections are absolutely airtight. Check all connections and joints. Flared fittings are recommended. ***Do not*** use compression fittings.

Open the air-bleed valve and start the burner. For clean bleed, slip a 3/16" ID hose over the end of the bleed valve and bleed into a container. Continue to bleed for 15 seconds after oil is free of air bubbles. Stop the burner and close the bleed valve.

TABLE 4 TWO-STAGE UNITS—TWO-PIPE SYSTEMS
SUNDSTRAND H3PB-B100 (150 PSI)
WEBSTER 22R210A-3EC 13 (150 PSI)

Lift (Feet)	Length of Tubing (Feet) ½" OD	⅝" OD
0	100	100
2	88	100
4	78	100
6	69	100
8	59	100
10	49	100
12	39	100
14	29	82
15	24	68

13. LIGHT-OFF AND ADJUSTMENT

Before re-starting the burner, preset the air shutter and the retention ring position for the particular firing rate according to TABLE 3.

If the fire is a little too rich, open the air shutter or move the combustion head forward by increasing dimension "A". At the lower inputs, a very slight change is usually enough.

Run a smoke test. Strive for zero or a trace. Each time further adjustment of air or retention ring is made, reset the draft.

Check CO_2. This should be 12 percent, and may be over 13 percent.

Check for good ignition and clean cut-off. If cut-off continues to be poor, look for air leaks in the suction line and correct them.

18 SERIES BOILER
CARLIN BURNER AND CONTROL INSTRUCTIONS

14. IMPORTANT CAUTIONS - BEFORE LEAVING THE JOB

1. Check all oil connections for leaks and be sure that the packing nut of oil shut-off valves are tight and that all pumpplugs are tight.

2. Be sure that burner air control adjustment is locked in position and that draft control adjustment is locked.

3. Check to be sure there is ample supply of fresh air to the boiler room. (See "Air Supply & Chimney Requirements".)

4. Be sure that thermostat and limit controls are properly adjusted and that fuses are tight.

15. FOLLOW-UP INSPECTION

After the burner has been in operation a few days, the following should be checked:

1. The flame adjustment and the condition of the heating surfaces.

2. Starting and stopping of the burner.

3. All joints in the oil supply system for possibility of leakage.

4. The adjustment and operation of:

   A. The primary control.
   B. The limit controls.
   C. The draft regulator.
   D. Other controls.

5. The general operation of the burner and heating system should be explained again to the home owner and specific recommendations should be made concerning:

   A. Thermostat adjustment.
   B. Necessity of air supply to burner.
   C. Care of burner.
   D. Care of heating plant.
   E. Simple steps to take if burner fails to operate, before calling service.

POSSIBLE DIFFICULTIES AND CAUSES

Burner fails to start:

1. Power circuit dead
2. Line switch or emergency switch open - burner out or loose fuse
3. Loose electrical connection
4. Limit control set too low
5. Master control safety switch open
6. Thermostat set too low
7. Broken thermostat wire or loose connection in thermostat circuit
8. Motor thermal protector switch open - reset button on motor

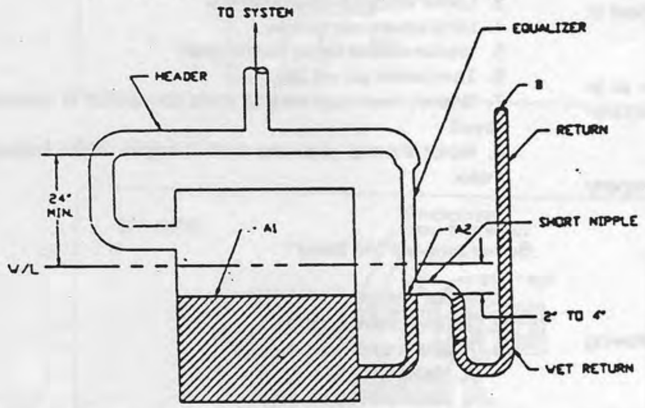
Burner runs but "no flame":

1. No oil in tank
2. Shut-off valve closed
3. Fuel unit air-bound due to:
   A. Tank running dry
   B. Shut-off valve closed
   C. Air leak in suction line - be sure all plugs on fuel unit are tight; also cover cap for pressure regulating screw; cover of oil filter assembly; packing nut at stem of oil shut-off valve
4. Excessive lift or high filter resistance - disconnect connector tube at fuel unit and check oil volume through pump. Insufficient flow may be due to clogged filter or excessive lift.
5. Excessive suction for type of system (one pipe or two pipe) - maximum lift and oil delivery will always be developed with a two pipe system.
6. Oil filter should be changed every heating season.

WEIL-McLAIN

ENGINEER'S NEWSLETTER!! ENGINEER'S NEWSLETTER!! ENGINEER'S NEWSLETTER!!

JANUARY 1987 EDITION # 57



QUESTION

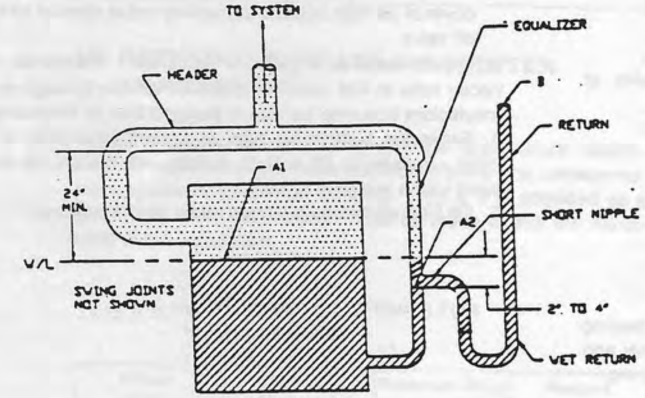
What is a Hartford Loop piping system?

ANSWER

The Hartford Loop Piping System was developed by the Hartford Insurance Company in the early 1900's as a means for keeping water in the boiler under steaming conditions—or in case of a return line break.

Here the pressure at "A," and "B" are unequal. Pressure at "A," and "A," are equal due to the equalizer line. If the water line drops to level of the "short nipple", no more water can be forced from the boiler.

Condensate will enter the boiler through the wet return.



QUESTION

Does the Hartford Loop Piping System do anything else?

ANSWER

YES!

The system provides a "drain" for the external steam piping.

As the boiler begins to make steam, the cooler piping will cause some condensation. The condensate can drain back to the boile through the equalizer.

In addition, steam entering the external header can be saturatec The velocity in the header will help to carry the moisture past the system take-off riser. This assures "dryer" steam in the mains and terminal units. Of course, the "moisture" will drain back to the boiler through the equalizer line.

QUESTION

As I understand it, the Hartford Loop Piping System does three things.

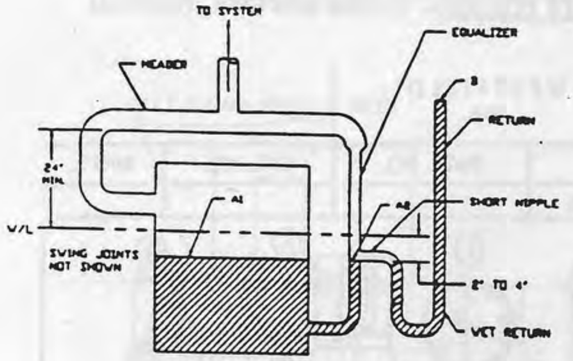
ANSWER

YES!

1. The piping system serves to equalize pressure to keep water in the boiler.
2. It provides a drain for the external piping.
3. And it helps to assure dry steam to the mains and terminal units.

Again, the "near boiler piping" must be considered part of the boiler for proper performance.

NEVER INSTALL A STEAM BOILER WITHOUT THE HARTFORD LOOP PIPING SYSTEM.



QUESTION

Why is a "short nipple" required at the return connection to the equalizer? These are difficult to install.

ANSWER

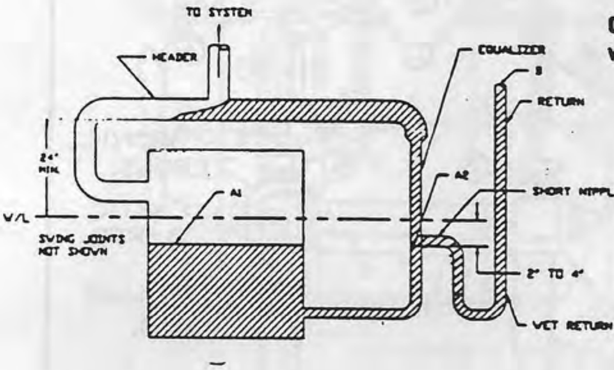
To eliminate "water hammer" at the connection.

Install something longer and you will probably get a service call.

Here's why:

Relatively cool condensate enters the equalizer and contacts a layer of steam. The steam condenses and is displaced. This sets up an oscillating action at the return connection and the water slams against the back of the tee.

With a short nipple, the distance is less and the reaction is not prevalent.



QUESTION

What is the purpose of the 24" min. from the waterline to the header?

ANSWER

Saturated steam enters the horizontal header. Moisture is separated by means of the system take-off riser and equalizer and drains back into the boiler.

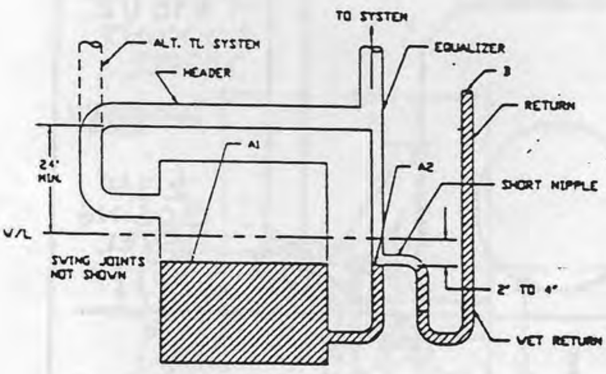
If the "moisture" fills the equalizer, the external header will flood. Of course everything gets pushed to the direction of flow.

This means the flow to the system is through less area, therefore the velocity increases.

Minor Problem: Saturated steam going to the system could cause water hammer.

Major Problem: Boiler would prime to the extent some of the boiler water would discharge into the system. Result: NOISE!

Anything less than 24" increases the chance for problems.



QUESTION

Can I tie the system riser into a tee at either end of the header? This would save a fitting, time, and it would be easier to install!

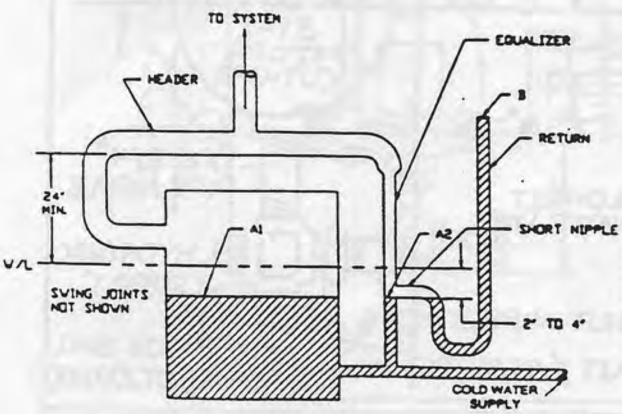
ANSWER

DON'T DO IT!

Pressure could still be equalized at "A_1," and "A_2". However, the piping system might not do the other things required.

If the system riser and equalizer are on opposite ends, separation of moisture from saturated steam can not be readily accomplished. Result: water hammer.

If the system riser and equalizer are on the same end, moisture can slam against the tee connector. Again, noise would result.



QUESTION

Where is the best place to install the make-up waterline to the boiler?

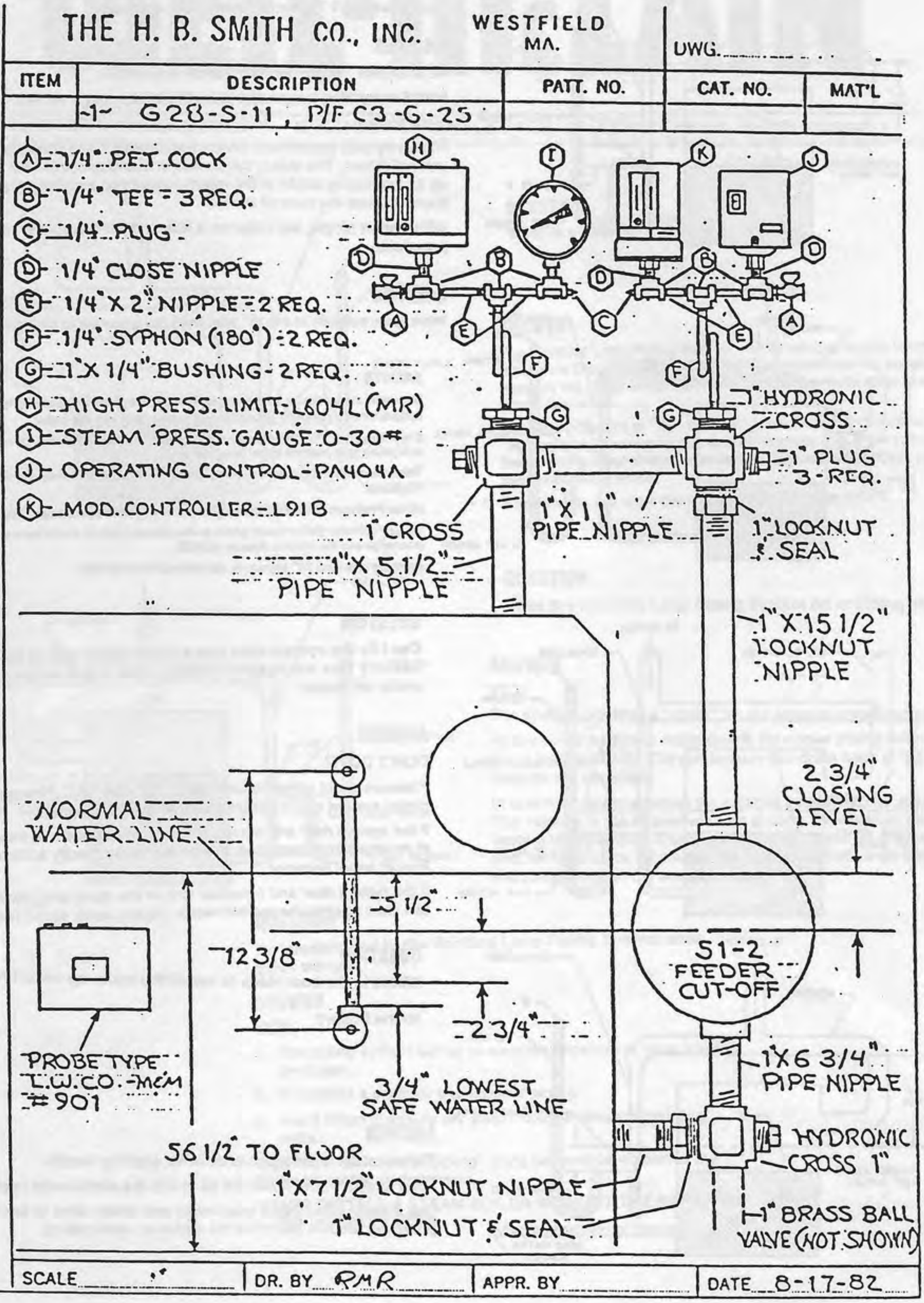
ANSWER

The equalizer is the place to tie-in for a gravity return.

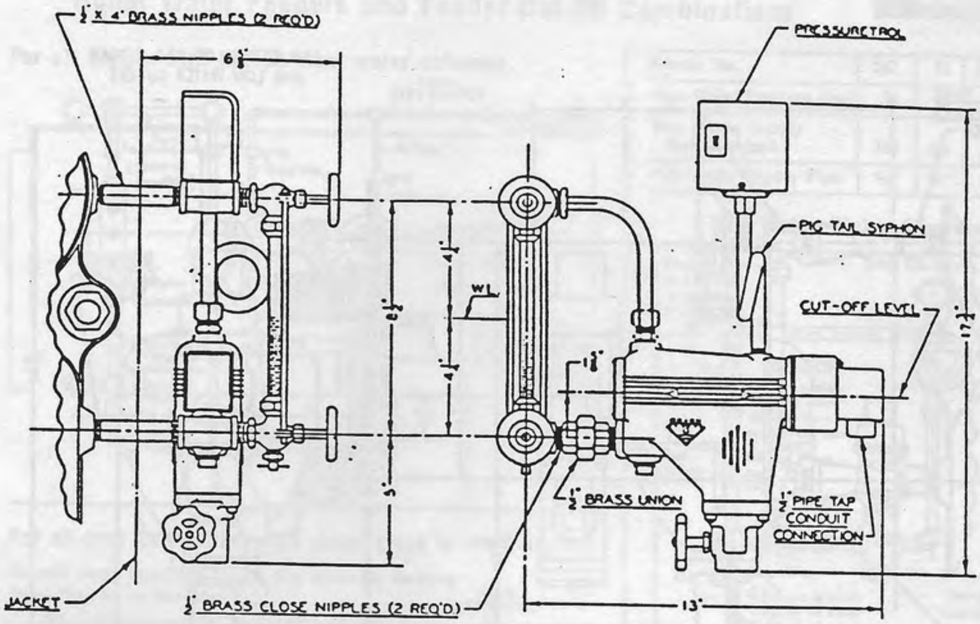
For a forced return, make the tie-in into the condensate receiver.

Use a globe valve (not a gate valve) and check valve or backflow preventer (double check) in the make-up water piping.

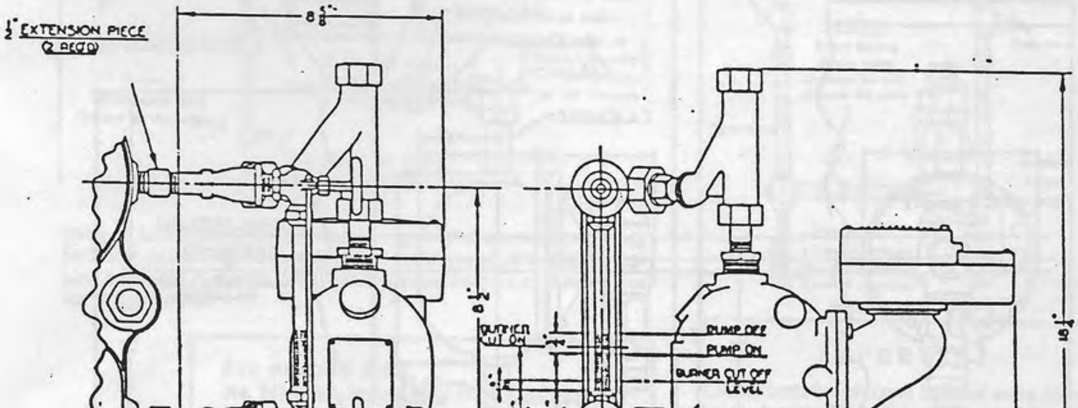
INSTRUCTIONS FOR INSTALLING A McDONNELL & MILLER No 51-2 LOW-WATER CUTOFF & FEEDER ON AN H.B. SMITH MODEL 28 BOILER



EXAMPLES OF FEEDER AND LOW-WATER CUTOFF INSTALLATION INTRUCTIONS
(ourtesy, Peerless Heater Co.)

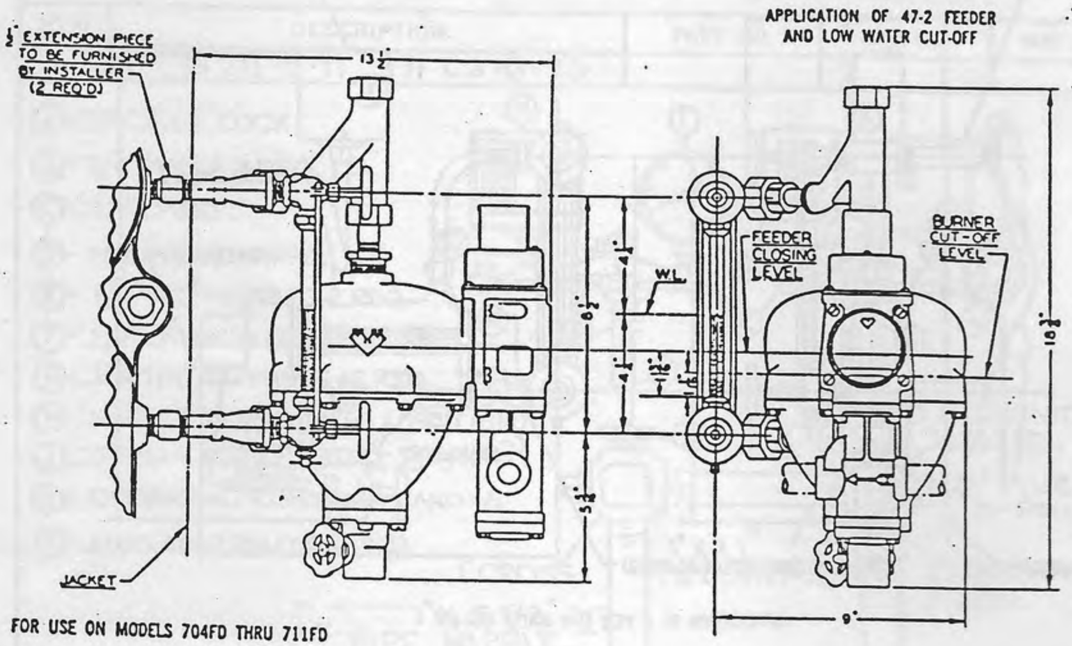


APPLICATION OF 67PE-2 LOW WATER CUT-OFF

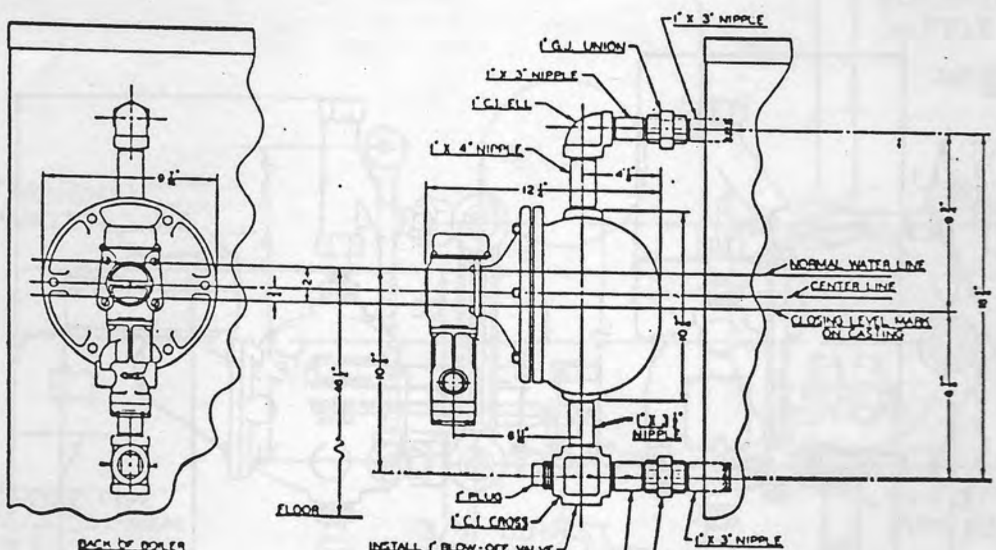


APPLICATION OF 42A PUMP CONTROL AND LOW WATER CUT-OFF

EXAMPLES OF FEEDER AND LOW-WATER CUTOFF INSTALLATION INTRUCTIONS
(ourtesy, Peerless Heater Co.)



FOR USE ON MODELS 704FD THRU 711FD



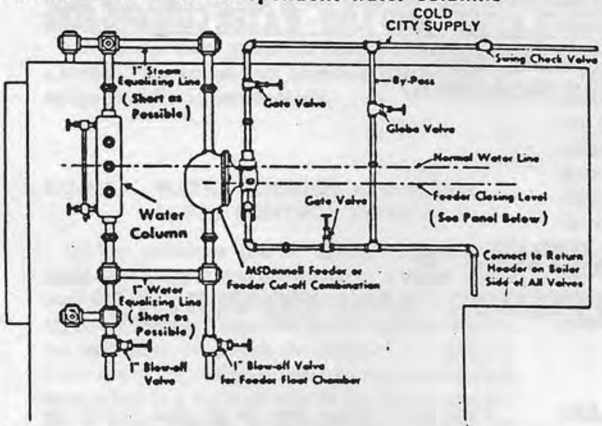
NOTES:
51 FEEDER OR 51-2 COMB. FEEDER CUT-OFF USED ON MODELS 0-713 PF THRU 0-720 PF AND 0-712 FD THRU 0-724 FD.
CONNECTING FITTINGS SHOWN ON THIS DRAWING ARE TO BE SUPPLIED BY INSTALLER.
ON COMB. FEEDER CUT-OFF MODELS THE BURNER CUT-OFF LEVEL IS 2 3/4" BELOW NORMAL WATER LINE.

INSTALLATION INSTRUCTIONS

McDONNELL Nos. 247, 247-2, 51, 51-2, 51-S, 51-S-2, 53 and 53-2 Boiler Water Feeders and Feeder Cut-Off Combinations

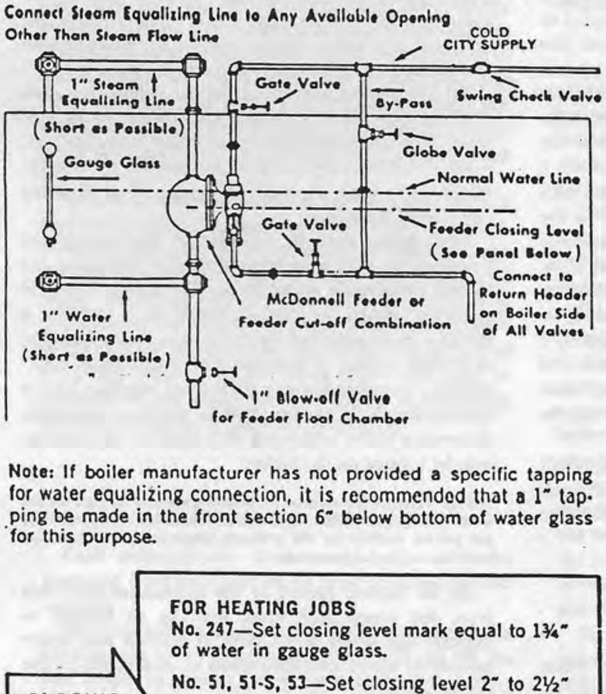
For Steam Boilers

For all boilers with independent water columns



For all cast iron boilers with water glass in front section

Connect Steam Equalizing Line to Any Available Opening Other Than Steam Flow Line



Note: If boiler manufacturer has not provided a specific tapping for water equalizing connection, it is recommended that a 1" tapping be made in the front section 6" below bottom of water glass for this purpose.

CLOSING LEVELS

FOR HEATING JOBS

No. 247—Set closing level mark equal to 1¾" of water in gauge glass.

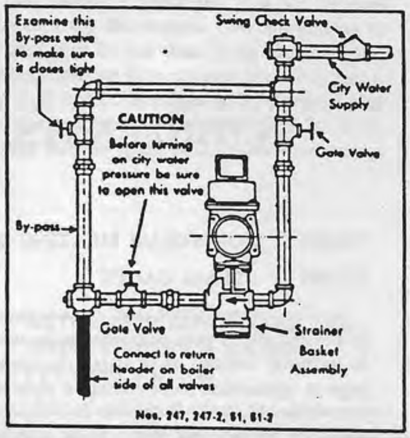
No. 51, 51-S, 53—Set closing level 2" to 2½" below normal boiler water line, but not lower than 1" of water in gauge glass.

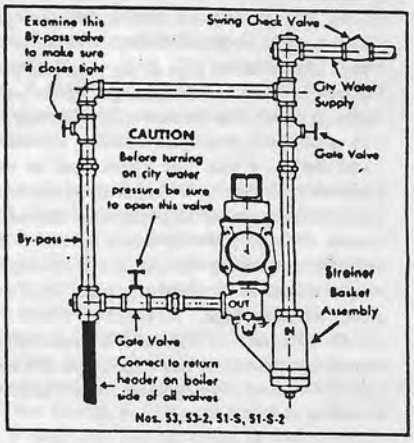
FOR PROCESS JOBS

All Controls—Set closing level at normal boiler water line, when no condensation is returned to boiler.

Feeder No.	247	51	51-S	53
Max. Boiler Pressure (psi)	30	35	35	75
Max. Water Supply Pressure (psi)	150	150	100	150
City Water Supply Pipe	½"	¾"	¾"	¾"

City Water Piping Diagrams





IMPORTANT

1. After installation open blow-off valve directly below feeder. This causes water level in float chamber to fall quickly, and you should hear the make-up valve open wide. To check operation of cut-off switch, open blow-off valve while burner is in operation; when float drops, burner should stop.

2. Instruct owner to flush feeder bowl once a month during heating season. Owner should have strainer basket assembly cleaned at least twice a year, more often if necessary.

EXERPTS FROM SECTION IV HEATING BOILERS OF THE ASME BOILER AND PRESSURE VESSEL CODE, 1983 EDITION REGARDING RULES FOR WATER COLUMNS, GAUGE GLASSES, AND LOW-WATER CUTOFFS FOR STEAM BOILERS

(Used by permission)

ARTICLE 6
INSTRUMENTS, FITTINGS, AND CONTROLS[1]

HG-600 FOR STEAM HEATING BOILERS

HG-601 STEAM GAGES

(a) Each steam boiler shall have a steam gage or a compound steam gage connected to its steam space or to its water column or to its steam connection. The gage or connection shall contain a siphon or equivalent device which will develop and maintain a water seal that will prevent steam from entering the gage tube. The connection shall be so arranged that the gage cannot be shut off from the boiler except by a cock placed in the pipe at the gage and provided with a tee- or lever-handle arranged to be parallel to the pipe in which it is located when the cock is open. The connections to the boiler shall be not less than ¼ in. standard pipe size, but where steel or wrought iron pipe or tubing is used, they shall be not less than ½ in. standard pipe size. The minimum size of a siphon, if used, shall be ¼ in. in inside diameter. Ferrous and nonferrous tubing having inside diameters at least equal to that of standard pipe sizes listed above may be substituted for pipe.

(b) The scale on the dial of a steam boiler gage shall be graduated to not less than 30 psi nor more than 60 psi. The travel of the pointer from 0 to 30 psi pressure shall be at least 3 in.

HG-602 WATER GAGE GLASSES

(a) Each steam boiler shall have one or more water gage glasses attached to the water column or boiler by means of valved fittings not less than ½ in. pipe size, with the lower fitting provided with a drain valve of a type having an unrestricted drain opening not less than ¼ in. in diameter to facilitate cleaning. Gage glass replacement shall be possible under pressure. Water glass fittings may be attached directly to a boiler.

Boilers having an internal vertical height of less than 10 in. may be equipped with a water level indicator of the Glass Bull's-Eye type provided the indicator is of sufficient size to show the water at both normal operating and low water cutoff levels.

(b) The lowest visible part of the water gage glass shall be at least 1 in. above the lowest permissible water level recommended by the boiler manufacturer. With the boiler operating at this lowest permissible water level, there shall be no danger of overheating any part of the boiler.

Each boiler shall be provided at the time of the manufacture with a permanent marker indicating the lowest permissible water level. The marker shall be stamped, etched, or cast in metal; or it shall be a metallic plate attached by rivets, screws, or welding; or it shall consist of material with documented tests[2] showing its suitability as a permanent marking for the application. This marker shall be visible at all times. Where the boiler is shipped with a jacket, this marker may be located on the jacket.

NOTE: Transparent material other than glass may be used for the water gage provided that the material will remain transparent and has proved suitable for the pressure, temperature, and corrosive conditions expected in service.

(c) In electric boilers of the submerged electrode type, the water gage glass shall be so located to indicate the water levels both at startup and under maximum steam load conditions as established by the manufacturer.

(d) In electric boilers of the resistance heating element type the lowest visible part of the water gage glass shall not be below the top of the electric resistance heating element. Each boiler of this type shall also be equipped with an automatic low-water

[1] This equipment to be installed prior to operation.

[2] Example of a nationally recognized standard is ANSI Z21.13.

electrical power cutoff so located as to automatically cut off the power supply before the surface of the water falls below the top of the electrical resistance heating elements.

(e) Tubular water glasses on electric boilers having a normal water content not exceeding 100 gal shall be equipped with a protective shield.

HG-603 WATER COLUMN AND WATER LEVEL CONTROL PIPES

(a) The minimum size of ferrous or nonferrous pipes connecting a water column to a steam boiler shall be 1 in. No outlet connections, except for damper regulator, feedwater regulator, steam gages, or apparatus which does not permit the escape of any steam or water except for manually operated blowdowns, shall be attached to a water column or the piping connecting a water column to a boiler (see HG-705 for introduction of feedwater into a boiler). If the water column, gage glass, low-water fuel cutoff, or other water level control device is connected to the boiler by pipe and fittings, no shutoff valves of any type shall be placed in such pipe, and a cross or equivalent fitting to which a drain valve and piping may be attached shall be placed in the water piping connection at every right angle turn to facilitate cleaning. The water column drain pipe and valve shall be not less than ¾ in. pipe size.

(b) The steam connections to the water column of a horizontal firetube wrought boiler shall be taken from the top of the shell or the upper part of the head, and the water connection shall be taken from a point not above the center line of the shell. For a cast iron boiler, the steam connection to the water column shall be taken from the top of an end section or the top of the steam header, and the water connection shall be made on an end section not less than 6 in. below the bottom connection to the water gage glass.

HG-604 PRESSURE CONTROL

Each automatically fired steam boiler shall be protected from overpressure by two pressure-operated controls.

(a) Each individual automatically fired steam boiler shall have a safety limit control that will cut off the fuel supply to prevent steam pressure from exceeding the 15 psi maximum allowable working pressure of the boiler. Each control shall be constructed to prevent a pressure setting above 15 psi.

(b) Each individual steam boiler or each system of commonly connected steam boilers shall have a control that will cut off the fuel supply when the pressure reaches an operating limit, which shall be less than the maximum allowable pressure.

(c) Shutoff valves of any type shall not be placed in the steam pressure connection between the boiler and the controls described in (a) and (b) above. These controls shall be protected with a syphon or equivalent means of maintaining a water seal that will prevent steam from entering the control. The connections to the boiler shall not be less than ¼ in. standard pipe size, but where steel or wrought iron pipe or tubing is used, they shall not be less than ½ in. standard pipe size. The minimum size of a syphon shall be ¼ in. standard pipe size or ⅜ in. O.D. nonferrous tubing.

HG-605 AUTOMATIC LOW-WATER FUEL CUTOFF AND/OR WATER FEEDING DEVICE

(a) Each automatically fired steam or vapor-system boiler shall have an automatic low-water fuel cutoff so located as to automatically cut off the fuel supply when the surface of the water falls to the lowest visible part of the water gage glass. If a water feeding device is installed, it shall be so constructed that the water inlet valve cannot feed water into the boiler through the float chamber and so located as to supply requisite feedwater.

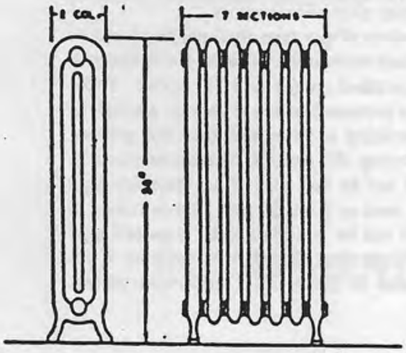
(b) Such a fuel cutoff or water feeding device may be attached directly to a boiler. A fuel cutoff or water feeding device may also be installed in the tapped openings available for attaching a water glass direct to a boiler, provided the connections are made to the boiler with nonferrous tees or Y's not less than ½ in. pipe size between the boiler and the water glass so that the water glass is attached directly and as close as possible to the boiler; the run of the tee or Y shall take the water glass fittings, and the side outlet or branch of the tee or Y shall take the fuel cutoff or water feeding device. The ends of all nipples shall be reamed to full-size diameter.

(c) Fuel cutoffs and water feeding devices embodying a separate chamber shall have a vertical drain pipe and a blowoff valve not less than ¾ in. pipe size, located at the lowest point in the water equalizing pipe connections so that the chamber and the equalizing pipe can be flushed and the device tested.

RADIATOR RATINGS

These ratings were taken from the Hydronics Institute's Guide № 200 Installation Guide for Residential Hydronic Heating Systems (Hot Water and Steam). (Used by permission) Note that these ratings are conservative.

COLUMN TYPE RADIATORS

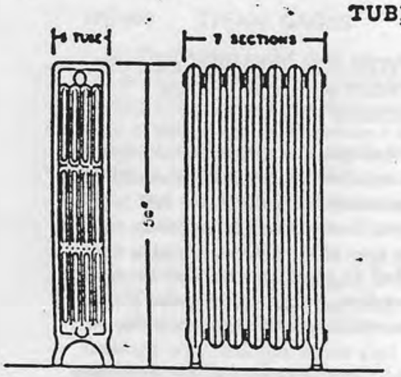


SIZE SHOWN 28 SQ.FT. RADIATION

SQ. FT. RADIATION PER SECTION

Height Inches	One Column	Two Column	Three Column	Four Column	Window
13	...	...	...	...	3
16	...	...	...	...	3¾
18	...	...	2¼	3	4¼
20	1½	2	...	...	5
22	...	...	3	4	...
23	1⅔	2⅓	...	...	...
26	2	2⅔	3¾	5	...
32	2½	3⅓	4½	6½	...
38	3	4	5	8	...
45	...	5	6	10	...

TUBE TYPE RADIATORS



SIZE SHOWN 35 SQ.FT. RADIATION

SQ. FT. RADIATION PER SECTION

Height Inches	Three Tube	Four Tube	Five Tube	Six Tube	Window Seven Tube
14	...	...	...	...	2½
17	...	...	...	...	3
20	1¾	2¼	2⅔	3	3⅓
23	2	2½	3	3½	...
26	2⅓	2¾	3½	4	4¼
32	3	3½	4⅓	5	...
38	3½	4¼	5	6	...

RATINGS OF SMALL TUBE RADIATORS—SQUARE FEET

Number of Sections	Length 1¼ Inches per Section	3 TUBE	4 TUBE		5 TUBE		6 TUBE		
		25" Height	19" Height	25" Height	22" Height	25" Height	19" Height	25" Height	32" Height
2	3½	3.2	3.2	4	4.2	4.8	4.6	6	7.4
4	7	6.4	6.4	8	8.4	9.6	9.2	12	14.8
6	10½	9.6*	9.6*	12*	12.6*	14.4*	13.8	18*	22.2*
8	14	12.8	12.8	16	16.8	19.2	18.4	24	29.6
10	17½	16.0*	16.0*	20*	21.0*	24.0*	23.0*	30*	37.0*
12	21	19.2	19.2	24	25.2	28.8	27.6	36	44.4
14	24½	22.4*	22.4*	28*	29.4*	33.6*	32.2*	42*	51.8*
16	28	25.6	25.6	32	33.6	38.4	36.8	48	59.2
18	31½	28.8*	28.8*	36*	37.8*	43.2*	41.4*	54*	66.6*
20	35	32.0	32.0	40	42.0	48.0	46.0	60	74.0
22	38½	35.2*	35.2*	44*	46.2*	52.8*	50.6*	66*	81.4*
24	42	38.4	38.4	48	50.4	57.6	55.2	72	88.8
26	45½	41.6*	41.6*	52*	54.6*	62.4*	59.8*	78*	96.2*
28	49	44.8	44.8	56	58.8	67.2	64.4	84	103.6
30	52½	48.0*	48.0*	60*	63.0*	72.0*	69.0*	90*	111.0
32	56	51.2	51.2	64	67.2	76.8	73.6	96	118.4
34	59½	54.4	54.4	68	71.4	81.6	78.2	102	125.8
36	63	57.6	57.6	72	75.6	86.4	82.8	108	133.2
38	66½	60.8*	60.8*	76*	79.8*	91.2*	87.4*	114	140.6
40	70	64.0	64.0	80	84.0	96.0	92.0	120	148.0
42	73½	67.2	67.2	84	88.2	100.8	96.6	126	155.4
44	77	70.4	70.4	88	92.4	105.6	101.2	132	152.8
46	80½	73.6	73.6	92	96.6	110.4	105.8	138	170.2
48	84	76.8	76.8	96	100.8	115.2	110.4	144	177.6
50	87½	80.0	80.0	100	105.0	120.0	115.0	150	185.0
52	91	83.2	83.2	104	109.2	124.8	119.6	156	192.4
54	94½	86.4	86.4	108	113.4	129.6	124.2	162	179.8
56	98	89.6	89.6	112	117.6	134.4	128.8	168	207.2

RATINGS - H.B. SMITH PRINCESS AND UNION RADIATORS

Princess

STEAM OR WATER

Dimensions

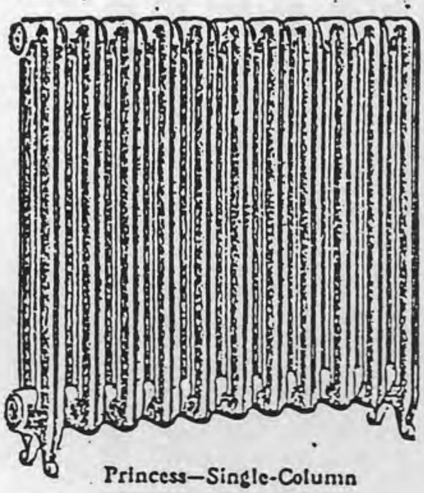
Princess

Width of Section.......... 5¼"

Length of Section.......... 3"

Height to Center of Regular Tapping................ 4⅛"

Regular Tapping, see page 34



Princess—Single-Column

Princess

STEAM OR WATER

Single-Column

Radiating Surface in Feet

Sec-tions	Total Length Ft.	In.	Height 46" 4½ ft. per sec.	37" 3½ ft. per sec.	31" 3 ft. per sec.	26" 2½ ft. per sec.	22" 2¼ ft. per sec.	19" 2 ft. per sec.
3	0	10	13½	10½	9	7½	6¾	6
4	1	1	18	14	12	10	9	8
5	1	4	22½	17½	15	12½	11¼	10
6	1	7	27	21	18	15	13½	12
7	1	10	31½	24½	21	17½	15¾	14
8	2	1	36	28	24	20	18	16
9	2	4	40½	31½	27	22½	20¼	18
10	2	7	45	35	30	25	22½	20
11	2	10	40½	38½	33	27½	24¾	22
12	3	1	54	42	36	30	27	24
13	3	4	58½	45½	39	32½	29¼	26
14	3	7	63	49	42	35	31½	28
15	3	10	67½	52½	45	37½	33¾	30
16	4	1	72	56	48	40	36	32
17	4	4	76½	59½	51	42½	38¼	34
18	4	7	81	63	54	45	40½	36
19	4	10	85½	66½	57	47½	42¾	38
20	5	1	90	70	60	50	45	40
21	5	4	94½	73½	63	52½	47¼	42
22	5	7	99	77	66	55	49½	44
23	5	10	103½	80½	69	57½	51¾	46
24	6	1	108	84	72	60	54	48
25	6	4	112½	87½	75	62½	56¼	50
26	6	7	117	91	78	65	58½	52
27	6	10	121½	94½	81	67½	60¾	54
28	7	1	126	98	84	70	63	56
29	7	4	130½	101½	87	72½	65¼	58
30	7	7	135	105	90	75	67½	60

Princess

STEAM OR WATER

Dimensions

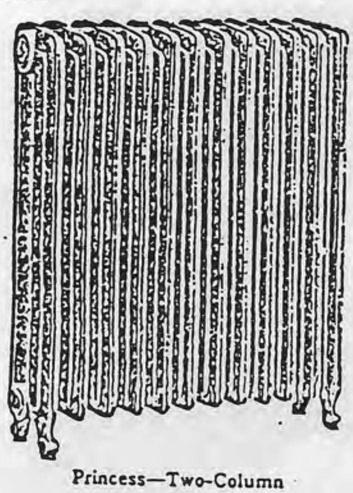
Princess

Width of Section....... 7"

Length of Section....... 3"

Height to Center of Regular Tapping........ 4⅛"

Regular Tapping, see page 34



Princess—Two-Column

Princess

STEAM OR WATER

Two-Column

Radiating Surface in Feet

Sec-tions	Total Length Ft.	In.	Height 46" 5 ft. per sec.	37" 4 ft. per sec.	31" 3½ ft. per sec.	26" 3 ft. per sec.	22" 2⅝ ft. per sec.	19" 2¼ ft. per sec.
3	0	10	15	12	10½	9	7⅞	6¾
4	1	1	20	16	14	12	10½	9
5	1	4	25	20	17½	15	13⅛	11¼
6	1	7	30	24	21	18	15¾	13½
7	1	10	35	28	24½	21	18⅜	15¾
8	2	1	40	32	28	24	21	18
9	2	4	45	36	31½	27	23⅝	20¼
10	2	7	50	40	35	30	26¼	22½
11	2	10	65	44	38½	33	28⅞	24¾
12	3	1	60	48	42	36	31½	27
13	3	4	65	52	45½	39	34⅛	29¼
14	3	7	70	56	49	42	36¾	31½
15	3	10	76	60	52½	45	39⅜	33¾
16	4	1	80	64	56	48	42	36
17	4	4	85	68	59½	51	44⅝	38¼
18	4	7	90	72	63	54	47¼	40½
19	4	10	95	76	66½	57	49⅞	42¾
20	5	1	100	80	70	60	52½	45
21	5	4	105	84	73½	63	55⅛	47¼
22	5	7	110	88	77	66	57¾	49½
23	5	10	115	92	80½	69	60⅜	51¾
24	6	1	120	96	84	72	63	54
25	6	4	125	100	87½	76	65⅝	56¼
26	6	7	130	101	91	78	68¼	58½
27	6	10	135	108	94½	81	70⅞	60¾
28	7	1	140	112	98	84	73½	63
29	7	4	145	116	101½	87	76⅛	65¼
30	7	7	150	120	105	90	78¾	67½

RATINGS - H.B. SMITH PRINCESS AND UNION RADIATORS

Princess

Princess

STEAM OR WATER

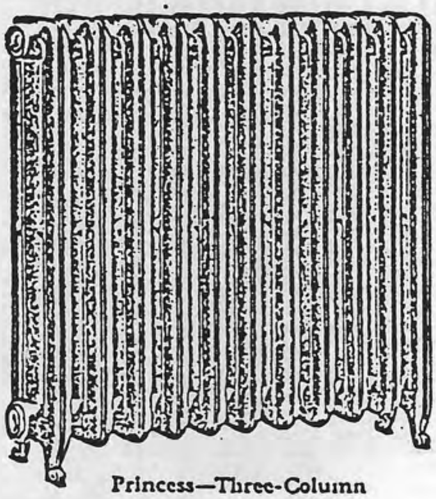
Dimensions

Width of Section ..... 9"

Length of Section..... 3¼"

Height to Center of Regular Tapping... 4¼"

Regular Tapping, see page 34



Princess—Three-Column

Princess

STEAM OR WATER

Three-Column

Radiating Surface in Feet

Sections	Total Length Ft.	Total Length In.	Height 46" 8 ft. per sec.	Height 37" 6½ ft. per sec.	Height 31" 5½ ft. per sec.	Height 26" 4½ ft. per sec.	Height 22" 4 ft. per sec.	Height 19" 3½ ft. per sec.
3	0	10¾	24	19½	16½	13½	12	10½
4	1	2	32	26	22	18	16	14
5	1	5½	40	32½	27½	22½	20	17½
6	1	8¾	48	39	33	27	24	21
7	1	11¾	56	45½	38½	31½	28	24½
8	2	3	64	52	44	36	32	28
9	2	6½	72	58½	49½	40½	36	31½
10	2	9½	80	65	55	45	40	35
11	3	¾	88	71½	60½	49½	44	38½
12	3	4	96	78	66	54	48	42
13	3	7¼	104	84½	71½	58½	52	45½
14	3	10½	112	91	77	63	56	49
15	4	1¾	120	97½	82½	67½	60	52½
16	4	5	128	104	88	72	64	56
17	4	8¼	136	110½	93½	76½	68	59½
18	4	11½	144	117	99	81	72	63
19	5	2¾	152	123½	104½	85½	76	66½
20	5	6	160	130	110	90	80	70
21	5	9¼	168	136½	115½	94½	84	73½
22	6	½	176	143	121	99	88	77
23	6	3¾	184	149½	126½	103½	92	80½
24	6	7	192	156	132	108	96	84
25	6	10¼	200	162½	137½	112½	100	87½
26	7	1½	208	169	143	117	104	91
27	7	4¾	216	175½	148½	121½	108	94½
28	7	8	224	182	154	126	112	98
29	7	11¼	232	188½	159½	130½	116	101½
30	8	2½	240	195	165	135	120	105

Note: These radiators are considerably higher in output than the usual column-type radiators. They usually carry the H.B. Smith name on the end section, and the sections are longer than those of the usual column-type radiators. In sizing a boiler based on installed radiation it is critical that the additional output of these radiators be included, or an undersize boiler will be the disastrous result.

The Union radiator has the same rating as the Princess radiator shown here; they are the same basic radiator, but the Union is highly ornamented.