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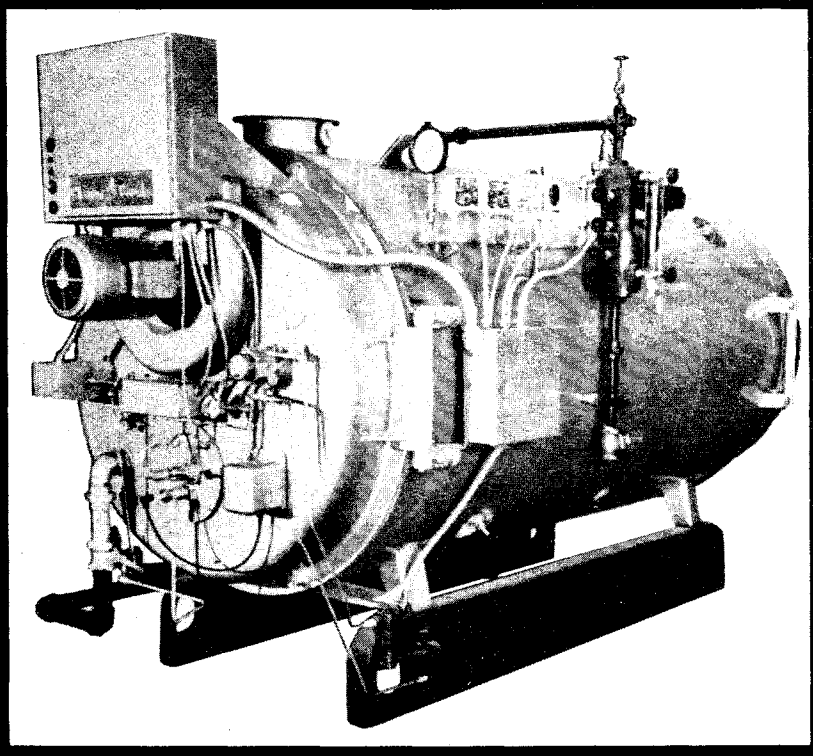
CLEAVER-BROOKS MODEL

CBH

PACKAGED BOILERS

Operation,
Service,
and Parts
Manual

15 Thru 100 HP
Fuel: Light Oil,
Gas or Combination



CLEAVER BROOKS®
The power of commitment.™

Manual Part No. 750-99
Printed in
U.S.A.

CLEAVER-BROOKS
MODEL CBH
PACKAGED BOILERS

Operation, Service, and Parts Manual

CLEAVER BROOKS®

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Manual Part No. 750-99

12/93 Printed in U.S.A.

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WARNING

DO NOT OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS YOU FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

DO NOT ALLOW OTHERS TO OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS THEY FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

FAILURE TO FOLLOW ALL APPLICABLE WARNINGS AND INSTRUCTIONS MAY RESULT IN SEVERE PERSONAL INJURY OR DEATH.

TO: Owners, Operators and/or Maintenance Personnel

This operating manual presents information that will help to properly operate and care for the equipment. Study its contents carefully. The unit will provide good service and continued operation if proper operating and maintenance instructions are followed. No attempt should be made to operate the unit until the principles of operation and all of the components are thoroughly understood. Failure to follow all applicable instructions and warning may result in severe personal injury or death.

It is the responsibility of the owner to train and advise not only his or her personnel, but the contractor's personnel who are servicing, repairing or operating the equipment, in all safety aspects.

Cleaver-Brooks equipment is designed and engineered to give long life and excellent service on the job. The electrical and mechanical devices supplied as part of the unit were chosen because of their know ability to perform; however, proper operating techniques and maintenance procedures must be followed at all times. Although these componesnts afford a high degree of protection and safety, operation of equipment is not to be considered free from all dangers and hazards inherent in handling and firing of fuel.

Any ''automatic'' features included in the design do not relieve the attendant of any responsibility. Such features merely free him/her of certain repetitive chores and give him/her more time tot devote to the proper upkeep of equipment.

It is solely the operator's responsibility to properly operate and maintain the equipment. No amount of written instructions can replace intelligent thinking and reasoning and this manual is not intended to relieve the operating personnel of the responsibility for proper operation. On the other hand, a thorough understanding of this manual is required before attempting to operate, maintain, service, or repair this equipment.

Because of state, local, or other applicable codes, there are a variety of electric controls and safety devices which vary considerably from one boiler to another. This manual contains information designed to show how a basic boiler operates.

Operating controls will normally function for long periods of time and we have found that some operators become lax in their daily or monthly tesing, assuming that normal operation will continue indefinitely. Malfunctions of controls lead to uneconomical operation and damage and, in most cases, these conditions ca nbe traced directly to carelessness and deficiencies in testing and maintenance.

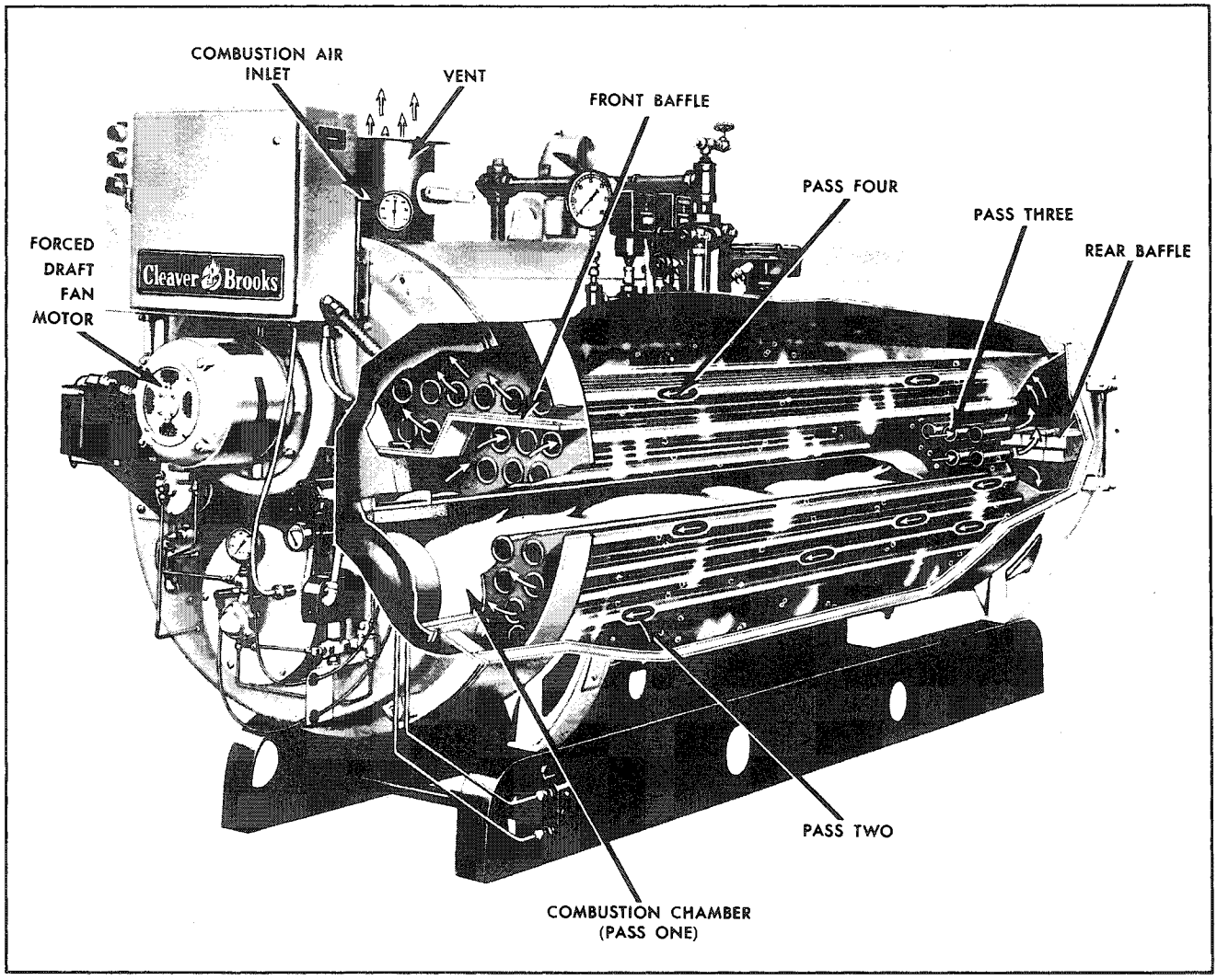
It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, nonthly and yearly maintenance activities and recording of any unusual operation will serve as a valuable guide to any necessary investigation.

Most instances of major boiler damage are the result of operation with low water. We cannot emphasize too strongly the need for the operator to periodically check his/her low water controls and to follow good maintenance and testing practices. Cross-connecting piping to low water devices must be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the low water devices. Float bowls of these controls must be inspected frequently to check for the presence of foreign substances that would impede float ball movement.

The waterside condition of the pressure vessel is of extreme importance. Waterside surfaces should be inspected frequently to check for the presence of any mud, sludge, scale or corrosion.

The services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices are essential.

The operation of this equipment by the owner and his/her operating personnel must comply with all requirements or regulations of his/her insurance company and/or other authority having jurisdiction. In the event of any conflict or inconsistency between such requirements and the warnings or instructions contained herein, please contact Cleaver-Brooks before proceeding.



THE FOUR PASS CONSTRUCTION OF A TYPICAL MODEL CB BOILER

Combustion air enters through the air inlet. The forced draft fan forces air through the rotary air damper and the diffuser into the combustion chamber. The main fire tube or combustion chamber, constitutes pass one. Baffling allows gases to pass to the front of the boiler only through pass two; here a baffle allows gases to pass to the rear of the boiler only through pass three. From the rear the gases are forced through pass four to the vent.

CHAPTER 1

GENERAL DESCRIPTION AND PRINCIPLES OF OPERATION

A. THE BOILER
B. THE BURNER AND CONTROL SYSTEM
C. CONTROL AND COMPONENT FUNCTION
D. AUTOMATIC IGNITION
E. COMBUSTION AIR
F. OIL FUEL FLOW
G. GAS FUEL FLOW

A. THE BOILER

The Cleaver-Brooks Model "CBH" Boiler is a packaged steel boiler consisting of a pressure vessel, oil or gas burner, burner controls, forced draft fan, air control damper, and associated components.

The boiler is a four pass horizontal firetube updraft boiler. The pressure vessel is constructed in accordance with the ASME Boiler and Pressure Vessel Code. Chapter 2 deals with this portion of the boiler.

This manual covers boilers designed for high or low pressure steam or hot water generation in capacities rated from 25 thru 100 horsepower.

The boiler and related equipment installation, by others, is to be in compliance with the standards of the National Board of Fire Underwriters. Installation should also conform to state and local codes governing such equipment. Prior to installation, the proper authorities having jurisdiction are to be consulted, permits obtained etc. All boilers in the above series comply, when equipped with optional equipment, to Factory Insurance Association Div. of Industrial Risk Insurers (F.I.A.), Factory Mutual (FM) or other insuring underwriters requirements.

B. THE BURNER AND CONTROL SYSTEM

The type of fuel used by the boiler determines the series classification. These are:

Series 100	Light oil (No. 2) only
Series 200	Light oil (No. 2) or gas
Series 700	Gas only

A boiler equipped to burn oil and gas includes equipment for each distinct fuel. Since the burner uses only one type of fuel at a time, a gas/oil selector switch is incorporated in the combination units.

The Model CBH boiler has the burner assembly attached to the front head, readily accessible for inspection and maintenance.

The oil burner is of the high pressure atomizing type and the gas burner is of the high radiant annular entry type. A gas burner is ignited by a gas pilot which is spark ignited. A burner that uses light oil fuel only is normally spark ignited. A combination gas-oil unit uses a gas pilot for ignition of both fuels.

The standard burner, whether firing on oil or gas, operates at two burning rates - high fire and low fire. An optionally equipped gas-fired boiler operates on a modulating firing principle. The burner and its components are described in detail later in this manual.

Combustion air is provided by a centrifugal blower located in the front head. Combustion air delivery to the burner is under the control of the damper motor. This same motor regulates the flow of gas fuel through a linkage system connected to the gas butterfly valve or by actuating switches that energize the oil valves. Fuel input and air are thus properly proportioned for most efficient combustion.

An electronic safety control programs the sequence of operation and in conjunction with a flame detector monitors the flame to shut the burner down in the event of loss of flame. Other safety controls shut the burner down under low water conditions or excessive steam pressure or water temperatures.

The burner control circuit operates on 115 volt, single phase 60 hertz (or 50 hertz when equipped)

alternating current. The forced draft fan motor is generally operated on 3 phase service at the available main power supply voltage.

The operating limit and other interlock devices wired into the circuitry provide safe operation of the burner and protect against incorrect operating techniques.

The major electrical components included in the standard control system consist of a programming control, limit and operating pressure or temperature controls, low water cut-off, damper motor, fuel valve(s), and motor starter.

The sequence of burner operation from start-up through shutdown is governed by the programming control in conjunction with the operating, limit and interlock devices. This programmer contains a timer that energizes or de-energizes other controls at the proper time.

The same control monitors the flame to confirm gas pilot operation prior to allowing main fuel valves to open. The ignition of low fire flame on a spark ignited oil burner must likewise be confirmed. The control will shut the burner down in the event of a flame loss or as a result of action by a safety interlock.

The safety interlocks include combustion and air proving equipment and — depending upon insurance company requirements — controls that prove the presence of adequate fuel pressure.

In addition to the standard basic controls supplied, other devices may be required to meet specific requirements of an insurance carrier or local code. Refer to the wiring diagram furnished with the burner to determine the specific controls in the burner and limit control circuits. The function of individual components is outlined in this chapter and the electrical sequence is covered in Chapter 3.

C. CONTROL AND COMPONENT FUNCTION

The term "control" covers the more important valves and components, including but not limited to electrical controls or those monitored by the programming control. The operator must become familiar with the individual functioning of all controls whether or not outlined before he can understand the boiler's operation, and procedures outlined in the manual.

Identify and locate each item using the figure callout.

The actual controls furnished with any given boiler will depend upon the type of fuel for which it is equipped and whether it is a hot water or steam boiler.

Boilers having optionally ordered features may have control components not listed here.

PROGRAMMING AND FLAME SAFEGUARD CONTROL (Figure 1-1)

Automatically programs each starting, operating, and shutdown period in conjunction with operating, limit, and interlock devices. This includes, in a timed and proper sequence, the operation of the blower motor, ignition system, fuel valve(s) and the damper motor. The sequence includes air purges prior to ignition and upon burner shutdown.

The flame detector portion of this control monitors both oil and gas flames and provides protection in the event of loss of a flame signal.

The control recycles automatically during normal operation, or following a power interruption. It must be manually reset following a safety shutdown caused by loss of flame. Incorporated is an internal checking circuit effective on every start which causes a safety lockout in the event anything causes the flame relay to hold in during this period.

The control contains the following major integral components that are referred to in the operating sequence text.

Master relay (1K): Energized when all the limit and operating controls and switches are closed to start program sequencing and to energize the forced draft fan motor starter.

Flame relay (2K): Energized when the flame detector senses a suitable flame. When de-energized by a flame loss it routes control circuit through the lockout switch.

Lockout Switch (LS): Trips in the event of failure to ignite the pilot or main burner flame, or on loss of flame. Additionally, on a CB-40 control, lock-out will occur upon the opening of inter-locks or a flame simulating condition during the programmer's checking period. A short cooling period is required before it can be reset. CAUTION. The reason for any lockout should be investigated and corrected before attempting to re-start.

Timer: Actuates cams to open and close switching contacts in a non-adjustable timed sequence to program the burner's operation through all the functions necessary to operate the burner.

Timer Position Dial: Indicates the position of the timer and the stage reached in burner operating cycle. (Figure 1-1)

Flame Detector: (figure 1-1): Monitors gas or oil pilot and energizes the programmer's flame relay in response to a flame signal. It continues to monitor main flame (oil or gas) after expiration of pilot proving period. A standardly equipped

boiler has a lead sulfide (infrared sensitive) detector.

BURNER SWITCH (Figure 1-1)

A manually operated start-stop switch used for directly starting and stopping burner operation.

FORCED DRAFT FAN MOTOR (Figure 1-1)

Directly drives a forced draft fan to provide combustion air. Also referred to as blower motor. On an oil fired unit the oil pump is driven from this motor by a V-belt.

FORCED DRAFT FAN MOTOR STARTER (Figure 1-1)

Energizes forced draft fan (blower) motor.

DAMPER MOTOR (Figure 1-1)

A two position motor that positions the air damper through a linkage system, to provide proper air-fuel ratio under low fire and high fire conditions. The motor is powered to the open position and spring returned to the closed.

The motor actuates one or more auxiliary switches.

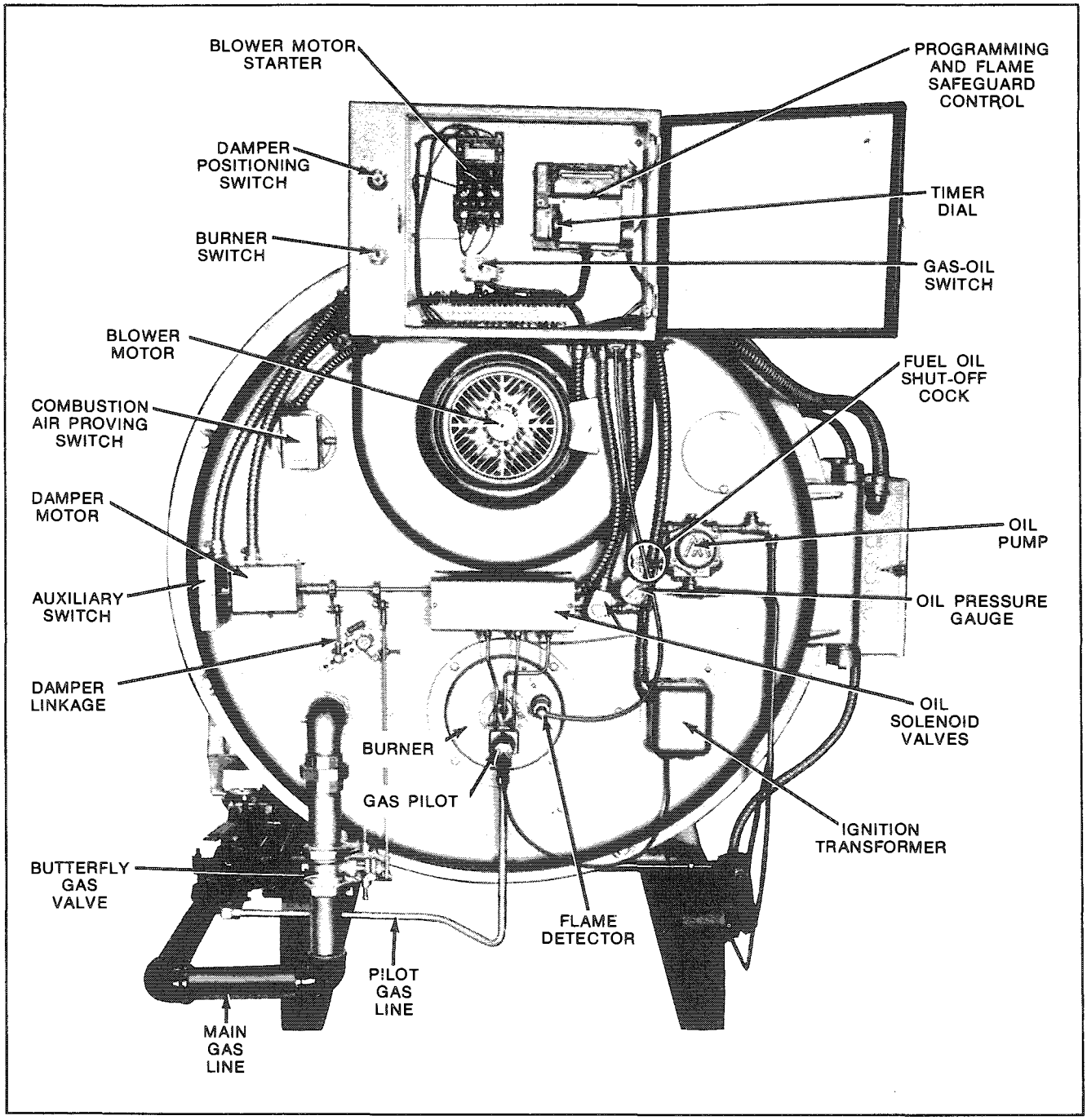


FIGURE 1-1. TYPICAL OIL AND GAS FIRED MODEL CBH BOILER

It also operates, through linkage, the butterfly gas valve.

A modulating motor can be supplied as optional equipment on a gas fired unit. (Figure 1-2) See Section G for details.

DAMPER POSITIONING SWITCH (Manual-Automatic) (Figure 1-1)

A three-position switch for manually setting either high fire or low fire rate or establishing a circuit through the high-low fire control for automatic operation.

AUXILIARY SWITCH(S) (Figure 1-1)

Actuated by damper motor shaft rotation. Each boiler has a switch that serves as a low fire switch to prove that the damper is in a closed position before ignition can take place. An oil fired boiler has additional switches that control oil solenoid valves for high fire operation. An optionally equipped boiler has an additional switch to prove damper opening during the pre-purge.

GAS/OIL SWITCH (Figure 1-1)

Toggle switch used to manually select circuitry for either gas or oil firing.

IGNITION TRANSFORMER (Figure 1-1)

Provides high voltage spark for ignition electrode of gas pilot or light oil burner ignition.

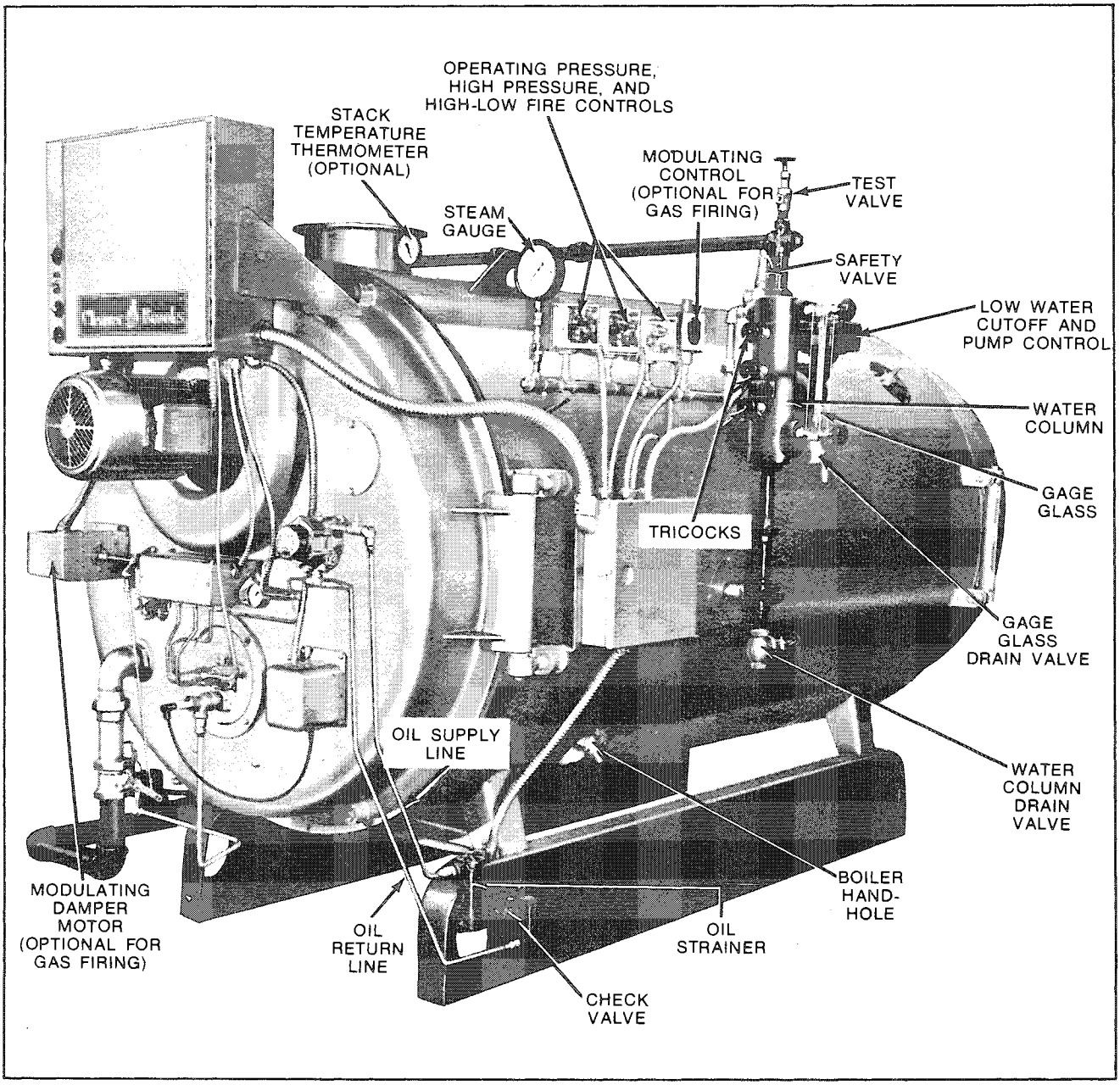


FIGURE 1-2 TYPICAL STEAM BOILER AND CONTROLS

OPERATING LIMIT PRESSURE CONTROL
Steam Boiler (Figure 1-2)
OPERATING LIMIT TEMPERATURE CONTROL - Hot Water Boiler (Figure 1-3)

Breaks a circuit to stop burner operation on a rise of boiler pressure or temperature above a selected setting. It is adjusted to start or stop the burner at a pre-selected pressure or temperature setting.

HIGH LIMIT PRESSURE CONTROL
Steam Boiler (Figure 1-2)
HIGH LIMIT TEMPERATURE CONTROL
Hot Water Boiler (Figure 1-3)

Breaks a circuit to stop burner operation at a pre-selected pressure or temperature above the operating limit control setting. This control must be manually reset to restore the circuit.

HIGH-LOW FIRE CONTROL (Figures 1-2 & 1-3)

A pressure or temperature control which, when placed into the circuit by proper setting of the damper positioning switch, makes or breaks the circuit to the damper motor causing the burner to operate at either high or low fire rate in accordance with load requirements.

MODULATING CONTROL (Figure 1-2)

Senses changing boiler pressures, or temperatures, and transmits this information to the modulating damper motor to change the firing rate. Provided only as optional equipment for a gas fired boiler. When installed on a 200 Series boiler, it is removed from the operating circuitry while the boiler is fired on oil.

LOW WATER CUT-OFF AND PUMP CONTROL (Steam Boiler) (Figure 1-2)

This float-operated control responds to the water level in the boiler. It performs two distinct functions:

(a) Stops firing of the burner if water level lowers below the safe operating point and low water light in the control panel; also causes low water alarm bell (optional equipment) to ring. Code requirements for some models require a manual reset type of low water cutoff. This type requires manual

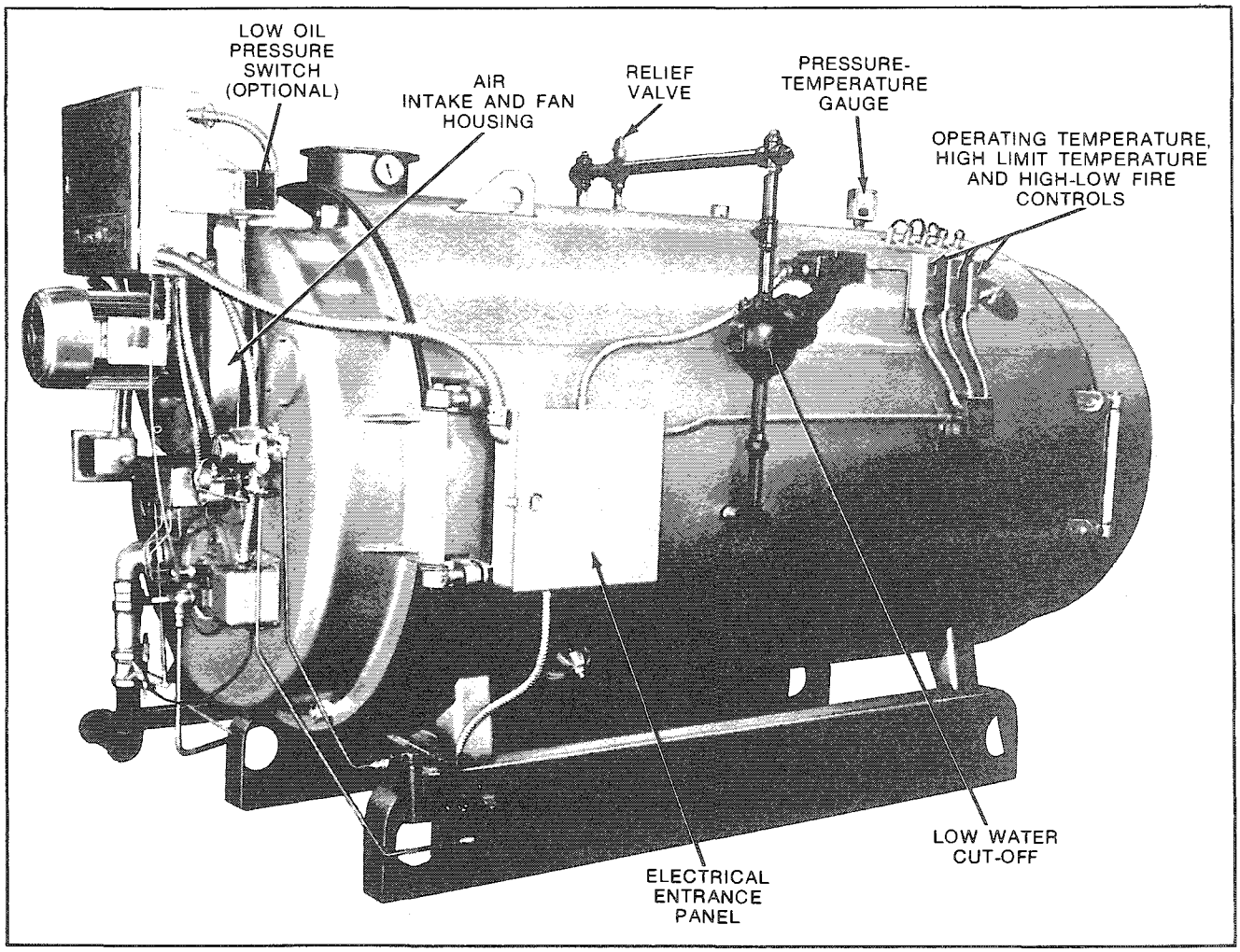


FIGURE 1-3. TYPICAL HOT WATER BOILER AND CONTROLS

resetting to start the burner after a low water shutdown.

(b) Starts and stops the feedwater pump (if used) to maintain water at the proper operating level.

NOTE; Determine that control is plumb after shipment and installation and throughout operating life.

AUXILIARY LOW WATER CUTOFF
(Not shown) (Optional equipment)

This float-operated control breaks the circuit to stop burner operation in the event boiler water drops below the master low water cutoff point. Manual reset type (optional equipment) requires manual resetting in order to start the burner after a low water condition.

LOW WATER CUT-OFF
(Hot Water Boiler) (Figure 1-3)

A float operated control that breaks a circuit to stop burner operation if water level in the boiler drops below a safe operating point.

WATER COLUMN (Figure 1-2)

This assembly houses the low water cutoff and pump control and includes the water gage glass, gage glass shutoff cocks, and trycocks. The gage glass provides a means for visually determining water level.

WATER COLUMN DRAIN VALVE (Figure 1-2)

The water column drain valve is provided so that the water column and its piping can be flushed regularly to assist in maintaining cross-connecting piping and float bowl clean and free of sediment. A similar drain valve is furnished with auxiliary low water cutoff (optional equipment) for same purpose.

WATER GAGE GLASS DRAIN VALVE
(Figure 1-2)

This valve is provided to flush the gage glass.

TEST VALVE (Figure 1-2)

This valve allows the boiler to be vented during filling, and facilitates routine boiler inspection.

PRESSURE GAUGE
(Steam Boiler) (Figures 1-1 & 1-2)

Indicates boiler's internal pressure.

TEMPERATURE/PRESSURE GAUGE
(Hot Water Boiler) (Figure 1-3)

A compound gauge that indicates boiler's internal water temperature and water pressure.

STACK THERMOMETER (Figure 1-2)
Indicates temperature of vented flue gases. (Optional)

SAFETY OR RELIEF VALVE (Figures 1-2 & 1-3)

A safety valve(s) is used on a steam boiler to relieve the boiler of pressures higher than the designed pressure or the pressure designated by the purchaser. A relief valve(s) is used on a hot water boiler for the same purpose.

Safety and relief valves and their escape and drain piping are to be installed to conform to the ASME Code requirements. (Figure 1-7)

WARNING: Only the valve manufacturer or his

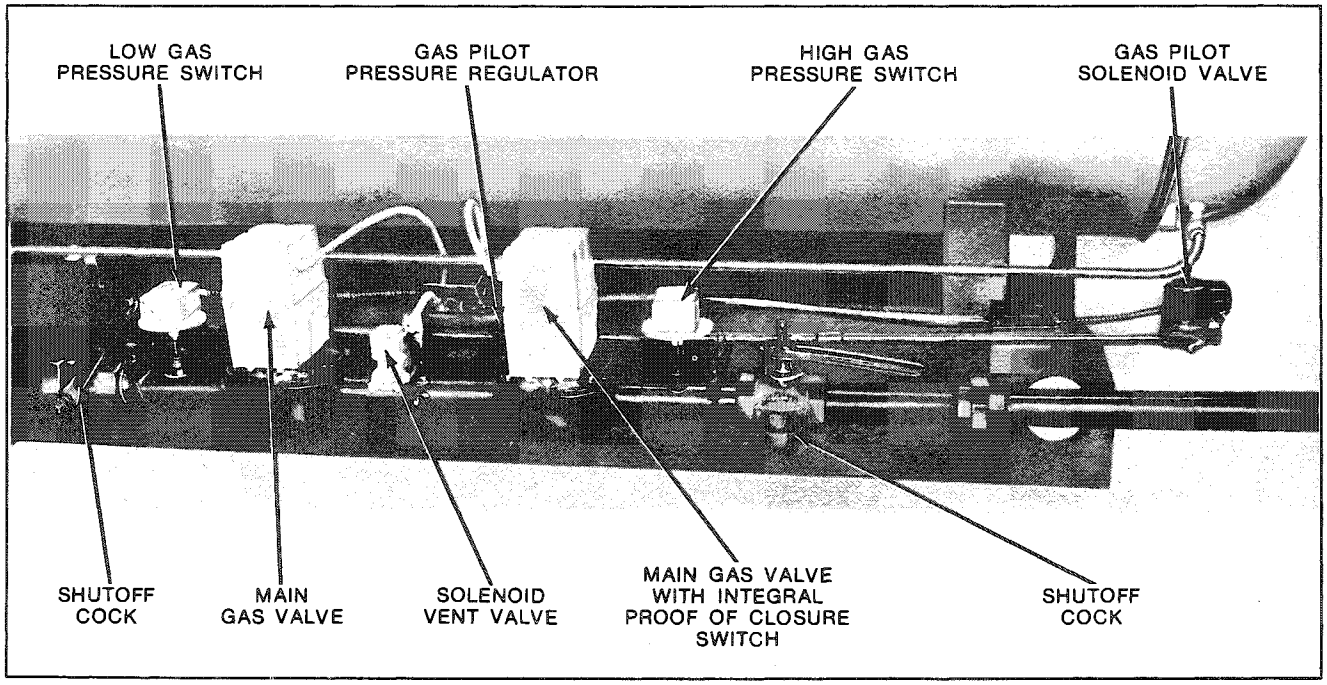


FIGURE 1-4. GAS TRAIN WITH TWO VALVES

representative should adjust or repair these valves.

COMBUSTION AIR PROVING SWITCH (Figure 1-1)

A pressure sensitive switch, actuated by air pressure, whose contacts close to prove sufficient pressure of combustion air from the forced draft fan.

OIL PUMP (Figure 1-1)

Draws oil from supply tank and delivers it under pressure to the burner nozzles. The pump contains an integral adjustable pressure regulator and rotary filter. The pump is driven by a V-belt connected to the blower motor.

OIL BURNER PRESSURE GAUGE (Figure 1-1)

Indicates the fuel pump discharge pressure to nozzle.

FUEL OIL VALVES (Figures 1-1 & 1-6)

Electrically operated to open in a controlled sequence to allow oil flow from the pump to the burner nozzles. The function of the valves is described in the oil fuel flow section later in this chapter.

FUEL OIL SHUT-OFF COCK (Figure 1-1)

For manually shutting off oil supply to burner.

LOW OIL PRESSURE SWITCH (Optional) (Figure 1-3)

Switch contacts open when fuel oil pressure drops below selected pressure. Switch will interrupt the limit circuit upon loss of sufficient fuel oil pressure for correct combustion.

AIR DAMPER (Figure 1-5)

Controls the amount of combustion air admitted to the burner in proper proportion to fuel input for efficient combustion at high or low firing rates.

NOTE: Depending upon the requirements of the insurance carrier or other governing agencies, the gas flow control system, or gas train, may consist of some, or all, of the following items. Refer to your boiler to determine those that are applicable. A typical gas train is shown in figure 1-4.

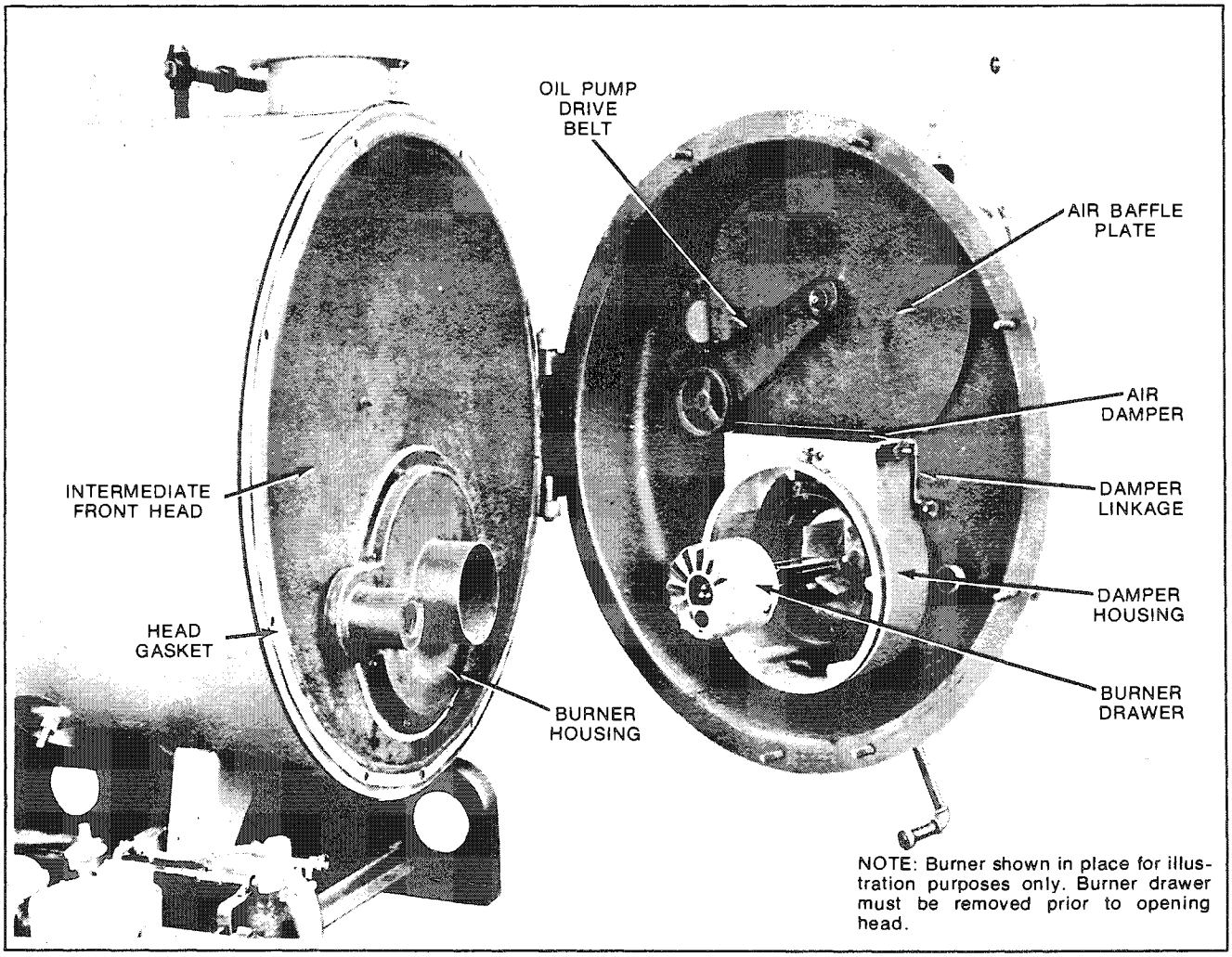


FIGURE 1-5. BOILER WITH FRONT HEAD OPEN, CBH 50-100A OIL AND GAS FIRED

GAS PILOT VALVE (Figure 1-4)

A solenoid valve that opens during the ignition period to admit fuel to the pilot. It closes after main flame is established. The sequence of energizing and de-energizing is controlled by the programming relay.

GAS PILOT SHUT-OFF COCK (not shown)

For manually opening or closing the gas supply to gas pilot valve.

GAS PRESSURE GAUGE (not shown)

Indicates gas pressure to pilot. (Optional)

GAS PRESSURE REGULATING VALVE (Figure 1-4)

Reduces incoming gas pressure to suit the pilot's requirement of between 5" to 10" W.C.

BUTTERFLY GAS VALVE (Figure 1-1)

The pivoted disc in this valve is actuated by connecting linkage from the damper motor to regulate the rate of gas flow to the burner.

MAIN GAS VALVE (Figure 1-4)

An electrically actuated shutoff valve. When open, it admits main flame gas through the butterfly gas valve. The valve may be equipped with a "proof of closure" switch connected into a pre-ignition interlock circuit. A second motorized shutoff gas valve is often used.

GAS VENT VALVE: (Figure 1-4) (Optional)

A normally open solenoid valve installed between the two main gas valves to vent gas to the atmosphere should any be present in the main gas

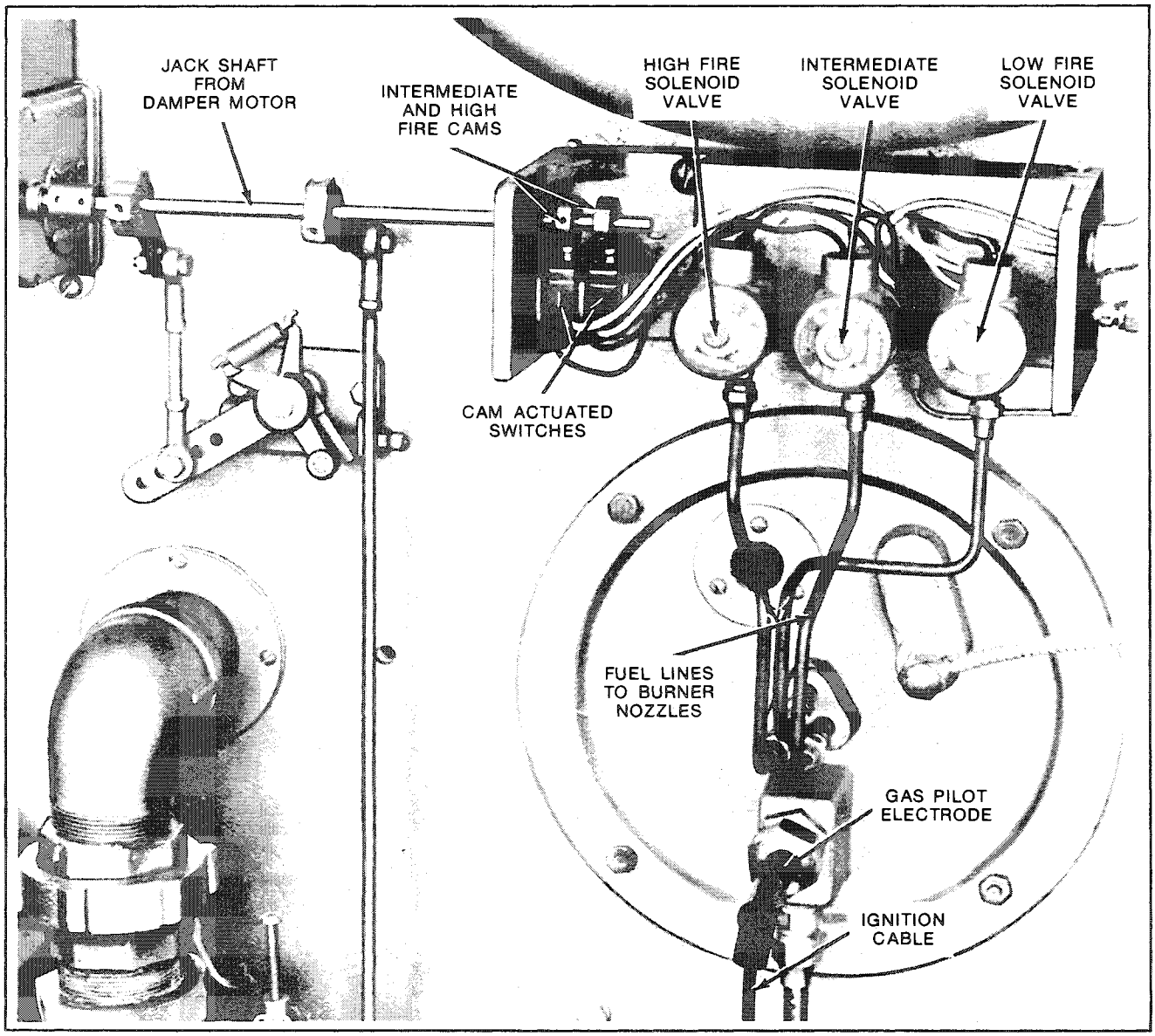


FIGURE 1-6. FUEL OIL CONTROL VALVES

line when the gas valves are de-energized. The vent valve closes when the gas valves are energized.

MAIN GAS COCK (Figure 1-4)

For manually opening and closing the main fuel gas supply downstream of the main gas line pressure regulator. A second shut-off cock, downstream of the main gas valve(s), may be installed to provide a means of shutting off the gas line whenever a test is made for leakage across the main gas valve.

LOW GAS PRESSURE SWITCH (Figure 1-4)

A pressure actuated switch that is closed whenever main gas line pressure is above a preselected pressure. Should the pressure drop below this setting, the switch contacts will open a circuit causing the main gas valve(s) to close, or prevent the burner from starting. This switch is usually equipped with a device that must be manually reset after being tripped.

HIGH GAS PRESSURE SWITCH (Figure 1-4)

A pressure actuated switch that is closed whenever main gas line pressure is below a preselected pressure. Should the pressure rise above the setting, the switch contacts will open a circuit causing the main gas valve(s) to close, or prevent the burner from starting. The switch is usually equipped with a device that must be manually reset after being tripped.

LEAKAGE CONNECTION

The body of the gas valve has a plugged opening that is used whenever it is necessary or desirous to conduct a test for possible leakage across the closed valve.

D. AUTOMATIC IGNITION

A gas burner (and an oil burner on a combination unit), is ignited by an interrupted type gas pilot. Some insurance regulations require that a light oil burner (Model 100) be ignited with a gas pilot although standardly this model has spark ignition.

The gas pilot flame is ignited automatically by an electric spark. Fuel for the pilot is supplied from the utility mains or from a tank (bottle) supply. Flow rate (flame size) is regulated by a pressure regulator (Figure 1-4). The burner is designed to have combustion air flow into and mix with the pilot gas stream to provide a suitable flame.

At the beginning of the ignition cycle, the pilot gas solenoid valve and ignition transformer are simultaneously energized. The ignition transformer supplies high voltage current for the igniting spark which arcs between the single electrode within the pilot tube and the wall of the tube itself. The gas pilot solenoid and transformer are de-energized after main flame is ignited.

On a Model 100 boiler with spark ignition, the low fire oil nozzle is ignited by a spark arcing between two electrodes supplied with high voltage current from the ignition transformer. At the beginning of the ignition cycle, the low fire oil solenoid valve and ignition transformer are simultaneously energized. The ignition transformer is de-energized after low fire is established and proven.

E. COMBUSTION AIR

Air for the combustion of fuel, (also called "secondary" air) is furnished by the forced draft fan (Figure 1-3) mounted in the front head. In operation, air pressure is built up in the entire head and forced through a diffuser plate for a thorough mixture with the fuel for proper combustion.

The supply of combustion air is governed by automatically throttling the output of the fan by regulating the air damper to furnish the proper amount of air for correct ratio of air to fuel for efficient combustion at both low and high firing rates.

F. OIL FUEL FLOW

An oil fired boiler is equipped with a belt driven fuel pump (Figures 1-1 & 1-5) that withdraws fuel oil from a storage tank. The pump has a greater capacity than the maximum burning rate and all oil not delivered to the burner nozzles is returned to the storage tank.

The pump has an integral pressure regulator that can be adjusted to provide the necessary atomizing

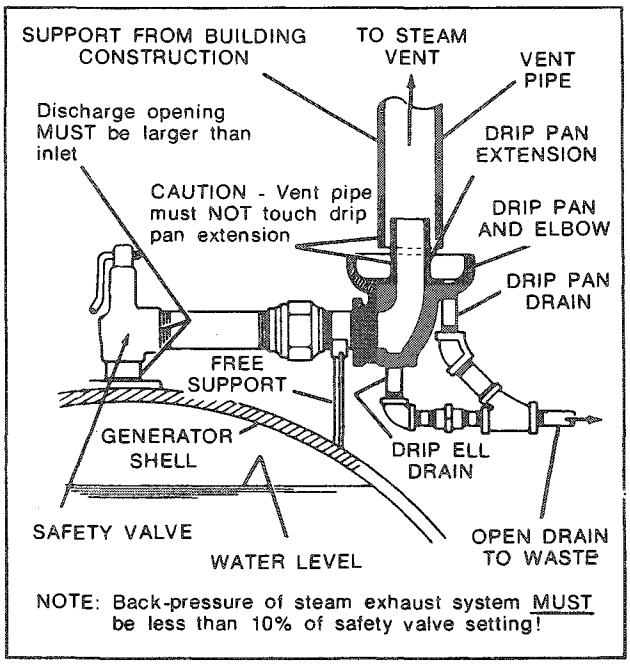


FIGURE 1-7. RECOMMENDED SAFETY VALVE INSTALLATION PROCEDURE

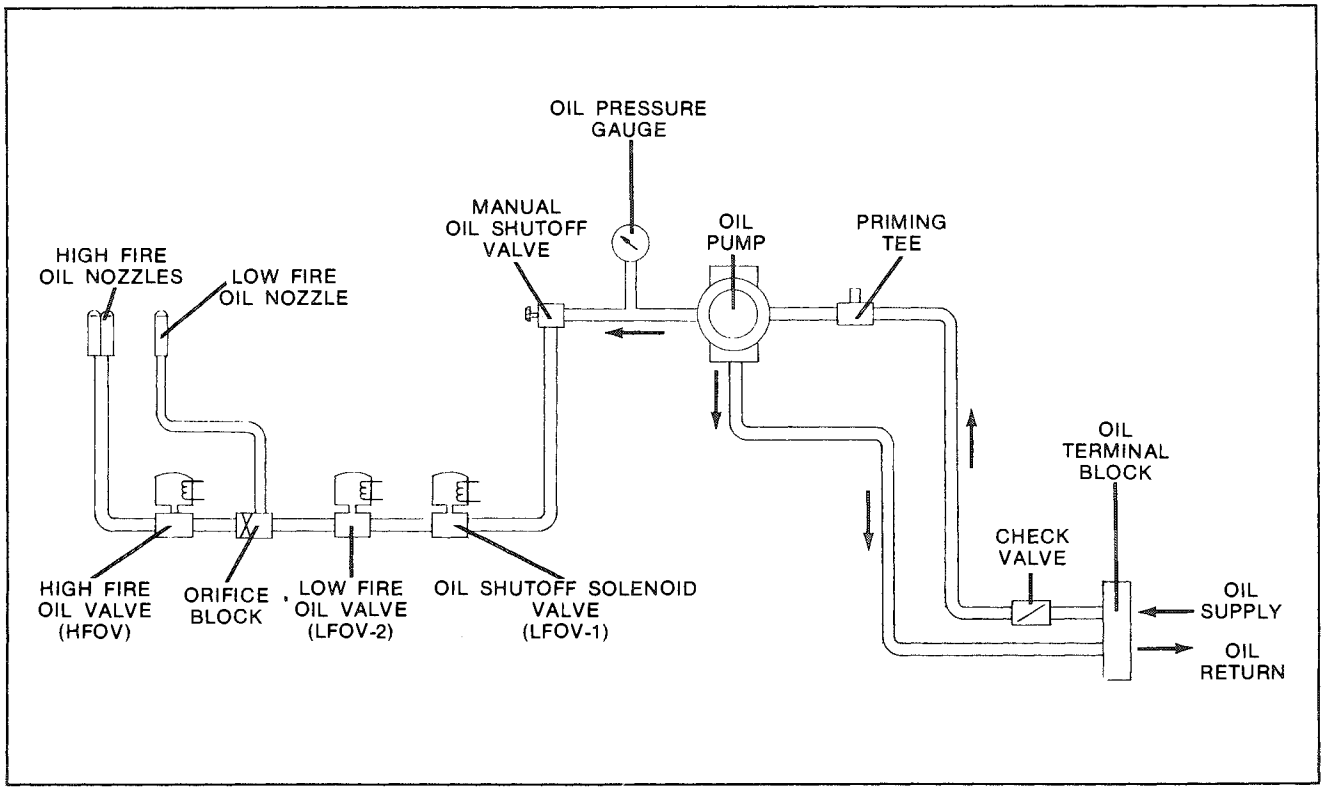


FIGURE 1-8. SCHEMATIC OIL FLOW DIAGRAM, MODEL CBH 25-40 AND 50A

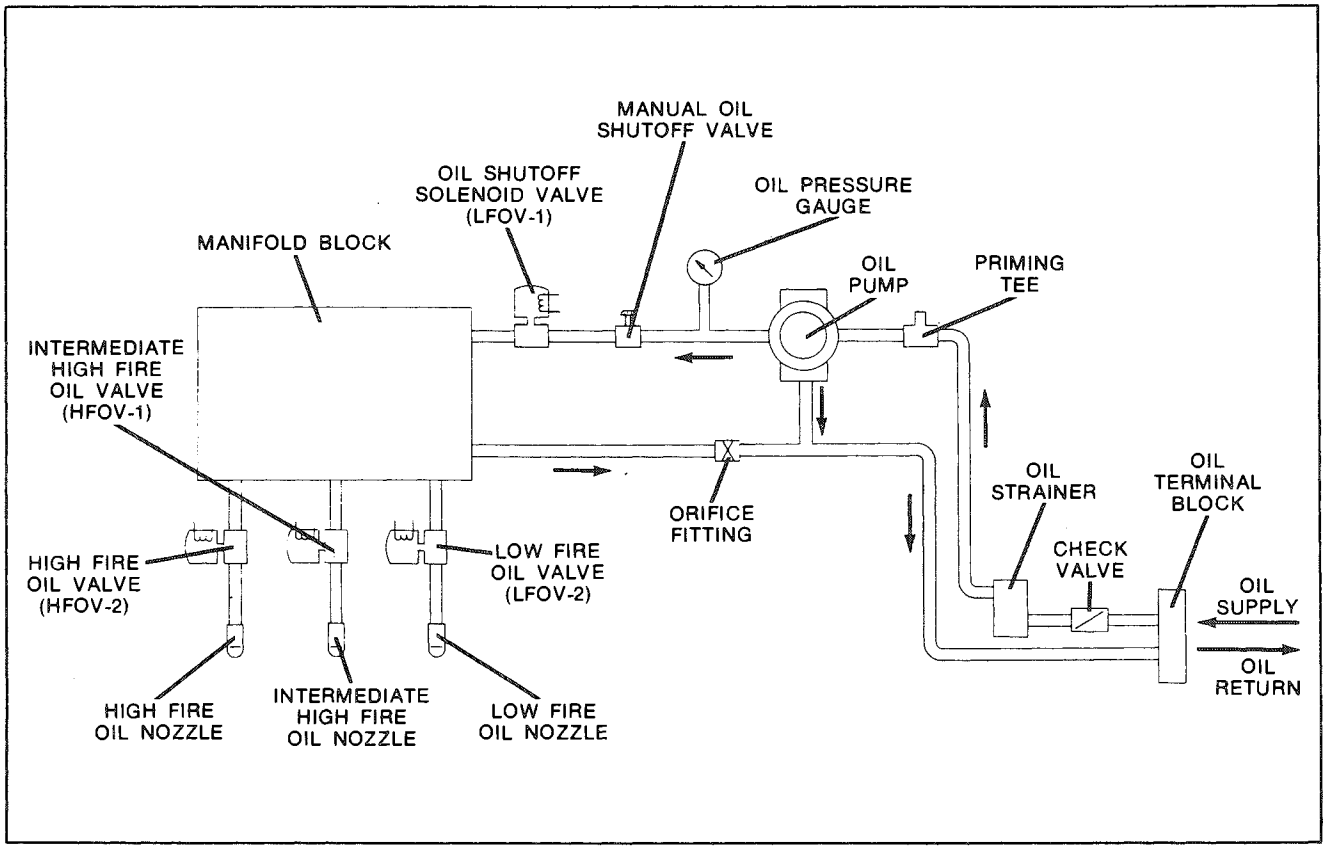


FIGURE 1-9 SCHEMATIC OIL FLOW DIAGRAM, MODEL CBH 50-100

pressure to the burner nozzles. This pressure is read on the oil pressure gauge.

Oil flow to the burner nozzles is controlled by solenoid valves. At the proper time in the operating sequence, the primary, or safety, shut-off valve (LFOV-1) and the low fire valve (LFOV-2) are energized by the programming control. The opening of these valves allows the oil to flow to the low fire nozzle.

When the damper motor moves to the high fire position, an auxiliary switch actuated by the motor, energizes a high fire valve.

Figure 1-8 shows the valves used on the 25 through 40 and 50A size boilers. The orifice block between the valves prevents a sudden pressure drop when the high fire valve opens.

The oil discharge from the pump on the 50 through 100 size flows into a manifold block (Figure 1-9). The intermediate valve is energized prior to the high fire valve. The purpose for this is to make the change from low to high fire smoother by balancing the oil input with the increasing flow of air as the damper opens. The return line from the manifold is orificed to maintain a constant pressure.

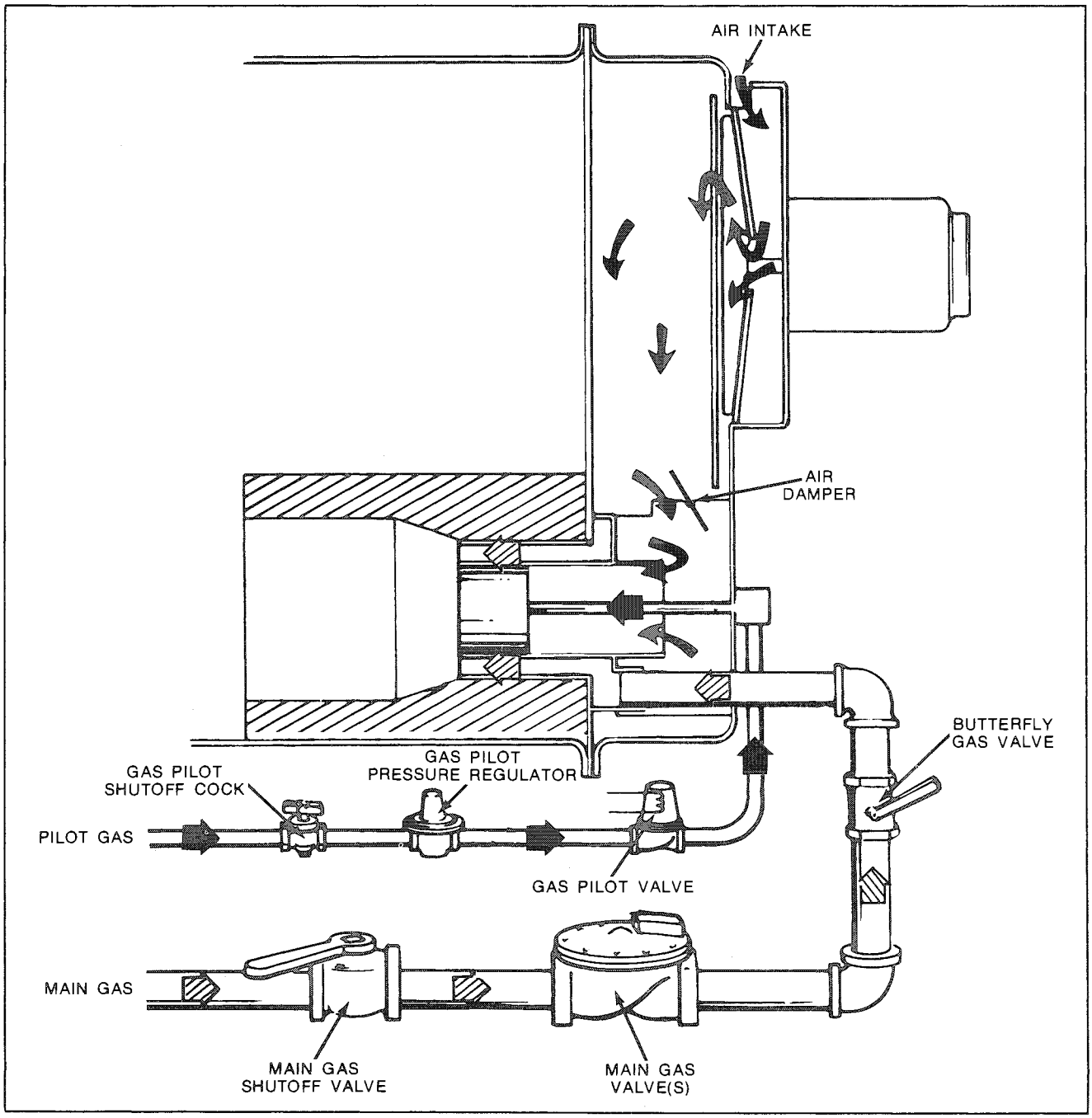


FIGURE 1-10. SCHEMATIC GAS FLOW DIAGRAM

G. GAS FUEL FLOW

The gas flow system is shown with the direction of flow indicated by arrows. (Figure 1-10)

Metered gas from the utility flows into the burner's gas piping through a main gas shut-off cock; through a pressure regulator where the pressure is reduced to the pressure suitable to the burner's requirements; through an electrically operated main gas valve and through a butterfly gas valve to the burner. Gas required for pilot operation is taken from this line prior to the main gas shut-off cock.

Gas for the pilot operation flows through a shut-off cock into a pressure regulator where the pilot operating pressure is established. A solenoid valve controls the flow of the gas and when energized (opened) allows the gas to flow to the pilot where it is mixed with combustion air. This mixture is ignited by a controlled electric spark to establish the pilot flame. The pilot burns only during the time required for main flame ignition.

At the beginning of the ignition cycle, the pilot solenoid valve is energized through circuitry in the programmer control and the pilot ignited. When pilot flame is proven, the programming control energizes the electrically operated main gas valve allowing flow through the butterfly valve to the burner. The rate of flow to the burner depends upon the position of the vane in the butterfly valve. This is mechanically controlled by the damper motor and varied in the same manner as the air damper, thus properly proportioning gas and combustion air.

High-Low Burner Operation

The standard burner is equipped for two position firing; either low or high. A pressure control on a steam boiler, or a temperature control on a hot water boiler, makes or breaks the circuit to the damper motor causing the burner to operate at either the high fire or the low fire rate in accordance with load requirements.

Modulating Burner Operation

An optionally equipped gas fired boiler has a modulating damper motor. This type of motor is reversible and will move in either direction or stop at any position within its range.

Through a linkage arrangement it controls the air damper and the butterfly gas valve to maintain a constant air-fuel ratio throughout the firing range.

Gas flows through the burner orifice ring to enter the combustion zone where it is intimately mixed with combustion air to produce main flame.

The main gas valve cannot be energized (opened) unless the combustion air proving switch is closed to indicate a sufficient supply of combustion air.

Some insurance requirements specify two main gas valves. Additional requirements call for a normally open vent valve to be placed between them for venting gas should any be present in main gas line when main gas valves are de-energized. The vent valve closes when the main gas valves open.

CHAPTER 2

THE PRESSURE VESSEL

A. GENERAL
B. CONSTRUCTION
C. WATER REQUIREMENTS
   1. HOT WATER BOILER
   2. STEAM BOILER
D. WATER TREATMENT
E. CLEANING
F. BOIL-OUT OF A NEW UNIT
G. WASHING OUT
H. BLOWDOWN—STEAM BOILER
I. PERIODIC INSPECTION
J. PREPARATION FOR EXTENDED LAY-UP

A. GENERAL

This chapter is devoted primarily to the waterside care of the pressure vessel.

Water requirements for both steam and hot water boilers are essential to boiler life and length of service. Constant attention to this area will pay dividends in the form of longer life, less down time, and prevention of costly repairs. Care taken in placing the pressure vessel into initial service is vital. The waterside of new boilers and new or remodeled steam or hot water systems may contain oil, grease or other foreign matter. A method of boiling out the vessel to remove these accumulations is described later in this chapter.

The subject of water supply and treatment cannot adequately be covered in this manual. Nevertheless it is of prime importance. The type of service your boiler performs has an important bearing in the amount of waterside care it will require.

Feedwater equipment should be checked and ready for use. See that all valves, piping, boiler feed pumps, and receivers are installed in accordance with prevailing codes and practices.

A boiler, as a part of a hot water system, requires proper circulation and the system must be operated as intended by its designer to avoid shock or severe, possibly damaging, stresses occurring to the pressure vessel.

The operator should familiarize himself with this chapter before attempting to place the unit into operation.

B. CONSTRUCTION

All pressure vessels are constructed in accordance with the ASME Boiler and Pressure Vessel Code. Steam boilers for operation at pressure not exceeding 15 psig, but within the limits of good safety valve practices, are constructed to section IV, Low Pressure Heating Boilers, of this Code. Hot water boilers for operation with water temperature not exceeding 240°F. may be built as 30 psig design, but because of static head may be built up to 160 psig design and constructed to section IV of Low Pressure Heating Boiler Code. For water temperatures between 240-250°F, minimum design pressure is 60 psig, but because of static head may be as high as 160 psig and constructed to section IV of Low Pressure Heating Boiler Code.

Those steam boilers designed for operation exceeding 15 psig are constructed in accordance with section I Power Boilers, of the ASME Code. Hot water boilers for operation over 250°F are likewise built to this Code.

C. WATER REQUIREMENTS

1. HOT WATER BOILER

Air Removal

The hot water outlet includes a dip tube which extends 2 to 3 inches into the boiler. This dip tube reduces the possibility of any air which may be trapped at the top of the shell from entering into the system.

Any oxygen or air which is released in the boiler will collect or be trapped at the top of the boiler shell.

The air vent tapping on the top center line of the boiler should be piped into the expansion or compression tank. Any air which is trapped at the top of the boiler will find its way out of the boiler through this tapping.

Minimum Boiler Water Temperature — The minimum recommended boiler water temperature is 170 degrees F. When water temperatures lower than 170 degrees F are used, the combustion gases are reduced in temperature to a point where the water vapor condenses. The net result is that corrosion occurs in the boiler and breeching.

This condensation problem is more severe on a unit which operates intermittently and which is greatly oversized for the actual load. This is not a matter which can be controlled by boiler design, since an efficient boiler extracts all the possible heat from the combustion gases. However, this problem can be minimized by maintaining boiler water temperatures above 170 degrees F.

Rapid Replacement of Boiler Water — The system layout and controls should be arranged to prevent the possibility of pumping large quantities of cold water into a hot boiler, thus causing shock, or thermal stresses. A formula, or "magic number" cannot be given, but it should be borne in mind that 200 degrees or 240 degrees water in a boiler cannot be completely replaced with 80 degrees water in a few minutes' time without causing thermal stress. This applies to periods of "normal-operation" as well as during initial start-up.

This problem can be avoided in some systems by having the circulating pump interlocked with the burner so that the burner cannot operate unless the circulating pump is running.

When individual zone circulating pumps are used, it is recommended that they be kept running - even though the heat users do not require hot water. The relief device or by-pass valve will thus allow continuous circulation through the boiler and can help prevent rapid replacement of boiler water with "cold" zone water.

Continuous Flow Through the Boiler — The system should be piped and the controls so arranged that there will be water circulation through the boiler under all operating conditions. The operation of three way valves and system controls should be checked to make sure that the boiler will not be by-passed. Constant circulation through the boiler eliminates the possibility of stratification within the unit and results in more even water temperatures to the system.

A rule of thumb of 1/2 to 1 gpm per boiler horsepower can be used to determine the minimum continuous flow rate through the boiler under all operating conditions.

Before initial firing or refiring after boiler has been drained, the operator should determine that a flow of water exists through the boiler.

Water Circulation

The chart in Fig. 2-1 shows the maximum G.P.M. circulation rate of boiler water in relation to full boiler output and system temperature drop.

Multiple Boiler Installations — When multiple boilers of equal or unequal size are used, care must be taken to insure adequate or proportional flow through the boilers. This can best be accomplished by use of balancing cocks and gauges in the supply line from each boiler. If balancing cocks or orifice plates are used, a significant pressure drop (e.g. 3-5 psi) must be taken across the balancing device to accomplish this purpose.

If care is not taken to insure adequate or proportional flow through the boilers, this can result in wide variations in firing rates between the boilers.

In extreme cases, one boiler may be in the "high fire" position, and the other boiler or boilers may be loafing. The net result would be that the common header water temperature to the system would not be up to the desired point. This is an important consideration in multiple boiler installations.

Pressure Drop Through Boiler — There will be a pressure drop of less than three feet head (1 psi-2.31 ft. hd.) through all standardly equipped Cleaver-Brooks boilers operating in any system which has more than a 10 degree F. temperature drop.

Pump Location — It is recommended that the system circulating pumps take suction from the outlet connection on the boiler and that they discharge to the system load. This puts the boiler and the expansion tank on the suction side of the pump. This location is preferred because it decreases air entry into the system and does not impose the system head on the boiler.

It is common practice to install a standby system circulating pump, and these main circulating pumps are usually located adjacent to the boilers in the boiler room.

Pump Operation — Pumps are normally started and stopped by manual switches. It is also desirable to interlock the pump with the burner so that the burner cannot operate unless the circulating pump is running.

Pressure

The design of the system and the usage requirements will often dictate the pressure exerted upon the boiler. Some systems are pressurized with air or with an inert gas, such as nitrogen. Caution must be exercised to make sure that the proper relationship of pressure to temperature exists within the boiler so that all of the boilers' internal surfaces are fully wetted at all times. It is

Boiler Size (BHP)	Boiler Output (1000) Btu/Hr	System Temperature Drop — Degrees F									
		10	20	30	40	50	60	70	80	90	100
		Maximum Circulating Rate — GPM									
15	500	100	50	33	25	20	17	14	12	11	10
20	670	134	67	45	33	27	22	19	17	15	13
30	1,005	200	100	67	50	40	33	29	25	22	20
40	1,340	268	134	89	67	54	45	38	33	30	27
50	1,675	335	168	112	84	67	56	48	42	37	33
60	2,010	402	201	134	101	80	67	58	50	45	40
70	2,345	470	235	157	118	94	78	67	59	52	47
80	2,680	536	268	179	134	107	90	77	67	60	54
100	3,350	670	335	223	168	134	112	96	84	75	67
125	4,185	836	418	279	209	168	140	120	105	93	84
150	5,025	1,005	503	335	251	201	168	144	126	112	100
200	6,695	1,340	670	447	335	268	224	192	168	149	134
250	8,370	1,675	838	558	419	335	280	240	210	186	167
300	10,045	2,010	1,005	670	503	402	335	287	251	223	201
350	11,720	2,350	1,175	784	587	470	392	336	294	261	235
400	13,400	2,680	1,340	895	670	535	447	383	335	298	268
500	16,740	3,350	1,675	1,120	838	670	558	479	419	372	335
600	20,080	4,020	2,010	1,340	1,005	805	670	575	502	448	402
700	23,430	4,690	2,345	1,565	1,175	940	785	670	585	520	470
800	26,780	5,360	2,680	1,785	1,340	1,075	895	765	670	595	535

FIGURE 2-1. CIRCULATION CHART

for this reason that the internal boiler pressure, as indicated on the water pressure gauge, must be held to the level shown in Fig. 2-2.

When initially firing a newly installed boiler or when cutting an existing boiler into an operating system, the boiler or boilers to be cut into operation MUST be pressurized equal to the system and/or other boilers prior to cutting in.

It is advisable to have a thermometer installed in the return line to indicate return water temperature. With this determined and with the supply water temperature to system known, the temperature differential will be established. With knowledge of the pumping rate, the operator can easily detect any excessive load condition and take appropriate corrective action. (See Figure 2-1).

Special caution must be taken to guard against any condition, or combination of conditions which might lead to the transfer of cold water to a hot boiler or hot water to a cold boiler. This is particularly true in the case of boilers which are operated for purposes other than supplying hot water for the normal system load (as an example, boilers equipped with coils for domestic hot water). It cannot be over emphasized that rapid changes in temperature within the boiler can, and sometimes do, cause damage.

2. STEAM BOILER

Feed Pump Operation

Make certain that all valves in the water feed line are open BEFORE turning on the pump motor to prevent possible damage to feed pump mechanism. After opening valves, momentarily energize feed pump motor to establish correct pump rotation. With correct rotation, close boiler feed pump entrance switch. Pump should shut down when water level reaches proper level shown in Figure 2-3.

Feedwater pumps must have adequate capacity to maintain required water level under all operating conditions. Check feedwater pumps periodically and maintain as necessary to prevent unexpected breakdowns.

NOTE: Prior to operating pump, carefully check alignment of flexible coupling if one is used. A properly aligned coupling will last

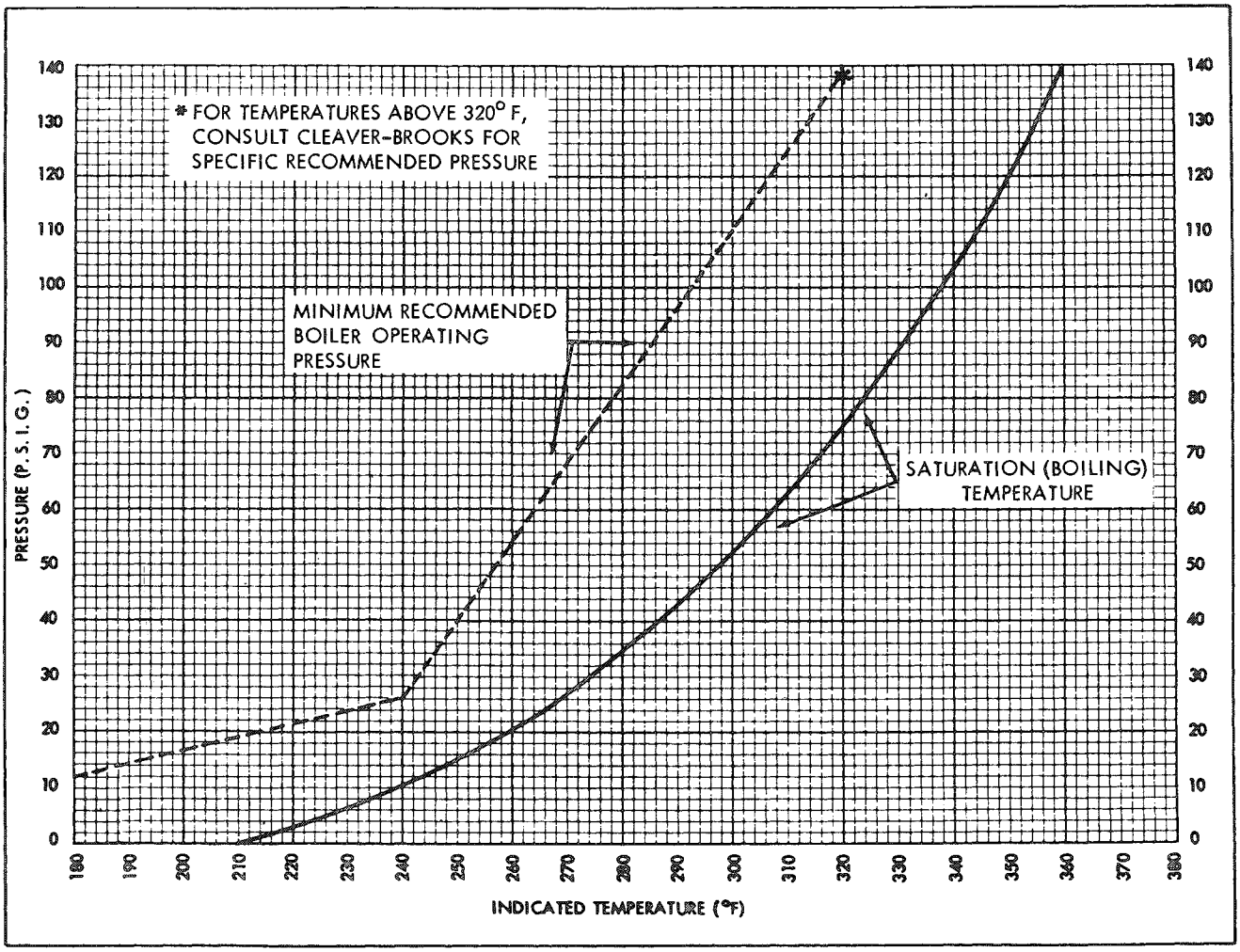


FIGURE 2-2. PRESSURE - TEMPERATURE CHART FOR HOT WATER BOILERS

a long time and provide trouble free mechanical operation.

Water Feeder Operation

This type of operation is usually applicable to boilers operating at 15 psi steam or less. It is only necessary to open the water supply line valve and the water feeder discharge valve. The water feeder should close when water reaches the proper level as shown in Figure 2-3.

NOTE: In the event that water column isolation valves are provided or installed, it must be established that these valves are not only open but that they are sealed or locked in the open position. If these valves are installed it is illegal to operate the boiler with closed or unsealed open valves.

D. WATER TREATMENT

Maximum effectiveness and long trouble-free life of pressure vessels, at the lowest cost consistent with good engineering and operating practice are functions of properly treated boiler feedwater. The recommendations of a water consultant or a reliable water treating company should be followed rigidly to prevent the presence of unwanted solids and corrosive gases.

Objectives of water treatment in general are:

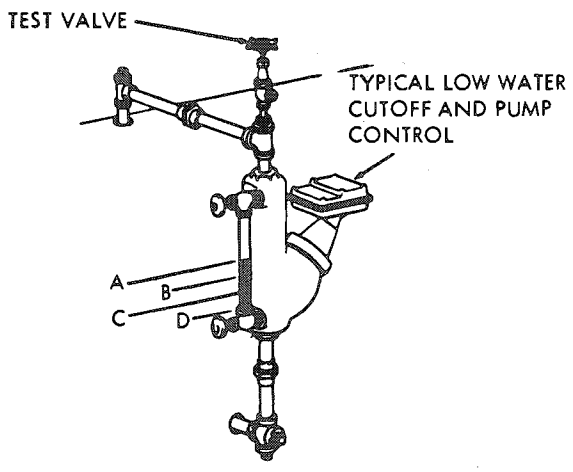
a) Prevention of hard scale deposits or soft sludge deposits which impair the rate of heat transfer and can lead to overheated metal and costly down time and repairs.

b) Elimination of corrosive gases in the supply or boiler water.

c) Prevention of intercrystalline cracking or caustic embrittlement of boiler metal.

d) Prevention of carryover and foaming.

The accomplishment of these objectives generally requires proper feedwater treatment before and after introduction of the water into the boiler. The selection of pre-treatment processes depends upon the water source, its chemical characteristics, amount of makeup water needed, plant operating practices, etc. These treating methods include



A. High level of water: Feed pump turns off at this point. Fill pressure vessel initially to this height.

B. Pump turns on when water level reaches B. Distance A-B is approximately 3/4 inch.

C. Low Water Cutoff Point: Burner will shut off if water level lowers to this point.

D. First visible point of gauge glass.

FIGURE 2-3. BOILER WATER LEVEL DETAILS (STEAM BOILER)

filtering, softening, de-mineralizing, deaerating and pre-heating. After-treatment involves chemical treatment of the boiler water.

Because of the variables involved, no one "boiler compound" can be considered a "cure-all" nor is it advisable to experiment with homemade treating methods. Sound recommendations and their employment should be augmented by a periodic analysis of the feedwater, boiler water, and condensate.

The internal or waterside surfaces of the pressure vessel should be inspected with sufficient frequency to determine the presence of any contamination, accumulations of foreign matter, of corrosion and/or pitting. If these conditions are detected the water consultant or feedwater treating company should be consulted for advice on corrective action.

It is recommended that a properly sized water meter be installed in the raw water make-up line to accurately determine the amount of raw water admitted to the boiler (steam or hot water) to aid the water treatment program in maintaining proper waterside conditions.

The general feeling exists that a hot water boiler does not require water treatment, but this is a false assumption. The recommendations of a reliable water treating company or a water consultant should be followed rigidly. Even though these units generally operate on closed systems and blowdown is seldom practiced, the need remains to be alert to system water losses and a water meter is recommended for water make-up lines.

E. CLEANING

Hot Water and Steam Piping

Steam and water piping systems connected to the boiler may contain oil, grease or foreign matter. These impurities must be removed to prevent damage to pressure vessel heating surfaces. On a steam system the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, attention must be given to the treatment of the raw water used as make up so that an accumulation of unwanted materials or corrosion does not occur. Follow the advice of your water treating company.

On a hot water system, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult water treatment companies for recommendations, cleaning compounds and application procedures.

Pressure Vessel

The waterside of the pressure vessel must be kept clean from grease, sludge and foreign material. Such deposits, if present, will not only shorten the life of the pressure vessel and interfere with efficient operation and functioning of control or safety devices, but might quite possibly cause unnecessary and expensive re-work, repairs and down time.

The installation and operating conditions which the boiler will be subjected to should be considered and cleaning of the waterside of the pressure vessel should be provided during the course of initial start-up.

The pressure vessel and the steam and return lines or hot water piping represent, in effect, a closed system. Although the steam and return (condensate) lines or the hot water piping system may have been previously cleaned it is possible that:

1) Cleaning has been inadequate.
2) Partial or total old system is involved.
3) Conditions may prevent adequate cleaning of piping.

The pressure vessel waterside should be inspected on a periodic basis. This will reveal true internal conditions and serve as a check against conditions

indicated by chemical analysis of the boiler water. Inspection should be made three months after initial starting and at regular 6, 9 or 12 month intervals thereafter. The frequency of further periodic inspections will depend upon the internal conditions found.

If any unwanted conditions are observed water consultant or water treating company should be contacted for recommendations.

Any sludge, mud or sediment found will have to be flushed out. The effectiveness of the blowdown practiced on steam boilers will be verified and scheduling or frequency of blowdown may have to be revised. The need for periodic draining or washout will also be indicated.

Any oil or grease present on the heating surfaces should be removed promptly by a boil-out with an alkaline detergent solution.

NOTE: Temperature of initial fill of water for hydrostatic tests, boil-out, or for normal operation should be as stated in the ASME Boiler Code.

F. BOIL-OUT OF A NEW UNIT

The internal surfaces of a newly installed boiler may have oil, grease or other protective coatings used in manufacturing. Such coatings must be removed since they lower the heat transfer rate and could cause over heating of a tube. Before boiling out procedures may begin, the burner should be ready for firing. The operator must be familiar with the procedure outlined under burner operation.

Your water consultant or water treating company will be able to recommend a cleaning or boil-out procedure. In the event such service is unavailable or is yet unselected, the following information may be of assistance.

Suggested procedure for boiling out new units is as follows:

1. Tri-sodium phosphate and caustic soda are the suggested chemicals for cleaning of boilers. The quantities will vary according to conditions but an amount of one pound of each chemical per 50 gallons of water is suggested. See chart below for boiler water capacity.

Boiler Model and Size	Water — Gallons		Water — Weight	
	Normal	Flooded	Normal	Flooded
CBH 25	210	235	1750	1960
CBH 30	205	230	1710	1915
CBH 40	275	310	2290	2585
CBH 50A	—	295	—	2460
CBH 50	375	440	3125	3665
CBH 60	350	420	2920	3500
CBH 70	550	650	4625	5420
CBH 80	535	630	4460	5250
CBH 100	610	715	5085	5960
CBH 100A	—	595	—	4960

2. When dissolving chemicals, the following procedure is suggested. Warm water should be put into a suitable container. Slowly introduce the dry chemical into the water stirring at all times until the chemical is completely dissolved. Add the chemical slowly and in small amounts to prevent excessive heat and turbulence.

CAUTION

Use of a suitable face mask, goggles, rubber gloves, and protective garments is strongly recommended when handling or mixing caustic chemicals. Do not permit the dry material or the concentrated solution to come in contact with skin or clothing.

3. An over flow pipe should be attached to one of the top boiler openings and routed to a safe point of discharge. A relief or safety valve tapping is usually used.
4. Water relief valves and steam safety valves must be removed before adding the boil-out solution so that neither it nor the grease which it may carry will contaminate these valves. Use care in removing and re-installing valves.

Refer to Section J in Chapter 5 for valve installation instructions.

5. All valves in the piping leading to or from the system must be closed to prevent cleaning solution from getting into the system.
6. Fill pressure vessel with clean water until top of tubes are covered. Add the cleaning solution and then fill to the top. The temperature of the water used in this initial fill should be at ambient temperature.
7. The boiler should then be fired intermittently at a low rate sufficient to hold solution just at the boiling point. Boil the water for at least five hours. Do not produce steam pressure.
8. Allow a small amount of fresh water to enter boiler to create a slight overflow that will carry off surface impurities.
9. Continue boil and overflow until water clears. Shut burner down.
10. Let boiler cool to 120°F or less, then drain using caution that the water is discharged with safety.
11. Remove hand hole plates and wash the waterside surfaces thoroughly using a high pressure water stream.
12. Inspect surfaces and if not clean repeat the boil out.
13. After closing openings and reinstalling safety or relief valves fill boiler and fire until water

is heated to at least 180°F to drive off any dissolved gases which might otherwise corrode the metal.

The above procedure may be omitted in the case of a unit previously used or known to be internally clean, however, consideration must be given to the possibility of contaminating materials entering the boiler from the system.

On a steam system, the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, attention must be given to the treatment of the raw water used as makeup so that an accumulation of unwanted materials or corrosion does not occur. Follow the advice of your water treating company.

On a hot water system, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult water treatment companies for recommendations, cleaning compounds and application procedure.

G. WASHING OUT

A. STEAM BOILER

No later than 3 months after initially placing the boiler into operation and starting service, and thereafter as conditions warrant, the pressure vessel should be drained after being properly cooled to near ambient temperature, handhole covers removed and internal waterside surfaces inspected for corrosion, pitting, or formation of deposits.

B. HOT WATER BOILER

In theory, a hot water system and boiler that has been initially cleaned, filled with raw water (and that water treated) and with no make-up water added will require no further cleaning or treatment. However, since the system (new or old) may allow entrance of air and unnoticed or undetected leakage of water, introductions of raw water make-up or air may lead to pitting, corrosion and formation of sludge, sediment, scale, etc., on the pressure vessel waterside.

If the operator is absolutely certain that the system is tight, then an annual waterside inspection may be sufficient.

If there is any doubt then the pressure vessel waterside should be inspected no later than 3 months after initially placing the boiler into operation and periodically thereafter as indicated by conditions observed during inspections.

FLUSHING OF PRESSURE VESSEL INTERIOR

Upon completion of inspection, the pressure vessel interior should be flushed out as required with a high pressure hose. If deposits are not fully removed by flushing this may require immediate consultation with your water consultant or feedwater treatment company, and in extreme cases, it may be necessary to resort to acid cleaning. Professional advice is recommended if acid cleaning is required.

These inspections will indicate the effectiveness of the feedwater treatment. The effectiveness of treatment, the water conditions, and the amount of fresh water make-up required are all factors to be considered in establishing frequency of future pressure vessel washout periods. The feedwater consultant or water treatment company service should include periodic pressure vessel inspection and water re-analysis.

H. BLOWDOWN — STEAM BOILER

Boiler water blowdown is the removal of some of the concentrated water from the pressure vessel and its replacement with feedwater so that a lowering of the concentration in the boiler water occurs.

Solids are brought in by the feedwater even though this water is treated prior to use through external processes designed to remove the unwanted substances that contribute to scale and deposit formations. However, none of these are in themselves capable of removing all substances and regardless of their high efficiency, a small amount of encrusting solids will be present in the boiler water.

Solids become less soluble in the high temperature of the boiler water and tend to crystalize and concentrate on heating surfaces. Internal chemical treatment is, therefore, required to prevent the solids from forming harmful scale and sludge.

Scale has a low heat transfer value and acts as an insulation barrier. This retards heat transfer, which not only results in lower operating efficiency and consequently higher fuel consumption, but more importantly can cause overheating of boiler metal. This can result in tube failures or other pressure vessel metal damage causing boiler down time and costly repairs.

Scale is caused primarily by calcium and magnesium salts, silica and oil. Any calcium and magnesium salts in the boiler water are generally precipitated by the use of sodium phosphate along with organic materials to maintain these precipitates or "sludge" in a fluid form. The solids such as sodium salts and suspended dirt do not readily form scale, but as the boiler water boils off as relatively pure steam, the remaining water is thicker with the solids. If this concentration is permitted to accumulate, foaming and priming will occur and the sludge can cause harmful deposits that bring about overheating of the metal.

The lowering or removal of this concentration requires the use of boiler water blowdown.

TYPES OF BLOWDOWN

There are two principal types of blowdown: intermittent manual blowdown and continuous blowdown.

A. Manual Blowdown

Manual or sludge blowdown is necessary for the operation of the boiler regardless of whether or not continuous blowdown is employed.

The blowdown tappings are located at the bottom or lowest part of the boiler so that in addition to lowering the dissolved solids in the pressure vessel water, it also removes a portion of the sludge which accumulates in the lower part of the vessel.

Equipment generally consists of a quick opening valve and a shut-off valve. These along with the necessary piping are not normally furnished with the boiler, but supplied by others. All piping must be to a safe point of discharge. Piping must be properly supported and free to expand.

B. Continuous Blowdown

Continuous blowdown is used in conjunction with a surface blow-off tapping (furnished on units 60'' diameter and larger) and is the continuous removal of concentrated water.

The surface blow-off opening, when furnished, is on the top center line of the pressure vessel and is provided with an internal collecting pipe terminating slightly below the working water level for the purpose of skimming surface sediment, oil or other impurities from the surface of the pressure vessel water.

A controlled orifice valve is used to allow a continual - yet controlled - flow of concentrated water.

Periodic adjustments are made to the valve setting to increase or decrease the amount of blowdown in accordance with the test analysis.

The flow control valve and piping are generally provided by others. All piping must be to a safe point of discharge.

C. Frequency of Manual Blowdown

When continuous blowdown is utilized, manual blowdown is primarily used to remove suspended solids or sludge. The continuous blowdown removes sediment and oil from the surface of the water along with a prescribed amount of dissolved solids.

When surface or continuous blowdown is not utilized, manual blowdown is used to control the dissolved or suspended solids in addition to the sludge.

In practice, the valve(s) of the bottom blowdown are opened periodically in accordance with an operating schedule and/or chemical control tests. From the standpoint of control, economy and results, frequent short blows are preferred to infrequent lengthy blows. This is particularly true when suspended solids content of the water is high. With the use of frequent short blows a more uniform concentration of the pressure vessel water is maintained.

In cases where the feedwater is exceptionally pure, or where there is a high percentage of return condensate, blowdown may be employed less frequently since less sludge accumulates in the pressure vessel. When dissolved and/or suspended solids approach or exceed pre-determined limits, manual blowdown to lower these concentrations is required.

It is generally recommended that a steam boiler be blown down at least once in every eight hour period, but this may vary depending upon water and operating conditions. The blowdown amounts and a schedule should be recommended by a water treating company or a water consultant.

A hot water boiler does not normally include openings for surface blowdown and bottom blowdown since blowdowns are seldom practiced. The need remains to be alert to system water losses and corresponding amount of raw water make-up. A water meter is recommended for water make-up lines.

D. Manual Blowdown Procedure

Blowdown is most effective at a time when generation of steam is at the lowest rate since feedwater input then is also low providing a minimum dilution of the boiler water with a low concentration feedwater.

Make sure blow-off piping, and tank if used, are in proper operating condition and discharge vents clear of obstruction, and that waste is piped to a point of safe discharge.

Most blow-off lines are provided with two valves, generally a quick opening valve nearest the boiler and a slow opening globe type valve downstream. Two slow opening valves or tandem valves may be used. Valves will vary depending upon pressure involved and make or manufacture. If seatless valves are installed follow the manufacturers' recommendations.

If a quick opening valve and a globe type or slow opening valve are in combination, the former is normally opened first and closed last with blowing down accomplished with the globe or slow opening valve.

When opening the second or down stream valve crack it slightly to allow the lines to warm up, then continue opening slowly.

CAUTION: Do not open the slow opening valve first and pump the lever action valve open and closed as water hammer is apt to break the valve bodies or pipe fittings.

The length of each blow should be determined by

actual water analysis. Lowering the water in the gage glass approximately 1/2" is often acceptable as a guide to adequate blow, however, this should not be interpreted as a rule since water analysis procedures should prevail. If the glass cannot be viewed by the party operating the valve, another operator should watch the glass and direct the valve operator.

Close the downstream (slow opening) valve first and a fast as possible. Then close the valve next to the boiler. Slightly crack the downstream valve and then close it tightly.

Under no circumstances should a blow-off valve be left open and the operator should never leave until the blowdown operation is completed and valves closed.

I. PERIODIC INSPECTION

Insurance regulations or local laws will require a periodic inspection of the pressure vessel by an authorized inspector. Sufficient notice is generally given to permit removal of the boiler from service and preparation for inspection.

When shutting down, the load should be reduced gradually and the pressure vessel cooled at a rate that avoids damaging temperature differential that can cause harmful stresses. Vessels should not normally be drained until all pressure is relieved - again to prevent uneven contraction and temperature differentials that can cause expanded tubes to leak. Draining the unit too quickly may cause the baking of deposits that may be present on the heating surfaces. Some heat, however, may be desirable to dry out the interior of the boiler.

If the internal inspection is being made at the request of an authorized inspector, it is well to learn from him whether he desires to observe the conditions prior to cleaning or flushing of waterside surfaces.

Be certain that a supply of manhole and handhole gaskets is available along with any other gaskets or items needed to place the unit back into operation after inspection.

Have available information on the boiler design, dimensions, generating capacity, operating pressure or temperature, time in service, defects found previously and any repairs or modifications. Also have available for reference records of previous inspections.

Be prepared to perform any testing required by the inspector including hydrostatic.

After proper cooling and draining of vessel, flush out the waterside with a high pressure water hose. Remove any scale or deposits from the waterside surfaces and check for internal or external corrosion and leakage.

The fireside surfaces should also be thoroughly cleaned so that metal surfaces, welds, joints, tube ends, fittings and any previous repairs can be readily checked.

Be sure that steam valves, system valves, (hot water) feedwater valves, blow-off valves, all fuel valves, valves to expansion tanks, and electrical switches are shut off prior to opening handholes, manhole and front or rear doors. Adequately vent the pressure vessel prior to entry. Flashlights rather than extension cords are recommended as a safety factor. Cleaners should preferably work in pairs.

Clean out the low water cut-off piping, the water level controls and cross connecting piping. Replace water gage glass and clean out water cocks and tricocks. Also check and clean drain and blowdown valves and piping.

Check all water and steam piping and valves for leaks, wear, corrosion and other damage. Replace or repair as required.

J. PREPARATION FOR EXTENDED LAY-UP

Many boilers used for heating or seasonal loads or for stand-by service may have extended periods of non-use. Special attention must be given to these so that neither waterside nor fireside surfaces are allowed to deteriorate from corrosion.

There are two methods of storage - wet or dry. Your water consultant or feedwater treating company can recommend the better method depending upon circumstances in the particular installation.

Whichever method is used, common sense dictates a periodic recheck of fireside and waterside conditions during lay-up to allow variations from the above methods for special area or job-site conditions.

Swing open boiler head at stack end of unit to prevent flow of warm, moist air through boiler tubes.

Although pollution control regulations may continue to limit the permissable sulphur content of fuel oils, care must be taken to avoid corrosion problems that sulphur can cause, especially in a boiler that is seasonally shut down. Dormant periods, and even frequent shutdowns, expose the fireside surfaces to condensation below the dew point during cooling. This moisture and any sulphur residue can form an acid solution. Under certain conditions, and especially in areas with high humidity, the corrosive effect of the acid will be serious enough to eat through or severely damage boiler tubes or other metal heating surfaces during the time that a boiler is out of service.

This condition does not generally occur during nor-

mal firing operation since the high temperature of operation vaporizes any condensation. However, proper boiler operation must be maintained, especially with a hot water boiler, to prevent the flue gases from falling below the dew point.

At the start of lay-up, thoroughly clean the fireside by removing any soot or other products of combustion from the tubes, tube sheets and other fireside surfaces. Brushing will generally suffice. Sweep away or vacuum any accumulation. The fireside surfaces may be flushed with water, however, all moisture must be eliminated after flushing and the surfaces dried by blowing air or applying some form of heat. It is good practice to protect the cleaned surfaces by coating them with an anti-corrosive material to prevent rust.

To prevent condensation from forming in the control cabinet, keep the control circuit energized.

Dry storage is generally employed when the boiler will be out of service for some time or where freezing temperatures may exist. In this method the boiler must be thoroughly dried because any moisture would cause corrosion. Both fireside and waterside surfaces must be cleaned of all scale, deposits, soot, etc. Steps must be taken to eliminate moisture by placing moisture absorbing materials such as quick lime (at 2 pounds for 3 cubic feet of volume) or silica gel (at 5 pounds for 30 cubic feet of volume) on trays inside the vessel. Fireside surfaces may be coated with an anti-corrosive material or grease or tar paint. Refractories should be brushed clean and wash coated. All openings to the pressure vessel such as manhole and handholes should be shut tightly. Feedwater and steam valves should be closed. Damper and vents should be closed to prevent air from reaching fireside surfaces. Periodic inspection should be made and absorption materials renewed.

Wet storage is generally used for a boiler held in stand-by condition or in cases where dry storage is not practical. The possibility of freezing temperatures must be considered. Care must again be taken to protect metal surfaces. Variables preclude definite recommendations, however, it is suggested that the pressure vessel be drained, thoroughly cleaned internally and re-filled to overflowing with treated water. If deaerated water is not available, the unit should be fired to boil the water for a short period of time. Additional chemicals may be suggested by the water consultant to minimize corrosion. Internal water pressure should be maintained at greater than atmospheric pressure. Nitrogen is often used to pressurize the vessel. Fireside surfaces must be thoroughly cleaned and refractory should be wash coated.

CHAPTER 3

SEQUENCE OF OPERATION

A. GENERAL
B. CIRCUIT AND INTERLOCK CONTROLS
C. SEQUENCE OF OPERATION — Oil or Gas Applicable to Standardly Equipped Boilers With CB-20 Flame Safe Guard and Control System
D. SEQUENCE OF OPERATION — Oil or Gas Applicable to Optionally Equipped Boilers With CB-40 Flame Safe Guard and Control System
E. FLAME LOSS SEQUENCE — CB-20 and CB-40 Programmers

A. GENERAL

This chapter outlines the electrical sequencing of the various controls through the starting cycle, ignition cycle, firing and shutdown.

The timer in the programming control sequences the operation of all other controls and components to provide an overall operating sequence.

In the schematic type wiring diagram provided for the boiler, the grounded (common) side of the power supply is shown as a vertical line on the right side of the diagram. All inductive components (coils, solenoids, transformers, lights, etc.) are connected to it. The hot side of the power supply is shown as a vertical line on the left side of the drawing. All the inductive components are connected to it through switches or contacts that permit the component to function when required.

Abbreviations for the various electrical components are listed in Figure 3-3. The sequences outlined in this chapter also employ these designations to aid in applying the text to the wiring diagram.

For an explanatory booklet on schematic wiring diagrams, request Cleaver-Brooks Bulletin C17-4095.

The burner and control system are in starting condition when the following conditions exist:

Boiler water is up to correct level closing the low water cut-off switch. The operating limit pressure control (steam boiler) or the operating limit temperature control (hot water boiler) and high limit pressure or temperature control are below their cut-off setting.

All entrance switches are closed and power is present at the line terminals of the forced draft fan starter.

These sequences do not attempt to correlate the action of the fuel supply system or feedwater system except for the interlock controls that directly relate to the action of the programming relay. Chapters 4 and 5 contain operating instructions and specific information on setting and adjusting the controls.

B. CIRCUIT AND INTERLOCK CONTROLS

The burner control circuit is a two wire system designed for 115 volt, single phase, 60 Hz (cycles), alternating current.

The programming control will also operate on 50 Hz, however, the timing values must be multiplied by 1.2.

Control circuit power is extended to programmer terminals L1 and L2. The hot line is extended to programmer terminals 3 and 4 thru limit controls.

The controls used in the limit circuit vary depending upon the fuel — oil or gas — and the specific requirement of applicable regulatory bodies. Refer to the boiler wiring diagram to determine the controls provided. The controls normally used are listed below and referred to in the following sequence:

Burner switch (BS)

Operating limit pressure or temperature control (OLC)

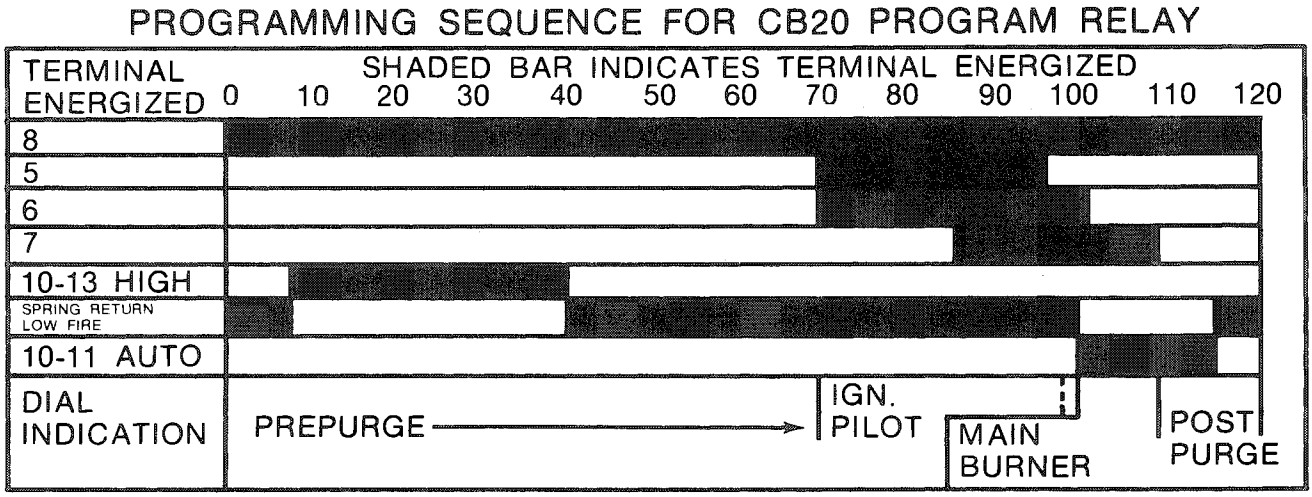


FIGURE 3-1.

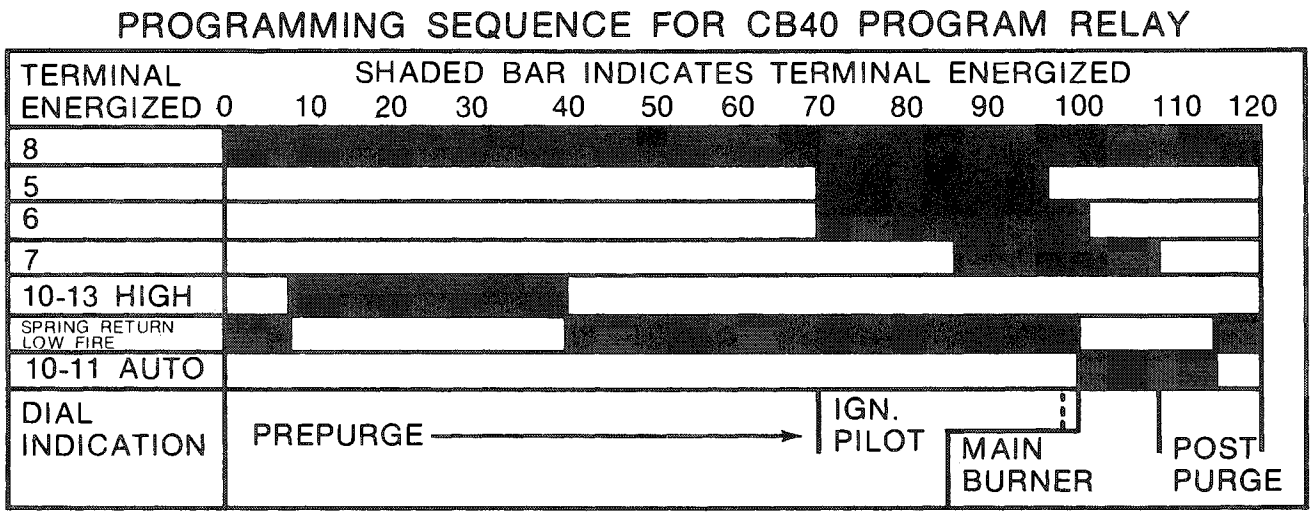


FIGURE 3-2.

High limit pressure or temperature control (HLC)

Low water cut-off (LWCO)

Low fire switch (LFS)

Auxiliary switches (AS-1) (AS-2)
100 and 200 series only

Gas-oil selector switch (GOS) 200 series only

High-low fire control (HLFC)

Damper positioning switch (DPS)

The controls used in the running interlock circuit are:

Blower motor starter interlock (BMSI)
Combustion air proving switch (CAPS)*
*Not used on some 100 series

C. SEQUENCE OF OPERATION — Oil or Gas

Applicable to a standardly equipped boiler with CB-20 flame safeguard and program control system.

This sequence covers burner operation from start-up thru shutdown. No attempt is made to correlate the action of the fuel supply system or feedwater system except for those controls that directly affect the action of the programming relay. Refer to the wiring diagram supplied for this boiler in following this sequence.

NOTE: The legend on the timer dial (Figure 1-3) indicates the position of the timer and the stage reached in the burner operating cycle. The bar-graph shown in Figure 3-1, or on the wiring diagram, indicates the

sequence of the various circuits. The technical bulletin for this control contains a schematic wiring diagram that details the timing sequence of the various programmer contacts. The following description refers to the dial indication and not to the timing, since the timer is interrupted and governed by other components during a normal cycle.

On a combination fuel unit, the gas/oil switch must be set for the proper fuel.

With the programmer energized and with all other operating conditions satisfied, the following programming sequence occurs:

PRE-PURGE PERIOD
Dial at Dot

When the burner switch is turned "on", power is routed through the limit controls to terminals 3 and 4. Relay 1K is energized. Power is also routed to the blower motor starter.

Programmer terminal 13 is powered (from terminal 10) to energize the damper motor which begins driving the damper to the open or high fire position. This allows a flow of purging air through the boiler prior to ignition.

The running interlock circuit to terminal 12 must be completed within 10 seconds after the start of timer rotation.

Continuity of the interlocks listed below complete this circuit which allows the sequence to continue. In the event any of these are not closed at this time, or if they subsequently open, relay 1K will be de-energized. The timer will complete its revolution to the starting position and the programmer will recycle.

The blower motor starter interlock (BMSI) is wired into the circuit to prove that the starter is energized and to interrupt the circuit if the starter should be de-energized for any reason.

The combustion air proving switch (CAPS) is actuated by air pressure from the forced draft fan to prove the presence of combustion air. This switch is not normally supplied on a 100 series boiler.

Toward the end of the purging period, terminal 13 is de-energized to break the circuit to the damper motor. The return spring in the motor brings it back to a closed position and the damper to low fire position.

To assure that the system is in low fire position prior to ignition, the low fire switch (LFS) must be closed to complete an interlock circuit to terminal 14. The timer will stop until the damper motor has returned to the low fire position and the contacts of the low fire switch are closed.

NOTE: A burner start cannot be made if the flame relay holds in for any reason. If, after the first 15 seconds of pre-purge, the flame relay should pull in for any reason the ignition cycle cannot be started. Instead, the timer will complete its revolution and attempt to recycle or lockout.

IGNITION PERIOD
Dial at "Pilot and Ignition"

A. Spark Ignited Oil Fired Burner (100 Series)

The ignition transformer is energized from terminal 5. The low fire solenoid valves are energized from terminal 6, which in this case is jumpered to terminal 7. With combustion air, ignition spark and oil present the low fire flame is ignited. When flame is detected, flame relay 2K is energized.

B. Gas Pilot Ignited Oil or Gas Fired Burner (200 and 700 Series)

The ignition transformer and the gas pilot solenoid valve are energized from terminal 5. With combustion air, ignition spark and gas present the pilot flame is established. When flame is detected, flame relay 2K is energized.

The pilot flame must be established and proven within a 10 second period in order for the ignition cycle to continue. If for any reason this has not happened, the system will shut down and safety lockout will occur.

CAUTION

The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart.

Dial at "Main Burner"

A. Spark Ignited Burner

Terminal 7 is now powered. The main fuel valve (LFOV), already opened, will continue to be energized from this terminal when terminal 6 is de-energized at the end of the main flame proving period.

B. Gas Pilot Ignited Burner

Main gas valve(s) (gas fired unit) or the low fire solenoid valves (oil fired unit) is energized from terminal 7. Main flame is ignited.

After a 10 second trial period for the proving of main flame, power is removed from terminal 5 de-energizing the ignition transformer and the gas pilot valve. The gas pilot flame is extinguished.

If for any reason main flame does not light or stay lit, relay 2K will drop out causing the fuel valve(s) to close. The safety switch will trip to lockout the control. Refer to flame loss sequence section for description of action.

CAUTION

The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart.

With the main flame established, terminal 11 is powered (from terminal 10) transferring power to the damper motor positioning switch and releasing burner from low fire position subject to following conditions:

With the damper positioning switch in the "low" position, the circuit to the damper motor is broken and motor remains in a closed or low fire position.

With the switch in the "high" position, the damper motor is powered directly and moves to an open or high fire position.

With the switch in the "auto" position, power is routed through the high-low fire control which makes or breaks the circuit to the damper motor as the load demands.

On an oil fired unit, the opening of the damper motor actuates switches which in turn energize the intermediate and high fire solenoid valves increasing the size of the fire to the high fire rate. Closing of the motor de-energizes the high fire valve reducing the flame to the low fire rate.

On a gas fired unit, the opening of the damper motor actuates, through linkage, the disc in the butterfly valve to allow a greater flow of gas, increasing the size of the flame to high fire rate. Closing of the motor decreases gas flow to a low fire rate.

This is the end of the burner starting cycle. Timer stops. Demand firing of boiler continues as required by load conditions.

BURNER SHUTDOWN
Dial at "Post Purge"

The burner will fire until steam pressure or water temperature in excess of demand is generated. With the high-low fire control properly adjusted, the damper motor should return to the low fire position before the operating limit control opens. When the operating limit control is opened the following sequence occurs:

Relay 1K drops out. The main fuel valve(s) is de-energized and closes. Flame is extinguished and flame relay 2K drops out. The blower motor continues to force air through the boiler in a post-purge period. The timer begins rotating.

Power is removed from terminal 11 breaking the circuit to the damper motor. The motor returns to the low fire position if it is not already in that position.

At the end of the operating cycle, terminal 8 circuit opens and de-energizes the blower motor. The timer stops as it reaches its original position.

The control is now in readiness for subsequent recycling and when steam pressure or water temperature drops to close the contacts of the operating control the burner again goes through its normal starting and operating cycle.

D. SEQUENCE OF OPERATION — Oil or Gas

Applicable to an optionally equipped boiler with the CB-40 flame safeguard and program control system.

The CB-40 control is used to comply with requirements of insurance underwriters such as Factory Insurance Association (F.I.A.) and the Factory Mutual Engineering Association (FM) and certain other codes. This programmer contains several interlock circuits requiring the use of some or all of the following devices in addition to those mentioned in Section B. Refer to the boiler wiring diagram to determine the controls provided and to follow this sequence.

High fire switch (HFS) (IRI)

Low oil pressure switch (LOPS)
100 and 200 series only

Low gas pressure switch (LGPS)
200 and 700 series only

High gas pressure switch (HGPS)
200 and 700 series only

This sequence covers burner operation from start-up thru shutdown. No attempt is made to correlate the action of the fuel supply system or feedwater system except for those controls that directly affect the action of the programming relay. Refer to the wiring diagram supplied for this boiler in following this sequence.

NOTE: The legend on the timer dial (Figure 1-3) indicates the position of the timer and the stage reached in the burner operating cycle. The bar-graph shown in Figure 3-2, or on the wiring diagram, indicates the sequence of the various circuits. The technical bulletin for this control contains a schematic wiring diagram that details the timing sequence of the various programmer contacts. The following description refers to the dial indication and not to the timing, since the timer is interrupted and governed by other components during a normal cycle.

On a combination fuel unit, the gas/oil switch must be set for the proper fuel.

With the programmer energized and with all other operating conditions satisfied, the following programming sequence occurs:

PRE-PURGE PERIOD
Dial at Dot

When the burner switch is turned "on", power is routed through the limit controls to terminals 3 and 4. Relay 1K is energized. Power is also routed to the blower motor starter.

Programmer terminal 13 is powered (from terminal 10) to energize the damper motor which begins driving the damper to the open or high fire position. This allows a flow of purging air through the boiler prior to ignition.

The timer will stop until the high fire switch (HFS) is made. If proof of high fire position is not required, the timer will not stop but will continue its cycle.

The running interlock circuit (to terminal 12) must be completed within 10 seconds after the start of timer rotation to energize relay 3K.

Continuity of the interlocks listed below allows the sequence to continue.

In the event any of these are not closed at this time, or if they subsequently open, relay 3K will be de-energized. This will prevent the fuel valve circuit from being energized, or if occurring later into the sequence, will de-energize this circuit. The timer will complete its revolution to the starting position and the programmer will lockout.

The blower motor starter interlock (BMSI) is wired into the circuit to prove that the starter is energized and to interrupt the circuit if the starter should be de-energized for any reason.

The combustion air proving switch (CAPS) is actuated by air pressure from the forced draft fan to prove the presence of combustion air.

When so equipped, the low oil pressure switch (LOPS) must be closed to indicate that sufficient fuel supply pressure exists.

Toward the end of the purging period, terminal 13 is de-energized to break the circuit to the damper motor. The return spring in the motor brings it back to a closed position and the damper to low fire position.

Existing F.I.A. requirements and/or others require additional pre-purge time beyond that normally provided by the programmer. This is accomplished through the use of a "purge extender" that is plugged into the programmer. This device allows the purging period to be extended by 30, 60 or 120 seconds depending upon the setting selected (refer to program control bulletin for details).

IMPORTANT: If the optional purge extender is not used, the purge jumper provided with the relay must be installed.

When the high fire switch closes, the purge extender is activated to provide the additional purge time. The programmer timer is stopped and the damper motor remains in high fire position until this timing is completed. Upon completion, the timer restarts and the damper motor returns to the low fire position.

To assure that the system is in low fire position prior to ignition, the low fire switch (LFS) must be closed to complete an interlock circuit to terminal 14. The timer will stop until the damper motor has returned to the low fire position and the contacts of the low fire switch are closed.

NOTE: The ignition trial cannot be started if for any reason the flame relay pulls in during the pre-purge. The timer will complete its revolution and lockout at the start position.

IGNITION PERIOD
Dial at "Pilot and Ignition"

A. Spark Ignited Oil Fired Burner

The ignition transformer is energized from terminal 5. The low fire solenoid valve is energized from terminal 6 which in this case is jumpered to terminal 7. With combustion air, ignition spark and oil present the low fire flame is ignited. When flame is detected, flame relay 2K is energized.

B. Gas Pilot Ignited Oil or Gas Fired Burner

The ignition transformer and the gas pilot solenoid valve are energized from terminal 5. With combustion air, ignition spark and gas present the pilot flame is established. When flame is detected, flame relay 2K is energized.

The pilot flame must be established and proven within a 10 second period in order for the ignition cycle to continue. If for any reason this has not happened, the system will shut down and safety lockout will occur.

CAUTION

The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart.

Dial at "Main Burner"

A. Spark Ignited Burner

Terminal 7 is now powered. The main fuel valve (LFOV), already opened, will continue to be energized from this terminal when terminal 6 is de-energized at the end of the main flame proving period.

B. Gas Pilot Ignited Burner

Main gas valve(s) (gas fired unit) or the low fire solenoid valve (oil fired unit) is energized from terminal 7. Main flame is ignited.

F.I.A. regulations, or others, require two main gas valves with a vent valve between them. As the

main gas valves are simultaneously energized and open, the normally open vent valve is also energized and closes.

After a 10 second trial period for the proving of main flame, power is removed from terminal 5 de-energizing the ignition transformer and the gas pilot valve. The gas pilot flame is extinguished.

If for any reason main flame does not light or stay lit, relay 2K will drop out causing the fuel valve(s) to close. The safety switch will trip to lockout the control. Refer to flame loss sequence section for description of action.

CAUTION

The cause for loss of flame or any other unusual condition should be investigated and corrected before attempting to restart.

With the main flame established, terminal 11 is powered (from terminal 10) transferring power to the damper motor positioning switch and releasing burner from low fire position subject to following conditions:

With the damper positioning switch in the "low" position, the circuit to the damper motor is broken and motor remains in a closed or low fire position.

With the switch in the "high" position, the damper motor is powered directly and moves to an open or high fire position.

With the switch in the "auto" position, power is routed through the high-low fire control which makes or breaks the circuit to the damper motor as load demands.

On an oil fired unit, the opening of the damper motor actuates switches which in turn energize the intermediate and high fire solenoid valves increasing the size of the fire to the high fire rate. Closing of the motor de-energizes the high fire valves reducing the flame to the low fire rate.

On a gas fired unit, the opening of the damper motor actuates, through linkage, the disc in the butterfly valve to allow a greater flow of gas, increasing the size of the flame to high fire rate. Closing of the motor decreases gas flow to a low fire rate.

BURNER SHUTDOWN
Dial at "Post Purge"

The burner will fire until steam pressure or water temperature in excess of demand is generated. With the high-low fire control properly adjusted, the damper motor should return to the low fire position before the operating limit control opens. When the limit control circuit is opened, the following sequence occurs:

Relays 1K, 3K and 4K drop out. The main fuel valve(s) is de-energized and closes. Flame is extinguished and flame relay 2K drops out. The blower motor continues to force air through the boiler in a post-purge period. The timer begins rotating.

Power is removed from terminal 11 breaking the circuit to the damper motor. The motor returns to the low fire position if it is not already in that position.

At the end of the operating cycle, terminal 8 circuit opens and de-energizes the blower motor. The timer stops as it reaches its original position.

The control is now in readiness for subsequent recycling and when steam pressure or water temperature drops to close the contacts of the operating control the burner again goes through its normal starting and operating cycle.

E. FLAME LOSS SEQUENCE

The CB-20 and CB-40 programmers recycle automatically each time the operating control closes or after a power failure. Both will lockout following a safety shutdown caused by failure to ignite the pilot, or the main flame, or by loss of flame. Lockout will also occur if flame or flame simulating condition occurs during the pre-purge period.

Both controls will prevent start-up or ignition if the pre-ignition or air flow interlocks open. The CB-20 control will recycle in an attempt to correct the shutdown situation (if it is self-correcting). The CB-40 control will lockout upon any abnormal condition affecting fuel or air supervisory controls.

The lockout switch must be manually reset following a safety shutdown. A short cool down period is necessary before the switch button can be depressed and operation resumed.

CAUTION

The cause for loss of flame or any unusual condition should be investigated and corrected before attempting to restart.

A. No pilot flame.

The pilot flame must be ignited and proven within a 10 second period after the ignition cycle begins — terminals 5 and 6 energized. The flame is proven by the pull-in of relay 2K. If 2K is not energized within this period, the fuel valve circuit (terminal 7) will not be powered and the fuel valve(s) will not be energized. The ignition circuit is immediately de-energized and the pilot valve closed.

The blower motor will continue to operate. The timer will stop after a short period of operation. Approximately 30 seconds after the ignition circuit is interrupted, the lockout switch (LS) will trip. Master relay 1K is de-energized. The flame failure light and the alarm bell (optional) are energized.

The timer resumes operation. When the dial indicator reaches the start or dot position the timer and blower motor will be de-energized. The lockout switch must be manually re-set before operation can be resumed. (Refer to caution above.)

B. Pilot but no main flame.

If the pilot flame is proven, the main fuel valve circuit is energized from terminal 7. The pilot flame will be extinguished 10 seconds later. The flame detecting circuit will break within 4 seconds to drop out the flame relay 2K. The main fuel valve circuit is de-energized to stop the flow of fuel. The blower motor continues to run.

The lockout switch will trip approximately 30 seconds later and relay 1K will be de-energized. The flame failure light and alarm bell (optional) are energized.

The timer resumes operation. When the dial indicator reaches the start or dot position the timer and blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to caution above.)

C. Loss of flame.

If a flame outage occurs during normal operation and/or the flame is no longer sensed by the detector, the flame relay 2K will trip within 4 seconds to de-energize the fuel valve circuit and shut off fuel flow. The blower motor continues operation. Approximately 30 seconds later the lockout switch will trip to de-energize master relay 1K. The flame failure light and alarm bell (optional) are energized.

The timer resumes operation. When the dial indicator reaches the start or dot position the timer and blower motor will be de-energized. The lockout switch must be manually reset before operation can be resumed. (Refer to caution above.)

If the burner will not start, or upon a safety lockout, the trouble shooting section in the operating manual and the technical bulletin should be referred to for assistance in pinpointing problems that may not be readily apparent. Familiarity with the programmer and other controls in the system can be obtained by studying the contents of the manual and this bulletin. Knowledge of the system and its controls will make troubleshooting much easier in the event it is necessary. Costly down time or delays can be prevented by systematic checks of the actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

Remember that this is a safety device and for the most part it is doing its job when it shuts down or refuses to operate. Never attempt to circumvent any of the safety features.

Preventive maintenance and scheduled inspection of all components should be followed. Periodic checking of the relay to see that a safety lockout will occur under conditions of failure to ignite either pilot or main flame, or from loss of flame is recommended.

AB	ALARM BELL
AS-1, 2	AUXILIARY SWITCH-1, 2
ALWCO	AUXILIARY LOW WATER CUT-OFF
AR	ALARM RELAY
BM	BLOWER MOTOR
BMF	BLOWER MOTOR FUSES
BMS	BLOWER MOTOR STARTER
BMSI	BLOWER MOTOR STARTER INTERLOCK
BS	BURNER SWITCH
CAPS	COMBUSTION AIR PROVING SWITCH
CCF-P	CONTROL CIRCUIT FUSE-PRIMARY
CCT	CONTROL CIRCUIT TRANSFORMER
CR-1	CONTROL RELAY-1
DISC	DISCONNECT
DM	DAMPER MOTOR
DMT	DAMPER MOTOR TRANSFORMER
DNS	DAY-NIGHT SWITCH
DPS	DAMPER POSITIONING SWITCH
FD	FLAME DETECTOR
FFL	FLAME FAILURE LIGHT
FVL	FUEL VALVE LIGHT
GOS	GAS-OIL SWITCH
GPV	GAS PILOT VALVE
HFS	HIGH FIRE SWITCH
HFOV-1, 2	HIGH FIRE OIL VALVE-1, 2
HLC	HIGH LIMIT CONTROL
HLFC	HIGH-LOW FIRE CONTROL
HGPS	HIGH GAS PRESSURE SWITCH
IT	IGNITION TRANSFORMER
LOPS	LOW OIL PRESSURE SWITCH
LDL	LOAD DEMAND LIGHT
LFOV	LOW FIRE OIL VALVE
LFS	LOW FIRE SWITCH
LWCO	LOW WATER CUT-OFF
LWL	LOW WATER LIGHT
LGPS	LOW GAS PRESSURE SWITCH
MGV	MAIN GAS VALVE
MGVAS	MAIN GAS VALVE AUXILIARY SWITCH
MGVV	MAIN GAS VENT VALVE
OLC	OPERATING LIMIT CONTROL
OL'S	OVER LOADS
OSOV	OIL SHUT-OFF VALVE
PT	PURGE TIMER

FIGURE 3-3.
MNEMONIC DESIGNATION OF
ELECTRICAL DEVICES

CHAPTER 4

STARTING AND OPERATING INSTRUCTIONS

A. GENERAL PREPARATIONS FOR INITIAL START-UP (ALL FUELS)
B. CONTROL SETTINGS (ALL FUELS)
C. OIL BURNER START-UP (100 and 200 SERIES)
D. GAS BURNER START-UP (200 and 700 SERIES)
E. NORMAL OPERATION (ALL FUELS)

A. GENERAL PREPARATION FOR INITIAL START-UP (ALL FUELS)

The instructions in this chapter assume that complete installation has been made and that all electrical, fuel, water and vent stack connections are completed.

The operator should have familiarized himself with the burner, boiler and all components. To quickly locate and identify the various controls mentioned in the following paragraphs refer to call-out photographs and the contents of Chapter 1.

Chapter 5 contains adjustment procedures and this should be reviewed prior to actual firing. The wiring diagram should also have been studied.

Verify supply of fuel and proper voltage. Check for blown fuses or fusetrons, open circuit breakers, dropped-out overloads etc. Check reset of all starters and controls having manual reset features. Check the lockout switch on the programmer and reset if necessary. The timer dial setting should be at the black dot.

The boiler should be filled with water to the proper operating level using water of ambient temperature. Make sure that treated feedwater is available and used. In a heating application the entire system should be filled and vented. Refer to Chapter 2 for water requirements.

On a steam boiler, open the test valve on the water column to vent air displaced during filling. Leave test valve open until escape of steam is noted after burner is operating.

CAUTION: Prior to firing make certain the discharge piping from safety or relief valves and discharge piping from all blowdown or drain valves is piped to a safe point of discharge so that emission of hot water or steam cannot possibly cause injury to personnel or damage to property.

Inspect all linkage for full and free movement of the damper and also of the butterfly gas valve on gas fired burners.

Check for proper rotation of blower motor by momentarily closing the motor starter. Rotation is counterclockwise when viewed from front of boiler.

Before operating boiler feed pump, if used, be sure all valves in the line are opened or properly positioned.

For safety's sake make a final pre-start-up inspection especially checking for any loose or incompleted piping or wiring or any other situation that might present a hazard.

B. CONTROL SETTINGS (ALL FUELS)

Inspect the operating limit control for proper setting. The pressure control on a steam boiler should be set slightly above highest desired steam pressure, but 10% lower than the setting of the safety valve(s). The temperature control on a hot water boiler should be set slightly above the highest desired water temperature and within the limits of the pressure vessel.

Inspect the high limit control for proper setting. On a high pressure steam boiler this should be set approximately 10 lbs. above the operating limit pressure control setting, if feasible, or midway between operating limit pressure and safety valve setting. The setting on a low pressure steam boiler may be 2 or 3 lbs. above the operating limit setting but must not exceed valve setting. On a hot water boiler the temperature control should be 5 to 10°

above the operating limit temperature control setting.

Inspect the high-low flame control for proper setting which should be slightly lower than that of the operating limit control.

Adjustment procedures for these controls is covered in Chapter 5.

Inspect the low water cut-off. Check for freedom of float and verify that control is functioning properly.

In the event the boiler is equipped with optional control devices not listed here, ascertain that their settings are correct. If additional information is required see your local Cleaver-Brooks representative or contact Cleaver-Brooks.

Set damper positioning switch at "low". Leave burner switch "off" but close all other power entrance switches (supplied by others).

C. OIL BURNER START-UP (100 and 200 Series)

PREPARATION FOR INITIAL FIRING

Verify that the driving belt for the oil pump is in place. Temporarily close the oil shut-off valve (Figure 1-1).

On a 200 series boiler, set the gas/oil selector switch to "Oil". Close main gas cock and open pilot gas cock.

Open all valves in the oil suction line and oil return line. The line from the storage tank to the pump should be filled with fuel. Short suction lines may be filled by use of the fuel pump. Long suction lines and those of large diameter pipe should be filled by priming or other means.

Manually hold in the blower motor starter until the oil pump picks up and circulates oil. The oil flow may be verified when the pressure gauge indicates a steady pressure reading of 175 psi (approximately). If no pressure shows on the gauge after a few moments stop the pump and prime the suction line. Continue this procedure until the oil flow is established.

A vacuum (or compound pressure - vacuum) gauge installed in the oil suction line will reveal the tightness of the system. Its readings should be observed and recorded for future guidance. Refer to Chapter 5 for further information on the oil piping system.

Check that damper positioning switch is set at "low". Turn burner switch to "on". The blower motor will start and oil pressure will be indicated on the gauge. The timer in the programming control will begin rotating.

The damper will open for the pre-purge period and allow a flow of air through the fireside area of the pressure vessel. The damper motor will return to the low fire position after this pre-purge is completed. The low fire switch must be closed for action to continue.

Now check for ignition spark. When the "pilot ignition" legend appears on the timer dial, the ignition transformer is energized. An electric spark should be visible when viewed through the rear door sight glass. If the unit has a gas pilot, its flame can be seen.

The main burner will not light since the oil shut-off valve is closed.

With evidence of a good spark (or gas pilot) and proper oil pressure, the unit is ready to be fired. Turn burner switch to "off". The programmer will complete its cycle and stop. Reset the safety switch in the event programmer locked out prior to the burner switch being turned off.

Review the sequence of operation given in Chapter 3 for a complete description of the action that takes place during a starting and operating cycle.

INITIAL START-UP AND FIRING

Set damper position switch to "low". Open the manual fuel oil valve (Figure 1-1). Turn burner switch "on". After the pre-purge period the burner will light and operate at its low fire rate.

In some instances on initial firing, air may be trapped in the fuel lines preventing ignition until it is completely expelled and replaced by fuel oil. It may be possible for the burner to go through several cycles until all lines are filled with oil. If ignition does not then occur, do not repeat unsuccessful lighting attempts without re-checking burner and pilot adjustments.

On an ignition failure the blower will continue running to purge the boiler of any unburned fuel vapors before stopping. After ignition failure wait a few moments before re-setting safety switch.

CAUTION: The burner and control system is designed to provide a pre-purge period of fan operation prior to establishing ignition spark and pilot flame. Do not attempt to alter the system in any way that might circumvent this feature.

When flame is established leave the burner in low fire position for approximately 30 minutes or until boiler is properly warmed, unless it reaches its normal operating pressure or temperature sooner.

A hot water boiler must have a continuous flow of system water through the vessel during the warm-up period. If conditions permit, the entire water content of the system and boiler must be warmed prior to increasing fuel input.

As normal pressure or temperature is approached at low fire, turn the damper positioning switch to "high". Observe the burner as it progresses to high

fire position. There possibly may be air trapped in the high fire oil lines and it may be necessary to operate the burner for several cycles to assure that these lines become filled with oil. Failure of oil to flow through the high fire nozzles promptly may cause the increased combustion air to extinguish the low fire flame.

After the unit is thoroughly warmed a combustion analysis test should be made with instruments and fuel flow and/or air flow regulated as required. Refer to adjustment procedures in Chapter 5. To properly perform this test and adjustment it is necessary that burner be allowed to fire at maximum rate sufficiently long enough to achieve desired results.

Refer to Section E of this chapter for normal firing operating and shutdown sequences.

CAUTION: It is advisable to check for tight shut-off of fuel valves. Review Chapter 5.

D. GAS BURNER START-UP (200 and 700 Series)

PREPARATION FOR INITIAL FIRING

Close main gas cock and open pilot gas cock.

On a 200 series boiler, set the gas-oil selector switch to "gas". Although not mandatory, it is suggested that oil pump belt be removed during periods of extended gas firing.

Check the linkage attached to the butterfly valve to insure that it has free movement and that all connections and set screws are tight. The linkage was set at the factory but if adjustment is required see Chapter 5.

Verify the presence and availability of gas. On a new installation, a representative of the gas utility should be present when gas is first turned into the system to supervise purging of the new gas line unless this has already been done.

Determine that sufficient gas pressure exists at the entrance to the gas train. This can be noted by installing a gas pressure test gauge in the line. Refer to Chapter 5 for information on pressures and flow rates.

Check that damper positioning switch is set to "low". Turn burner switch to "on". The blower motor will start and the programming control timer will begin rotating.

The damper will open for the pre-purge period and allow a flow of air through the fireside area of the pressure vessel. The damper motor will return to the low fire position after this pre-purge period is completed. The low fire switch must be closed for action to continue.

Now check for ignition spark and gas pilot. When the legend "pilot ignition" appears in the timer dial, the ignition transformer and gas pilot valve are energized. The gas pilot flame may be viewed through the sight glass on the rear door.

The main burner will not light since the main gas shut-off cock is closed. When the timer dial indicates "main burner" determine that the main gas valve opens when energized. In the case of a diaphragm valve, the click of its solenoid will indicate that it is energized. The valve will not actually open since there is no gas pressure available. During normal operation the position of the diaphragm valve may be determined by observing the flag in the window on top of the valve which shows black when the valve is closed and yellow when opened. In the case of a motorized valve, yellow showing on the stem indicates that the valve is closed.

As soon as valve action is confirmed, turn the burner switch off and let programmer finish its cycle. Check to see that the gas valve has closed.

With evidence of a good pilot and operating main gas valve, unit is ready to be fired. Reset the safety switch in the event programmer locked out prior to the burner switch being turned off.

Review of the sequence of operation given in Chapter 3 for a complete description of the action that takes place during a starting and operating cycle.

INITIAL START-UP AND FIRING

Set damper positioning switch to "low". Turn the burner switch "on" and when the timer dial indicates "main burner", slowly open the main gas cock. Main flame should ignite unless there is air present in the line. In this event, turn the burner switch "off" and allow programmer to run through its normal shutdown cycle. Several efforts may be necessary to "bleed" air from the line.

On an ignition failure, the blower will continue running to purge the burner of any unburned fuel vapors before stopping. After ignition failure wait a few moments before resetting the safety switch.

CAUTION: The burner and control system is designed to provide a pre-purge period of fan operation prior to establishing ignition spark and pilot flame. Do not attempt to alter the system in any way that might circumvent this feature.

When main flame is established observe that it is extinguished promptly when burner is shut down. Burner will normally continue to burn for a second or two after shutdown due to the gas remaining downstream of the cut-off valve. If flame continues to burn for a longer period, or during blower motor spin down, immediately turn burner switch "off" and close main gas cock. Investigate and correct the cause of valve leakage before re-lighting the burner. The main gas valve is tight seating provided nothing prevents tight closure. Foreign

material may be present in either new or renovated gas lines unless adequate care is taken in cleaning, purging and providing a suitable strainer.

When flame is established leave the burner in low fire position for approximately 30 minutes or until boiler is properly warmed, unless it reaches its normal operating pressure or temperature sooner.

A hot water boiler must have a continuous flow of system water through the vessel during the warm-up period. If conditions permit, the entire water content of the system and boiler must be warmed prior to increasing fuel input.

After normal pressure or temperature is approached at low fire, turn the damper positioning switch to "high". Observe the burner as it progresses to "high" fire position. In the event the butterfly gas valve movement is not properly coordinated with the air damper, it is possible that increased secondary air may extinguish the low fire flame. After the unit is thoroughly warmed and running in high fire, a combustion analysis should be made, with instruments, and fuel flow and/or air flow regulated as required. Refer to the adjustment procedures in Chapter 5. To properly perform this analysis and adjustment it is necessary that burner be allowed to fire at maximum rate and sufficiently long enough to achieve desired results.

The main gas pressure regulator and the pilot gas regulator have a vent opening which must be free from obstructions for proper operation of the device. Local codes or insurance requirements may require discharge piping to the outside of the building. Make sure that this piping is not obstructed.

Refer to Section E of this chapter for normal starting operating and shutdown information.

E. NORMAL OPERATION—ALL FUELS

START-UP

Check water level and supply.

Check setting of all operating controls. Check all reset and lockout mechanisms.

Programmer timer dial should be at the black dot.

On a combination fuel unit (Series 200) the fuel selector switch should be set for the appropriate fuel.

Turn the burner switch "on". Observe action of burner and controls to assure proper functioning.

Allow boiler to run at low fire until properly warmed up before allowing burner to go to high fire.

OPERATING

Normal operation should be with the damper positioning switch set at "auto" and under the control of the high-low fire control.

With the switch set at "auto", burner will operate on a high-low firing basis according to the load demands.

The burner will continue to operate until the operating limit pressure or temperature setting is reached, unless:

a. Burner is manually turned "off".

b. Low water condition is detected by low water level control.

c. Current or fuel supply is interrupted.

d. Pressure of combustion air drops below minimum level.

NOTE: There can be other reasons for shutdowns such as motor overload, flame outages, tripped circuit breakers, blown fusetrons or through interlock devices in the system.

SHUTDOWN

When the operating limit pressure or temperature control opens due to pressure or water temperature increase, or if the burner switch is turned "off", the following sequence occurs:

The fuel valve is de-energized and flame extinguished. The timer resumes operation and the blower motor continues running to force air through the furnace during the post purge period.

At the end of the post purge the blower motor is de-energized. The timer has returned to its original position and stops.

Refer to Chapter 3 for timing sequence.

Unit is ready to re-start.

CHAPTER 5

ADJUSTMENT AND MAINTENANCE

A. GENERAL
B. PERIODIC INSPECTION
C. WATER LEVEL CONTROLS
D. WATER GAGE GLASS
E. OPERATING CONTROLS
   Setting and Adjusting
   Pressure Controls — Steam Boiler
   Temperature Controls — Hot Water Boiler
   Combustion Air Proving Switch
   Low Gas Pressure Switch
   High Gas Pressure Switch
   Programming Control
   Control Operational Test
F. OIL BURNER
   Burner Nozzles
   Oil Pump
   Combustion Adjustment
G. GAS BURNER
   Gas Pilot Adjustment
   Gas Pressure and Flow
   Combustion Adjustment
H. SWITCH AND CAM ADJUSTMENT
I. AIR DAMPER ADJUSTMENT
J. SAFETY VALVES
K. MOTORIZED GAS VALVE
L. SOLENOID VALVES
M. REFRACTORY
N. DOOR CLOSING AND SEALING
O. FORCED DRAFT FAN
P. FIRESIDE CLEANING
Q. LUBRICATION

A. GENERAL

While each boiler is tested for correct operation before shipment from the factory, variable conditions such as burning characteristics of the fuel used and operating load conditions may require further adjustment after installation to assure maximum operating efficiency and economy. Prior to placing the boiler into initial service, a complete inspection should be made of all controls, connecting piping, wiring, and all fastenings such as nuts, bolts and setscrews to be sure that no damage or mis-adjustments occurred during shipment and installation.

A well planned maintenance program avoids unnecessary down time or costly repairs, promotes safety and aids boiler code and local inspectors. An inspection schedule with a listing of procedures should be established. It is recommended that a boiler room log or record be maintained, recording daily, weekly and monthly and yearly maintenance activities. This provides a valuable guide and aids in obtaining economies and length of service from Cleaver-Brooks equipment.

Even though the boiler has electrical and mechanical devices that make it automatic or semi-automatic in operation, these devices require systematic and periodic maintenance. Any "automatic" features do not relieve the operator from responsibility, but rather free him of certain repetitive chores, providing him time to devote to upkeep and maintenance.

Good housekeeping helps maintain a professional appearing boiler room. Only trained and authorized personnel should be permitted to operate, adjust or repair the boiler and its related equipment. The boiler room should be kept free of all material and equipment not necessary to the operation of the boiler or heating system.

Alertness in recognizing an unusual noise, improper gauge reading, leaks, etc., can make the operator aware of a developing malfunction permitting prompt corrective action that may prevent extensive repairs or unexpected down time. Any steam, water or fuel leaks hsould be repaired as soon as they are noticed. Leaks are wasteful as well as hazardous. Include in the program, preventive maintenance measures such as regularly checking the tightness of connections, locknuts, setscrews, packing glands, etc.

The air-fuel ratio should be checked often since this will alert the operator to losses in combustion efficiency which do not produce visible flame changes. Variations in fuel composition from one time to another may require re-adjustment of the burner. A combustion analyzer should be used to adjust fuel input for maximum operating efficiency and economy.

B. PERIODIC INSPECTION

Insurance regulations or local laws require a periodic inspection of the pressure vessel by an authorized inspector.

Chapter 2 contains information relative to this inspection.

Inspections of this type are usually, though not necessarily, scheduled for periods of normal boiler down time such as an off season. This major inspection can often be used to accomplish maintenance, replacements or repairs that cannot easily be done at other times. This also serves as a good basis for establishing a schedule for annual, monthly or other periodic maintenance programs.

While this inspection pertains primarily to the waterside and fireside surfaces of the pressure vessel, it provides the operator an excellent opportunity for detailed inspection of all components of the boiler including piping, valves, pumps, gaskets, refractory, etc. Comprehensive cleaning, spot painting or repainting and the replacement of expendable items should be planned for and taken care of during this time. Any major repairs or replacements that may be required should also, if possible, be coordinated with this period of boiler shutdown.

Replacement spare parts, if not on hand, should be ordered sufficiently prior to shutdown.

Cleaver-Brooks boilers are designed, engineered and built to give long life and excellent service on the job. Good operating practices and conscientious maintenance and care will obtain efficiency and economy from their operation and contribute to long years of performance.

C. WATER LEVEL CONTROLS AND WATERSIDE OF PRESSURE VESSEL

The need to periodically check water level controls and the waterside of the pressure vessel cannot be over-emphasized. Most instances of major boiler damage are the result of operating with low water or the use of untreated (or incorrectly treated) water.

Always be sure of the boiler water level. The water column should be blown down routinely. Check samples of boiler water and condensate in accordance with procedures recommended by your water consultant. Refer to sections H and I in Chapter 2 for blowdown instructions and internal inspection procedures.

A typical water level control is mounted in the water column. The control has 2 float actuated mercury switches. One switch is connected to the burner limit circuit and will stop the burner if a low water condition occurs. On a steam boiler the other switch is connected to the feedwater circuit to energize a water pump or feeder valve to maintain water at the proper operating level.

Usually, the control is of the automatic reset type and will remake the limit circuit when the water level is restored. Some applications require that a control be equipped with a manual reset mechanism that must be manually reset before the burner can be restarted.

Since low water cut-off devices are generally set by the original manufacturer, no attempt should be made to adjust these controls to alter the point of low water cut-off or point of pump cut-in or cut-out. If a low water device should become erratic in operation or if its setting changes from previous established levels, check for reasons and correct: repair or replace as required.

Figure 5-1 is a replica of the low water cut-off plate attached to a steam boiler. These instructions should be followed on a definite schedule. These controls normally function for long periods of time which may lead to laxity in testing on the assumption that normal operation will continue indefinitely.

The controls' operation may be checked by stopping the water supply to the boiler while the burner is operating at low fire. While under constant attendance allow the water to lower at a normal rate. If a control does not break the circuit to stop the burner at the proper point then SHUT DOWN THE BURNER IMMEDIATELY. Repair or replace the control at once.

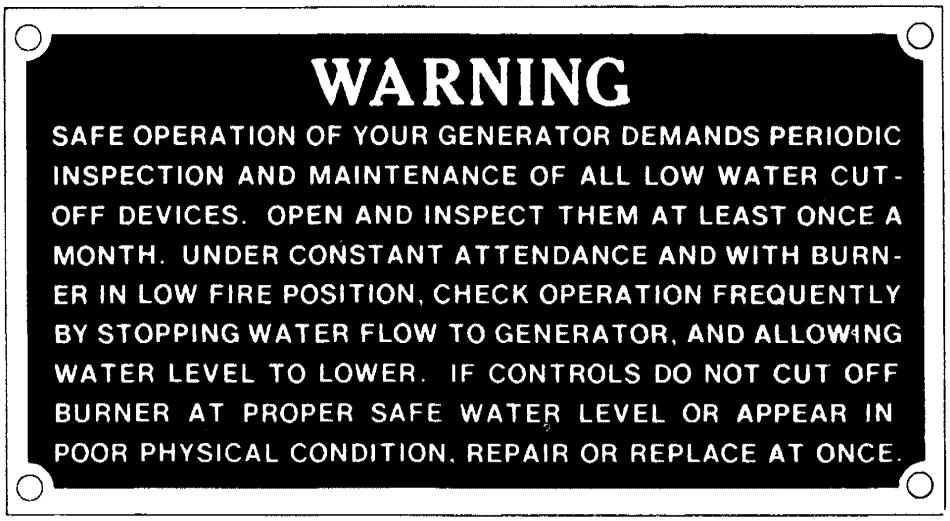


FIGURE 5-1. LOW WATER PLATE

On a steam boiler, the head mechanism of the low water cut-off device(s) should be removed from the bowl at least once a month to check and clean the float ball, the internal moving parts, and the bowl or water column.

Remove the pipe plugs from the tees or crosses and make certain the cross connecting piping is clean and free of obstructions. Controls must be mounted in a plumb position for proper performance. Determine that piping is vertically aligned after shipment and installation and throughout life of equipment.

A scheduled blowdown of the water controls on a steam boiler should be maintained.

It is impractical to blowdown the low water cut-off devices on a hot water boiler since the entire water content of the system would become involved. Many hot water systems are fully closed and any loss of water will require make-up and additional feedwater treatment that might not otherwise be necessary. Since the boiler and system arrangement usually makes it impractical to perform daily and monthly maintenance of the low water cut-off devices, it is essential to remove the operating mechanism from the bowl annually or more frequently, if possible, to check and clean float ball, internal moving parts, and the bowl housing. Also check the cross connecting piping to make certain that it is clean and free of obstruction.

D. WATER GAGE GLASS

A broken or discolored glass should be replaced at once. Periodic replacement should be a part of the maintenance program. Always use new gaskets when replacing a glass. Use a proper size rubber packing. Do not use "loose packing" which could be forced below the glass and possibly plug the valve opening.

Close the valves when replacing the glass. Slip a packing nut, a packing washer, and packing ring onto each end of the glass. Insert one end of the glass into the upper gage valve body far enough to allow the lower end to be dropped into the lower body. Slide the packing nuts onto each valve and tighten.

If the glass is replaced while the boiler is in service, open the blowdown and slowly bring the glass to operating temperature by cracking the gage valves slightly. After glass is warmed up, close the blowdown valve and open the gage valves completely.

Check try-cocks and gage cocks for freedom of operation and clean as required. It is imperative that the gage cocks are mounted in exact alignment. If they are not, the glass will be strained and may fail prematurely.

E. OPERATING CONTROLS

In general when adjusting controls check to see that they are level, especially those containing mercury switches. On temperature sensing controls make sure that the bulb is properly bottomed in its well. Make sure that connecting tubing is not kinked or damaged.

Controls are carefully calibrated during their manufacture and do not normally require re-calibration. The dial settings are generally quite accurate although it is not unusual to have a slight variation between a scale setting and an actual pressure gauge or thermometer reading and to readjust control setting to agree with these readings. This is predicated, however, on pressure gauges and thermometers being accurate.

Most of the operating controls require very little maintenance beyond occasional inspection. Examine tightness of electrical connections. Keep

controls clean. If any dust accumulates in the interior of the control, remove with a low pressure air hose taking care not to damage the mechanism.

Examine any mercury tube switches for damage or cracks: this condition, indicated by a dark scum over the normally bright surface of the mercury, may lead to erratic switching action. Make certain that controls of this nature are correctly leveled using the leveling indicator if provided. Piping leading to various controls actuated by pressure should be cleaned if necessary. Covers should be left on controls at all times.

Dust and dirt can cause excessive wear and overheating of motor starter and relay contacts and maintenance of these is a requirement. Starter contacts are plated with silver and are not harmed by discoloration and slight pitting. Do not use files or abrasive materials such as sandpaper on the contact points since this only wastes the metallic silver with which the points are covered. Use a burnishing tool or a hard surface paper to clean and polish contacts. Replacement of the contacts is necessary only if the silver has worn thin.

Thermal relay units (overloads) are of the melting-alloy type and when tripped, the alloy must be given time to re-solidify before relay can be reset. If over-loads trip out repeatedly when motor current is normal replace them with new overloads. If this condition continues after replacement it will be necessary to determine the cause of excessive current draw.

Power supply to the boiler must be protected with dual element fuses (fusetrons) or circuit breakers. Similar fuses should be used in branch circuits and standard one-shot fuses are not recommended.

SETTING AND ADJUSTING

Burner controls properly set to match load demands will provide operational advantages and achieve the following desirable objectives:

(a) The burner will be operating in low fire position prior to shut down.

(b) The burner will operate at low fire for a brief period on each start during normal operation.

(c) Eliminates frequent burner on-off cycling.

Normal operation of the burner should be with the damper positioning switch in the "auto" position rather than either "low" or "high". This allows the burner to automatically shift from one firing rate to the other in accordance with load requirements.

When firing a cold boiler, it is recommended that the burner be kept under manual flame control until normal operating pressure or temperature is approached. If the burner is not under manual control on a cold start, it will immediately move to high fire as soon as the program control releases the circuit that holds the burner in low fire during ignition. The high-low fire control will be calling for high fire and the burner will move to that position as rapidly as the damper motor can complete its travel. This rapid heat input can subject the pressure vessel metal and refractory to undesirable conditions.

Any control setting must not cause the boiler to operate at or in excess of the safety valve setting. Settings that do not exceed 90% of the valve setting are recommended, with lower settings greatly desirable if load conditions permit. Avoid having the operating pressure too near the valve set pressure, because the closer the operating pressure is to the valve pressure, the greater the possibility of valve leakage. Continued leakage, however slight, will cause erosion and necessitate early valve replacement. The control settings on a hot water boiler must be within the temperature and pressure limits of the boiler.

Ideally, the burner operating controls should be set under actual load conditions. Often, especially on new construction, the boiler is initially started and set to operate under less than full load requirements. As soon as possible thereafter the controls should be reset to provide maximum utilization of the firing system.

In the setting of these controls, consideration must be given to the time required for a burner restart. Upon each start, there is a prepurge period of some length, plus the fixed time required for the proving of the pilot and main flame. This, plus approximately one-half minute required for damper motor travel from low to high fire, may allow pressure or temperature to drop below desirable limits.

The mechanics of setting the controls are:

PRESSURE CONTROLS—Steam Boiler

The pressure controls that serve as the operating limit control and as the high-low fire control are equipped with an adjustable differential setting. See the following portion of this section for adjustment procedures.

The switch in the control opens when the steam pressure reaches a pressure equal to the main scale setting and closes at a pressure equal to that shown on the main scale, MINUS the amount of differential.

In an installation that does not require very close control of the steam pressure, the differential setting should be adjusted to its maximum, since this will provide less frequent burner cycling.

The high-low fire control should be set to open at 5 to 10 psi. lower than the operating limit setting. The suggested setting on a low pressure steam boiler is 2 to 3 psi. The differential setting on this control may be set low, to give quite close control

of steam pressure. In any case, the control should be adjusted so that it de-energizes the damper motor, causing burner to go to low fire, at a pressure below the limit control opening point. When the pressure controls are properly set the burner will maintain steam pressure within narrow limits.

On a rise in steam pressure, the high-low fire control opens its contacts and the damper motor returns to low fire position. The burner continues to operate at low fire rate. If steam pressure drops, the control will again close to energize the damper motor and return the burner to high fire. If steam pressure continues to rise, the boiler will remain at low fire rate. Should the boiler pressure reach the set point of the operating limit control, its contacts will open to turn off the burner. When boiler pressure drops, the operating limit control contacts close, causing the burner to restart. It is desirable to have the high-low fire control adjusted so that the burner does not immediately go to high fire upon start, but rather operates at low for a brief period before decreasing steam pressure causes control to close and the burner to drive to high fire.

OPERATING LIMIT PRESSURE CONTROL (Steam) (Honeywell L404A)

Set "cut-out" (burner off) pressure on the main scale using the large adjusting screw. Set differential on the short scale turning the small adjusting screw until the indicator points to the desired difference between cut-out and cut-in pressures. The "cut-in" (burner on) pressure is the cut-out pressure MINUS the differential. The cut-out pressure should not exceed 90% of the safety valve setting.

HIGH LIMIT PRESSURE CONTROL (Steam) (Honeywell L404C)

Set "cut-out" (burner off) pressure on scale using adjusting screw. The control will break a circuit to shut off burner when pressure reaches this point. The setting should be sufficiently above the operating limit pressure control to avoid shutdowns, and preferably not exceed 90% of safety valve setting. This control requires manual resetting after tripping on a pressure increase. To reset, allow boiler pressure to return to normal and then press the reset button.

HIGH-LOW FIRE CONTROL (Honeywell L404A) (Steam)

Set the "cut-out" pressure—the point at which the burner will return to low fire—on the main scale using the large adjusting screw. This setting should be sufficiently below the cut-out setting of the operating limit control so that the burner will return to the low fire position prior to shutting off at the operating limit.

The "cut-in" pressure—the point at which the burner drives to high fire—is set on the differential scale. This setting is equal to the cut-out pressure MINUS the amount of the differential. It should be adjusted so that it is sufficiently below the burner "on" pressure of the operating control so that the burner when starting will operate briefly at the low fire position prior to advancing to high fire.

TEMPERATURE CONTROLS— Hot Water Boiler

The temperature controls that serve as the operating limit control and as the high-low fire control are equipped with an adjustable differential setting. The switch in the control opens when the water temperature reaches a temperature equal to the dial setting and closes at a temperature equal to the dial setting MINUS the amount of differential. See following portion of this section for instructions on control adjustment.

In an installation that does not require very close control of the water temperature, the differential setting should be adjusted as widely as possible since this will provide less frequent burner cycling.

The operating limit temperature control should be set slightly above the highest desired water temperature and within the limits of the pressure vessel. The high limit control should be set 5 to 10 degrees above the operating limit temperature control setting. The high-low fire control should be adjusted so that it is below the burner "on" temperature of the operating control.

Relative settings of the temperature controls are as follows:

High Limit Control
Open — 190° F.

Operating Limit Control
Open — 180° F.
Close — 170° F.

High-Low Fire Control
Open — 170° F. (Low Fire)
Close — 165° F. (High Fire)

With settings similar to these, the following operational sequence occurs. On a rise in boiler water temperature, the high-low fire control opens its contacts at 170 degrees F. to de-energize the damper motor and place the burner in its low fire range.

If temperature decreases during low fire, the burner will return to high fire as soon as the high-low fire control closes at its 165 degree setting As temperature increases during high fire rate the burner will be switched back to low fire when the control opens at 170 degrees.

If temperature increases during low fire, the burner will shut down when the operating limit setting of 180 degrees is reached. When temperature drops back to 170 degrees the operating limit will close

to restart the burner. The unit will fire at its low rate unless temperature continues to drop to 165 degrees, at which time the high-low fire control will close to move the burning rate to high fire.

The settings listed are typical and will vary according to job requirements. However, setting the controls with these relations to each other is desirable, since this will prevent the burner from shutting down while in high fire or from immediately going to high fire upon restarting.

OPERATING LIMIT TEMPERATURE CONTROL (Hot Water) (Honeywell L4008A)

Set "cut-out" (burner off) temperature on scale by inserting a screwdriver through the cover opening to engage the slotted head adjusting screw.

The "cut-in" (burner on) temperature is the cut-out temperature MINUS the differential. The differential is adjustable from 5 to 30 degrees F. Differential is adjusted by rotating the wheel on the back of the snap switch.

HIGH LIMIT TEMPERATURE CONTROL (Hot Water) (Honeywell L 4008E)

Set the "cut-out" (burner off) temperature on scale using adjusting screw. This control will break the circuit and lockout on a rise in water temperature above the setting. The setting should be sufficiently above the operating limit temperature to avoid unnecessary shutdowns. On 30 lb. hot water generators the setting is not to exceed 240 degrees F. The control requires manual resetting after tripping on a temperature increase. To reset allow water temperature to drop below the cut-out setting, less differential, and then press the manual reset button.

HIGH-LOW FIRE CONTROL (Hot Water) (Honeywell L4008A)

Set the "cut-out" temperature—the point at which the burner will return to low fire—on the indicating dial. This setting should be sufficiently below the cut-out setting of the operating limit temperature control so that the burner will return to the low fire position prior to shutting off at the operating limit.

The "cut-in" temperature—the point at which the burner drives to high fire—is set on the differential scale. This setting is equal to the cut-out temperature MINUS the amount of the differential. It should be adjusted so that it is sufficiently below the burner "on" temperature of the operating control so that the burner when starting can operate briefly in the low fire position prior to advancing to high fire.

COMBUSTION AIR PROVING SWITCH

Air pressure against the diaphragm actuates the switch which, when made, completes a circuit to prove the presence of combustion air. Since the pressure of the combustion air is at its minimum value when the damper is full open, the switch should be adjusted under that situation. It should be set to actuate under a condition of minimum pressure, but not too close to that point to cause nuisance shutdowns.

The test switch in the programmer will stop the timer only during the low fire period of the prepurge or during the pilot ignition period. To stop the timer during the high fire portion of prepurge, it is necessary to do the following:

CB-20 - Turn off both the burner switch and the main power. Remove the programmer from its base. Check the instruction manual for the control and locate the position of contact M3A. Carefully work a narrow strip of paper between the contact points. An alternate method is to insert a thin wood wedge between the timer cam and the spring leaf for this contact.

Use extreme care not to bend or damage the contacts. CAUTION: Line voltage is present at most contacts.

Reinstall the control and restore main power.

CB-40 - Remove the purge extender or the purge extender jumper. See the instruction manual for details.

Turn the burner switch on. The blower motor and the timer will start (provided the low water control and limit controls are made). The timer will stop after a few seconds. The damper motor will drive to its open position and stop there.

Attach a test lamp or volt meter from switch terminal W to ground. Turn the adjustment screw until this circuit is broken. Then add a half turn or so to the adjusting switch to remake the circuit.

Turn the burner switch off. Remove the paper slip or wood wedge from the CB-20 relay Replace the purge extender or purge extender jumper on a CB-40 relay.

With the programmer returned to operating condition, turn the burner switch on and observe whether unit cycles normally.

If the air switch is not adjusted to make within its allotted time, the CB-20 control will keep recycling. The CB-40 control will lock out and require manual resetting to restart.

LOW GAS PRESSURE SWITCH

Turn adjusting screw until indicator on scale moves to a pressure setting slightly below the operating gas pressure. The control will break a circuit if pressure is below this value. The control should be finally adjusted to prevent operation with low gas pressure, but should not be set at a value close enough to normal operating pressure to cause unnecessary shutdowns. When setting this

control consideration must be given to the fact that gas line distribution pressure may decrease under some conditions and it is advisable that the control does not cut out unnecessarily.

The switch must be manually reset after tripping on a drop of gas pressure below the cut-out setting. To reset allow gas pressure to rise and press the manual reset button.

HIGH GAS PRESSURE SWITCH

Turn adjusting screw until indicator on scale moves to a pressure setting slightly above the maximum operating gas pressure. The control will break a circuit if pressure exceeds this value. The control should be adjusted to prevent operation with excessive gas pressure but should not be set at a value close enough to normal operating pressure to cause unnecessary shutdowns.

This switch must be manually reset after tripping on a rise of gas pressure above the cut-out setting. To reset allow gas pressure to drop and press the manual reset button.

LOW OIL PRESSURE SWITCH
(Optional)

This control prevents burner from igniting or stops its operation when the oil pressure drops below a set point. The control contains a single-pole, single-throw mercury switch which closes on a pressure rise. Pressure settings are made with the knobs on the face of the control. The "low" setting indicates the point at which switch action takes place on a pressure drop. Initially set this knob to the bottom of the scale. Adjust the "high" knob to a point slightly below the normal operating oil pressure. Then set "low" knob somewhat lower. The burner will operate as long as oil pressure exceeds the lower setting.

PROGRAMMING CONTROL

This control requires no adjustment, nor should any attempt be made to alter contact settings. The contacts may require occasional cleaning. If so, follow instructions given in the manufacturer's bulletin. Do not use abrasive materials. The control cabinet door should be closed during normal operation.

The manufacturer's bulletin also contains trouble-shooting information.

The flame detector lens should be cleaned as often as operating conditions demand. Use a soft cloth moistened with detergent if necessary.

Replacement of internal components, other than the plug in amplifier is neither practical nor recommended.

CAUTION

When replacing a control or cleaning contacts, be sure to open the main power supply switch, since the control is "hot" even though the burner switch is off.

A periodic safety check procedure should be established to test the complete safeguard system at least once a month or oftener. Tests should verify safety shut down and a safety lock out upon failure to ignite the pilot, upon failure to ignite the main flame, and upon loss of flame. Each of these conditions should be checked on a scheduled basis. These tests will also verify fuel valve tightness.

Checking Pilot Flame Failure

Close the gas pilot shutoff cock. Also shut off the main fuel supply. Turn the burner switch "on". The pilot system will be energized at the end of the prepurge period. Since there is no pilot flame to be detected, the pilot valve will be de-energized and the main fuel valves will not be energized. Check to see that there is an ignition spark but no flame. The programmer will complete its cycle during which time the lockout switch will trip on a safety lock out.

Turn the burner switch off. Reset the safety switch after allowing the thermal element to cool for a few moments. Reopen the gas pilot shut off cock and re-establish main fuel supply.

Checking Failure to Light Main Flame

Leave the gas pilot shut off cock open. Shut off the main burner fuel supply. Turn the burner switch on. The pilot will light upon completion of the pre-purge period. The main fuel valve(s) will be energized but there should be no flame. Relay 2K should drop out within 4 seconds after main burner ignition trial ends. The safety switch should trip and lock out about 30 seconds after end of the ignition trial.

Turn the burner switch off. Reset the safety switch after allowing the thermal element to cool for a few moments. Re-establish the main fuel supply.

Checking Loss of Flame

With the burner in normal operation, shut off the main burner fuel supply to extinguish main flame. Relay 2K should drop out within 4 seconds after flame is extinguished. The blower motor runs during the post purge. The lock out switch will trip approximately 30 seconds later de-energizing master relay 1K.

Turn the burner switch off. Reset the safety switch after allowing the thermal element to cool for a few moments. Re-establish main fuel supply.

CONTROL OPERATIONAL TEST

Proper operation of the various controls should be verified and tested when the boiler is initially placed into service or whenever a control is replaced. Periodic checks should be made there-

after in accordance with a planned maintenance program.

The operating limit control may be checked by allowing steam pressure or water temperature to increase until the burner shuts down. Depending upon the load, it may be necessary to manually increase the firing rate to raise steam pressure to the burner shut off point. If load is heavy, the header valve can be closed or throttled until the pressure increases. Observe the steam gauge to check the cutoff pressure as the operating limit control shuts the burner down. Open the header valve to release steam pressure or vent steam and check the cut-in setting as the burner restarts. Check the high-low fire control for desired operating pressure range.

Water temperature, on a hot water boiler that may be operating at less than full load, may be raised by manually increasing the firing rate until the burner shuts down thru the action of the operating limit control. Observe the thermometer to verify the desired settings at the point of cut-out and again when burner restarts. Check the modulating control for the desired temperature range.

Observe the ignition and programming control operations to make sure that they are correct. Check the proper operation and setting of the low water cut-off (and pump operating control, if used).

Proper operation of the flame failure device should be checked at time of starting and at least once a week thereafter. Refer to previous section for information on flame safety checks.

Check for tight shut-off of all fuel valves. Despite precautions and strainers, foreign material may lodge under a valve seat preventing tight closure. Promptly correct any conditions causing leakage.

F. OIL BURNER

GENERAL

There are relatively few adjustments that can be made to the burner drawer, however, a check should be made to see that all components are properly located and that all holding devices such as setscrews properly tightened. Figures 5-3 and 5-4 cover typical burner drawers and show pertinent dimensions.

The burner drawer should be periodically inspected for evidence of damage due to improperly adjusted combustion. The air cooling tubes surrounding the nozzles should be inspected occasionally for any carbon residue or any clogging that might be caused by unusual dusty or lint-laden atmosphere. The setting of the oil nozzle in relation to the opening in the cooling tube is important and should be maintained.

DIFFUSER

Proper positioning of the diffuser should be maintained so that oil spray or flame does not impinge on it. Remove any carbon or other deposits if any have accumulated so that air flow pattern is not affected. Do not attempt to change the gap or angle of the fins.

BURNER NOZZLES

Efficient oil burner operation requires clean nozzles. The nozzles deliver a spray of extreme fineness to assure proper mixing with the air stream. If at any time the flame becomes "stringy or lazy" it is possible that one or more of the nozzles is clogged or worn. Even though the oil pressure gauge may indicate correct pressure, plugged or partially plugged nozzles will greatly reduce oil delivery.

The nozzles may be cleaned. However, if they appear worn or if they have been in service for a considerable time, it is more economical to replace them. Any cleaning should be done with a wood splinter rather than with any metal to avoid damaging the hole in the tip or the oil grooves. Check strainer and clean if necessary.

CBH Boiler Size	Low Fire Nozzle			High Fire Nozzle (CBH 25-50A) Intermediate Nozzle (CBH 50-100)			High Fire Nozzle			Max. Input BTU/Hr.	Max. Firing Rate GPH
	Size	Spray Angle	Part Number	Size	Spray Angle	Part Number	Size	Spray Angle	Part Number		
25	2.5	30° HV	899-93	2.0	30° HV	899-23	2.0	30° HV	899-23	1,045,000	7.5
30	3.0	30° HV	899-26	2.5	30° HV	899-93	2.5	30° HV	899-93	1,255,000	9.0
40	4.5	30° HV	899-31	3.0	30° HV	899-26	3.0	30° HV	899-26	1,675,000	12.0
50A	8.3	30° HV	899-60	3.0	30° HV	899-26	4.0	30° HV	899-20	2,095,000	15.0
50	4.0	45° PLP	899-12	4.0	45° PLP	899-12	4.0	45° PLP	899-12	2,095,000	15.0
60	5.0	45° PLP	899-18	5.0	45° PLP	899-18	5.0	45° PLP	899-18	2,510,000	18.0
70	6.0	45° PLP	899-35	6.0	45° PLP	899-35	6.0	45° PLP	899-35	2,930,000	21.0
80	7.0	45° PLP	899-61	7.0	45° PLP	899-61	7.0	45° PLP	899-61	3,350,000	24.0
100	8.3	45° PLP	899-39	8.3	45° PLP	899-39	8.3	45° PLP	899-39	4,185,000	30.0

NOTE: Nozzle size is rating at 100 PSI oil pressure. Flow rate increases with pressure.

FIGURE 5-2. NOZZLE SIZES, LOCATION AND FIRING RATE

Nozzles may be of different capacities and it is extremely important that they are replaced in proper firing order. Nozzles can be identified by the capacity and spray angle stamped on them. See chart 5-2 for proper location of nozzles.

The capacity stamped on side of nozzle represents delivery rate with oil pressure at 100 psi. Since the burner is designed to use considerably higher atomizing oil pressures, the capacity of the nozzle is greatly increased. Do not assume that undersized nozzles are installed on the basis of nozzle marking compared to the burner input.

The oil pressure required for full burner input is approximately 175 psi. Oil pressure is adjusted by the regulator in the fuel oil pump and final pressure setting may be slightly higher or lower. If smoke occurs at open damper, the pressure should be adjusted downward to clear the fire. See the later section covering oil burner combustion adjustment.

IGNITION SYSTEM

Maintain the proper gap and dimensions of the ignition electrode(s) for best ignition results. Figures 5-3 or 5-4 show the correct settings.

Inspect electrode tips for signs of pitting or combustion deposits and dress as required with a fine file. Inspect the insulators of the electrodes and the feed through insulators for evidences of cracks or chipping. If any are present replace the items, since this can cause grounding of ignition voltage. Carbon is an electrical conductor, so it is necessary to keep the insulating portion of electrode wiped clean if any is present. Ammonia will aid in removing carbon or soot.

Check ignition cables for cracks in the insulation. Also see that all connections between transformer and electrodes are tight.

Light Oil Strainer

The fuel oil strainer screen must be removed and cleaned at regular intervals. It is advisable to remove this screen each month and clean thoroughly by immersing in solvent and blowing dry with compressed air. To remove, loosen cover cap screw being careful not to lose the copper gasket. Tap strainer cover gently to loosen. Check cover gasket. Slip pliers into the cross on the top of the strainer and twist counterclockwise to remove the basket. Re-assemble in reverse order.

OIL PUMP

Problems attributed to the pump can generally be traced to other causes such as broken or restricted fuel lines, lack of fuel, clogged filters, stuck or closed valves, a high vacuum or even an excessive head of oil.

The pressure gauge (Figure 1-1) reveals that the pump gears are pumping and building up a steady even pressure to deliver oil to the nozzles and at the pressure to which the integral regulator has been set. Collapse of the nozzle spray below the set limit can indicate worn internal parts, although these units are designed to give long periods of operation without undue wear. If this situation is verified, it is generally advisable to replace the

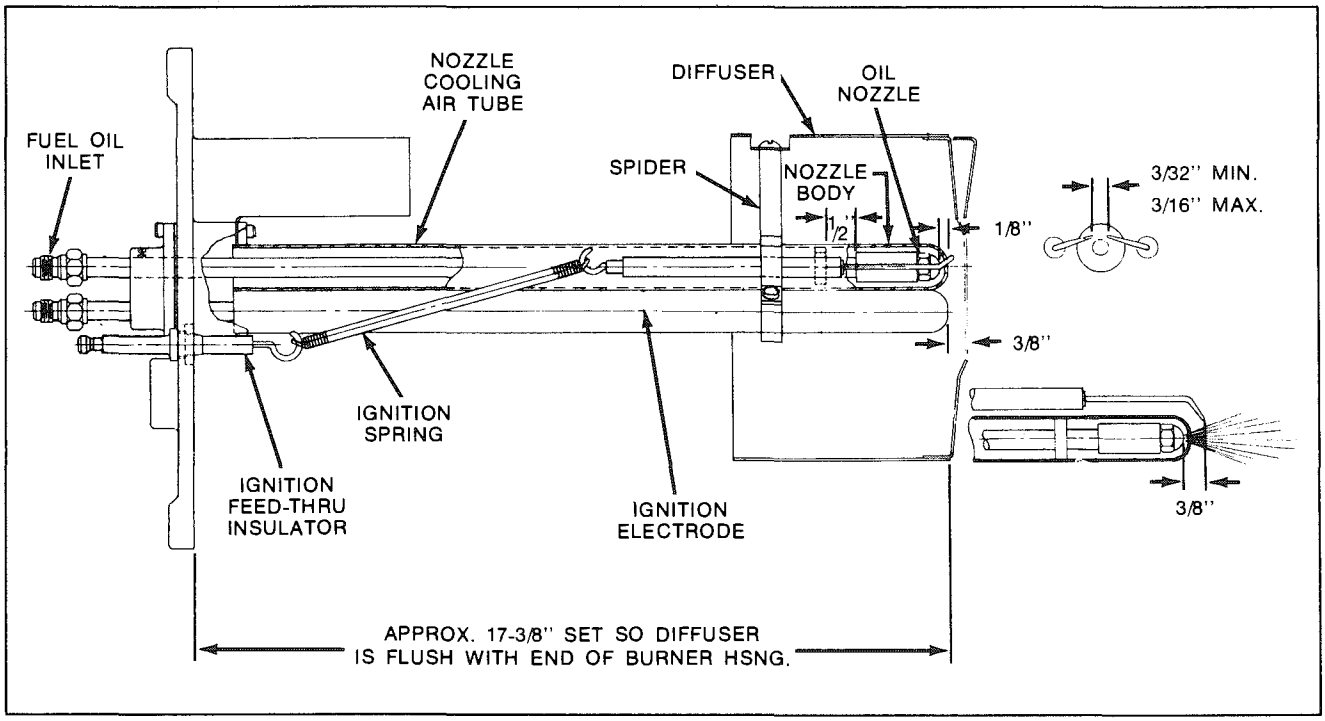


FIGURE 5-3. OIL BURNER, SPARK IGNITED-CBH 50-100

pump. It is recommended that removed pumps be returned to the factory for complete reconditioning rather than replacement of individual parts.

If the oil supply is below the level of the pump, a vacuum gauge installed at the suction port of the pump is helpful in checking the condition of the suction line and aids in pinpointing problems. Normally a vacuum reading should not exceed 10". Vacuums higher than this can lead to problems in oil separation or in erratic or declining delivery. Excessive readings can indicate restrictions such as kinked or clogged lines, sticking or closed valves, or even a frozen oil line. If there is no reading look for air leaks in the lines, valve fittings, or pump. On gravity fed installations a vacuum gauge should read zero. If not, this is evidence of restrictions being present.

If the oil supply is above the level of the pump, a pressure gauge installed in the pump bypass port may be used to determine that the head of oil is not too great. If the head pressure is over 10 psi. damage or seal leakage can occur. A pressure reducing valve should be installed in this instance.

Seal leakage may also be caused by restrictions in the return line.

In an initial start-up a pump noise in the form of a whine may be noticed. This is a condition that results from air in the oil line and should cease as soon as the pump is able to clear the line of air. If the condition persists after a long period of operation, it may indicate a leak in the suction line.

OIL PUMP BELT

The V-belt driving the oil pump requires no servicing and no preservatives or dressing compounds should be used. Belts normally stretch with use and proper tension should be maintained. Do not apply excessive tension since this can result in damage to the pump shaft bearings.

On a combination fired unit it is an acceptable practice to remove the belt when gas is being used for extended periods, although it is not absolutely necessary to do this. If left connected, oil will merely be circulated back to the tank. However pump and belt life will be extended if the belt is removed.

COMBUSTION ADJUSTMENT — OIL

Each boiler is adjusted prior to shipment from the factory, however circumstances caused by shipment, installation, or operating load conditions may require further adjustment to assure maximum operating efficiency and economy. Periodic rechecks of adjustments and settings are also recommended.

The burner system should be adjusted on the basis of a combustion efficiency analysis after the unit has been in operation sufficiently long to assure a warm boiler.

Proper air-fuel ratio should be established by the use of a combustion gas analyzer. This instrument measures the content by percent of carbon dioxide (CO_2), oxygen (O_2) and carbon monoxide(CO) in

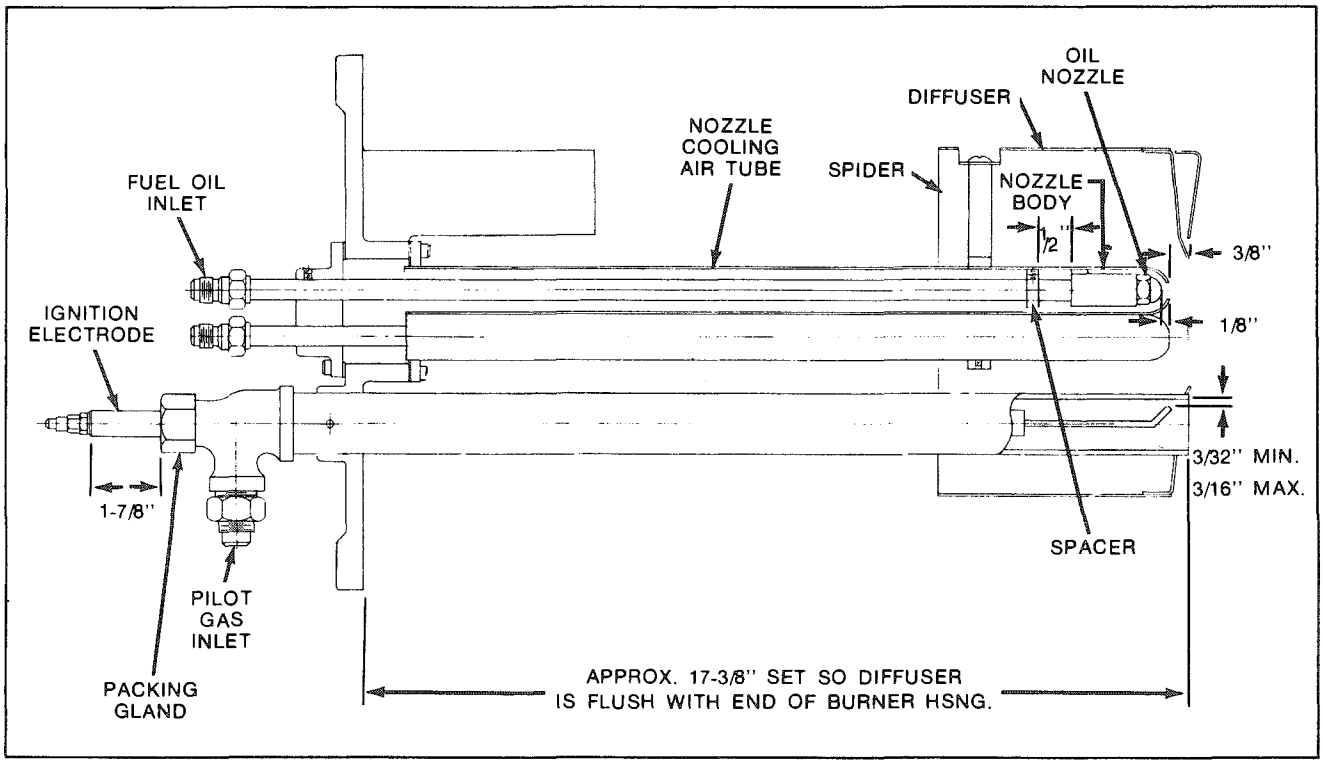


FIGURE 5-4. OIL AND GAS BURNER, GAS PILOT IGNITED, CBH 50-100

the flue gas. Efficiency is measured by the percentage of CO_2 present in the flue gas. The ideal setting from a standpoint of efficiency is reached when there is no measurable percentage of oxygen present. It is, however, more practical to set the burner to operate with a reasonable amount of excess air to compensate for minor variations in the pressure or burning properties of oil. 15 to 20 percent excess air is considered normal. A CO_2 range of 12 to 13% is desirable. The burner should never be operated with an air-fuel ratio that indicates a detectable percentage of carbon monoxide.

Turn the burner to high fire and let it operate at this rate for several minutes. Observe the color and size of the flame. Color alone is a poor means of determining efficiency, although it can serve as a guide for tentative setting. If smoke or haze is visible additional combustion air is required. If the flame is overly bright, rumbles or emits sparks the amount of combustion air will have to be reduced.

Determine that the proper atomizing oil pressure exists as mentioned in the preceding section covering nozzles. In some instances, conditions may require that the oil pressure be reduced below the suggested setting if a desired flue gas analysis can not be obtained with an open damper.

Take a sample of flue gas with an instrument known to be in good working order and determine CO_2 reading. Based on this analysis, make any required adjustments to increase or decrease air flow. See the section on air damper adjustment in this chapter.

Recheck low fire to determine whether it was affected by high fire adjustments. If so, additional linkage adjustment may be required.

G. GAS BURNER

GENERAL

There are relatively few adjustments that can be made to the burner drawer, however, a check should be made to see that all components are properly located and that all holding devices such as setscrews are properly tightened. Periodically inspect the burner drawer for evidence of damage due to improperly adjusted combustion.

Check the gas pilot electrode for proper setting (see figure 5-4) and also for any cracks in the porcelain insulator. Cracks can cause grounding of ignition voltage. Check the tip of electrode for signs of pitting and dress as required. Check the ignition cable for insulation cracks. See that all connections between transformer and electrode are tight.

GAS PILOT FLAME ADJUSTMENT

The size of the gas pilot flame is regulated by adjusting the gas flow through the pilot gas regulator. The flame must be sufficient to ignite the main flame and to be seen by the flame detector but an extremely large flame is not required. An overly rich flame can cause sooting of the flame detector. Too small a flame can cause ignition problems.

To check the pilot flame, visually observe it thru the rear sight port. A flame that encircles approximately one-half of the diffuser is satisfactory. To control the flame size, make the necessary adjustment to the gas pilot regulator.

A preferred method of setting a flame is to obtain a micro-amp reading of the flame signal. This can be measured with a good quality micro-ammeter or a suitable multi-meter with a zero to 25 micro amp DC rating.

The meter is connected to a jack in the amplifier of the flame safeguard control. Use a meter connecting plug harness (Cleaver-Brooks 884-72). Connect the plus (red meter lead) to the red tab of the harness and the minus (black meter lead) to the black tab before inserting the plug in the meter jack.

(1) To measure and adjust the pilot, turn the damper switch to low. Fully open the pilot shut-off cock. Close the cock in the main gas line.

(2) Connect the micro-ammeter as outlined above.

(3) Turn burner switch on. Let the burner go through the normal pre-purge cycle. When the ignition area of the timer dial is opposite the index notch, set the timer switch to the TEST position to stop the timer. Relay 2K should pull in when the pilot ignites.

(4) If the pilot flame is not established within ten seconds, turn off the burner switch. Repeat the lighting attempt.

NOTE: On an initial starting attempt, portions of the fuel lines may be empty and require "bleeding" time. It is better to accomplish this with repeated short lighting trial periods with intervening purge periods than to risk prolonged fuel introduction. If the pilot does not light after several attempts, check all components of the pilot system.

(5) When the pilot flame is established, remove the flame detector from the burner plate. The pilot flame can then be observed thru this opening.

CAUTION: Keep eyes sufficiently away from the sight tube opening and wear a protective shield or suitable glasses. Never remove the flame detector while the main burner is firing.

(6) To make the final adjustment, slowly close the gas pilot regulator until the flame can no longer be seen through the sight tube.

Then slowly open the regulator until a flame providing full sight tube coverage is observed.

This adjustment must be accomplished within the time limit of the safety switch or approximately 30 seconds after the detector is removed. If the control shuts down, allow several moments for the thermal element in the safety switch to cool and then manually reset it. Replace the detector and repeat from step 3.

(7) When a suitable flame is obtained, replace the detector. Observe the reading on the micro-ammeter. The reading should be between two and five micro-amps and the reading must be steady. If the reading fluctuates, recheck the adjustment. Make sure that the flame detector is properly seated and that the lens is clean.

(8) Reset the timer switch from the TEST position to the NORM position.

(9) If main flame has not been previously established, proceed to do so in accordance with instructions elsewhere in the manual.

(10) The micro-amp reading of the main flame signal should also be checked. Observe the flame signal for pilot alone, pilot and main burner flame together and the main burner flame at high, low, and intermediate firing rate positions. Readings should be steady and in the range indicated in paragraph 7. If there are any deviations, refer to the trouble-shooting section in the technical bulletin.

The gas burner housing surrounding the diffuser plate should be periodically checked for any signs of damage that might be caused by an improperly adjusted burner or by a poor seal to the refractory. Routine maintenance should include this resealing which can be done with a mixture of refractory cement and asbestos pulp. Use care not to clog or obstruct the holes in the face of the gas housing. The diffuser should be positioned as shown in Figure 5-4. Do not attempt to change the gap or angle of the fins.

GAS PRESSURE AND FLOW INFORMATION

Because of variables in both the properties of gas and the supply system, it will be necessary to regulate the pressure of the gas to a level that produces a steady, dependable flame that yields highest combustion efficiency at rated performance yet prevents overfiring. Once this optimum pressure has been established, it should be recorded and periodic checks made to verify that the regulator is holding the pressure at this level. Occasional modification in fuel composition or pressure by the supplier may, at times, require readjustment to return the burner to peak efficiency. Since the gas pressure regulator itself is usually furnished by others, detailed adjustment instructions and adjusting procedures recommended by the manufacturer should be followed.

Pressure

The gas supplied must provide not only the quantity of gas demanded by the unit, but must also be at a pressure high enough to overcome the pressure-loss due to the frictional resistance imposed by the burner system and the control valves.

The pressure required at the entrance to the burner train for rated boiler output is termed "net regulated pressure". The gas pressure regulator must be adjusted to achieve this pressure to assure full input.

The pressure requirement varies with boiler size, altitude, and type of gas train. Refer to Table 1 for pressure requirements.

TABLE 1
Minimum Net Regulated Gas Pressure For Rated Boiler Output
(Required at Gas Train Entrance)

Boiler Size (H.P.)	*Standard and FM Approved Train*	*FIA Approved Train*
25	4.5	5.0
30	4.5	5.0
40	4.5	5.0
50A	7.0	7.5
50	4.5	5.0
60	4.5	5.5
70	5.0	6.0
80	5.5	7.5
100	8.5	11.5
100A	9.5	13.0
100S	9.5	13.0

The pressures listed are based on 1000 BTU/CU. FT. natural gas and elevations up to 700 feet above sea level. For installation at higher altitudes, multiply the selected pressure by the proper factor from Table 2.

TABLE 2

Altitude Feet Above Sea Level	*Correction Factor*
1000	1.04
2000	1.13
2500	1.18
3000	1.22
4000	1.33
5000	1.44
6000	1.57
7000	1.70
8000	1.84
9000	2.01

Gas Flow

The volume of *gas flow* is measured in terms of cubic feet and is determined by a meter reading. The *gas flow rate* required for maximum boiler output depends on the heating value (BTU/CU. FT.) of the gas supplied. The supplying utility can provide this information.

To obtain the required number of cubic feet per hour of gas, divide the heating value (BTU/CU. FT.) into the required burner input (BTU/HR.).

See Table 3 for input requirements.

TABLE 3

Boiler Horsepower	*Maximum Input BTU/Hr.*
25	1,046,000
30	1,255,000
40	1,674,000
50	2,092,000
60	2,511,000
70	2,929,000
80	3,347,000
100	4,184,000

Pressure Correction

The flow rate outlined in the previous section is figured on a "base" pressure which is usually atmospheric or 14.7 psi.

Meters generally measure gas in cubic feet at "line" or supply pressure. The pressure at which each cubic foot is measured and the correction factor for this pressure must be known in order to convert the quantity indicated by the meter into the quantity which would be measured at "base" pressure.

To express the volume obtained from an actual meter reading into cubic feet at base pressure it is necessary to multiply the meter index reading by the proper pressure factor obtained from Table 4.

Conversely: to determine what the meter index reading should be in order to provide the volume of gas required for input, divide the desired flow rate by the proper pressure correction factor. This answer indicates the number of cubic feet at line pressure which must pass through the meter to deliver the equivalent number of cubic feet at base pressure.

TABLE 4
Pressure Correction Factors

Regulator Inlet Pressure	*Pressure Factor*	*Regulator Inlet Pressure*	*Pressure Factor*
1 psig	1.05	9 psig	1.59
2 psig	1.11	10 psig	1.66
3 psig	1.18	11 psig	1.72
4 psig	1.25	12 psig	1.81
5 psig	1.32	13 psig	1.86
6 psig	1.39	14 psig	1.93
7 psig	1.45	15 psig	2.00
8 psig	1.52		

As an example: assume that a 70 horsepower boiler is installed at 2,000 feet above sea level; is equipped with a standard gas train; and that 1,000 BTU natural gas is available with an incoming gas pressure of 3 psig. The pressure and flow requirements can be determined as follows:

Pressure

Correction for the 2,000 feet altitude must be made since altitude has a bearing on the net regulated gas pressure. The standard gas train requires 5.0" WC gas pressure at sea level (Table 1). Table 2 indicates a correction factor of 1.13 for 2,000 feet. Multiplying these results in a calculated net regulated gas requirement of approximately 5.7" WC. This is the initial pressure to which the regulator should be adjusted. Slight additional adjustment can be made later, if necessary, to obtain the gas input needed for burner rating.

Flow

Since the gas flow rate is based on standard conditions of flow, correction must be made for the supply pressure through the meter of 3 psig. Determine the flow rate by dividing the BTU content of the gas into the burner input (Table 3) and "correct" this answer by applying the correction factor for 3 psig (Table 4).

$$\frac{\text{BTU/HR Input}}{\text{BTU/CU. FT.}} = \text{CFH (Cubic feet/Hour)}$$

OR

$$\frac{2{,}929{,}000}{1{,}000} = 2{,}929 \text{ CFH (At 14.7\# atmospheric "base" pressure)}$$

THEN

$$\frac{2{,}929}{1.18} = 2482 \text{ CFH}$$

This is the CFH (at line pressure) which must pass through the meter so that the equivalent full input requirement of 2,929 CFH (at base pressure) will be delivered.

Checking Gas Flow

Your gas supplier can generally furnish a chart developed to determine the cubic feet/hour reading from the meter based on the number of seconds per revolution of the 10 cubic feet dial. This provides a knowledge of the flow rate after a relatively short observation period.

Lacking a chart of this nature it is possible to "clock the gas meter" as follows:

(1) Turn off all other gas appliances that may be served by the meter.

(2) Set burner at high fire.

(3) Note meter reading and record consumption for 3 minutes.

(4) The following formula will provide the required gas input for a 3 minute period:

Input (BTU/HR) ÷ Heating Value (BTU/CU. FT.) ÷ 20 = Gas input in cubic feet for 3 minutes.

(5) Apply any necessary pressure correction factor to this answer to obtain the desired rate.

(6) To illustrate: — using circumstances from previous example, compute as follows:

BTU/HR ÷ BTU/CU. FT. ÷ 20 = 3 minute input in cu. ft.

OR

2,929,000 ÷ 1000 ÷ 20 = 146.5 cu. ft. (base pressure)

146.5 ÷ 1.18 (pressure correction) = 124.5 cu ft. (line pressure)

(7) If the input timed for 3 minutes does not agree with the rating indicated by the formula adjust the gas pressure regulator to increase or decrease flow as required.

NOTE: The information given in this section is for all practical purposes sufficient to set and adjust controls for gas input. Your gas supplier can if necessary furnish exact correction factors that take into consideration BTU content, exact base pressure, specific gravity, temperature, etc., of the gas used.

COMBUSTION ADJUSTMENT — GAS

Gas input adjustment is accomplished by increasing or decreasing the pressure of gas downstream of the pressure regulator. Any required adjustment to the regulator should be done with burner at high fire and with the gas butterfly valve wide open.

In the event linkage or regulator adjustments are required proceed as follows. Initially set the linkage by backing out the low fire stop screw so the valve is closed. Then run screw out two complete turns. Adjust the connecting rod so that tension is released.

It is not practical to list specific setting of the connection points or of the angles of the arms. The final setting should provide a coordinated movement of the damper and the gas valve. If the gas valve opens rapidly, compared to the air damper, an overly rich fire will occur during transition between the two firing positions. This improper fuel-air ratio can cause sooting of the fireside surfaces. If it opens too slowly then the proportionally greater air flow should extinguish the flame.

Points to remember are that the motor arm must complete its full travel and that the valve arm should travel its required arc without excessive stretching of the over ride springs. The closer that the swivel joint in the motor arm is to the hub the less distance it will travel. To increase the valve arm travel, move the connecting rod closer to the hub or away from it if decreased travel is required.

This low fire setting should be regarded as tentative until proper gas pressure for high fire operation is established.

After operating at low fire for a sufficient period of time to assure a warm boiler, turn the damper positioning switch to "high". Observe the burner as it progresses toward high fire. In the event gas pressure is too low or if the butterfly valve movement is not properly co-ordinated with the air damper, it is possible that increased air flow may extinguish the flame. Immediately turn burner off. Determine and correct condition causing flame failure before repeating attempt.

At high fire position, the butterfly valve should be wide open as indicated by the slot on the end of its shaft. Set and lock the high fire stop screw until it is just touching the valve arm.

Determine the actual gas flow from a meter reading as outlined in another section. If corrections are necessary to obtain the required input, increase or decrease the gas pressure by adjusting the pressure regulator. Turn its adjusting screw clockwise to increase pressure, or counter clockwise to decrease pressure.

When the high fire gas flow is established, no further adjustment of the regulator is required.

With proper gas flow, any further adjustment necessary to obtain a desirable flue gas analysis must be done with the air damper. Check all adjustments with a combustion gas analyzer.

When the high fire air/fuel ratio is set, shut the burner down, re-light and check low fire. It may be necessary to re-adjust the low fire stop screw or the linkage. To assure that low fire position of the butterfly valve is always the same, allow a minimum of one turn of the stop screw for over-travel.

Any adjustment must not cause extensive stretching of the override springs. If linkage adjustments are made, recheck to determine that high fire is not affected.

The appearance or color of the gas flame is not an indication of its efficiency since an efficient gas flame will vary from transparent blue to translucent yellow.

Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion gas analyzer. This instrument measures the content, by percentage, of carbon dioxide (CO_2), oxygen (O_2), and carbon monoxide (CO) in the flue gas.

Burner efficiency is measured by the amount or percentage of CO_2 present in the flue gas. The theoretical maximum CO_2 percentage for natural gas is approximately 11.7% . As shown in Chart 5-5 this is attained when there is no excess oxygen (O_2) or carbon monoxide (CO). A definite percentage of excess air (oxygen) is required by most local gas authorities and of course, the burner should never be operated with an air-fuel ratio that indicates a detectable percentage of carbon monoxide.

Subject to local regulations pertaining to specific amounts of excess oxygen, it is generally recommended that CO_2 readings of between 9-1/2 and 10-1/2% be attained with corresponding O_2 readings of 2 to 4% .

H. SWITCH AND CAM ADJUSTMENT

LOW FIRE SWITCH — ALL BOILERS

The low fire switch (LFS), used on all boilers, must be closed to complete programmer circuitry assuring that damper is in low fire position before ignition takes place. The switch opens when the damper motor drives to open during pre-purge and closes when the motor resumes its low fire position upon completion of pre-purge. The switch therefore, must be actuated just prior to the damper reaching its closed position.

The low fire switch circuit is connected to damper motor terminals B and W. The switch makes B-W during the closing stroke (motor shaft moves in the direction of the CLOSE arrow on outside of case).

To adjust the switch:

1. Remove motor cover.

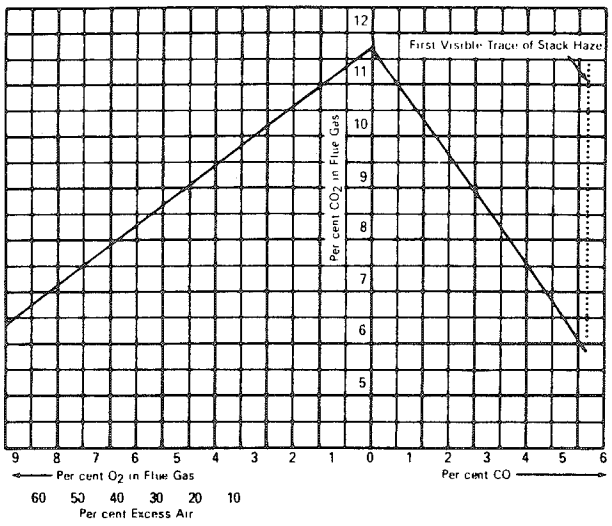


FIGURE 5-5. FLUE GAS ANALYSIS CHART FOR NATURAL GAS

CAUTION

Disconnect power supply before adjusting the switch cam.

2. Insert a screwdriver in a slot in the switch cam (white plastic) located near the center of the motor. Each slot in the cam equals approximately 20 degrees of motor rotation.
3. Move cam the correct number of degrees by moving cam in the direction of the OPEN arrow on the outside of the motor case. The switch should make at approximately 8 to 10 degrees on motor closing.

IMPORTANT!

The switch should not be adjusted to operate closer than 5 degrees from ends of the motor stroke.

4. Repower the motor and check the point at which the switch makes. Readjust if necessary.

HIGH FIRE OIL VALVE SWITCH (CBH 25-40 and 50A) or HIGH FIRE SWITCH (CBH 50-100)

A Q607A switch (single microswitch) attached to the damper motor, serves as the auxiliary switch that actuates the high fire oil valve on the CBH 25-40 and 50A oil fired boilers; or as the high fire switch, when insurance requirements call for it, on the CBH 50-100 boilers. See Figure 1-1.

The high fire switch (HFS) is used, when required, to prove that the air damper opens during pre-purge. Its terminals should make when the damper is nearly open and just before the timing of the programmer de-energizes the damper motor. See wiring diagram for sequence timing of the control.

The following directions are based on adjusting the switch prior to its attachment to the motor. While particularly useful during replacement, they also serve as a guide for final adjustment.

a) BEFORE attaching the switch to the mounting bracket, depress the scale lock and rotate the scale so that the zero mark on the black scale is approximately at the index mark as shown in Figure 5-6.

b) Release the scale lock and loosen thumb nut.

c) Loosen both cam locking screws. Align the two cam lobes so that only the operational cam (silver colored) will cause switch lever movement. Tighten the differential cam screw.

d) The switching action desired is for the normally open leads (red and blue) to close as the motor reaches its open position. Using the index mark as a reference point, push the

scale lock down and turn the scale clockwise approximately 70° (motor stroke is 75°). Release the scale lock.

e) Turn cam until the cam roller of the switch lever is exactly over the outer corner of the operational cam lobe. Slight movement of the cam at this point should produce an audible click in the switch. Tighten the operational cam's locking screw.

f) No cam differential is desired between the make and the break of the contacts, so be sure that the differential cam lobe (brass colored) and the operational cam lobe are aligned so that the differential cam has no effect on the switch.

g) Tighten thumb screw.

h) Mount the switch on the motor. Connect the red and blue leads to the oil valve circuit (HFOV) or to the high fire switch (HFS) as shown on your boiler wiring diagram. The yellow lead is not required and its end should be insulated to prevent short circuits.

i) Check out the operation of the switch under actual operating conditions. Readjust the cam if necessary to assure oil valve opening and closing at the desired point. If the switch is used for proving that the air damper reaches high fire position during pre-purge, the setting is not critical and it should make between two-thirds and full motor travel.

HIGH FIRE SWITCH — CBH 25 THRU 40 AND 50A

When insurance requirements call for a high fire switch on the 25 thru 40 and 50A sizes, a Q607B switch (two micro-switches) is attached to the damper motor.

The first switch is used for the high fire oil valve circuit. The second switch is used to prove that the air damper is open during pre-purge.

The following directions are based on adjusting the switch prior to its attachment to the damper. While particularly useful during replacement, they also serve as a guide for final adjustment.

a) BEFORE attaching switch to the mounting bracket, depress the scale lock and rotate the scale so that the zero mark on the black scale is close to the index mark as shown in Figure 5-7.

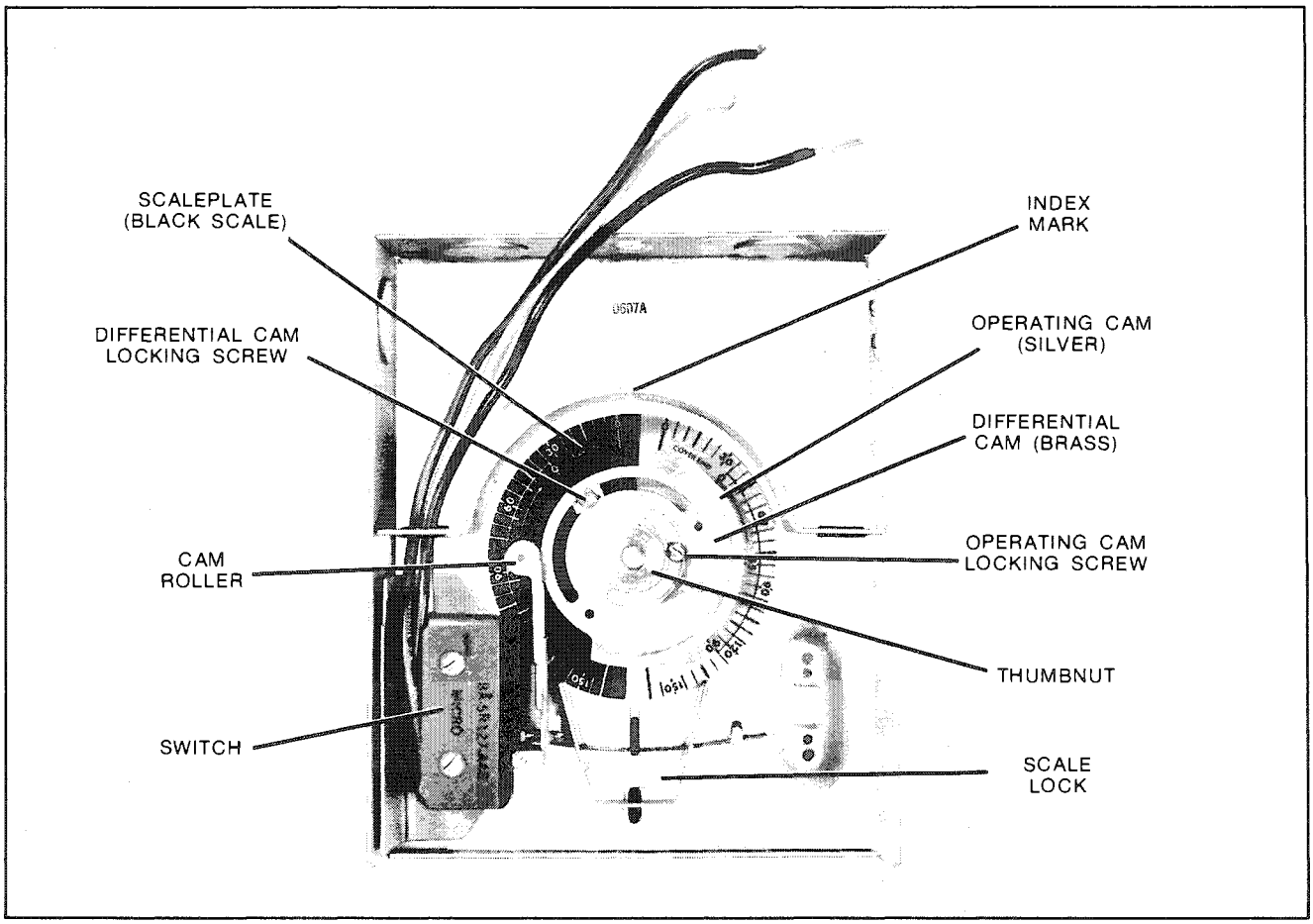


FIGURE 5-6. Q607A AUXILIARY SWITCH (SINGLE MICRO-SWITCH)

b) Release the scale lock. Remove the thumb nut and the top set of cams.

c) Proceed with steps 'c' thru 'i' of preceding section to get the high fire oil valve (HFOV) setting on switch No. 1.

d) Place the second set of cams on the shaft. Make sure that the operational cam's locking screw is on the opposite side of the shaft as the switch the cam is to operate (when the scale plate is set near zero).

e) Loosen both cam locking screws. Align the two cam lobes so that only the operational cam (silver colored) will cause switch lever movement. Tighten the differential cam screw.

f) Depress the scale lock. Turn cam so that the cam roller of the No. 2 switch lever is exactly over the outer corner of the operational cam lobe when the scale indicates 60° or more of motor travel. This switch is used to prove damper opening during pre-purge. Connect the leads into the circuit as indicated on your wiring diagram. The yellow lead is not required and its end should be insulated to prevent a short circuit.

g) Check the operation of the switches under actual operating conditions. Make any necessary cam adjustments to assure that the oil valve opens at the desired point and that the high fire switch makes when the damper is open.

HIGH FIRE OIL VALVE SWITCHES — CBH 50-100

Oil fired CBH boilers in sizes 50 thru 100 have two adjustable cam actuated switches located at the end of the jackshaft connected to the damper motor. See Figure 1-6. Their purpose is to energize

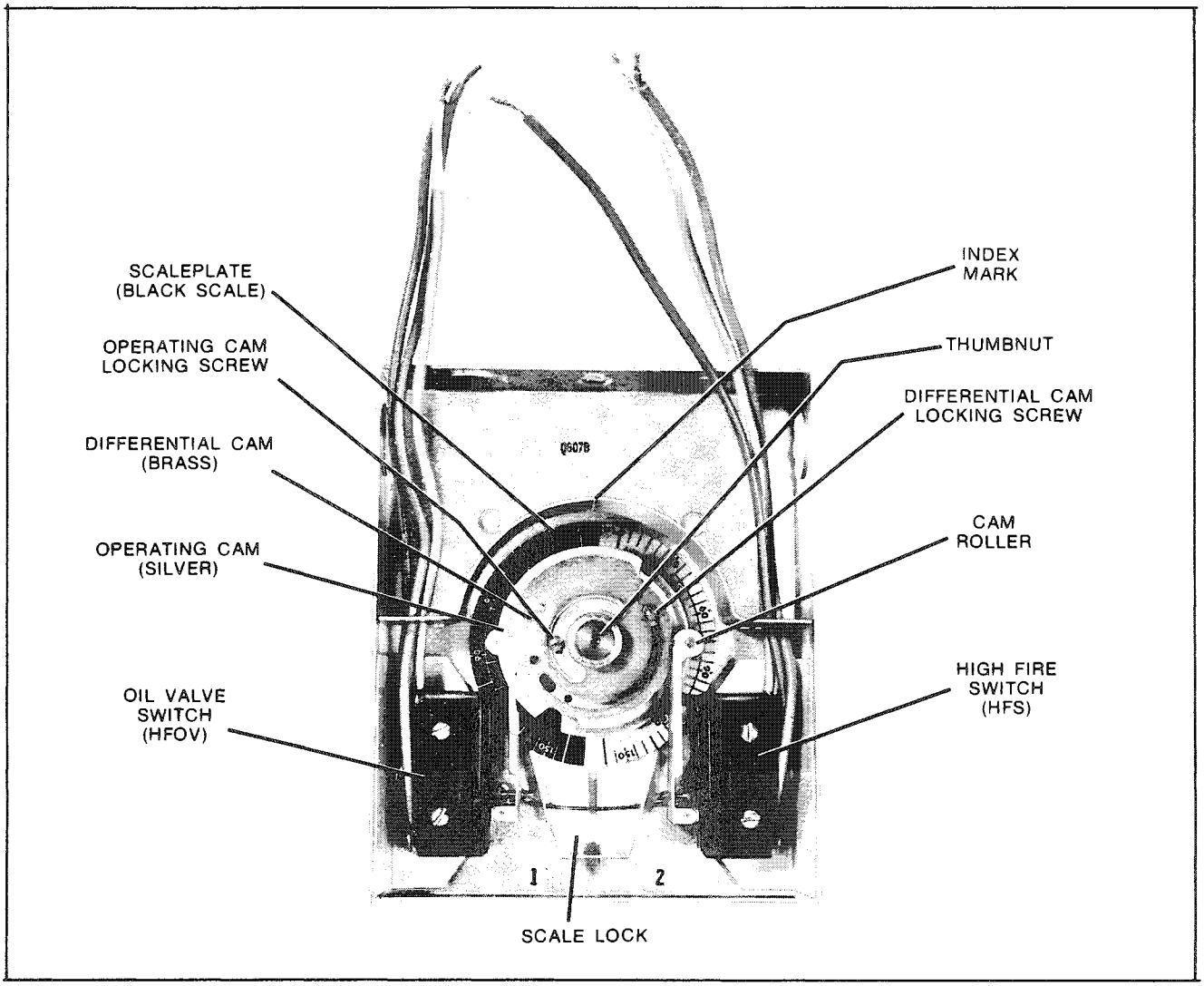


FIGURE 5-7. Q607B AUXILIARY SWITCH (TWO MICRO-SWITCHES)

the intermediate (HFOV-1) and the high fire (HFOV-2) oil valves.

The variables involved preclude specifying the position of the cams by degree of angle since their point of actuation is directly related to the amount of damper travel on a particular burner. Damper movement may be set to a greater or lesser amount of opening depending upon job conditions and combustion needs. Cam position can best be explained by detailing the function of the switch it actuates.

The first switch (AS-1) is actuated to close midway between low and high fire. This causes the intermediate oil valve to open and the second nozzle to fire, providing an increased firing rate for a smoother change-over between the low and the high fire rates and vice versa. As it moves towards the high fire, the air damper allows an increasing amount of air into the boiler. The valve should open at approximately mid-range, but definitely at a point when sufficient air is present so that there is no incomplete combustion or smoke caused by an improper air/fuel ratio. The positioning of the cam must be guided by observing the fire or stack when the valve opens. If smoke or haze is noticed, reposition cam to slightly retard valve opening.

The second oil valve switch (AS-2) should be actuated just as damper reaches its open position. On the basis of a combustion analysis, damper position or linkage adjustment may be required to provide more or less air at this point.

In the event of a component replacement, note position of cams and replace them as near as possible to their original position; but be sure to check for proper switch actuation. If a switch is replaced, make sure that wiring connections are correct. The set screw holding the cam should be checked occasionally for tightness.

I. AIR DAMPER ADJUSTMENT

Since the rate at which fuel is delivered is adjustable only within narrow limits, setting of the air damper is the primary means of obtaining the correct ratio of fuel to air to insure the most efficient combustion. The arms and connecting rod that transmit motion from the damper motor to the air damper (and to the gas butterfly valve on a gas-fired unit) are set at the factory and should not normally need further adjustment. If adjustments are required, proceed as follows:

Normally, at low fire the damper is cracked slightly open. A stop screw limits the amount of travel. With the burner firing at low rate, back off the screw to allow the damper to further close until a slight haze appears in the stack. Gradually open the damper until the haze disappears. Lock the adjustment screw in this position.

Turn the damper positioning switch to high fire. Turn the high fire adjustment screw to slightly close the air damper until a slight haze appears. Re-adjust the screw to open the damper to a position where the haze disappears. Lock the adjustment screw in this position.

Consider these settings to be only approximately correct. Final adjustment should be made using a flue gas analyzer.

Adjust the linkage and the arms so that a smooth damper movement occurs. Observe the burner as it cycles to high fire and back to low to be sure that the air flow is coordinated with the fuel flow. Too much air may extinguish the flame while an insufficient amount will cause a smokey changeover.

The following factors can serve as guides in linkage adjustment:

(a) The damper motor must be able to complete its full travel range of 75 degrees. A restriction can cause damage.

(b) The closer the swivel joint in the motor arm is to the hub, the less distance it will travel.

(c) The amount of damper opening increases when its connecting joint is closer to the hub. To decrease opening move the ball joint away from the hub.

(d) Final adjustments should result in a coordinated movement of the damper and damper motor.

(e) Over-travel linkage should not be required to extend its spring to fullest stretch.

Periodically check for proper adjustment. Check tightness of setscrews to prevent slippage. Occasionally oil swivel joints with a graphite or silicone type lubricant.

J. SAFETY VALVES

The safety valve is a very important safety device and deserves attention accordingly.

The purpose of the valve(s) is to prevent pressure build up over the design pressure of the pressure vessel. The size, rating and number of valves on a boiler is determined by the ASME Boiler Code. The installation of a valve is of primary importance to its service life. A valve must be mounted in a vertical position so that discharge piping and Code required drains can be properly piped to prevent build up of back pressure and accumulation of foreign material around the valve seat area. Apply only a moderate amount of pipe compound to male threads and avoid overtightening as this can distort the seats. Use only flat jawed wrenches on the flats provided. When installing a flange connected valve, use a new gasket and draw the mounting bolts down evenly. Do not install or remove side outlet valves by using a pipe or wrench in the outlet.

A drip pan elbow or a flexible connection between

the valve and the escape pipe is recommended. See Figure 1-7. The discharge piping must be properly arranged and supported so that its weight does not bear upon the valve.

Do not paint, oil, or otherwise cover any interior or working parts of the safety valve. A valve does not require any lubrication or protective coating to work properly.

Follow the recommendations of your boiler inspector regarding valve inspection and testing. The frequency of testing, either by the use of the lifting lever or by raising the steam pressure, should be based on the recommendation of your boiler inspector, and/or the valve manufacturer, and in accordance with sections VI and VII of the ASME Boiler and Pressure Vessel Code.

Avoid excessive operation of the safety valve as even one opening can provide a means of leakage. Safety valves should be operated only often enough to assure that they are in good working order. When a pop test is required, raise the operating pressure to the set pressure of the safety valve, allowing it to open and reseat as it would in normal service.

Do not hand operate the valve with less than 75% of the stamped set pressure exerted on the underside of the disc. When hand operating, be sure and hold the valve in an open position long enough to purge accumulated foreign material from the seat area and then allow the valve to snap shut.

Frequent usage of the safety valve will cause the seat and disc to become wire drawn or steam cut. This will cause the valve to leak and necessitate down time of the boiler for valve repair or replacement. Repair of a valve must be done only by the manufacturer or his authorized representative.

Avoid having the operating pressure too near the safety valve set pressure. A 10% differential is recommended. An even greater differential is desirable and will assure better seat tightness and valve longevity.

Steam is expensive to generate and, for the sake of economy, wastage should be avoided whenever possible.

K. MOTORIZED GAS VALVE

Should the valve fail to operate, check its operation by applying test leads of the proper voltage to terminals 1 and 2 of the actuator. Make certain that the main shut off cock is closed prior to testing. If the actuator fails to operate, it must be replaced. The actuator is not field repairable nor should it be disassembled.

To remove the actuator, loosen the two 5/32" allen setscrews that hold the actuator collar to the valve bonnet.

After replacement, cycle the valve with the fuel shut off to determine that it opens and closes. If the valve has a visual indicator, observe the colored indicator; yellow - shut; red - open.

The auxiliary switch normally used as a valve closed indication switch is replaceable as a component.

L. SOLENOID VALVES: GAS PILOT-FUEL OIL-VENT VALVES

Foreign matter between the valve seat and seat disc can cause leakage. Valves are readily disassembled, however, care must be used during disassembly to be sure that internal parts are not damaged during the removal and that re-assembly is in proper order.

A low hum or buzzing will normally be audible when coil is energized. If valve develops loud buzzing or a chattering noise check for proper voltage and clean plunger assembly and interior plunger tube thoroughly. Do not use any oil. Make sure that plunger tube and solenoid are tight when reassembled. Take care not to nick, dent or damage the plunger tube.

Coils may be replaced without removing the valve from the line. Be sure to turn off power to the valve. Check coil position and make sure that any insulating washers or retaining springs are reinstalled in proper order.

M. REFRACTORY

The Cleaver-Brooks boiler is shipped with completely installed refractory. This consists of the rear head, the inner door and the furnace liner. Normal maintenance requires little time and expense and prolongs the operating life of the refractory. Preventive maintenance through periodic inspection will keep the operator informed of the condition of the refractory and will guard against unexpected and unwanted down time and major repairs.

Frequent wash-coating of refractory surfaces is recommended. High temperature bonding air-dry type mortar, diluted with water to the consistency of light cream, is used for this purpose. Re-coating intervals will vary with operating loads and are best determined by the operator when the heads are opened for inspection.

Rear Door

The rear door is a steel shell containing horizontal baffle tiles and lined with insulation material and castable refractory (See Figure 5-8).

Burned or discolored paint on the outer surface of the door does not necessarily indicate refractory trouble, but may be an indication of other con-

ditions such as:

(a) Leaking gaskets.

(b) Improper seal.

(c) Door retaining bolts insufficiently or unevenly tightened.

(d) The air line to the rear sight tube may be blocked or loose.

(e) Repainted with other than heat resistant paint.

Therefore, before assuming that refractory requires re-working:

(a) Check condition of tadpole gasket.

(b) Check condition of insulating cement protecting the tadpole gasket.

(c) Check the horizontal baffle tile for large cracks, breaks, chipped corners, etc.

(d) Check for cracks in castable refractory at ends of baffle tile.

(e) Check tightness of door bolts.

(f) See that air line to sight tube is clear and connections are tight. If necessary, blow clear with an air hose.

It is normal for refractories exposed to hot gases to develop thin "hairline" cracks. This by no means indicates improper design or workmanship. Since refractory materials expand and contract to some degree with changes in temperature they should be expected to show minor cracks due to contraction when examined at low temperature. Cracks up to approximately 1/8" across may be expected to close at high temperature. If there are any cracks that are relatively large (1/8" to 1/4" in width) clean them and fill with high temperature bonding mortar. Any gap that may show between the castable refractory and the baffle tile should be filled in a similar fashion.

After opening the rear door, clean off the flange surface of the door with a scraper or wire brush. Clean the surface of the refractory carefully with a fiber brush to avoid damaging the surface. Clean the mating surfaces of the baffle tile and the boiler shell. Remove all dried out sealing material.

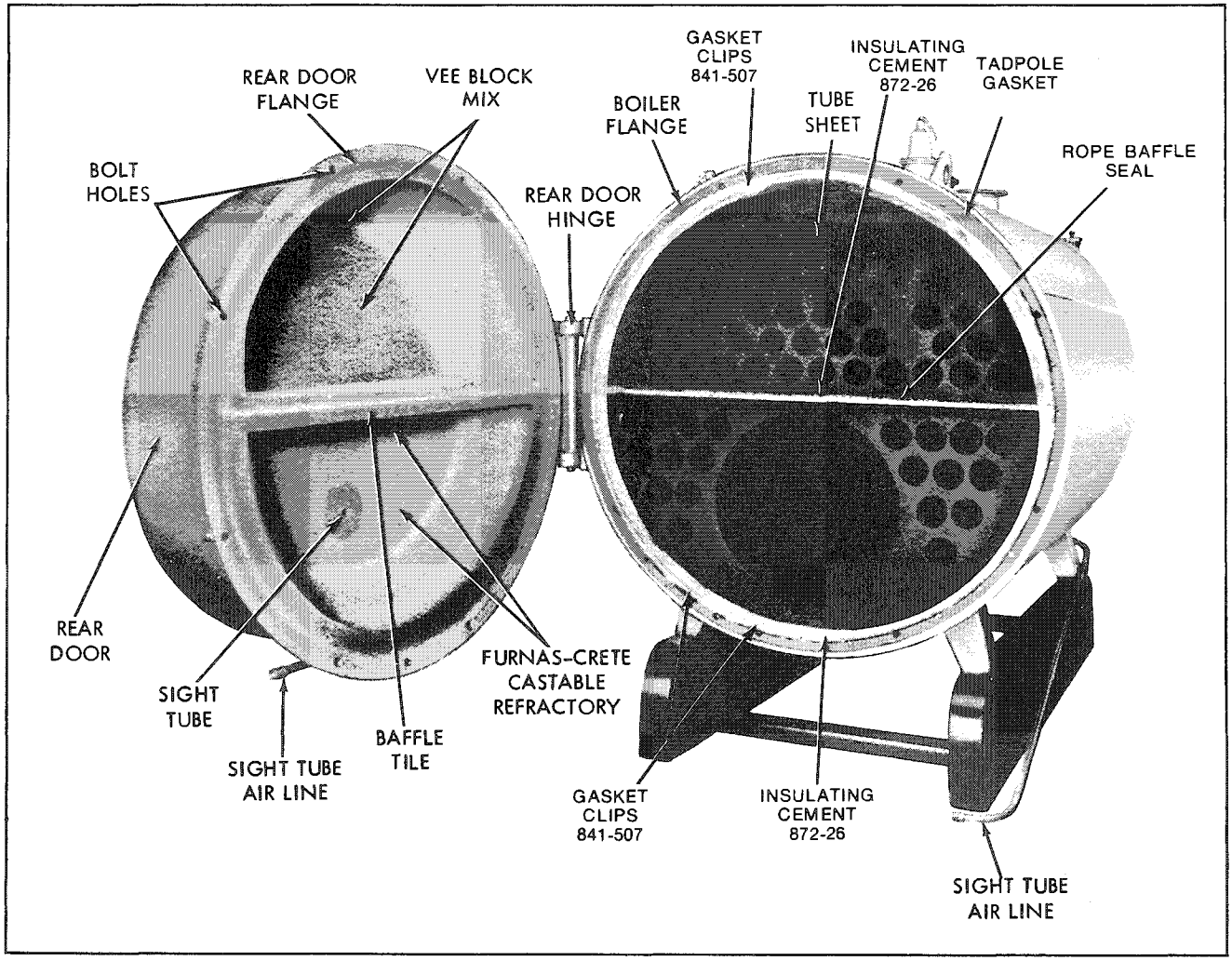


FIGURE 5-8. REAR DOOR OPEN

Wash-coat the lower half of the rear door refractory prior to closing.

The upper half of the door contains a lightweight insulating material similar to that used in the inner door. A thin wash-coat mixture applied gently with a brush is helpful in maintaining a hard surface.

If the baffle tile or the refractory requires replacement, contact your local Cleaver-Brooks representative or write to the Cleaver-Brooks Service Department for a copy of bulletin C10-4101 covering major repair or replacement of rear door refractory.

Front Inner Door

The front inner door is lined with a lightweight castable insulation material. Thin, "hairline" cracks may develop after a period of time, however, these will generally tend to close due to expansion when the boiler is fired.

A thin wash-coat mixture applied gently with a brush is helpful in maintaining a hard surface.

Minor repairs can be accomplished by enlarging or cutting out affected areas, making certain that they are clean and then patching as required.

Should the entire installation require replacement, remove existing material and clean to bare metal. Inspect the retaining pins and replace if necessary. Reinforcing wire suitably attached may also be used. The recommended insulation is known as Vee Block Mix and is available in 50 lb. bags (CB Part Number 872-162).

Mix the material with water to a troweling consistency. Mixing should be completely uniform with no portion either wetter or drier than another. Trowel this mixture into any areas that are being patched. If replacing complete insulation begin at bottom of door and apply the mixture to a thickness equal to the protecting shroud. With a trowel apply horizontally back and forth across the door in layers until the required thickness is reached.

Allow to air-dry as long as possible. If immediate use of boiler is required, fire as slowly as possible to avoid rapid drying of the material.

Furnace Liner

Maintenance consists of occasional wash coating of the entire liner. Face all joints or cracks by applying high temperature bonding mortar with a trowel or fingertips. This should be done as soon as cracks are detected.

Should segments of the liner burn away or fall out, replace the entire refractory. Any refractory that may break out should be removed as soon as detected so that it will not fuse to the bottom of the furnace and obstruct the burner flame.

If replacement is necessary, refer to Chapter 7 and order proper replacement materials. Remove existing refractory and thoroughly clean that portion of the furnace covered by the liner to remove all old refractory cement or other foreign material to insure new liner seating firmly to the steel. Inspect furnace metal for soundness.

It is recommended that the tile be dry fitted, match marked, removed and then reinstalled with the proper amount of refractory cement. Thin joints are desirable. Generally it will be necessary to shave a portion from one or more tile to obtain a fit. If a fill piece is required, cut it to fit and install this piece at the bottom of the furnace.

Allow refractory to air dry as long as possible. If immediate use of boiler is required fire at low rate and intermittently if possible.

N. DOOR CLOSING AND SEALING

Whenever the front or rear door is opened for inspection, the head gaskets should be checked for hardening and brittleness. Doubtful gaskets should be replaced. Coat the gasket with an oil and graphite mixture before closing the door. Make certain that all gasket retaining rivets are in place. The flange of the door should be clean and free of any hardened cement, scale, etc.

Check the condition of the rope used as a baffle seal. Replace if necessary. If the rope is in good condition, liberally coat it with an insulating pulp prior to closing. Make sure that the rope is properly positioned.

If it is necessary to replace the rope, wire brush the tube sheet area to remove all old sealing material. Place a new piece of 1-1/2" diameter rope (853-924) on the lip of the baffle tile. Hold it in place with furnace cement or an adhesive.

NOTE: Earlier models had several steel bar segments tack welded across the tube sheet to serve as a gasket retainer for 5/8" diameter rope. It is suggested that these bars be removed and 1-1/2" diameter rope used.

Generously apply a seal, consisting of a pulp mixture of insulating cement and water, around the entire rear door circumference. Place the pulp around the inside diameter of the head gasket as shown in Figure 5-8. Also coat the tube sheet area adjacent to the baffle tile.

When the door is closed, the pulp will compress to protect the tadpole gasket and to form a seal between the refractory surface and the tube sheet.

The insulating pulp seal is not needed or used on the front head. Make sure that gaskets are in position when closing.

When closing the door, bolts should be run in snug and tightened evenly to avoid cocking door and

damaging gasket. Start tightening at top center and alternate between top center bolt and bottom center bolt until both are drawn up-tight. Do not overtighten. Continue tightening sequence along top and bottom, tightening bolts alternately until door is secured and gas tight. After boiler is back in operation re-tighten the bolts to compensate for any expansion.

NOTE: Proper sealing of doors is essential to avoid leakage of combustion gases and loss of heat and operating efficiency.

O. FORCED DRAFT FAN

The position of the impeller vanes with relation to the air intake housing is extremely important to the output capacity of the fan. The impeller vanes should not rub or contact the air housing but at the same time the clearance must not be more than 1/32''. Spacing washers of various thicknesses are used to obtain desired clearance.

Check occasionally to see that fan is securely tightened to the motor shaft. Examine the vanes for deposits of dust or dirt since these build ups can cause a decrease in air capacity or lead to an unbalanced condition.

If motor was replaced or if motor leads were disconnected, make sure that impeller rotation is proper before starting operation. Rotation on most models is counterclockwise when viewed from the front of the boiler. Notice the direction arrow on the impeller housing.

P. FIRESIDE CLEANING

Soot and non-combustibles are effective insulators and if allowed to accumulate will reduce heat transfer to the water and increase fuel consumption. Soot and other deposits can be very moisture absorbent and may attract moisture to form corrosive acids which will deteriorate fireside metal.

Clean-out should be performed at regular frequent intervals depending upon load, type and quality of fuel, internal boiler temperature, and combustion efficiency. A stack temperature thermometer, if used, can be a guide to clean-out intervals since an accumulation of soot deposits will raise the flue gas temperature.

Tube cleaning is accomplished by opening front and rear doors. Tubes may be brushed from either end. All loose soot and accumulations should be removed. Any soot or other deposits should be removed from the furnace and tube sheets.

Refer to Section N of this chapter for instructions on properly closing front and rear heads.

The vent stub and stack should be cleaned at regular intervals. Commercial firms are available to perform this work. The stack should be inspected for damage and repaired as required.

The fireside should be thoroughly cleaned prior to any extended lay-up of the boiler. Depending upon circumstances a protective coating may be required. See Section J in Chapter 2.

Q. LUBRICATION

Electric Motors

Manufacturers of electric motors vary in their specifications for lubrication and care of motor bearings and their recommendations should be followed.

Ball bearing equipped motors are pre-lubricated. The length of time a bearing can run without having grease added will depend upon many factors. The rating of the motor, type of motor enclosure, duty, atmospheric conditions, humidity, and ambient temperatures are but a few of the factors involved.

Complete renewal of grease can, when necessary, be accomplished by forcing out the old grease with the new. Thoroughly wipe those portions of the housing around the filler and drain plugs (above and below bearings). Remove the drain plug (bottom) and free the drain hole of any hardened grease which may have accumulated. With the motor not running, add new grease through the filler hole until clear grease starts to come out of the drain hole. Before replacing the drain plug run the motor for 10 to 20 minutes to expel any excess grease. The filler and drain plugs should be thoroughly cleaned before they are replaced.

The lubricant used should be clean and equal to one of the good commercial grades of grease locally available. Some lubricants that are distributed nationally are:

Gulf Oil	—Precision Grease No. 2
Humble Oil	—Andok B
Texaco	—Multifak No. 2
Phillips	—1 B + RB No. 2
Fiske Bros.	—Ball Bearing Lubriplate
Standard/Mobile	—Mobilux No. 2

Control Linkage

Apply a non-gumming dripless high temperature lubricant, such as graphite or a silicone derivative to all pivot points and moving parts. Work lubricant in well and wipe excess. Repeat application at required intervals to maintain freedom of motion of parts.

Solenoid valves and motorized valves require no lubrication.

CHAPTER 6

TROUBLE SHOOTING

A. BURNER DOES NOT START
B. NO IGNITION
C. GAS PILOT FLAME, BUT NO MAIN FLAME
D. LOW FIRE FLAME, BUT NO HIGH FIRE FLAME
E. LOSS OF FLAME
F. DAMPER MOTOR

This section assumes that the unit has been properly installed and adjusted and that it has been running for some time prior to the trouble listed in the heading of each section. It is further assumed that the operator has become thoroughly familiar with both burner and manual by this time. The points under each heading are set down briefly as possible causes, suggestions or clues to simplify locating the source of trouble. Methods of correcting the trouble, once it has been identified, may be found elsewhere in this manual.

If the burner will not start, or operate properly, refer to this trouble shooting section and to the programming relay bulletin for assistance in pinpointing problems that may not be readily apparent. Familiarity with the programmer and other controls in the system may be obtained by studying the contents of this manual and the bulletin. Knowledge of the system and its controls will make troubleshooting much easier. Costly down time or delays can be prevented by systematic checks of the actual operation against the normal sequence to determine the stage at which performance deviates from normal. Following a routine may possibly eliminate overlooking an obvious condition, often one that is relatively simple to correct.

If an obvious condition is not apparent, check the continuity of the circuits with a voltmeter or test lamp. Each circuit can be checked and the fault isolated and corrected. Most circuitry checking can be done between appropriate terminals on the terminal boards in the control cabinet or the entrance box. Refer to the schematic Wiring Diagram for terminal identification.

A. BURNER DOES NOT START

1. Main disconnect switch open.
2. Blown fuses, tripped overloads, loose electrical connections.
3. Combustion control safety switch requires resetting
   a) Refer to manufacturer's bulletin
   b) Check for power between terminals L1 and L2 (terminal board 4 and 5)
   c) If relay 1K pulls in, but the blower motor does not start, check for power at programmer terminal 8
   d) Check that appropriate relay contacts are closed (see programmer bulletin)
4. Limit circuit not completed - no power to programmer terminal 3
   a) Pressure or temperature is above setting of operating control
   b) Water below required level
      1) Check manual reset button, if provided, on low water control
   c) Fuel pressure must be within settings of low pressure and high pressure switches
5. Motor defective.
6. If burner starts, but shuts down after a few seconds check the air proving switch circuit.

B. NO IGNITION

1. Lack of spark
   a) Electrode grounded or porcelain cracked
   b) Improper electrode setting
   c) Loose terminal or ignition cable; cable shorted
   d) Inoperative ignition transformer
   e) Check appropriate program relay contacts
2. Spark but no flame
   a) Lack of fuel — no gas pressure, closed valve, empty tank, broken line,etc.
   b) Inoperative pilot solenoid or low fire oil valve

c) Insufficient or no voltage to gas pilot solenoid valve. Check power at relay terminal 5

3. Low fire switch open
   a) Damper motor not closed, slipped cam, defective switch
   b) Damper jammed or linkage binding
4. Check interlocks and circuit to relay terminal 12
5. Timer switch (CB20 or CB40) in TEST position and timer stopped in "pre-purge"

C. PILOT FLAME, BUT NO MAIN FLAME

1. Insufficient pilot flame
2. Gas fired unit:
   a) Manual gas cock closed
   b) Main gas valve inoperative
   c) Low or high gas pressure (reset switch if necessary)
3. Oil fired unit:
   a) Oil supply cut-off by obstruction, closed valve, or loss of suction
   b) Pump inoperative; belt broken or slipping
   c) No fuel
   d) Inoperative solenoid valve
   e) Check oil nozzles and lines
4. Inoperative programmer
   a) If relay 2K does not pull in when pilot flame lights, check flame detector, contacts, amplifier
   b) Flame detector defective, sight tube obstructed or detector lens dirty
   c) If relay 2K pulls in but fuel valve isn't energized, check for voltage at terminal 7. If no voltage check contacts. (See bulletin)

D. BURNER STAYS IN LOW FIRE

1. Pressure or temperature above high-low fire control setting
2. Damper positioning switch in wrong position
3. Inoperative damper motor (See Section F)
4. Defective high-low fire control
5. Binding or loose linkage, cams, setscrews, etc.
6. Check appropriate relay contacts

E. SHUTDOWN OCCURS DURING FIRING

1. Loss or stoppage of fuel supply
2. Defective fuel valve; loose electrical connection
3. Flame detector weak or defective
4. Lens dirty or sight tube obstructed
5. If the programmer lockout switch has not tripped, check the limit circuit controls, interlock, or blower motor
6. If the lockout switch has tripped;
   a) Check fuel lines and valves
   b) Check flame detector
   c) Visually check appropriate timer and relay contacts, (refer to program control manual)
   d) Check blower motor and all interlocks (CB-40)
   e) Lockout switch malfunctioning
      1) Stuck contacts
7. Improper air-fuel ratio (lean fire)
   a) Slipping linkage
   b) Damper stuck open
   c) Fluctuating fuel supply
      1) Temporary obstruction in fuel supply
      2) Temporary drop in gas pressure
8. Interlock device inoperative or defective

F. DAMPER MOTOR DOES NOT OPERATE

1. Damper positioning switch in wrong position
2. Linkage loose or jammed
3. Motor does not drive to open or close during pre-purge or close on burner shutdown
   a) Check appropriate contacts (See bulletin)
4. Motor does not operate on demand
   a) Damper positioning switch in wrong position
   b) High-low fire control improperly set or inoperative
   c) Check appropriate contacts (See bulletin)
5. Motor inoperative
   a) Loose electrical connection
   b) Faulty damper motor transformer

CHAPTER 7

PARTS ORDERING INSTRUCTIONS AND PARTS LIST

FURNISH COMPLETE INFORMATION WHEN ORDERING PARTS — When ordering parts for your boiler, be sure to include on your order the serial number of the boiler from the name plate. Your order should state the Cleaver-Brooks part number and the name and description of the part required. Also state the quantity desired; and specify method of shipment. Indicate date material is required. If parts are required for accessory equipment, such as an electric motor, pump, etc., which may not be shown in the parts reference material, be sure to give the complete name plate data from the accessory for which the parts are required.

WHERE TO ORDER PARTS — Repair or replacement parts for CB Boiler should be ordered from your Cleaver-Brooks representative or from Cleaver-Brooks of Canada, Ltd., P.O. Box 458, Stratford, Ontario.

RETURNING PARTS FOR REPAIR — Parts to be repaired should be directed to your Cleaver-Brooks representative or Cleaver-Brooks of Canada Ltd., 161 Lorne Ave., Stratford, Ontario, attention Parts Center. A purchase order or a letter authorizing repairs and giving complete details should be mailed to your representative or Cleaver-Brooks. Prior to returning please remove fittings or accessories from the component, properly drain and clean part, to comply with shipping regulations and include inside of the package a packing slip identifying the part with your company's name.

If you desire to return parts for reasons other than repair or exchange, please contact your representative or the Parts Center in Stratford stating reasons for the return and await permission and directions prior to returning the material.

(Be sure to show the serial number of your unit on all parts orders and correspondence.)

SERIAL NO.

IT IS RECOMMENDED THAT YOUR LOCAL CLEAVER-BROOKS REPRESENTATIVE BE CONTACTED FOR PROMPT SUPPLY OF REPLACEMENT PARTS.

CLEAVER-BROOKS

Usage Column indicates parts that apply to a particular unit. If no designation is given, parts apply to all models in all horsepower ranges.
"HW" Indicates "Hot Water"
"LP" Indicates "Low Pressure"
"HP" Indicates "Horsepower"

Usage Column indicates parts that apply to a particular unit. If no designation is given, parts apply to all sizes and series covered by this manual.

CLEAVER-BROOKS CBH SERIES BOILERS

FUEL DESIGNATIONS:

SERIES	FUEL
100	No. 2 Oil
200	No. 2 Oil or Gas
700	Gas

SIZES:

NUMBER SHOWN IN USAGE COLUMN INDICATES HORSEPOWER

25 = 25 H.P.
30 = 30 H.P.
40 = 40 H.P.
50A = 50 H.P.
} These sizes have 36" Diameter Shells

50 = 50 H.P.
60 = 60 H.P.
70 = 70 H.P.
80 = 80 H.P.
100 = 100 H.P.
} These sizes have 48" Diameter Shells

PRESSURES

"H.W."	Indicates	HOT WATER UNIT
"L.P."	Indicates	LOW PRESSURE UNIT i.e. 15 lbs. Max. Pressure
"POWER"	Indicates	HIGH PRESSURE UNIT i.e. 150 lbs. Max. Pressure

NOZZLE SELECTION CHART

BOILER SIZE	QTY.	SIZE	QTY.	SIZE
25	2	2.0 GPH	1	2.5 GPH
30	2	2.5 GPH	1	3.0 GPH
40	2	3.0 GPH	1	4.5 GPH
50A	1	8.3 GPH	1	4.0 GPH
			1	3.0 GPH
50	3	4.0 GPH		
60	3	5.0 GPH		
70	3	6.0 GPH		
80	3	6.5 GPH		
100	3	8.3 GPH		

PART NO.	DESCRIPTION
899-23	Nozzle, 2.0 GPH 30° Monarch, w/Strainer
899-93	Nozzle, 2.5 GPH 30° Monarch, w/Strainer
899-26	Nozzle, 3.0 GPH 30° Monarch, w/Strainer
899-20	Nozzle, 4.0 GPH 30° Monarch, w/Strainer
899-12	Nozzle, 4.0 GPH 45° Monarch, w/Strainer
899-18	Nozzle, 5.0 GPH 45° Monarch, w/Strainer
899-35	Nozzle, 6.0 GPH 45° Monarch, w/Strainer
899-61	Nozzle, 6.5 GPH 45° Monarch, w/Strainer
899-60	Nozzle, 8.3 GPH 30° Monarch, w/Strainer
899-39	Nozzle, 8.3 GPH 45° Monarch, w/Strainer

Part No.	Req.	Description	Usage
		GASKETS	
32-442	3	Gasket, Head, Front & Rear	
32-443	1	Gasket, Door to Dry Oven	
32-746	1	Gasket, Burner Housing to Head	25-50A
32-742	1	Gasket, Burner Drawer	
853-209	5	Gasket, Handhole, 2-3/4 x 3-1/2	
32-516	3	Gasket, Head, Front & Rear	
32-518	1	Gasket, Dry Oven to Door	
32-848	1	Gasket, Burner Drawer	
32-1149	1	Gasket, Burner Housing to Head	50-100
32-572	1	Gasket, Dry Oven to Tube Sheet	
32-1564	1	Gasket, Damper Housing	
853-152	6	Gasket, Handhole, 3-1/4 x 4-1/2	
853-394	—	Gasket, Tadpole - Front Baffle	38" 25-50A; 50" 50-100
853-924	—	Gasket, Rope, 1-1/2" - Rear Baffle	36" 25-50A; 48" 50-100
841-494	24	Rivet, Split, 9/64 x 3/4	Inner Door
841-551	12	Rivet, Split, 1/4 x 7/8	Front Baffle
841-507	12	Fastener, Rear Head Gasket	
		BURNER PARTS	
275-128	1	Diffuser	25-50A 100 Series
275-129	1	Diffuser	25-50A 200 & 700 Series
275-122	1	Diffuser	50-60-70 100 Series
275-126	1	Diffuser	80-100 100 Series
275-123	1	Diffuser	50-60-70 200 & 700 Series
275-127	1	Diffuser	80-100 200 & &700 Series
		Nozzle, Burner (See Chart)	
435-62	2	Electrode	25-50A 100 Series
435-66	2	Electrode	50-100 100 Series
435-23	1	Electrode, Gas Pilot	25-50A 200 & 700 Series
435-79	1	Electrode, Gas Pilot	50-100 200 Series
435-42	1	Electrode, Gas Pilot	50-100 700 Series
94-179	2	Ignition Feed-Thru Insulator	100 Series
904-36	1	Grommet, Gas Pilot Electrode	
57-68	1	Pipe, Gas Pilot	25-50A 200 & 700 Series
57-171	1	Pipe, Gas Pilot	50-100 200 Series
57-30	1	Pipe, Gas Pilot	50-100 700 Series
90-226	1	Scanner Tube	25-50A 200 & 700 Series
90-227	1	Scanner Tube	50-100 200 & 700 Series
8-884	1	Bracket, Scanner Tube	
899-11	1	Body, Nozzle, Pilot	25-50A
899-52	1	Body, Nozzle, Dual	25-50A
100-100	3	Body, Nozzle	50-100
851-77	1	Mica, Porthole	
134-59	1	Spider, Burner	25-50A 100 Series
134-58	1	Spider, Burner	25-50A 200 Series
134-52	1	Spider, Burner	25-50A 700 Series

Part No.	Req.	Description	Usage
		BURNER PARTS (cont.)	
134-67	1	Spider, Burner	50-100 100 & 200 Series
134-55	1	Spider, Burner	50-100 700 Series
134-66	3	Spider, Oil Line	50-100 100 & 200 Series
90-280	1	Air Cooling Tubing Assembly	50-100 100 & 200 Series
32-1731	1	Gasket, Air Cooling Tubing	50-100 100 & 200 Series
40-177	1	Housing, Burner, Oil	25-50A
40-179	1	Housing, Burner, Gas and Oil	25-50A
40-221	1	Housing, Burner, Oil	50-100
40-227	1	Housing, Burner, Gas & Oil	50-100
		ELECTRICAL CONTROLS AND COMPONENTS	
832-107	1	Transformer, Ignition, 115 V/60 Cycles, 6000 Sec. V	Gas Pilot
832-118	1	Transformer, Ignition, 115 V/60 Cycles, 10,000 Sec. V	L.O. Pilot
817-16	1	Control, Pressure, 0-15 lb, MH L404A	L.P.
817-110	1	Control, Pressure, 5-150 lb, MH L404A	Power to 150 lb.
817-111	1	Control, Pressure, 10-300 lb, MH L404A	Power Over 150 lb.
817-415	1	Control, Pressure, 0-15 lb, MH L404C	L.P.
817-109	1	Control, Pressure, 5-150 lb, MH L404C	Power to 150 lb.
817-900	1	Control, Pressure, 10-300 lb, MH L404C	Power to 250 lb.
836-45	1	Switch, Mercury, for L404A and L404C	
817-251	1	Control, Pressure, 0-15 lb, MH L91A	L.P.
817-204	1	Control, Pressure, 5-150 lb, MH L91A	Power to 150 lb.
817-234	1	Control, Pressure, 10-300 lb, MH L91A	Power Over 150 lb.
832-764	1	Coil, Potentiometer for L91A	
817-400	1	Control, Temperature, 100-240 degrees F, L4008A	Hot Water
817-1050	1	Control, Temperature, High Limit, L4008E	Hot Water
817-1244	1	Control, Temperature, 160-260 degrees F, T991A	Hot Water
817-399	1	Well	For L4008A & E
817-378	1	Well	For T991A
828-27	1	Clip	For 817-399
904-60	1	Grommet	And 817-378 Wells
894-3268	1	Motor, Damper, M436A	
836-429	1	Switch, Auxiliary, Q607A	
836-742	1	Switch, Auxiliary, Q607B	
894-2812	1	Motor, Modulating, M941C	
832-235	1	Transformer, Damper Motor, 115/25V, 60 Cycles	For 894-2812
836-209	1	Potentiometer, MH 30112	
836-210	1	Switch, Burner	
836-261	1	Switch, Damper Positioning	
836-211	1	Switch, Oil-Gas Selector	
817-436	1	Switch, Air Pressure MHC645A1	Combustion Air
292-47	1	Ignition Cable, 12"	
292-99	1	Ignition Cable, 18"	
292-126	1	Ignition Cable, 15"	
836-384	1	Switch, Micro, YZ-2RD-A2	
817-774	1	Switch, Gas Pressure, C645A	Low Gas Pressure Switch
817-1935	1	Switch, Gas Pressure, C645B	High Gas Pressure Switch

Part No.	Req.	Description	Usage
		PROGRAMMING CONTROLS AND COMPONENTS	
833-2200	1	Control, Programmer, CB-20	
833-2201	1	Control, Programmer, CB-40	
833-2204	1	Amplifier, Infra-red, R7248A1020	For CB 20 & CB-40
833-2205	1	Amplifier Infra-red (Ampli-check) R7248B	
817-1801	1	Cell, Lead Sulfide (Infra-red) 104662D	
817-1742	1	Flame Detector, Assembly C7015A	Includes Cell, Cable, Lens, Etc.
833-2209	1	Purge Extender - (Plug-in Module)	For CB-40
		The following are used on special order or preceded the above.	
833-1964	1	Control, Programmer, CB-2-1A	
833-1965	1	Control, Programmer, CB-4-1A	
833-1967	1	Amplifier, Infra-red, R7258A	For CB-2-1A & CB-4-1A
833-1166	1	Control, Programmer, 6009C	
833-1921	1	Control, Programmer, CB-3	
833-1814	1	Control, Programmer, 6080C	
832-160	1	Cell, Lead Sulfide, Fireye	
817-139	1	Flame Detector, Assembly, Fireye	
832-747	1	Tube, Electron, 12AX7	For CB1, 6009,
832-748	1	Tube, Electron, 12BH7A	CB3 & 6080C
		The following are factory rebuilt controls available on a trade-in exchange basis only.	
833-2222	1	Control, CB-20 (FR)	
833-2223	1	Control, CB-40 (FR)	
833-2045	1	Control, CB-2-1A (FR)	
833-2046	1	Control, CB-4-1A (FR)	
833-1157	1	Control, CB-1 (FR)	
833-1168	1	Control, 6009C (FR)	
833-1883	1	Control, 6080C (FR)	
833-1936	1	Control, CB-3 (FR)	
833-2224	1	Amplifier, R7248A (FR)	CB-20, CB-40
833-2047	1	Amplifier, R7258A (FR)	CB-2-1A, CB-4-1A
833-2225	1	Purge Extender (FR)	
		FUEL OIL COMPONENTS	
948-70	3	Valve, Solenoid, 115/50-60, 1/8", 826281	
832-1000	1	Coil, Solenoid, 115/50-60	For 948-70
880-81	1	Kit, Spare Parts	For 948-70
948-195	1	Valve, Solenoid, 115/50-60, 1/4", 8262C232W	
832-1064	1	Coil, Solenoid, 115/50-60	For 948-195
901-366	1	Pump, Oil, Sundstrand H4EA-200	25-30
901-367	1	Pump, Oil, Sundstrand H5FA-200	40-50A
901-586	1	Pump, Oil, Webster 22R626A1BE4	50-100
923-96	1	Strainer, 112832	For 901-366
923-93	1	Strainer, 112842	For 901-367
853-514	1	Gasket, Strainer Cover, 110441	For 901-366, 901-367
529-11	1	Strainer, Fuel, CBCO	50-100
171-28	1	Basket, Double, CBCO	For 529-11
32-350	1	Gasket, Cover, CBCO	For 529-11
32-351	1	Gasket, Bolt, CBCO	For 529-11
29-442	1	Flange, Pump Adapter	
825-42	1	Valve, Needle, 1/8" NPT x 1/4" ODC	
940-2447	1	Valve, Check, Horizontal, 3/8"	
854-23	1	Snubber, Gauge	50-100

Part No.	Req.	Description	Usage
		GAS VALVES AND COMPONENTS	
940-278	1	Valve, Solenoid, 1/2", 115/60, K3A	Gas Pilot
832-208	1	Coil, Solenoid, 115 V.	For 940-278
918-93	1	Regulator, Gas Pilot, 1/2" Maxitrol 4005	
940-947	1	Valve, Diaphragm, 2", 115/60, V48F	25-50A
945-139	1	Actuator, Gas Valve, V4005A	
945-143	1	Actuator, Gas Valve, V4055D	w/"Proof of Closure"
940-4539	1	Valve Body, 2", V5055A	
940-4544	1	Valve Body, 2", V5055C	"Valve Closed Indicator"
		NOTE: Check actuator or valve nameplate when ordering a replacement.	
940-231	1	Valve, Gas Butterfly, 2"	
948-53	1	Valve, Solenoid, 1", N.O., 8215A53	Vent Valve
832-1066	1	Coil, Solenoid, 115 V.	For 948-53
880-117	1	Kit, Spare Parts	For 948-53
		LINKAGE	
883-14	1	Ball Joint	
883-11	1	Ball Joint, 90°	
82-27	1	Spring, Over Ride	
882-15	2	Arm, Spring Holding	
287-5	1	Arm, Over Ride	
318-1	1	Coupling, Drive Shaft	50-100
2-96	1	Arm, Damper Motor & Gas Linkage	25-50A
2-65	1	Arm, Damper Motor & Gas Linkage	50-100
287-18	1	Arm, Damper Shaft	25-50A
2-66	1	Arm, Damper Shaft	50-100
287-30	1	Arm, Damper Counter Shaft	50-100
287-24	1	Arm, Gas Butterfly Valve	25-50A
287-19	1	Arm, Gas Butterfly Valve	50-100
12-8	2	Cam, Oil Valve Switch	
		WATER LEVEL CONTROLS	
817-99	1	Head, Operating Mechanism, McD&M 150M HD	Power to 150 PSI
817-85	1	Head, Operating Mechanism, McD&M 150 HD	L.P. Only & HW
817-389	1	Head, Operating Mechanism, McD&M 194M HD	Power Over 150 PSI
817-778	1	Head, Operating Mechanism, McD&M 42-C-HD	
817-779	1	Head, Operating Mechanism, McD&M 64-C-HO	
836-44	1	Switch, Mercury, 3 Wire, Auto Reset, SA-150-124	For 817-85
836-93	1	Switch, Mercury, 3 Wire, Manual Reset, SA-150M-124	For 817-99
836-46	1	Switch, Mercury, 2 Wire, SA-150-125	For 150 & 42 Controls
853-268	1	Gasket, Float Housing, 150-14	For 150 Controls
853-555	1	Gasket, Head, For 42 & 64	
822-13	1	Switch, No. 11	For 64 Control
836-323	1	Switch, Mercury, Pump, SA42-125	For 64 Control
836-303	1	Switch, Assembly, 5M	For 194 Control
853-546	1	Gasket, Head	For 194 Control
851-199	1	Glass, Gage, 5/8" x 9-1/2"	Power
851-137	1	Glass, Gage, 5/8" x 7-1/8"	L.P.
853-115	2	Gasket, Gage Glass, 5/8"	
825-92	3	Trycock, 1/2"	
825-132	1	Set, Water Gage Cock	Power to 150 PSI
825-134	1	Set, Water Gage Cock	L.P.

Part No.	Req.	Description	Usage
		BLOWER MOTORS AND IMPELLERS	
894-637	1	Motor, 3/4 HP, 115/230/1/60/3600	25-30
894-668	1	Motor, 3/4 HP, 208/220/440/3/60/3600	25-30
894-772	1	Motor, 3/4 HP, 575/3/60/3600	25-30
894-638	1	Motor, 1 HP, 115/230/1/60/3600	40
894-669	1	Motor, 1 HP, 208/220/440/3/6/3600	40
894-775	1	Motor, 1 HP, 575/3/60/3600	40
894-804	1	Motor, 1-1/2 HP, 115/230/1/60/3600	50A
894-996	1	Motor, 1-1/2 HP, 208/220/440/3/60/3600	50A
894-1322	1	Motor, 1-1/2 HP, 575/3/60/3600	50A
894-743	1	Motor, 1-1/2 HP, 115/230/1/60/3600	50
894-741	1	Motor, 1-1/2 HP, 208/220/440/3/60/3600	50
894-776	1	Motor, 1-1/2 HP, 575/3/60/3600	50
894-744	1	Motor, 2 HP, 115/230/1/60/3600	60-70
894-742	1	Motor, 2 HP, 208/220/440/3/60/3600	60-70
894-777	1	Motor, 2 HP, 575/3/60/3600	60-70
894-1228	1	Motor, 3 HP, 115/230/1/60/3600	80
894-807	1	Motor, 3 HP, 208/220/440/3/60/3600	80
894-1231	1	Motor, 3 HP, 575/3/60/3600	80
894-1155	1	Motor, 3 HP, 115/230/1/60/3600	100
894-1154	1	Motor, 3 HP, 205/220/440/3/60/3600	100
894-1652	1	Motor, 3 HP, 575/3/60/3600	100
894-3180	1	Motor, 5 HP, 200/3/60/3600	100
894-3181	1	Motor, 5 HP, 230/460/3/60/3600	100
894-3196	1	Motor, 5 HP, 575/3/60/3600	100
		NOTE: When ordering a replacement motor be sure to furnish nameplate data of present motor.	
192-107	1	Impeller	25
192-108	1	Impeller	30
192-109	1	Impeller	40
192-112	1	Impeller	50A
192-68	1	Impeller	50
192-69	1	Impeller	60
192-104	1	Impeller	70
192-66	1	Impeller	80
192-67	1	Impeller	100
		NOTE: Above impellers are standard. For boiler installed at altitudes higher than 3000 feet or for 50 cycle motors consult factory giving complete information.	
869-170	1	Nut, Impeller, 5/8''-18	25 thru 40
869-172	1	Nut, Impeller, 3/4''-16	50A, 50 thru 100
809-168	1	V-Belt, 4L340	25 thru 50A
809-105	1	V-Belt, 4L510	50 thru 100
921-30	1	Sheave, Motor, 2.5 P.D., 1/2'' Bore, 1A Groove	25 thru 40
921-460	1	Sheave, Motor, 2.5 P.D., 5/8'' Bore, 1A Groove	50A
921-393	1	Sheave, Motor, 5.0 P.D., 5/8'' Bore, 1A Groove	50 thru 100
921-342	1	Sheave, Oil Pump, 4.7 P.D., 7/16'' Bore, 1A Groove	25 thru 50A
921-140	1	Sheave, Oil Pump, 6.0 P.D., 7/16'' Bore, 1A Groove	50 thru 100

Part No.	Req.	Description	Usage
		BLOWER MOTORS AND IMPELLERS (cont.)	
91-75	*	Washer, 1/8'' Thick	50A, 50 thru 100
91-67	*	Washer, Spacing, .005	25 thru 40
91-68	*	Washer, Spacing, .015	25 thru 40
91-69	*	Washer, Spacing, .030	25 thru 40
91-72	*	Washer, Spacing, .005	50A, 50 thru 100
91-73	*	Washer, Spacing, .015	50A, 50 thru 100
91-74	*	Washer, Spacing, .030	50A, 50 thru 100
91-88	*	Washer, Spacing	25 thru 40
91-99	*	Washer, Spacing	50A
91-71	*	Washer, Spacing	50 thru 100
914-86	1	Ring, Snap, No. 5100-75	25 thru 40
914-147	1	Ring, Snap, No. 5100-78	50A, 50 thru 100
841-721	1	Key, Impeller, 3/16 x 3/16 x 5/8	25 thru 40
841-648	1	Key, Impeller, 1/4 x 1/4 x 7/8	50A, 50 thru 100
		GAUGES AND THERMOMETERS	
850-82	1	Gauge, 2'', 0-200 PSI	
850-476	1	Gauge, 2'', 0-300 PSI	
850-109	1	Gauge, Gas, 0-20 Oz. & 0-35''	
850-122	1	Guage, 4-1/2'', 0-200 PSI	
850-243	1	Gauge, 4-1/2'', 0-30 PSI & 0-30 In.	50-100
850-293	1	Gauge, 3-1/2'', 0-200 PSI, 60-260°F.	
850-265	1	Gauge, 3-1/2'', 0-60 PSI, 0-70 Ft., 60-260°F.	
850-266	1	Gauge, 3-1/2'', 0-30 PSI & 0-30-In.	25-50A
937-28	1	Thermometer, 3'', 200-700°F.	Stack Temperature
937-59	1	Thermometer, 3-1/2'', 100-300°F. Remote Bulb	
817-641	1	Well	For 937-59
		REFRACTORY	
94-133	1	Refractory, Oven	25-50A 100 Series
94-134	1	Refractory, Oven	25-50A 200 & 700 Series
94-131	5	Refractory, Furnace Liner	25-50A 100 Series
94-132	6	Refractory, Furnace Liner	25-50A 200 & 700 Series
94-219	1	Refractory, Oven	50-100 100 Series
94-220	1	Refractory, Oven	50-100 200 & 700 Series
94-152	8	Refractory, Furnace Liner	50-100 All Series
872-47	1	Cement, Refractory (50 lb. Drum)	
872-26	—	Cement, Insulating	Bulk—Order by Pounds
872-162	1	Cement, Vee-Block Mix (50 lb. Bag)	
94-115	7	Tile, Rear Baffle	25-50A
94-172	9	Tile, Rear Baffle	50-100
465-103	1	Door, Front Inner	25-40
465-299	1	Door, Front Inner	50A
465-121	1	Door, Front Inner	50-100
		NOTE: For complete rear door refractory replacement, consult your local Cleaver-Brooks service agency or the Cleaver-Brooks Parts Department.	

Part No.	Req.	Description	Usage
		MISCELLANEOUS	
814-8	1	Brush, Flue, 1-7/8"	25-50A
814-7	1	Brush, Flue, 2-3/8"	50-100
550-42	1	Window, Observation	Rear Door
851-26	1	Glass, Pyrex	For 550-42
853-213	2	Gasket, Sight Glass	For 550-42
317-57	1	Cover, Handhole, 2-3/4" x 3-1/2"	25-50A
317-58	1	Cover, Handhole, 3-1/4" x 4-1/2"	50-100
104-399	1	Yoke, Handhole	25-50A
104-449	1	Yoke, Handhole	50-100 15 PSI & H.W.
958-48	1	Yoke, Handhole	50-100 Power (U.S.)
958-49	1	Yoke, Handhole	50-100 Power (Can.)
51-160	1	Nut, Head Bolt, 5/8"	
868-194	1	Capscrew, Head Bolt, 5/8" x 4"	
868-94	1	Capscrew, Head Bolt, 5/8" x 4-1/2"	

IMPORTANT NOTICE

The manufacturer's bulletin for the particular Flame Safe Guard and Programming Control installed on your boiler is supplied along with this operating manual. In the event that a replacement control bulletin is required, the model and form number is listed below. Order from your Cleaver-Brooks representative.

CONTROL MODEL	CLEAVER-BROOKS BULLETIN NO.	MANUFACTURER'S BULLETIN NO.
CB-20	C9-767	—
CB-40	C9-768	—
CB-3	C9-758	—
4580	—	C-60
5022	—	C-14
6080, 6580	—	C-30