

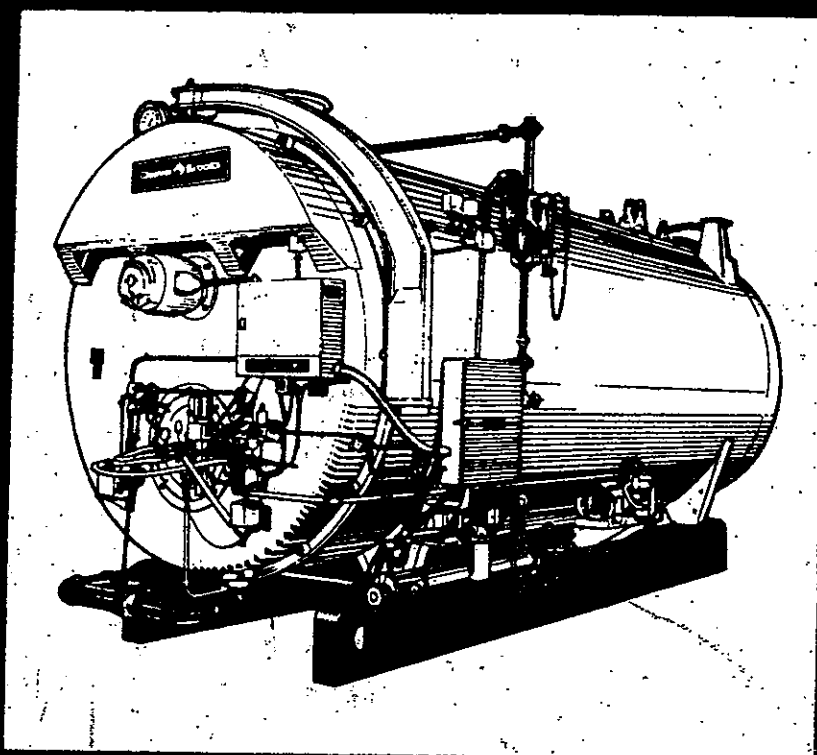
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CLEAVER-BROOKS MODEL CB[®] PACKAGED BOILERS

Operation,
Service
and Parts
Manual

400 Thru 800 HP

FUEL: LIGHT OIL,
HEAVY OIL,
GAS OR COMBINATION



Cleaver-Brooks

DIVISION OF AQUA-CHEM, INC.
Milwaukee, Wisconsin 53201

Service and Parts Coast to Coast
Boilers and Accessories for the Complete Boiler Room

Manual Part No. 750-94

CONTENTS

| | |
|--|----------|
| CHAPTER 1 — GENERAL DESCRIPTION AND PRINCIPLES OF OPERATION | |
| A. The Boiler | 1 |
| B. The Burner and Control System | 1 |
| C. Control and Component Function | 1 |
| D. Controls Common to All Boilers | 1 |
| E. Steam Controls (All Fuels) | 1 |
| F. Hot Water Controls (All Fuels) | 1 |
| G. Controls For Gas Firing (Including Combination) | 1 |
| H. Controls For Oil Firing (Including Combination) | 1 |
| J. Additional Controls For Heavy Oil | 1 |
| K. Controls For Combination Burners Only | 1 |
| L. Combustion Air | 1 |
| M. Automatic Ignition | 1 |
| N. Atomizing Air | 1 |
| O. Oil Fuel Flow — Light Oil | 1 |
| P. Oil Fuel Flow — Heavy Oil | 1 |
| Q. Gas Fuel Flow | 1 |
| R. Modulating Firing | 1 |
| CHAPTER 2 — THE PRESSURE VESSEL | 2 |
| A. General | 2 |
| B. Construction | 2 |
| C. Water Requirements | 2 |
| 1. Hot Water Boiler | 2 |
| 2. Steam Boiler | 2 |
| D. Water Treatment | 2 |
| E. Cleaning | 2 |
| F. Boil-out of a New Unit | 2 |
| G. Washing Out | 2 |
| H. Blowdown — Steam Boiler | 2 |
| I. Periodic Inspection | 2 |
| J. Preparation for Extended Lay-up | 2 |
| CHAPTER 3 — SEQUENCE OF OPERATION | 3 |
| A. General | 3 |
| B. Circuit and Interlock Controls | 3 |
| C. Sequence of Operation — CB-20 — Oil or Gas | 3 |
| D. Sequence of Operation — CB-40 — Oil or Gas | 3 |
| E. Flame Loss Sequence | 3 |
| CHAPTER 4 — STARTING AND OPERATING INSTRUCTIONS | 4 |
| A. General Preparation for Start-up | 4 |
| B. Control Settings — Steam and Hot Water | 4 |
| C. Gas Pilot | 4 |
| D. Atomizing Air | 4 |
| E. Firing Preparations For No. 2 Oil Series 100-200 | 4 |
| F. Firing Preparations For No. 6 Oil Series 400-600 | 4 |
| G. Firing Preparations For Gas Series 200-400-700 | 4 |
| H. Start-Up, Operating and Shutdown — All Fuels | 4 |
| J. Control Operational Tests and Checks | 4 |
| CHAPTER 5 — ADJUSTMENT PROCEDURES | 5 |
| A. General | 5 |
| B. Linkage — Modulating Motor and Air Damper | 5 |
| C. Modulating Motor | 5 |
| D. Modulating Motor Switches — Low Fire and High Fire | 5 |
| E. Operating Controls — General | 5 |
| F. Modulating Pressure Control — (Steam) | 5 |
| G. Operating Limit Pressure Control — (Steam) | 5 |
| H. High Limit Pressure Control — (Steam) | 5 |
| I. Modulating Temperature Control — (Hot Water) | 5 |
| J. Operating Limit Temperature Control — (Hot Water) | 5 |
| K. High Limit Temperature Control — (Hot Water) | 5 |

CONTENTS (Continued)

| | | |
|--|---|------|
| L. | Low Water Cut-Off Devices | 5-9 |
| M. | Combustion Air Proving Switch | 5-9 |
| N. | Atomizing Air Proving Switch | 5-9 |
| O. | Gas Pilot Flame Adjustment | 5-10 |
| P. | Gas Pressure and Flow Information | 5-10 |
| Q. | Gas Fuel Combustion Adjustment | 5-12 |
| R. | Low Gas Pressure Switch | 5-15 |
| S. | High Gas Pressure Switch | 5-15 |
| T. | Fuel Oil Pressure and Temperature — General | 5-15 |
| U. | Fuel Oil Combustion Adjustment | 5-15 |
| V. | Burner Drawer Adjustments | 5-17 |
| W. | Oil Drawer Switch | 5-18 |
| X. | Low Oil Temperature Switch | 5-18 |
| Y. | High Oil Temperature Switch | 5-19 |
| Z. | Low Oil Pressure Switch | 5-19 |
| AA. | Electric Oil Heater Thermostat | 5-19 |
| BB. | Steam Oil Heater Thermostat | 5-20 |
| CC. | Hot Water Oil Heater Thermostat | 5-20 |
| DD. | Steam Heater Pressure Regulator | 5-20 |
| CHAPTER 6 — TROUBLE SHOOTING | | 6-1 |
| A. | Burner Does Not Start | 6-1 |
| B. | No Ignition | 6-2 |
| C. | Pilot Flame, But No Main Flame | 6-2 |
| D. | Burner Stays in Low Fire | 6-2 |
| E. | Shutdown Occurs During Firing | 6-2 |
| F. | Modulating Motor Does Not Operate | 6-2 |
| CHAPTER 7 — INSPECTION AND MAINTENANCE | | 7-1 |
| A. | General | 7-1 |
| B. | Fireside Cleaning | 7-2 |
| C. | Water Level Controls and Waterside | 7-2 |
| D. | Water Gage Glasses | 7-3 |
| E. | Electrical Controls | 7-3 |
| F. | Programming Control | 7-4 |
| G. | Oil Burner Maintenance | 7-5 |
| H. | Gas Burner Maintenance | 7-6 |
| I. | Motorized Gas Valve | 7-7 |
| J. | Solenoid Valves | 7-7 |
| K. | Cam Spring | 7-7 |
| L. | Forced Draft Fan | 7-8 |
| M. | Safety Valves | 7-8 |
| N. | Fuel Oil Valves | 7-9 |
| O. | Air Pump and Components | 7-9 |
| P. | Refractory | 7-13 |
| Q. | Door Closing and Sealing | 7-15 |
| R. | Lubrication | 7-15 |
| S. | Oil Heaters — Electric, Steam, Hot Water | 7-16 |
| CHAPTER 8 — PARTS ORDERING INSTRUCTIONS AND PARTS LIST | | 8-1 |

TO: Owners, Operators 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.

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 known ability to perform; however, proper operating techniques and maintenance procedures must be followed at all times. Although these components 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 of certain repetitive chores and give him more time to 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.

Because of state, local or other applicable codes there are a variety of electrical controls and safety devices which vary considerably from one installation 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 testing assuming that normal operation will continue indefinitely. Malfunctions of controls leads to uneconomical operation and damage and in most cases these conditions can be traced directly to carelessness and deficiencies in testing and maintenance.

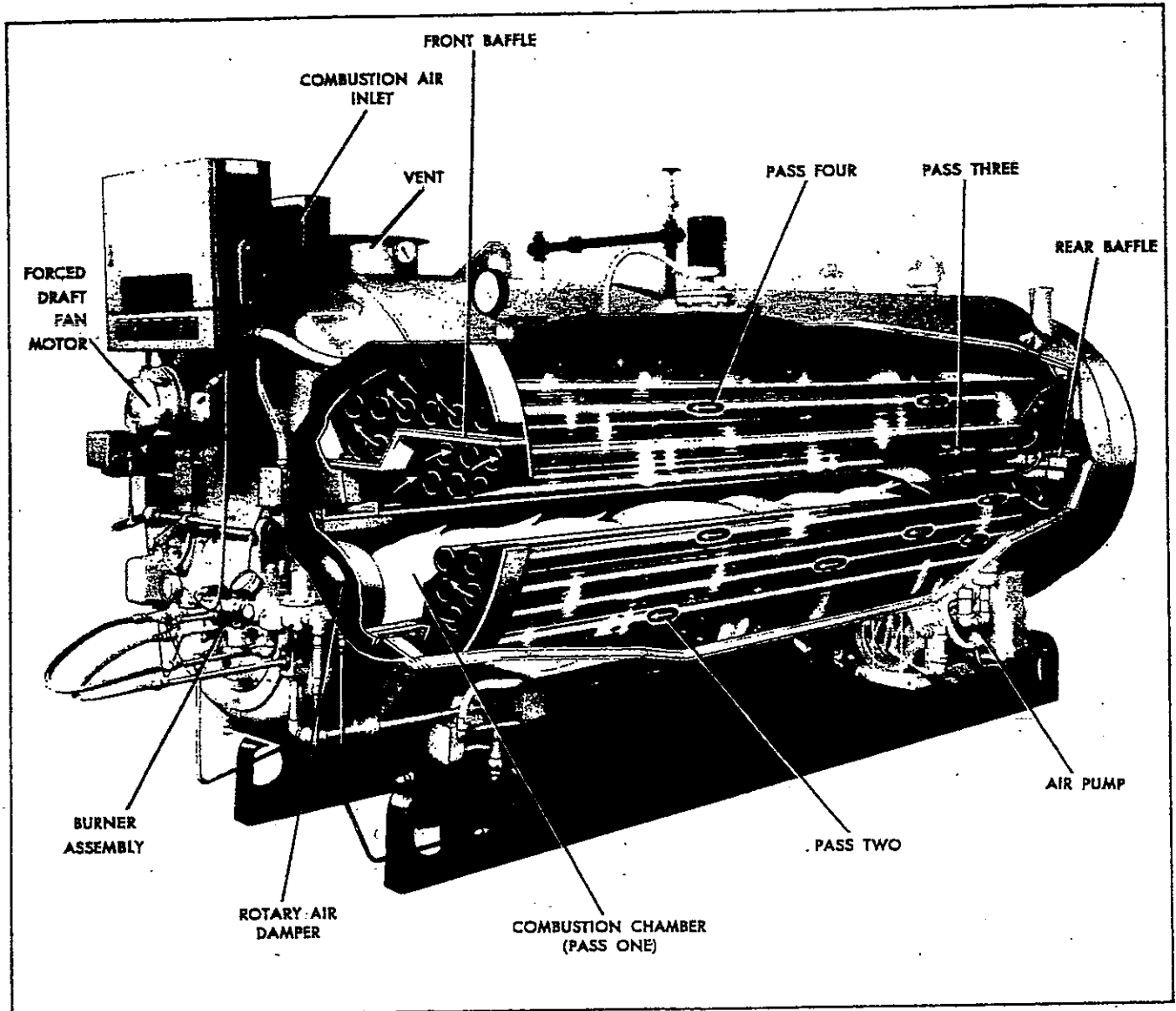
It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly and yearly maintenance activities and recording of any unusual operation will serve as a valuable guide to any necessary investigation.

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 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 the 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.

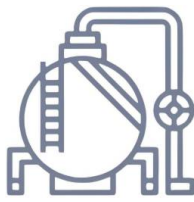
It is customary to engage the services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices.

The operation of this equipment by the owner and his operating personnel must comply with all requirements or regulations of his insurance company and/or any other authority having jurisdiction. These legal requirements take precedence over anything contained herein.



THE FOUR PASS CONSTRUCTION OF A TYPICAL 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.



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CHAPTER 1

GENERAL DESCRIPTION AND PRINCIPLES OF OPERATION

- A. THE BOILER
- B. THE BURNER AND CONTROL SYSTEM
- C. CONTROL AND COMPONENT FUNCTION
- D. CONTROLS COMMON TO ALL BOILERS
- E. STEAM CONTROLS (ALL FUELS)
- F. HOT WATER CONTROLS (ALL FUELS)
- G. CONTROLS FOR GAS FIRING (INCLUDING COMBINATION)
- H. CONTROLS FOR OIL FIRED BOILERS
- J. CONTROLS FOR HEAVY OIL
- K. CONTROLS FOR COMBINATION BURNERS
- L. COMBUSTION AIR
- M. AUTOMATIC IGNITION
- N. ATOMIZING AIR
- O. OIL FUEL FLOW — LIGHT OIL
- P. OIL FUEL FLOW — HEAVY OIL
- Q. GAS FUEL FLOW
- R. MODULATING FIRING

The general information in this manual applies directly to Cleaver-Brooks "CB" Boiler Models in sizes ranging from 400 thru 800 boiler horsepower for the following fuels:

- SERIES 100 LIGHT OIL (NO. 2)
- SERIES 200 LIGHT OIL (NO. 2) OR GAS
- SERIES 400 HEAVY OIL (NO. 6) OR GAS
- SERIES 600 HEAVY OIL (NO. 6) ONLY
- SERIES 700 GAS ONLY

NOTE: Although the Series 400 or 600 burner is designed and designated to burn No. 6 oil the burner will handle grades 4 and 5 equally well with some possible modifications. While this manual contains pertinent information on No. 6 fuel oil, all references to this fuel should be considered applicable to all grades of heavy oil.

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 (F.I.A.), Factory Mutual (FM) or other insuring underwriters requirements.

A. THE BOILER

The "CB" Boiler is a packaged firetube boiler of welded steel construction and consists of a pressure vessel, burner, burner controls, forced draft fan, damper, air pump, refractory and appropriate boiler trim.

Rated Capacity 400 thru 800 HP

Operating Pressure:

Steam 15-150 psig, or higher if specified

Hot Water 30-150 psig, or higher if specified

Fuel Oil or Gas or Combination

Ignition Automatic

Firing Full modulation through operating ranges

Burner (Oil) Air atomizing (low pressure)

Burner (Gas) Non-premix orificed type

Flame Safeguard and Program Control:

Standardly equipped boilers CB-20

Factory Insurance Association (F.I.A.)

(optional equipment) CB-40
or as approved by F.I.A.

Factory Mutual (FM)

(optional equipment) CB-40
or as approved by FM.

Air Damper: Rotary Type (electrically modulated)

Steam Trim ASME Cod

Water Trim ASME Cod

The horsepower rating of the boiler is indicated by the numbers following the fuel series. Thus, CB700-600 indicates a gas fired 600 HP boiler.

B. THE BURNER AND CONTROL SYSTEM

The oil burner is of the low pressure, air atomizing (nozzle) type. The gas burner is of the non-premix orifice type. The burners are ignited by spark ignited gas pilot. The pilot is of the interrupted type and is extinguished after main flame is established.

NOTE: A series 100 boiler is usually equipped with a light oil pilot although a gas pilot is frequently used.

The burners equipped to burn oil and gas include 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 a combination burner.

It is important that the burner model and serial number, shown on the nameplate, be included in any correspondence or parts order.

Regardless of which fuel is used, the burner operates with full modulation (within its rated operating range) through potentiometer-type positioning controls, and the burner returns to minimum firing position for ignition. High pressure boilers (above 15 psi) can be wired for both low pressure and high pressure modulation as optional equipment. This enables the boiler to operate at lower pressure during off-load hours, but at a somewhat reduced steam output dependent upon lower steam pressure and steam nozzle sizing.

The flame safeguard and programming control includes an infra-red sensitive flame detector to supervise both oil and gas flames and to shut the burner down in the event of loss of flame signal. The programming portion of the control provides a pre-purging period, proving of the pilot and main flame, and a period of continued blower operation to purge boiler of all unburned fuel vapor. Other safety controls shut down the burner under low water conditions, excess steam pressure, or water temperature.

Safety interlock controls include combustion and atomizing air proving switches and, depending upon the fuel and insurance carrier requirements, controls that prove the presence of adequate fuel pressure plus temperature proving controls when heated fuel oil is used.

The sequence of burner operation from start-up thru shut-down is governed by the programming control in conjunction with the operating, limit and interlock devices which are wired into the circuitry to provide safe operation and protect against incorrect operating techniques.

All "CB" boilers have the burner assembly attached to the front head. The entire head may be swung open for inspection and maintenance.

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 and the flow of oil through a cam operated metering valve. Fuel input and air are thus properly proportioned for most efficient combustion.

Filtered primary air for atomizing fuel oil is furnished independently of combustion air by an air pump.

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.

Indicator lights signaling load demand, fuel valve, low water, and flame failure conditions are standard equipment.

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 call-out.

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. Refer to the applicable group or groups listed below which apply to the particular boiler.

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

- D. Controls common to all boilers
- E. Steam controls (all fuels)
- F. Hot water controls (all fuels)
- G. Controls for gas firing

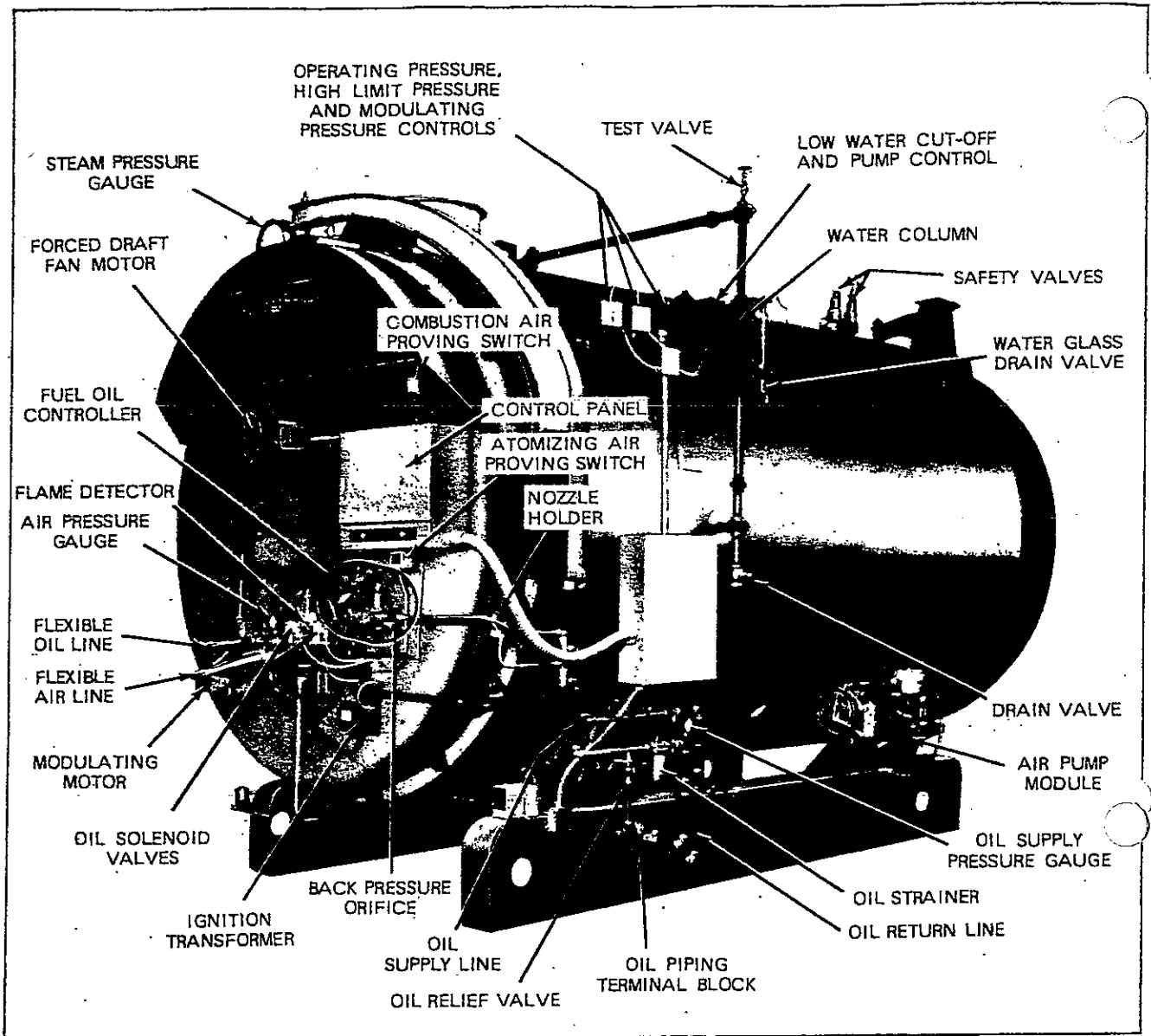


FIGURE 1-1 TYPICAL STEAM BOILER - LIGHT OIL FIRED

- H. Controls for oil firing
- J. Additional controls for heavy oil
- K. Oil and gas burner

D. CONTROLS COMMON TO ALL BOILERS

- (1) Forced Draft Fan Motor (figure 1-1): Drives forced draft fan directly to provide combustion air. Also referred to as a blower motor.
- (2) Forced Draft Fan Motor Starter (figure 1-7): Energizes forced draft fan (blower) motor.
- (3) Forced Draft Fan (figure 1-10): Furnishes all air, under pressure, for combustion of pilot fuel and main fuel and for purging.
- (4) Ignition Transformer (figure 1-1): Provides high voltage spark for ignition of gas pilot or light oil pilot.
- (5) Modulating Motor (figure 1-1): Operates the rotary air damper and fuel valves through a cam and linkage system to provide proper air-fuel ratios under all boiler load conditions.
- (6) Low Fire Switch (figure 5-7): An internal auxiliary switch, cam actuated by the motor shaft, which must be closed to indicate that the air damper and fuel metering valve are in the low fire position before an ignition cycle can occur.
- (7) Burner Switch (figure 1-7): A manually operated start-stop switch for directly starting a stopping operation of burner.

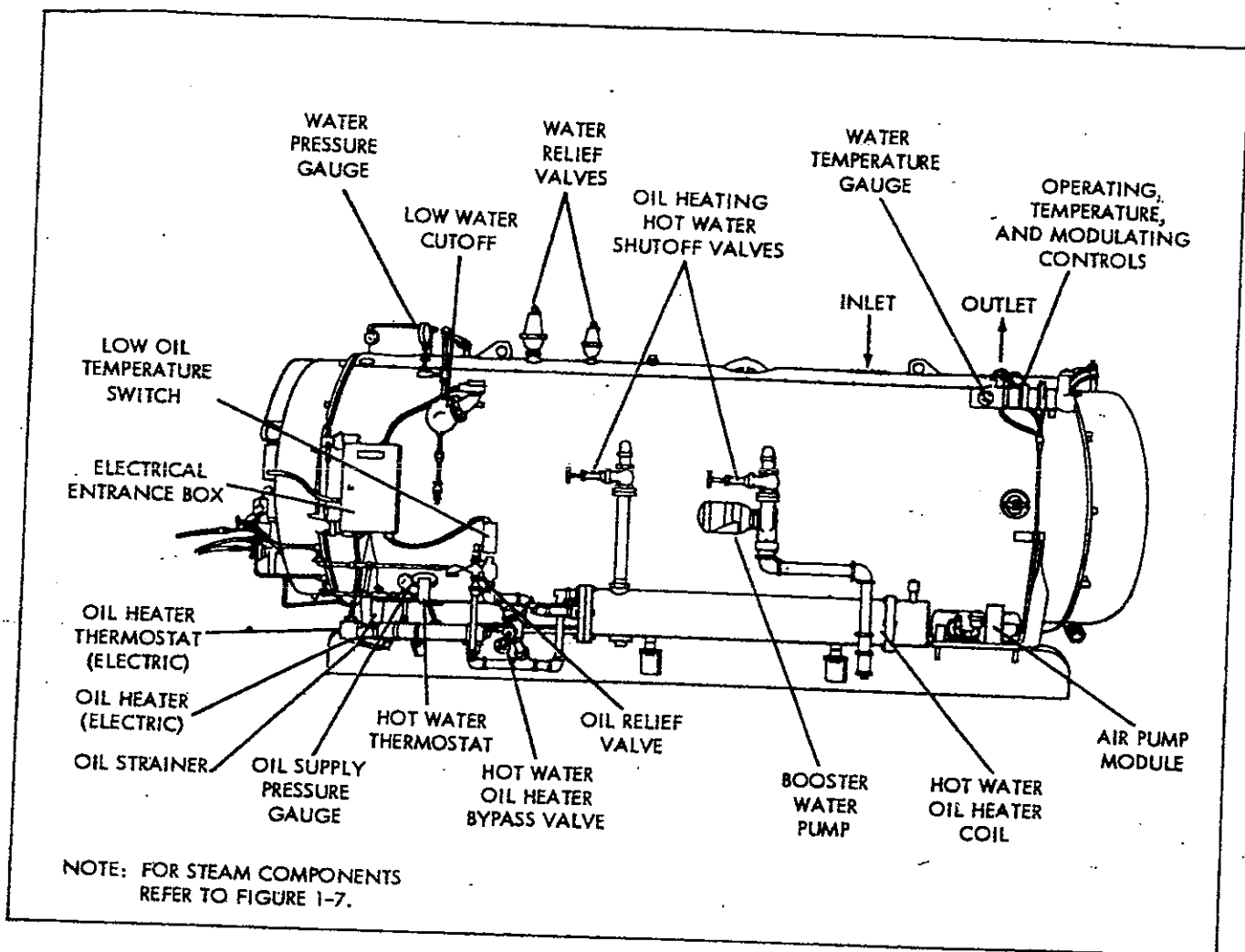


FIGURE 1-2. TYPICAL HOT WATER BOILER

(8) Manual-Automatic Switch (figure 1-7): When set at "automatic", subsequent operation is at the command of the modulating control which governs the position of the modulating motor in accordance with load demand. When set at "manual" the modulating motor, through the manual flame control, can be positioned at a desired burner firing rate. The primary purpose of the manual position is for testing and setting the air-fuel ratio through the entire firing range.

(9) Manual Flame Control (figure 1-7): A manually operated potentiometer that permits the positioning of the modulating motor to a desired burner firing rate when the manual-automatic switch is set on manual. It is used primarily for initial or subsequent setting of fuel input throughout the firing range. It has no control over the firing rate when the manual-automatic switch is set on "automatic".

(10) Modulating Motor Transformer (figure 1-7): Reduces control circuit voltage (115VAC) to required voltage (24VAC) for operation of the modulating motor.

(11) Indicator Lights (figure 1-7): Provide visual information on operation of boiler as follows:

- Flame Failure
- Load Demand
- Fuel Valve (valve open)
- Low Water.

(12) Programming and Flame Safe Guard Control: 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 purge periods 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 re-cycles automatically during normal operation, or following a power interruption. It must be manually reset following a safety shutdown caused by a loss of flame. Incorporated is an internal checking circuit, effective on every start,

that will prevent burner operation in the event anything causes the flame relay to hold in during this period.

This control contains the following major integral components that are referred to in the operating sequence text (See figure 1-7).

- 12a) Master Relay (1K): Energized when all the limit and operating controls and lock-out switches are closed to start program sequencing and to energize the forced draft fan motor starter.
 - 12b) Flame Relay (2K): Energized when the flame detector senses a suitable burner flame. When de-energized by a loss of flame it routes control circuit through the safety switch.
 - 12c) 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.
 - 12d) Timer: Actuates cams to open and close switching contacts in a non-adjustable timed program to sequence the burner's operation through all the functions necessary to operate the burner.
 - 12e) Timer Position Dial: Indicates the position of the timer and the stage reached in burner operating cycle.
- (13) 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.
- (14) Combustion Air Proving Switch (figure 1-1): A pressure sensitive switch actuated by air pressure from the forced draft fan. Its contacts close to prove presence of combustion air. The fuel valves can not be energized unless this switch is satisfied.
- (15) Alarm (not shown): Sounds to notify the operator of a condition requiring attention. The alarm is available as optional equipment.
- (16) Stack Thermometer (figure 1-1): Indicates temperature of vented flue gases.
- (17) Diffuser (figure 1-4 and 1-10): This is a circular plate located at the furnace end of the burner drawer to impart a rotary swirling motion to combustion air immediately prior to its entering the flame, thus providing a thorough and efficient mixture with the fuel.
- (18) Rotary Air Damper (figure 1-4 and 1-10): This damper provides accurate control of com-

bustion air in proportion to fuel input for various load demands. It consists of two concentric cylinders with openings. The outer is stationary. The inner is rotated, under control of the modulating motor, to vary the effective size of the opening where they overlap.

E. STEAM CONTROLS (ALL FUELS)

(1) Steam Pressure Gauge (figure 1-1): Indicates boiler's internal pressure.

(2) Operating Limit Pressure Control (figure 1-1): Breaks a circuit to stop burner operation on a rise of boiler pressure above a selected setting. It is adjusted to stop or start the burner at a preselected pressure setting.

(3) High Limit Pressure Control (figure 1-1): Breaks a circuit to stop burner operation on a rise of pressure above a selected setting. It is adjusted to stop the burner at a preselected pressure above the operating limit control setting. This control is normally equipped with a manual reset.

(4) Modulating Pressure Control (figure 1-1): Senses changing boiler pressures and transmits this information to the modulating motor to change the burner's firing rate when the manual-automatic switch is set on automatic.

(5) Low Water Cutoff and Pump Control (figure 1-1): 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 low below the safe operating point and energizes the 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 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.

(6) 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.

CAUTION

See comment after paragraph 5.

(7) Low Water Pump Control Instruction Plate (figure 7-1): Gives instructions and information of operation of low water devices.

(8) Water Column (figure 1-1): This assembly houses the low water cutoff and pump control and includes the water gage glass, gage glass shutoff cocks, and trycocks.

(9) Water Column Drain Valve (figure 1-1): 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.

(10) Water Gage Glass Drain Valve (figure 1-1): This valve is provided to flush the gage glass.

(11) Test Valve (figure 1-1): This valve allows the boiler to be vented during filling, and facilitates routine boiler inspection.

(12) Safety Valve(s) (figure 1-1): Safety valves relieve the boiler of pressure higher than the design pressure or a lower pressure, if designated. Safety valves and their escape piping shown in figure 1-9 are to be installed to conform to the ASME code requirements.

WARNING

Only the safety valves' manufacturer's representative should adjust or repair the boiler safety valves.

**F. HOT WATER CONTROLS
(ALL FUELS)**

(1) Water Temperature Gauge (figure 1-2): Indicates the boiler's internal water temperature.

(2) Water Pressure Gauge (figure 1-2): Indicates the boiler's internal water pressure.

(3) Operating Limit Temperature Control (figure 1-2): Breaks a circuit to stop burner operation on a rise of boiler temperature above a selected setting. It is adjusted to stop or start the burner at a preselected operating temperature.

(4) High Limit Temperature Control (figure 1-2): Breaks a circuit to stop burner operation on a rise of temperature above a selected setting. It is adjusted to stop burner at a preselected temperature above the operating temperature control setting. The high limit temperature control normally is equipped with a manual reset.

(5) Modulating Temperature Control (figure 1-2): Senses changing boiler temperature and transmits this information to the modulating motor to change the burner's firing rate when the manual-automatic switch is set on automatic.

(6) Low Water Cutoff (figure 1-2): Breaks the circuit to stop burner operation if water level in

boiler drops below safe operating point, activating low water light and optional alarm bell if burner is so equipped.

(7) Auxiliary Low Water Cutoff (optional), (not shown): Breaks the circuit to stop burner operation if the water level in boiler drops below the master low water cutoff point.

(8) Relief Valve(s) (figure 1-2): Relief Valve(s) relieve the boiler of pressure higher than the design pressure or a lower pressure, if designated. Relief valves and their discharge piping are to be installed to conform to ASME code requirements.

WARNING

Only the relief valves' manufacturer's representative should adjust or repair the boiler relief valves.

G. CONTROLS FOR GAS FIRING

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 1-3.

(1) Gas Pilot Valve: 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. A second gas pilot valve may be required by insurance regulations.

(2) Gas Pilot Vent Valve: When a second gas pilot valve is required, a normally open vent valve is installed between them. Its purpose is to vent gas to the atmosphere, should any be present in the pilot line when the pilot valves are closed. The valve closes when the pilot valves are energized.

(3) Gas Pilot Shut-off Cock: For manually opening or closing the gas supply to gas pilot valve.

(4) Gas Pilot Adjusting Cock: Provided to regulate the size of the gas pilot flame. (Figure 5-14.)

(5) Gas Pilot Aspirator: Improves flow of gas to the pilot. (Figure 5-14.)

(6) Gas Pressure Gage: Indicates gas pressure to pilot.

(7) Gas Pressure Regulating Valve: Reduces incoming gas pressure to suit the pilot's requirement of between 5" to 10" W.C.

(8) Butterfly Gas Valve: The pivoted disc in this valve is actuated by connecting linkage from the gas modulating cam to regulate the rate of gas flow to the burner.

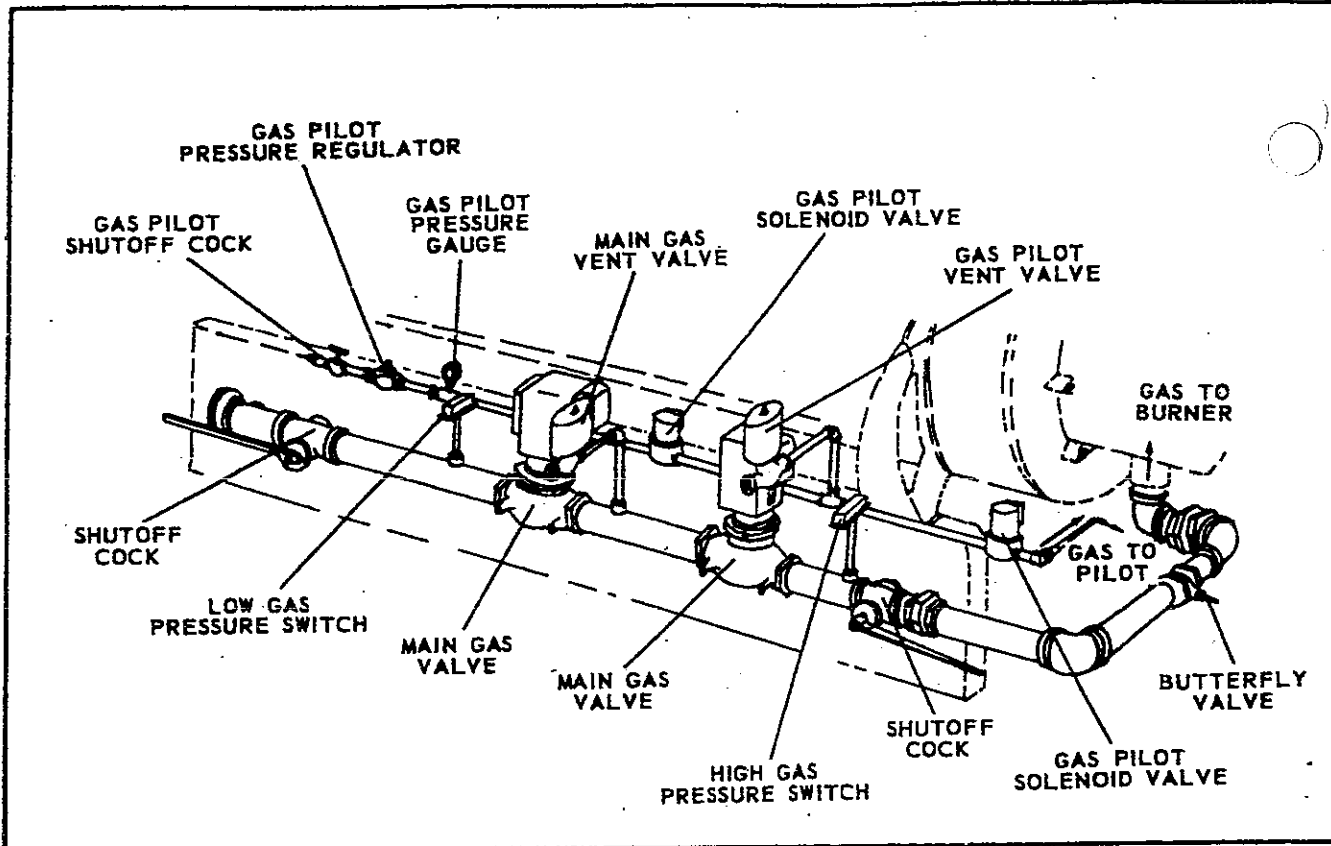


FIGURE 1-3 TYPICAL GAS TRAIN

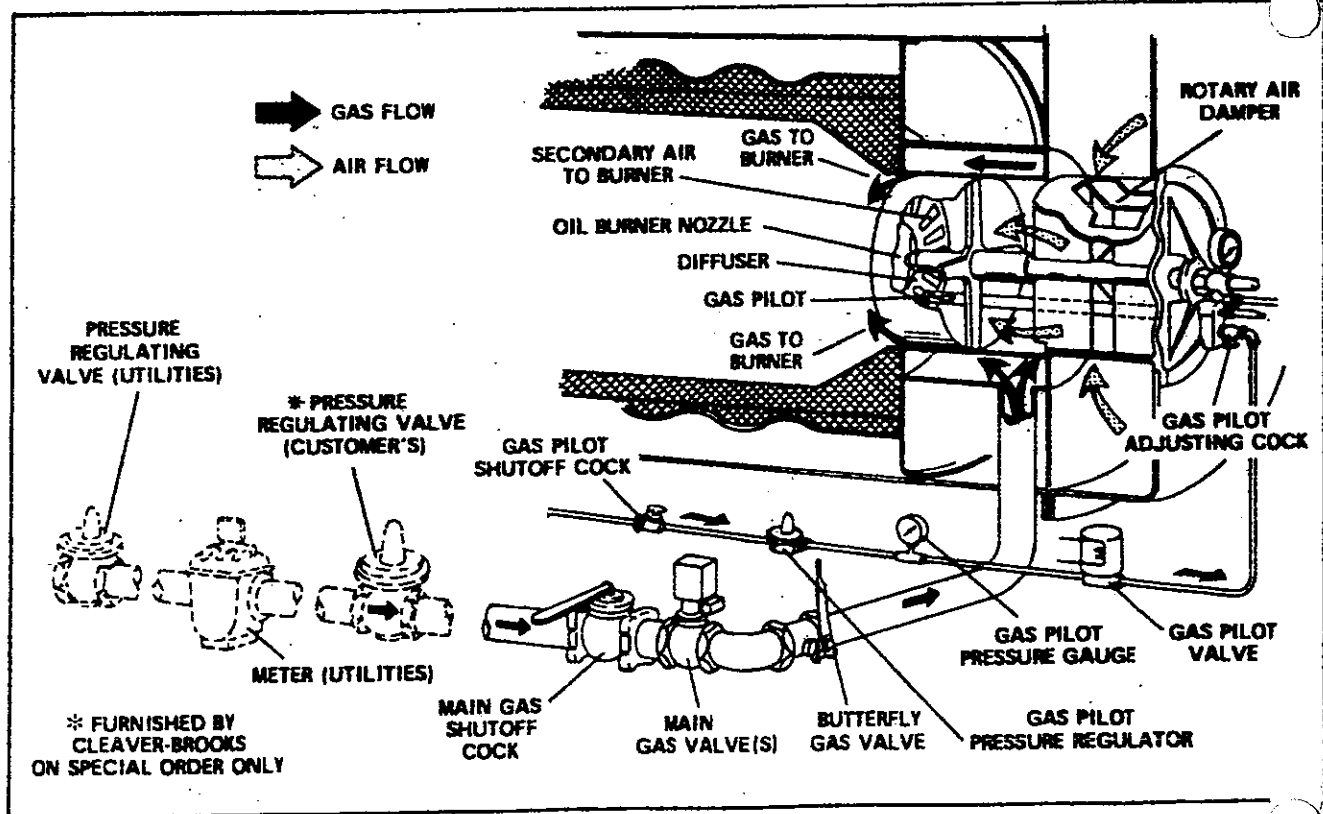


FIGURE 1-4 SECONDARY AIR FLOW WITH GAS TRAIN

(9) Gas Modulating Cam: An assembly, consisting of a quadrant, a series of adjustable allen-head screws and a contour spring, provided for adjustment of gas input at any point in the modulating range. (Figure 5-1.)

(10) Main Gas Cock: 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.

(11) Main Gas Valves: Electrically actuated shut-off valves that open simultaneously to admit gas to the burner. The downstream valve is equipped with a "proof of closure" switch that is connected into the pre-ignition interlock circuit.

(12) Main Gas Vent Valve: 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 line when the gas valves are de-energized. The vent valve closes when the gas valves are energized.

(13) Low Gas Pressure Switch: 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.

(14) High Gas Pressure Switch: 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.

(15) Leakage Connection: The body of the gas valve has a plugged opening that is used whenever it is necessary or desirable to conduct a test for possible leakage across the closed valve.

H. CONTROLS COMMON TO OIL FIRED BOILERS (INCLUDING COMBINATION)

The following items are applicable to all oil fired or gas and oil fired boilers. Additional controls for No. 6 oil are listed in section J.

(1) Oil Drawer Switch (figure 4-1): Opens the limit circuit if oil drawer burner gun is not latched in the forward position required for burning oil.

(2) Atomizing Air Proving Switch (figure 1-1): Pressure actuated switch whose contacts are closed when sufficient atomizing air pressure from the air pump is present for oil firing. Oil valve(s) will not

open or will not remain open unless switch contacts are closed.

(3) Air Pump Module (figure 1-1 and 7-7): This assembly provides the compressed air required to atomize the fuel oil for proper combustion. It is started automatically by the programmer's sequence. It includes components described below.

(4) Air Pump Motor (figure 7-7): This motor drives the air pump and an air cooling fan. The motor is started and stopped simultaneously with the forced draft fan motor.

(5) Air Pump (figure 7-7): Provides air for atomization of fuel oil.

(6) Air Filter (figure 7-7): An oil bath type strainer to clean the air supply prior to entering air pump.

(7) Check Valve (figure 7-7): Prevents lubricating oil and compressed air from surging back through the pump and air filter when pump stops.

(8) Air-oil Receiver Tank (figure 7-7): Holds supply of oil for lubricating the air pump. Separates lube oil from atomizing air before delivery to nozzle.

(9) Atomizing Air Pressure Gauge (figure 1-1): Indicates the atomizing air pressure at the burner gun.

(10) Lube Oil Level Sight Glass (figure 7-7): Indicates the level of lubricating oil in the air-oil receiver tank.

(11) Lube Oil Cooling Coil (figure 7-7): Cools the lubricating oil before it enters the air pump. A fan driven by the air pump motor circulates cooling air over the coil.

(12) Lube Oil Strainer (figure 7-7): Filters lubricating oil before it enters the air pump.

(13) Lube Oil Fill Pipe and Strainer (figure 4-7): Used when adding oil to the air-oil receiver tank.

(14) Low Oil Pressure Switch (optional): 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.

(15) Oil Solenoid Valve (figure 1-1): Opens when energized thru contacts in the programmer and allows fuel oil flow from the oil metering valve to the burner nozzle. A light oil fired burner uses two valves operating simultaneously.

(16) Fuel Oil Controller (figures 1-1 and 1-5): An assembly combining into a single unit the gauges, regulators and valves required for regulating the flow of fuel oil. All controllers have the following integral parts. In addition to these, the controller used on a No. 6 oil fired burner has additional components described in Section J.

(a) Oil Metering Valve: Valve metering stem moves to increase or decrease the orifice area

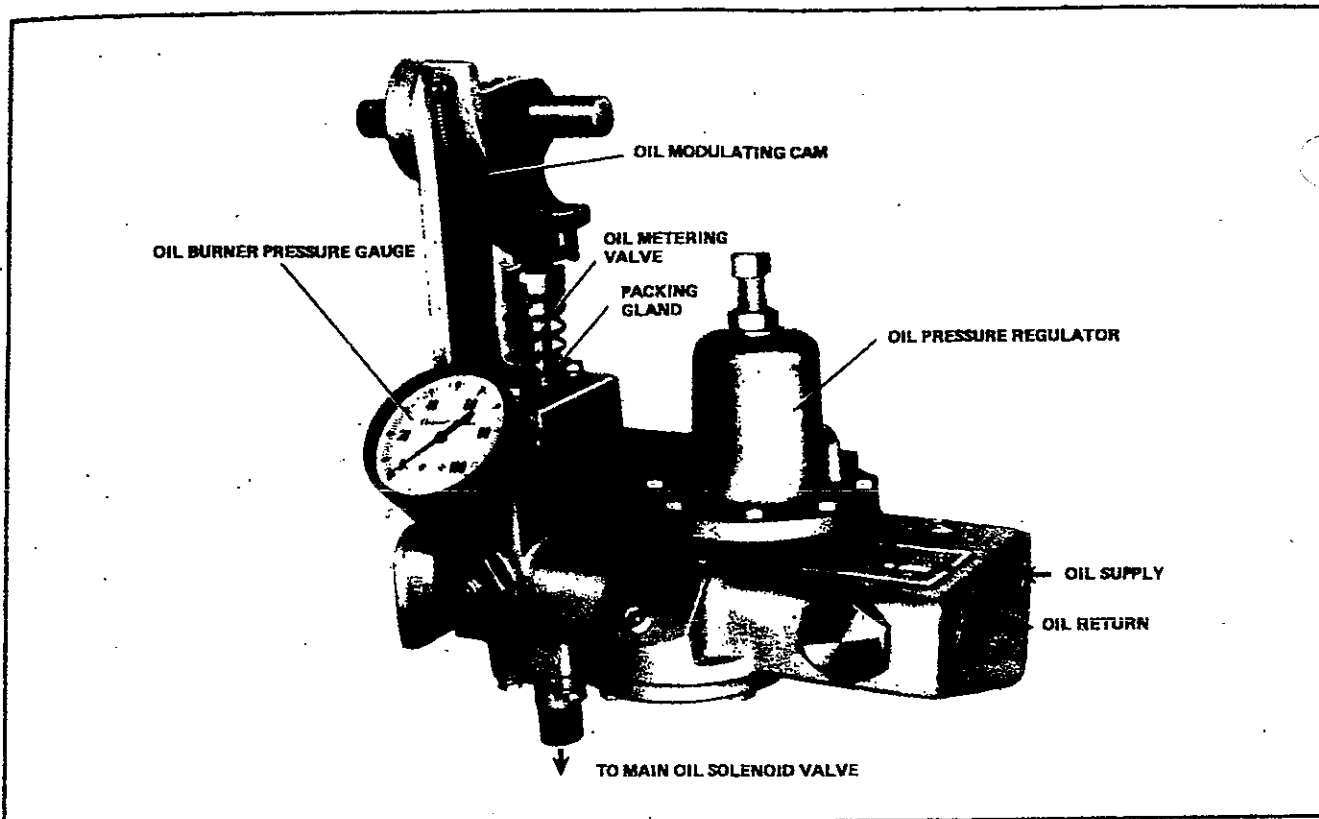


FIGURE 1-5 OIL CONTROL VALVE ASSEMBLY — FOR LIGHT OIL.

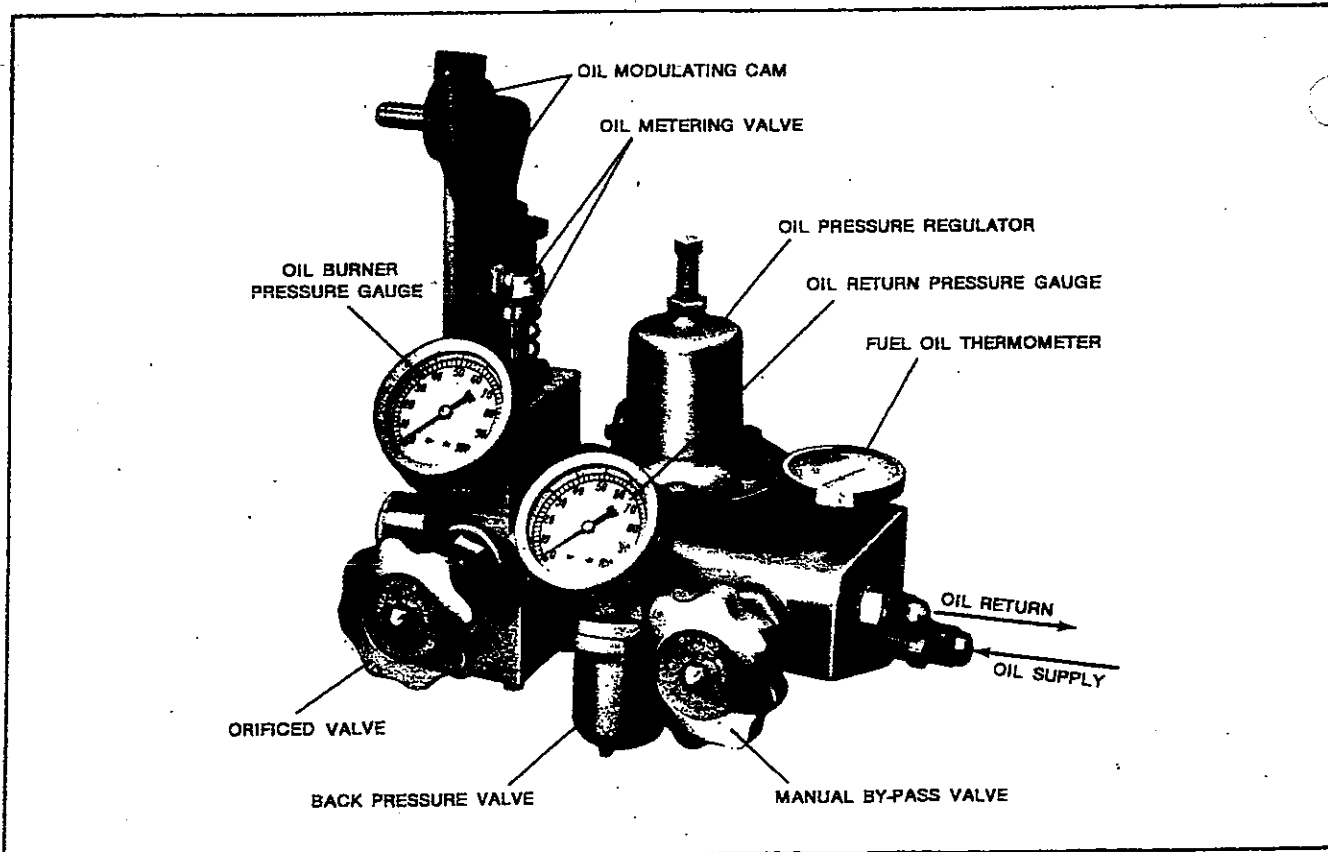


FIGURE 1-6 OIL CONTROL VALVE ASSEMBLY — FOR HEAVY OIL

to regulate the supply of fuel oil to the burner nozzle in accordance with boiler load variances. Stem movement is controlled by the modulating motor through linkage and the oil metering cam.

- (b) Oil Modulating Cam: Assembly consisting of a quadrant, a series of adjustable allen-head screws and a contour spring provided for adjustment of oil input at any point in the modulating range.
- (c) Oil Burner Pressure Gauge: Indicates pressure of the fuel oil at the metering valve.
- (d) Oil Pressure Regulator: For adjustment of the pressure of oil at the metering valve.
- (17) Fuel Oil Pump (not shown): Transfers fuel oil from storage tank and delivers it under pressure to the burner system.
- (18) Oil Relief Valve (figure 1-1): Bypasses excess fuel oil and maintains pressure indicated on oil supply pressure gauge.
- (19) Fuel Oil Strainer (figure 1-1): Provided to prevent foreign matter from entering the burner system.
- (20) Gas Pilot: See Section G for description of the various components.
- (21) Light Oil Pilot Valve (not shown): When a light oil pilot is furnished, a solenoid valve is provided to control flow of fuel to the pilot nozzle. It is energized through the contacts of a programmer when pilot ignition is desired. It is de-energized to shut off pilot fuel flow after main flame is ignited and established.
- (22) Back Pressure Orifice (figure 1-1): A restriction located in the oil return line immediately downstream of the fuel oil controller to create back pressure. (100 and 200 series only).

J. ADDITIONAL CONTROLS FOR HEAVY OIL

NOTE: Items 6 and 7 are applicable only on a hot water boiler.

- (1) Oil Heater Switch (figure 1-7): Manually provides power to oil heater system.
- (2) Oil Heater (Electric) (figures 1-2 and 1-8): Used for heating sufficient fuel oil for low fire flow during cold starts before steam or hot water is available for heating. The heater must be turned off during extended boiler lay-up, or at any time fuel oil transfer pump is stopped.
- (3) Oil Heater (Steam/Hot Water) (figures 1-2 and 1-8): Heats fuel oil through medium of steam or hot water. Electric heater is housed in the steam heater, but is housed separately on a hot water heater. Steam oil heaters on 15 psi boilers will operate at boiler pressure. Steam oil heaters furnished on high pressure boilers are also to be oper-

ated at less than 15 psi. This is accomplished with a steam pressure regulator valve.

- (4) Oil Heater Thermostat—Electric (figures 1-2 and 1-8): Senses fuel oil temperature and energizes or de-energizes the electric oil heater to maintain required temperature.
- (5) Oil Heater Steam Thermostat (figure 1-8): Senses fuel oil temperature and controls the opening and closing of the steam heater valve to maintain the selected temperature.
- (6) Oil Heater Hot Water Thermostat (figure 1-2): This control is used on a hot water boiler to sense fuel oil temperature and control the starting and stopping of the booster water pump to supply hot water to the pre-heating assembly to maintain the selected temperature.
- (7) Booster Water Pump (figure 1-2): Started and stopped by the hot water thermostat to regulate the flow of hot water through the hot water oil heater to maintain temperature of fuel oil.
- (8) Oil Heater Steam Valve (figure 1-8): A normally closed solenoid valve opened by the oil heater steam thermostat to allow flow of steam to the steam heater to maintain temperature of fuel oil.
- (9) Steam Heater Check Valve (figure 1-8): Prevents oil contamination of the waterside of pressure vessel should any leakage occur in the oil heater.
- (10) Steam Heater Pressure Regulator (figure 1-8): Adjust to provide reduced (usually less than 15 psi) steam pressure to the heater to properly maintain the required fuel oil temperature. This regulator and the pressure gauge are not furnished on 15 psi units.
- (11) Steam Trap (figure 1-8): Drains condensate and prevents loss of steam from the steam oil heater. Its discharge must be piped to waste.
- (12) Check Valve (Steam Heater Discharge) (figure 1-8): Prevents air entry during shutdown periods when cooling action may create vacuum within steam heater.
- (13) Oil Supply Pressure Gauge (figures 1-2 and 1-8): Indicates fuel oil pressure in the oil heater and supply pressure to the fuel oil controller's pressure regulator.
- (14) Low Oil Temperature Switch (figures 1-2 and 1-8): Thermostatic switch that prevents burner from starting, or stops burner firing if fuel oil temperature is lower than required for oil burner operation.
- (15) High Oil Temperature Switch (Optional) (Not Shown): Switch contacts open when fuel oil temperature raises above a selected temperature. Switch will interrupt the limit circuit in the event fuel oil temperature rises above the selected point.
- (16) In addition to the components of the fuel oil

controller mentioned in Section H, the following are used with a heavy oil fired burner (See Figure 1-6).

- (a) Fuel Oil Thermometer: Indicates temperature of fuel oil being supplied to the fuel oil controller.
- (b) Back Pressure Valve: For adjustment of the oil pressure on the downstream side of the metering valve. Also regulates rate of return oil flow.
- (c) Oil Return Pressure Gauge: Indicates the oil pressure on return side of fuel oil controller.
- (d) Manual By-Pass Valve: Provided as a time saver in establishing oil flow. When open it

permits circulation of oil through the supply and return lines. Prior to initial light off this valve *must* be closed.

- (e) Orifice Oil Control Valve: Valve may be opened prior to start-up to aid in establishing fuel oil flow through the controller. Prior to initial light off this valve *must* be closed. Its disc has an orifice to permit a continuous circulation of hot fuel oil through the controller.
- (17) Air Purge Valve (not shown). Solenoid valve opens simultaneously with closing of oil solenoid valve at burner shutdown allowing compressed air to purge oil from the burner nozzle and adjacent

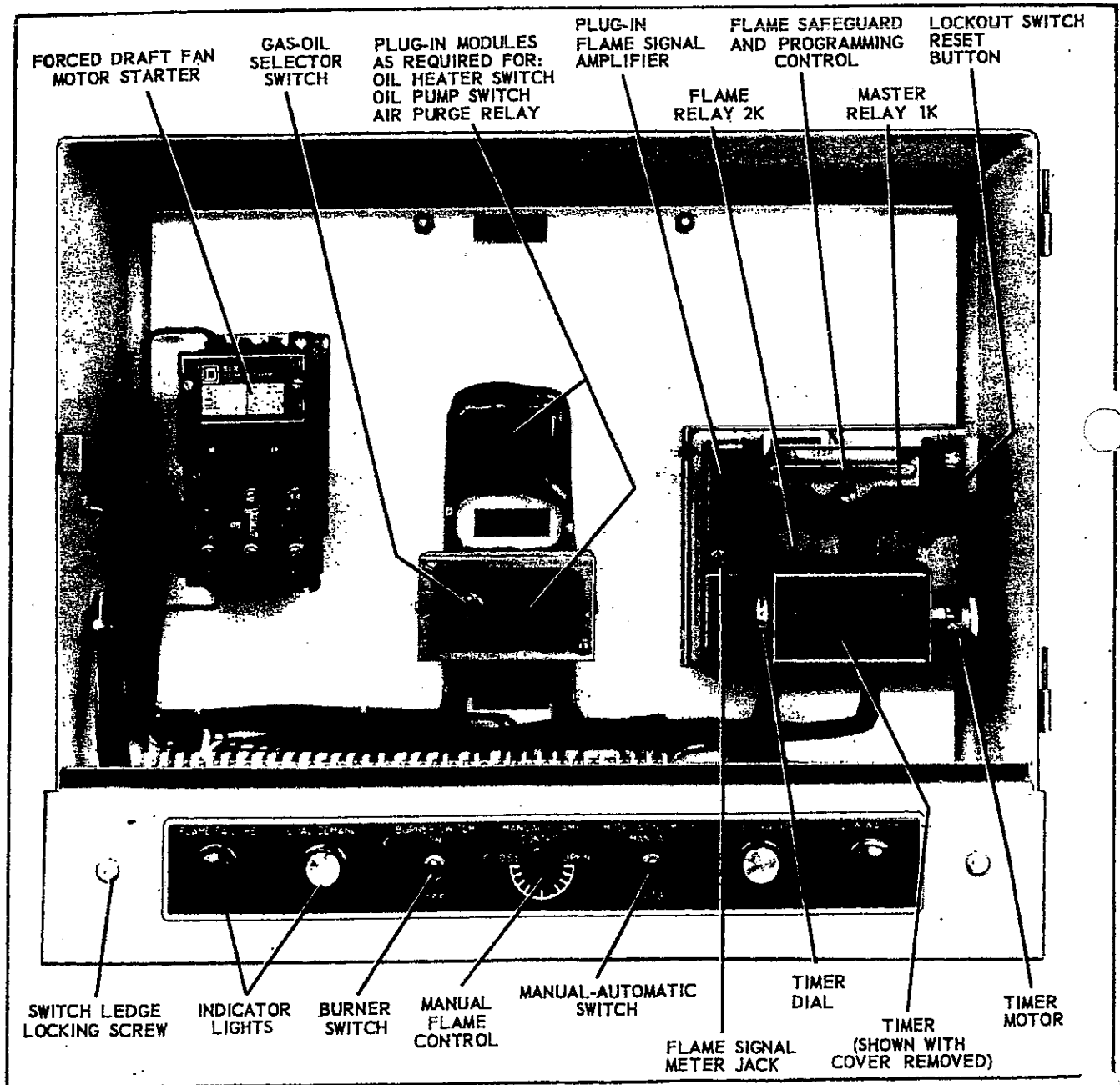


FIGURE 1-7 TYPICAL CONTROL PANEL WITH CB-20 PROGRAMMER

pipng. This oil is burned by the diminishing flame which continues burning for approximately 4 seconds after oil solenoid valve closes.

(18) Air Purge Orifice Nozzle (not shown): Limits purging air to proper quantity for expelling unburned oil at normal delivery rate.

(19) Air Purge Orifice Nozzle Filter (not shown): Filters the purging air of any particles which might plug the air purge orifice nozzle.

(20) Air Purge Check Valve (not shown): Valve check prevents fuel oil from entering the atomizing air line.

(21) Air Purge Relay (figure 1-7): When energized, controls operation of air purge valve.

K. CONTROLS FOR COMBINATION BURNERS ONLY

(1) Gas-Oil Switch (figure 1-7): Burners equipped to burn either oil or gas include equipment for each fuel. The selector switch routes electrical circuitry through those controls and interlocks required for the particular fuel. Chapter 4 details the required mechanical functions of each fuel system.

L. COMBUSTION AIR

Air for combustion of fuel (often referred to as "secondary" air) is furnished by the forced draft fan (Figure 1-10) mounted in the boiler head. In operation, air pressure is built up in the entire head and is forced through a diffuser plate for a thorough mixture with the fuel for proper combustion. The supply of secondary air to the burner is governed by automatically throttling the output of the fan by regulating the rotary air damper. This furnishes the proper amount of air for correct ratio of air to fuel for efficient combustion at all firing rates.

M. AUTOMATIC IGNITION

Oil or gas burners are ignited by an interrupted type pilot. The pilot flame is ignited automatically by an electric spark.

A series 100 burner usually is equipped with a pilot fired with light oil fuel. All other burners, as well as a series 100 burner complying to insurance underwriters' requirements, are equipped with a gas burning pilot. In the case of a combination burner, the gas pilot is used to ignite either the main gas flame or the oil flame. Either pilot serves the same function and unless exception is taken in the text the term pilot is used interchangeably.

At the beginning of the ignition cycle, and governed by the programming control, the pilot solenoid valve and ignition transformer are simultaneously energized.

The ignition transformer supplies high voltage current for the igniting spark. A gas pilot has a single electrode and a spark arcs between the tip of the electrode and the wall of the tube surrounding it. A light oil pilot has two electrodes and the arc is between their tips. The pilot solenoid valve and the transformer are de-energized after main flame is ignited and established.

Fuel for the gas pilot is supplied from the utilities' mains or from a tank (bottle) supply. Secondary air flows into and mixes with the pilot gas stream to provide an adequate flame.

Insurance regulations may require two gas pilot solenoids with a normally open vent valve between them. The vent valve closes when the gas pilot valves open; and opens when the gas pilot valves shut to vent gas should any be present in the pilot line during the de-energized period of the gas pilot valves.

Fuel for a light oil pilot is provided from the line that supplies oil under pressure for the main flame. A solenoid actuated valve controls flow of oil to the pilot nozzle. This valve is energized simultaneously with the ignition transformer at the beginning of the ignition cycle and is de-energized after main flame is ignited and established.

N. ATOMIZING AIR

Air for atomizing the fuel oil (often referred to as "primary air") is pumped by the air pump into the air-oil receiver tank and delivered under pressure through a manifold block to the oil burner nozzle.

The atomizing air mixes with the fuel oil just prior to the oil leaving the nozzle.

Atomizing air pressure is indicated by the air pressure gauge on the burner gun. Leakage of atomizing air into the oil line in the burner gun is prevented by a neoprene o-ring around the rear of the oil tube within the manifold block.

Air pressure from the pump also forces sufficient oil from the tank to the pump bearings to lubricate them and also to provide a seal and lubrication for the pump vanes. As a result the air delivered to the tank contains some lube oil, however; most of it is recovered through baffles and filters in the tank before the air passes to the burner.

Some of the primary air is also used to assist the oil pressure regulators of the fuel oil controller. This is explained in Chapter 4.

O. OIL FUEL FLOW — LIGHT OIL

The oil fuel flow system is shown in schematic diagram form in figure 1-11. Oil flow is indicated by arrows and the pertinent controls are called out.

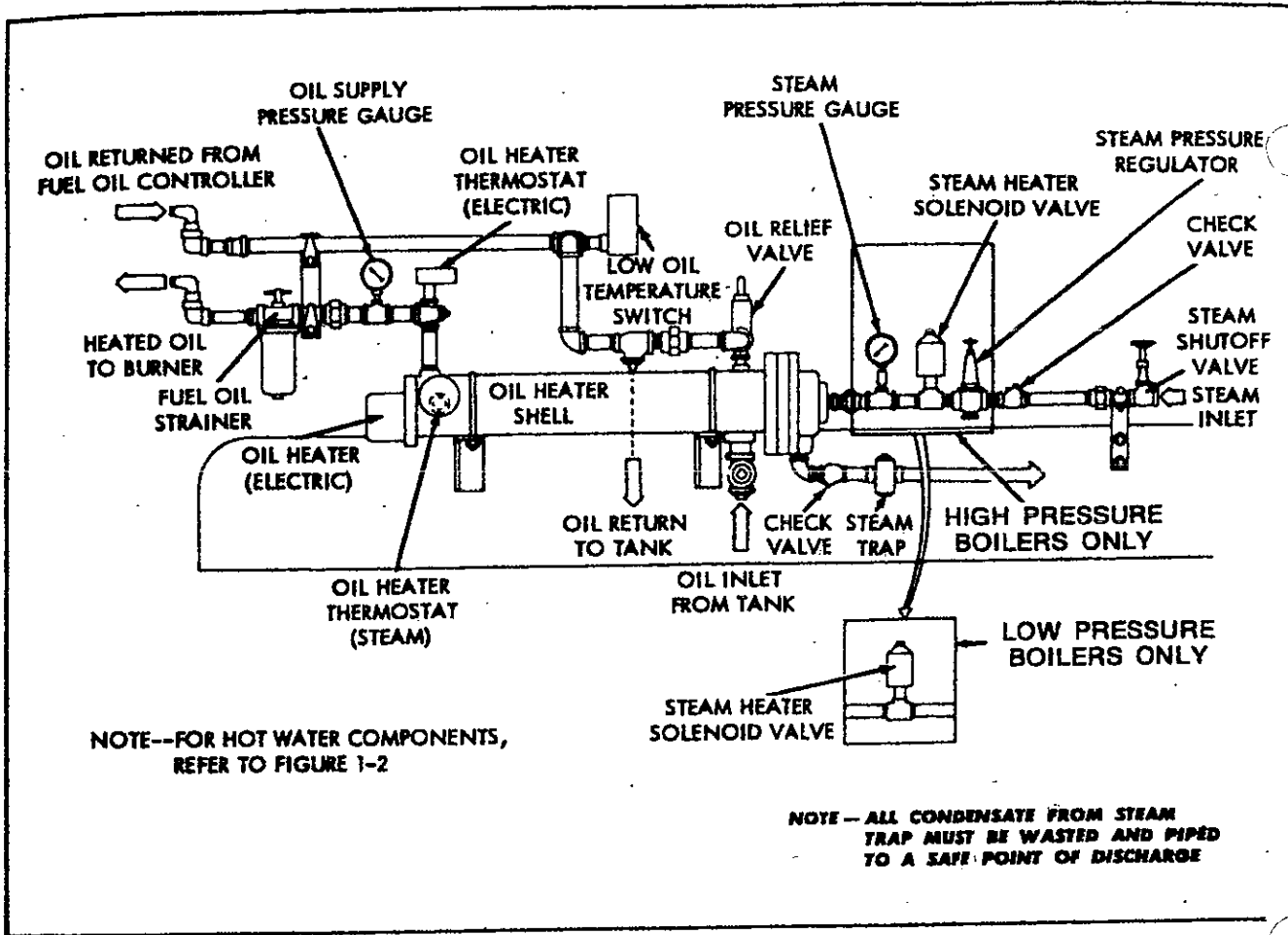


FIGURE 1-8 OIL HEATING ASSEMBLY (STEAM)

Fuel oil is delivered into the system by a supply pump which delivers part of its discharge to the oil burner. Excess oil is returned to the oil storage tank through the fuel oil relief valve and oil return line. Normally the pump operates only while the burner is in operation although often a positioning switch is provided so that either continuous or automatic pump operation can be obtained.

The oil flows through a fuel oil strainer provided to prevent any foreign material from flowing through the control valves and nozzle. The fuel oil controller contains in a single unit, a metering valve, a regulator and a gauge required to regulate the pressure and flow of oil to the burner. The adjustable regulator controls the pressure. To assist in this regulating, back pressure is created by an orifice nozzle located in the oil return line immediately downstream of the fuel oil controller.

The programming control energizes or de-energizes the solenoid oil valves to permit or cut off oil flow to the burner. Two valves, operating simultaneously, are used. These valves are closed when de-energized. They can not be opened (energized) unless the combustion air proving switch and the atomizing air proving switch are closed. These are

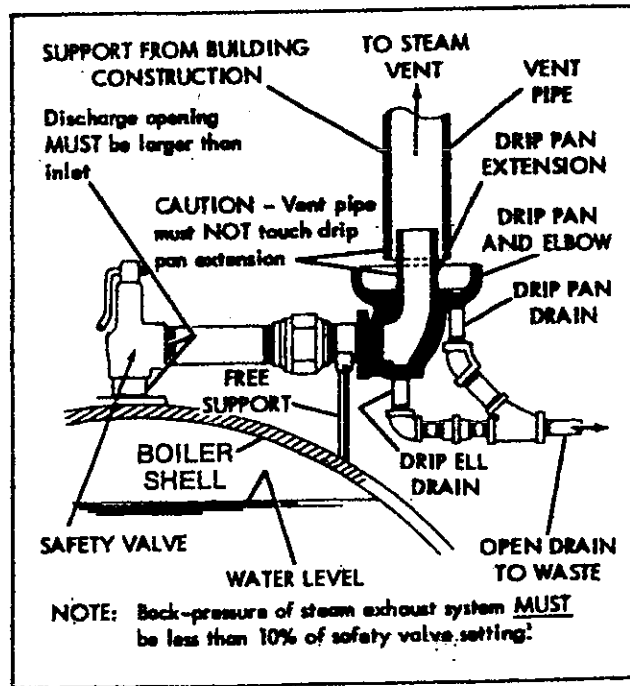


FIGURE 1-9 RECOMMENDED SAFETY VALVE INSTALLATION PROCEDURE

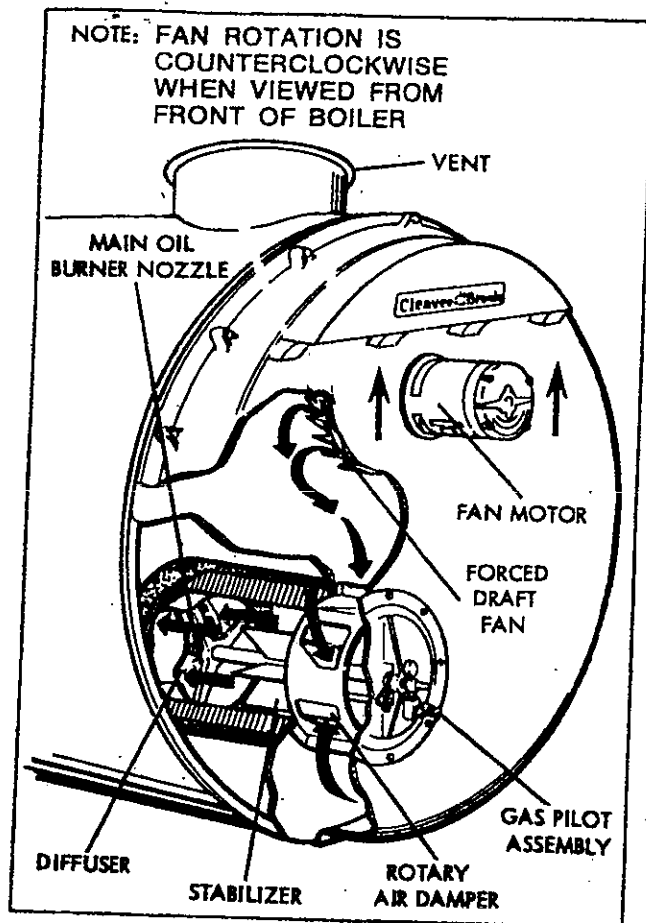


FIGURE 1-10
SECONDARY AIR FLOW DIAGRAM

satisfied, respectively, by sufficient combustion air pressure from the forced draft fan and pressurized air from the air pump.

The oil flow to the burner is controlled by the movement of the metering stem in the oil metering valve which varies the flow to meet load demands. The metering valve and the air damper are controlled simultaneously at all times by the modulating motor to proportion combustion air and fuel for changes in load demand.

P. OIL FUEL FLOW — HEAVY OIL

The oil fuel flow and circulating system is shown in schematic diagram form in Figure 1-12. The pertinent controls are called out and the oil flow is indicated by arrows.

Fuel oil is delivered into the system by the fuel oil supply pump which delivers part of its discharge to the oil heater. The remainder of the fuel oil returns to the oil storage tank thru a fuel oil relief valve and oil return line.

The combination electric and steam oil preheater is controlled by thermostats. The electric oil heater thermostat energizes the electric heater which is provided to supply heated oil on cold starts. The steam heater thermostat controls the operation of the steam solenoid valve to permit a flow of steam to the heater when steam is available.

A hot water boiler is equipped to heat the oil with hot water from the boiler unless other pre-heating equipment is utilized. The electric heater, which is housed separately, is sized to provide heated oil on a cold start. The hot water thermostat controls the operation of a pump that supplies hot water to the oil heater when hot water is available.

The heated oil flows thru a fuel oil strainer to prevent any foreign matter from entering the control valves and nozzle.

The fuel oil controller contains in a single unit the necessary valves, regulators and gauges to regulate the pressure and flow of oil to the burner.

The programming control energizes or de-energizes the solenoid oil valve to permit or cut off oil flow to the burner. The oil solenoid is closed when de-energized. It cannot be opened (energized) unless the combustion air proving switch, the atomizing air proving switch and the low oil temperature and any pressure switches are closed. These are satisfied, respectively, by sufficient combustion air pressure from the forced draft fan, pressurized air from the air pump and sufficient oil temperature and pressure.

The oil flow to the burner is controlled by the movement of the metering stem of the oil metering valve which varies the flow to meet load demands. The metering valve and the air damper are controlled simultaneously at all times by the modulating motor to proportion combustion air and fuel for changes in load demand.

Oil is purged from the burner gun upon each burner shut down. The air purge solenoid valve opens as the fuel valve closes and diverts atomizing air thru the oil line. This assures a clean nozzle and line for the subsequent restart.

Q. GAS FUEL FLOW

The gas flow system is shown in figure 1-4. Gas flow is indicated by arrows and the pertinent con-

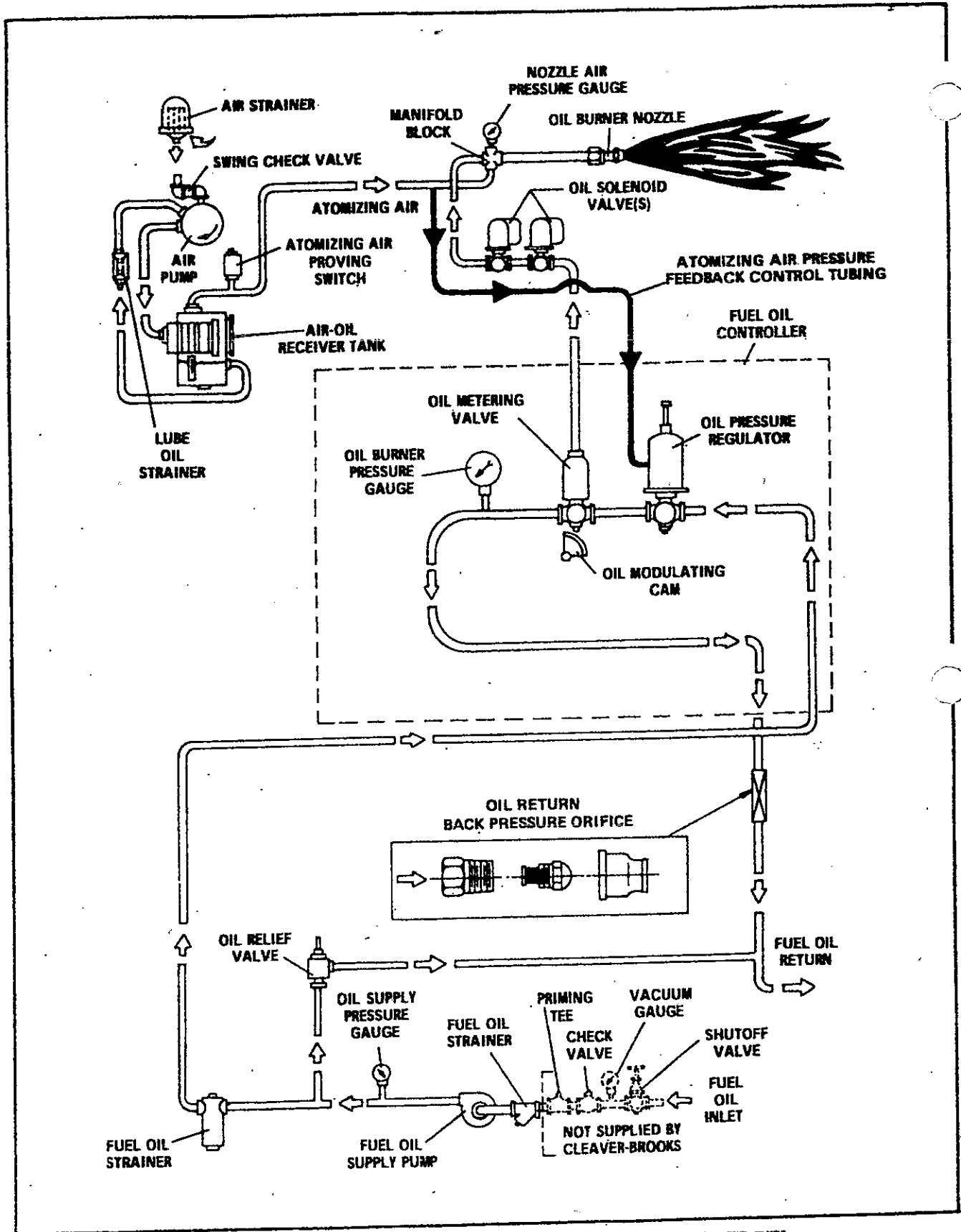


FIGURE 1-11 SCHEMATIC DIAGRAM FOR LIGHT OIL FLOW

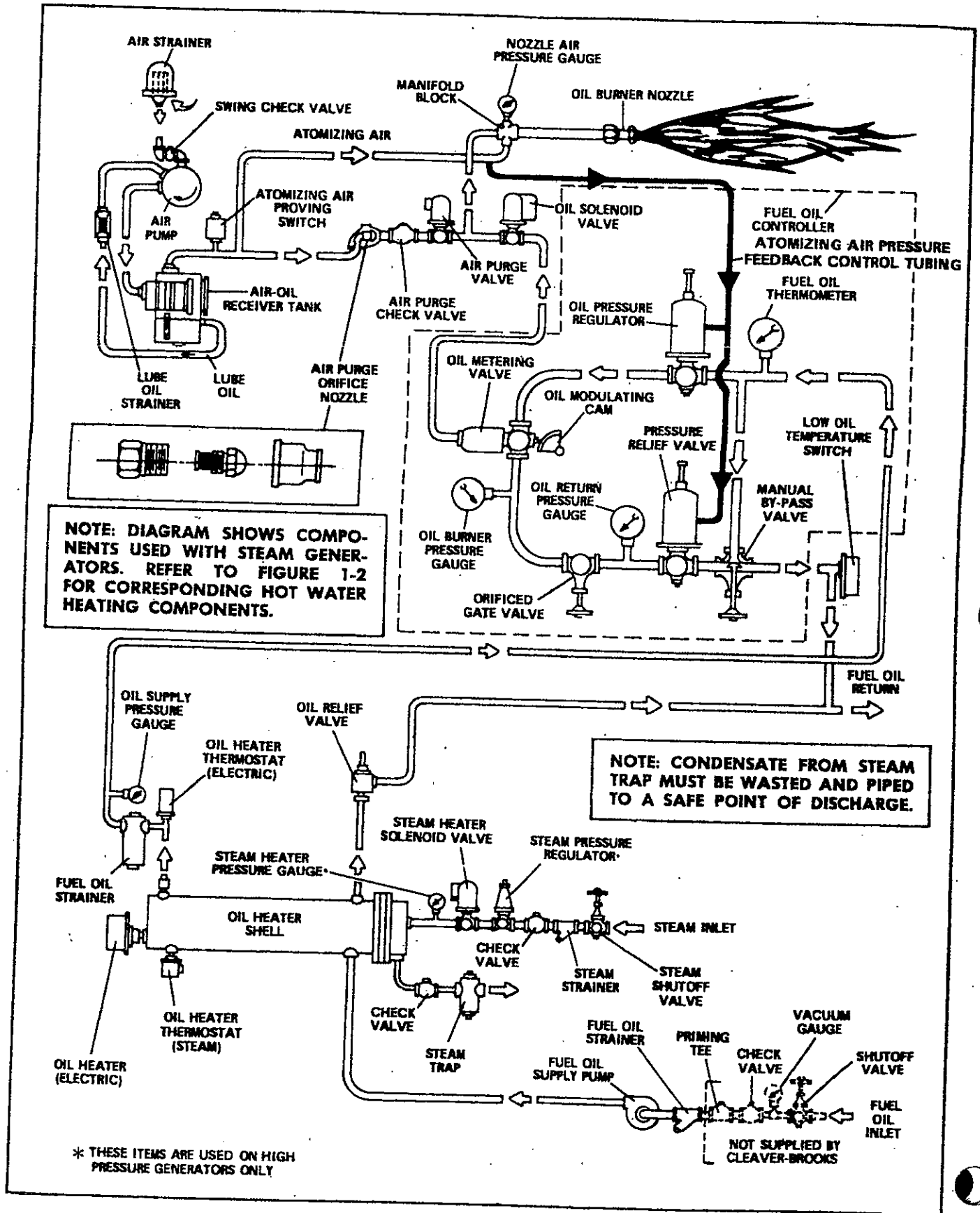


FIGURE 1-12 SCHEMATIC DIAGRAM FOR NO. 6 HEAVY OIL FLOW (STEAM-ELECTRIC HEATED)

trols are shown. Combustion air travel is also shown and indicated by a different type of arrow.

Metered gas from the utility flows through the pressure regulator at a reduced pressure suitable to the burner's requirements, through the main gas shut-off cock, main gas valve(s) and modulating butterfly gas valve to the non-premix orifice type burner.

The main gas valve is of the normally closed type and is opened (energized) in proper sequence by the programming control.

The butterfly gas valve modulates the flow of gas from low through high fire settings. The position of the butterfly valve disc is governed by the gas modulating cam. The butterfly gas valve, and the air control damper are controlled simultaneously by the modulating motor to proportion combustion air and fuel for changes to load demand.

The gas flow rate required for rated burner input depends upon the heating value (BTU/cubic foot) of the gas supplied. The gas pressure regulator adjusts the gas pressure (flow rate) to the entrance of the gas train. The regulator is not always supplied with the burner, but may be provided by others.

The main gas valves cannot be energized (opened) unless the combustion air proving switch is closed to indicate a sufficient supply of combustion air. The low gas pressure and high gas pressure switches must be closed to prove sufficient, but not excessive, gas fuel pressure.

R. MODULATING FIRING

The modulating motor, through a linkage arrangement, controls the air damper and the butterfly gas valve or the oil metering valve to maintain a constant air-fuel ratio throughout the firing range.

During burner operation, the motor is controlled by a modulating pressure control on a steam boiler, or by a modulating temperature control on a hot water boiler. A manually operated potentiometer is provided to permit the positioning of the

motor at a desired burner firing rate. This is used primarily for initial or subsequent checking and setting of fuel input. Normal operation should be with the manual-automatic switch in the "automatic" position and under the control of the modulating control.

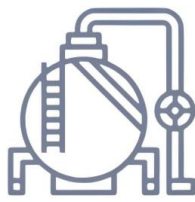
The modulating motor (commonly called a damper motor) is reversible. It has an internal limit switch that restricts shaft rotation to 90°. During normal operation the motor will move in either direction or stop at any position within this range.

The motor's potentiometer is electrically connected to a matching potentiometer in the modulating control. Changing steam pressure or water temperature alters the electrical resistance of the modulating controller's potentiometer. This change in resistance compels an integral balancing relay to start, stop, or reverse the motor rotation. Rotation in either direction continues until the resistance ratio of the two potentiometers are equal.

When this occurs, the motor stops in a position that allows the proper fuel and combustion air flow to meet operating demands.

A feature designed into the circuitry is that the modulating motor must be in the low fire position during ignition and remain there until the main flame is established. A low fire switch, integral to the motor, is actuated by the rotation of the motor. The switch must be closed to establish that the damper and fuel metering valves are in low fire position before the programmer commences into the ignition period. During this time, neither the manual flame control nor the modulating control have any control over the damper motor, regardless of their setting.

An optionally equipped boiler has a second integral switch used to establish that the motor has driven the damper to an open position during the pre-purge period. This switch closes, as high fire position is approached, to complete an internal circuit in the programmer and allow continuation of the programming cycle.



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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.

The type of service which your boiler performs has an important bearing in the amount of waterside care it will require.

The subject of water supply and treatment cannot adequately be covered in this manual. Nevertheless it is of prime importance.

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.

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

Boilers, as a part of a hot water system, require 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.

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.

Another reason for maintaining boiler water temperature above 170 degrees F is to provide a sufficient temperature "head" when No. 6 fuel oil is to be heated to the proper atomizing temperature by the boiler water in a safety type oil preheater. (The electric preheater on the boiler must provide additional heat to the oil if boiler water temperature is not maintained above 200 degrees F.)

NOTE: If the water temperature going to the system must be lower than 170 degrees F, the boiler water temperature should be a minimum of 170 degrees F (200 degrees F if used to preheat No. 6 oil) and mixing valves should be used.

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 the thermal stress. This applies to periods of "normal operation" as well as during initial start-

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 the 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.

| 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

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 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.

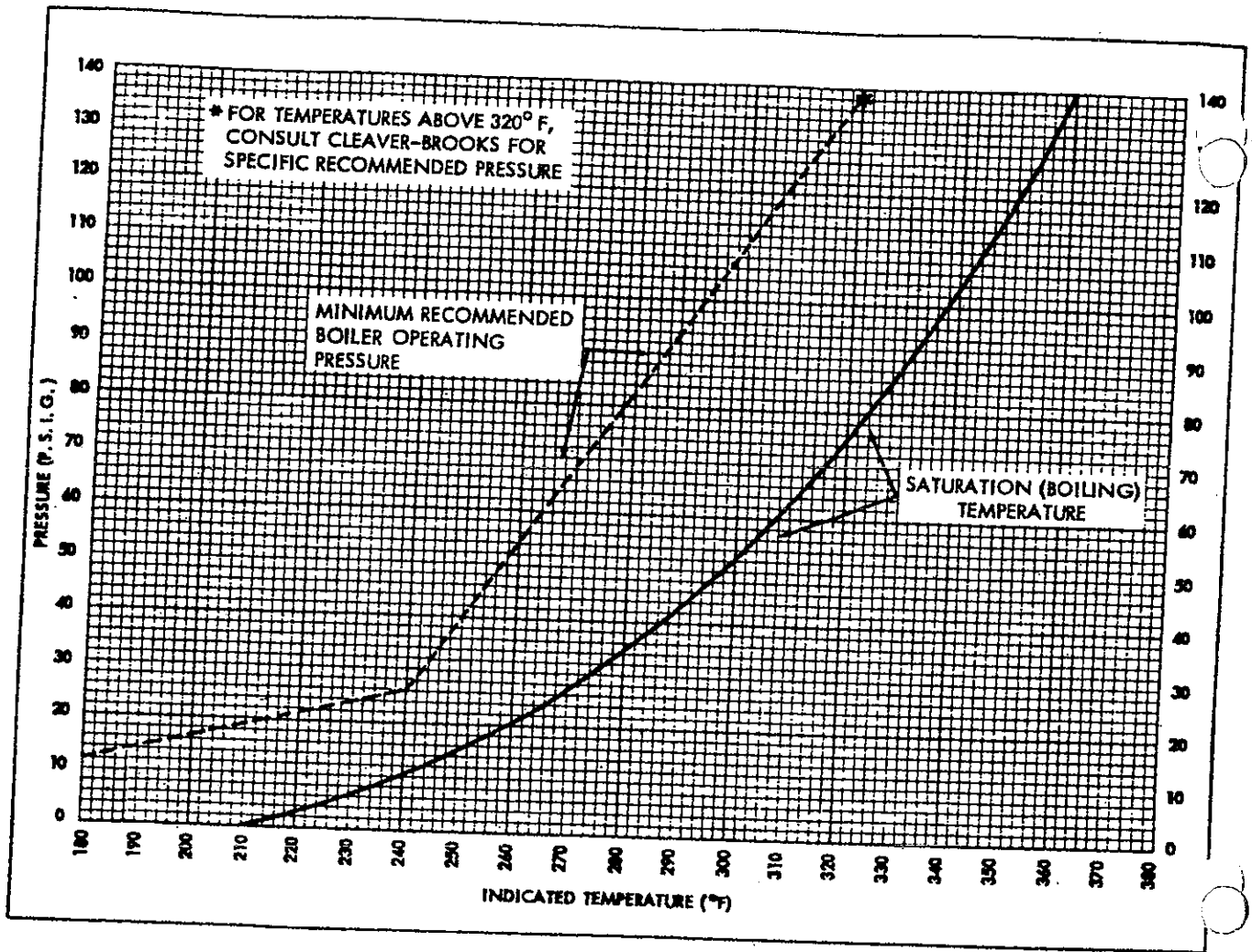


FIGURE 2-2. PRESSURE - TEMPERATURE CHART FOR HOT WATER BOILERS

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.

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 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

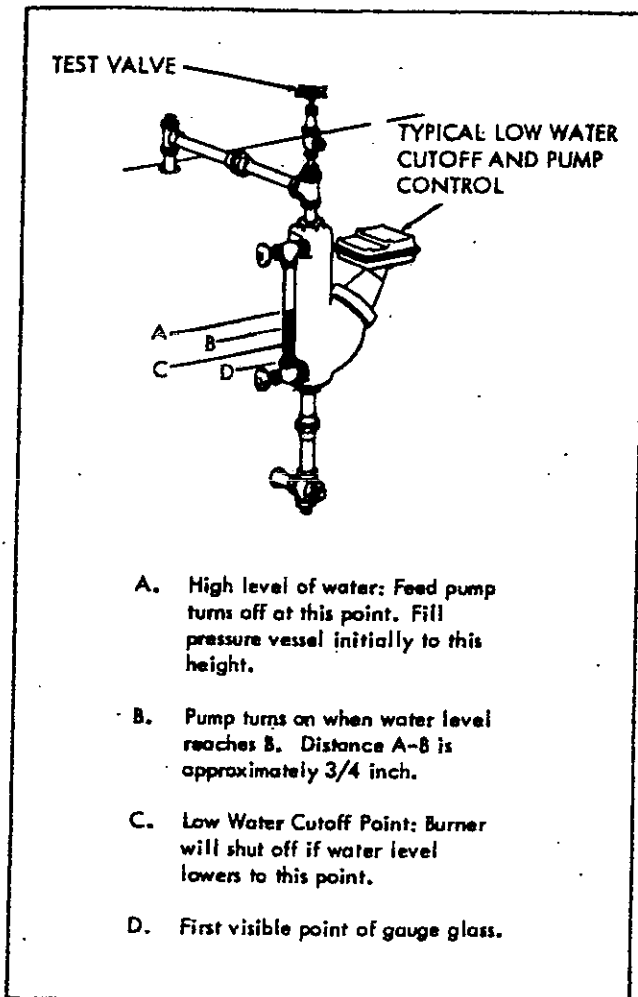


FIGURE 2-3. BOILER WATER LEVEL DETAILS (STEAM BOILER)

NOTE: Prior to operating pump, carefully check alignment of flexible coupling if one is used. A properly aligned coupling will last a long time and provide trouble free mechanical operation.

Water Feeder Operation

This type of operation is usually applicable to boilers operating at 15psi 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.

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 wash-out 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 prior to initial firing 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.

| Gen-erator Sizes | Water--Gallons | | Water--Weight | |
|---------------------|----------------|---------|---------------|---------|
| | Normal | Flooded | Normal | Flooded |
| 400 | 1840 | 2475 | 15340 | 20630 |
| 500 | 2315 | 3110 | 19300 | 25925 |
| 600 | 2810 | 3780 | 23425 | 31510 |
| 700 | 3330 | 4395 | 27730 | 36600 |
| 800 | 3330 | 4395 | 27730 | 36600 |

2. When dissolving chemicals, the following procedure is suggested. Warm water should

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 M in Chapter 7 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 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 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 feed-water 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 that are designed to remove unwanted substances which 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 crystallize 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 tapings 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 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 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 as 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 water-side 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 tri-cocks. 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.

Too many conditions exist to lay down definite rules. 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 permissible sulphur content of fuel oils, care must be taken to avoid corrosion problems that sulphur can cause, especially in a boiler that is seasonally shutdown. 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.

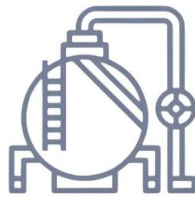
This condition does not generally occur during normal firing operation since the high temperature operation vaporizes any condensation. However, proper boiler operation must be maintained, especially with a hot water boiler, to prevent the flue gases from falling below the dew point.

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 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.



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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

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 low water light is off. 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. Load demand light glows.

All entrance switches are closed and power is present at the line terminals of the forced draft fan starter. Power must also be present to the starter of the oil pump motor. When the fuel is heavy oil, power must also be present at the relay terminals of the oil heater.

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 and to the damper motor transformer (DMT). 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

PROGRAMMING SEQUENCE FOR CB20 PROGRAM RELAY

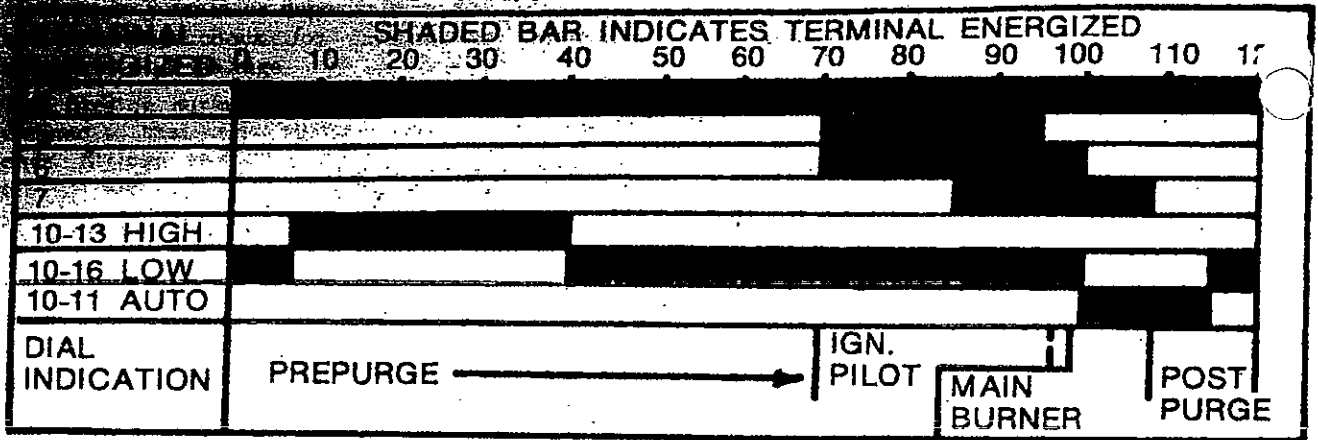


FIGURE 3-1.

PROGRAMMING SEQUENCE FOR CB40 PROGRAM RELAY

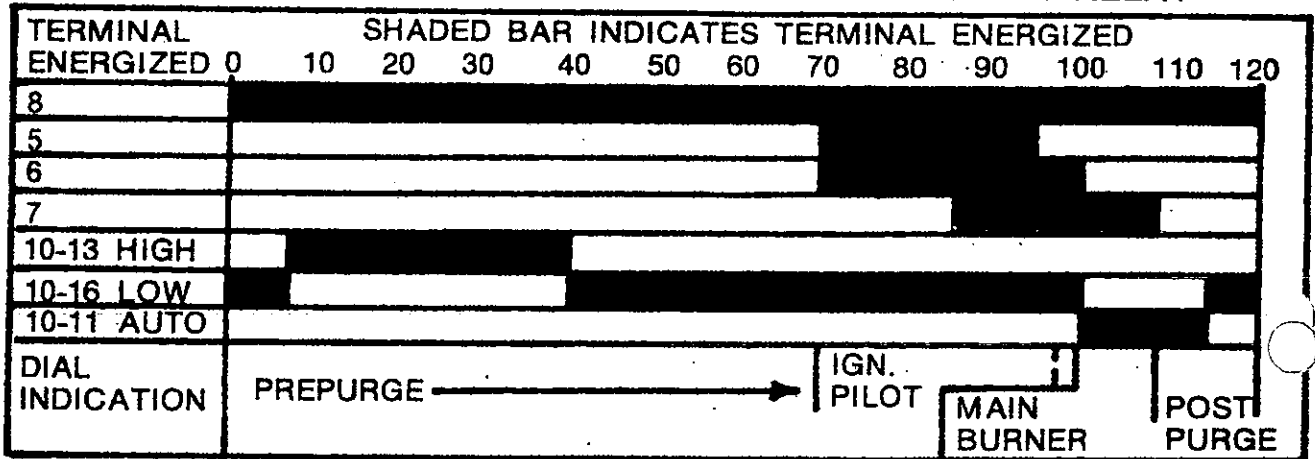


FIGURE 3-2.

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 (OLPC) (OLTC)
- High limit pressure or temperature control (HLPC) (HLTC)
- Low water cut-off (LWCO)
- Gas/oil switch (GOS) — combination burner only
- Oil drawer switch (ODS) — oil burner
- Low oil temperature switch (LOTS) (No. 6 oil only)
- Low gas pressure switch (LGPS)
- High gas pressure switch (HGPS)
- Proof of valve closure (AS)

The controls used in the running interlock circuit are:

- Blower motor starter interlock (BMSI)
- Combustion air proving switch (CAPS)
- Atomizing air proving switch (AAPS)

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 feed-water system except for those controls that directly affect the action of the programming relay. Refer to the wiring diagram supplied for this boiler following this sequence.

NOTE: The legend on the timer dial (Figure 1-7) 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 in this manual 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 and the timer motor. When firing oil, the air pump motor starter is also powered.

Programmer terminals 10 and 13 are powered 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.

NOTE: When terminals 10 and 13 are powered, the R-B (high fire) potentiometer circuit is completed and the damper motor will drive to its open or high fire position. When terminals 10 and 16 are powered the R-W (low fire) potentiometer circuit is made and the motor will return to its closed or low fire position. In either instance, neither the manual flame control, the modulating control nor the manual-automatic switch have any effect on the damper motor.

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.

The oil drawer switch (ODS) must be made when oil fuel is fired to prove that the burner gun is in its proper position. The atomizing air proving switch (AAPS) must be closed to indicate the presence of air from the air compressor before the fuel valve circuit can be completed. When No. 6 oil is used, the low oil temperature switch (LOTS) must be closed to prove that the oil is heated to desired temperature.

On a gas fired burner, the low gas pressure switch (LGPS) and the high gas pressure switch (HGPS) must be closed to prove sufficient but not excessive gas fuel pressure.

Toward the end of the purging period, terminals 10-13 open and 10-16 close. The motor and damper return to the closed or 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 lockout at the start position.

IGNITION PERIOD

Dial at "Pilot and Ignition"

The ignition transformer (IT) and the gas pilot valve (GPV) are energized from terminal 6. The pilot flame is ignited and as soon as it 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.

With a proven pilot, the main fuel valve(s) (OV or MGV) is energized from terminal 7. The fuel valve light is also energized. Main flame is ignited.

After a 15 second trial period for the proving of main flame, power is removed from terminal 6 de-energizing the ignition transformer and the pilot valve. The 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 to close.

| | | | |
|-------|---|--------|-----------------------------------|
| | A | | |
| A | Amber (Color of Pilot Light) | EDS | Emergency Door Switch |
| AAFL | Atomizing Air Failure Light | | |
| AAPS | Atomizing Air Proving Switch | | |
| AB | Alarm Bell | | F |
| ACMCB | Air Compressor Motor Circuit Breaker | FCIPL | Fuel Changeover In Progress Light |
| ACMS | Air Compressor Motor Starter | FD | Flame Detector |
| AFSV | Air Flow Solenoid Valve | FDPS | Flow Differential Pressure Switch |
| AGV | Auxiliary Gas Valve | FFL | Flame Failure Light |
| AH | Alarm Horn | FON | Fan On |
| ALWCO | Auxiliary Low Water Control | FOFF | Fan Off |
| AM | Ammeter | FOL | Flame On Light |
| AMS | Atomizing Media Switch | FPM | Feed Pump Motor |
| AOV | Auxiliary Oil Valve | FPMS | Feed Pump Motor Starter |
| APR | Air Purge Relay | FS | Flow Switch |
| AR | Alarm Relay | FVEL | Fuel Valve Energized Light |
| AS | Auxiliary Switch (Mounted on Damper Motor) | FVL | Fuel Valve Light |
| ASS | Alarm Silencing Switch | | |
| ASV | Atomizing Steam Valve | | G |
| ATS | Alarm Test Switch | | Green (Color of Pilot Light) |
| | B | G | Gas Cock Auxiliary Switch |
| B | Blue (Color of Pilot Light) | GCAS | Gas Cock Switch |
| BDCS | Breaching Damper Closed Switch | GCS | Gauge Glass Light |
| BDOS | Breaching Damper Open Switch | GGL | Gauge Glass Light Switch |
| BHS | Boiler - Header Switch | GGLS | Gas - Oil Switch |
| BIOL | Boiler In Operation Light | GOS | Gas Oil Valve |
| BM | Blower Motor | GOV | Gas Pilot Valve |
| BMCB | Blower Motor Circuit Breaker | GPV | Gas Pilot Vent Valve |
| BMF | Blower Motor Fuses | GPVV | Gas Valve Energized Light |
| BMS | Blower Motor Starter | GVEL | |
| BMSI | Blower Motor Starter Interlock (included in BMS) | | H |
| BMSS | Blower Motor Selector Switch | HATC | High Ambient Temperature Control |
| BS | Burner Switch | HFAV | High Fire Automatic Valve |
| BSS | Boiler Selector Switch | HFOV | High Fire Oil Valve |
| BWPM | Booster Water Pump Motor | HFS | High Fire Switch |
| BWT | Booster Water Thermostat | HFS-A | High Fire Switch - Air |
| | C | HGPL | High Gas Pressure Light |
| CAAL | Combustion Air Adequate Light | HGPS | High Gas Pressure Switch |
| CAFL | Combustion Air Failure Light | HLC | High Limit Control |
| CAP | Capacitor: 0.005 MF, 600 Volts | HLPC | High Limit Pressure Control |
| CAPS | Combustion Air Proving Switch | HLTC | High Limit Temperature Control |
| CAPR | Combustion Air Proving Relay | HMC | Header Modulating Control |
| CCCB | Control Circuit - Circuit Breaker | HOPL | High Oil Pressure Light |
| CCF | Control Circuit Fuse | HOPS | High Oil Pressure Switch |
| CCT | Control Circuit Transformer | HOLC | Header Operating Limit Control |
| CL | Canopy Light | HOLT | High Oil Temperature Light |
| CLS | Canopy Light Switch | HOTS | High Oil Temperature Switch |
| CPOL | Control Power on Light | HSPC | High Steam Pressure Control |
| CR | Control Relay | HSPL | High Steam Pressure Light |
| CWPS | Circulating Water Pump Switch | HWAR | High Water Alarm Relay |
| CWPM | Circulating Water Pump Motor | HWC | High Water Control |
| | D | HWL | High Water Light |
| DISC | Disconnect (Entrance) Switch | (I.C.) | Instantaneously Closed |
| DMT | Damper Motor Transformer | (I.O.) | Instantaneously Open |
| | | IL | Ignition Light |
| | | IRL | Ignition Ready Light |
| | | IT | Ignition Transformer |

ELECTRICAL NOMENCLATURE USED IN WIRING DIAGRAMS
FIGURE 3-3

| | | | |
|--------|--------------------------------------|--------|----------------------------------|
| | L | | |
| LAMPS | Low Atomizing Media Pressure Switch | OL'S | Thermal Overloads |
| LASPS | Low Atomizing Steam Pressure Switch | OPM | Oil Pump Motor |
| LDL | Load Demand Light | OPR | Oil Purge Relay |
| LDS | Low Draft Switch | OPS | Oil Pump Switch |
| LFAV | Low Fire Automatic Valve | OPV | Oil Purge Valve |
| LFL | Low Fire Light | ORV | Oil Return Valve |
| LFOV | Low Fire Oil Valve | OSS | Oil Selector Switch |
| LFPS | Low Fire Pressure Switch | OT | Outdoor Thermostat |
| LFTC | Low Fire Temperature Control | OV | Oil Valve |
| LFS-A | Low Fire Switch - Air | OVAS | Oil Valve Auxiliary Switch |
| LFS-F | Low Fire Switch - Fuel | OVEL | Oil Valve Energized Light |
| LFS-G | Low Fire Switch - Gas | | P |
| LFS-O | Low Fire Switch - Oil | PAPS | Purge Air Proving Switch |
| LGPL | Low Gas Pressure Light | PC | Pump Control |
| LGPS | Low Gas Pressure Switch | PCL | Purge Complete Light |
| LIAPS | Low Instrument Air Pressure Switch | PCR | Pump Control Relay |
| LLTC | Low Limit Temperature Control | PFPS | Positive Furnace Pressure Switch |
| LOPL | Low Oil Pressure Light | PHGPS | Pilot High Gas Pressure Switch |
| LOPR | Low Oil Pressure Relay | PIPL | Purge in Progress Light |
| LOPS | Low Oil Pressure Switch | PIS | Pilot Ignition Switch |
| LOTL | Low Oil Temperature Light | PLGRS | Pilot Low Gas Pressure Switch |
| LOTS | Low Oil Temperature Switch | PMS | Plug Mold Strip |
| LSPC | Low Steam Pressure Control | POL | Power On Light |
| LTS | Lamp Test Switch | PPCL | Pre-Purge Complete Light |
| LWAR | Low Water Alarm Relay | PPL | Pre-Purging Light |
| LWCO | Low Water Cut Out | PR | Program Relay |
| LW/FFA | Low Water/Flame Failure Alarm | PRL | Purge Ready Light |
| LWL | Low Water Light | PSS | Purge Start Switch |
| | M | PT | Purge Timer |
| MAS | Manual - Automatic Switch | PTAS | Purge Timer Auxiliary Switch |
| MAM | Microammeter | | R |
| MC | Modulating Control | R | Red (Color of Pilot Light) |
| MDM | Modulating Damper Motor | RS | Range Switch |
| MFC | Manual Flame Control (Potentiometer) | | S |
| MFVEL | Main Fuel Valve Energized Light | SBOV | Surface Blow Off Valve |
| MFVW | Motorized Feed Water Valve | SC | Scanner |
| MGV | Main Gas Valve | SDL | Steam Demand Light |
| MGVAS | Main Gas Valve Auxiliary Switch | SHT | Steam Heater Thermostat |
| MGVEL | Main Gas Valve Energized Light | SHV | Steam Heater Valve |
| MGVV | Main Gas Vent Valve | SS | Selector Switch |
| (MOM) | Momentary | | T |
| MOV | Main Oil Valve | (T.C.) | Time Closed |
| MOVAS | Main Oil Valve Auxiliary Switch | (T.O.) | Time Open |
| MPC | Modulating Pressure Control | TB | Terminal Block |
| (MR) | Manual Reset (Used as Suffix) | TD | Time Delay |
| MTC | Modulating Temperature Control | TFWR | Transistorized Feed Water Relay |
| | N | | U |
| (N.C.) | Normally Closed | UVFD | Ultra-Violet Flame Detector |
| (NO) | Normally Open | | V |
| | O | VM | Volt Meter |
| ODS | Oil Drawer Interlock Switch | VV | Vent Valve |
| OH | Oil Heater | | W |
| OHCB | Oil Heater Circuit Breaker | W | White (Color of Pilot Light) |
| OHF | Oil Heater Fuses | WC | Water Column |
| OHR | Oil Heater Relay | WCBDS | Water Column Blow Down Switch |
| OHS | Oil Heater Switch | | |
| OHT | Oil Heater Thermostat | | |
| OLC | Operating Limit Control | | |

ELECTRICAL NOMENCLATURE USED IN WIRING DIAGRAMS
FIGURE 3-3A

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.

Dial at "Main Burner"

With the main flame established, terminals 10 and 11 are powered to transfer the modulating motor circuit to either the manual flame control (MFC) or to the modulating control (MC) depending upon the setting of the manual-automatic switch (MAS). This allows operation in ranges above low fire.

With the manual-automatic switch set at automatic, subsequent modulation will be at the command of the modulating control which governs the position of the modulating motor. The air damper and the cam controlled metering valve are actuated by the motor through a linkage and cam assembly to provide modulated firing rates.

NOTE: Normal operation of the burner should be with the switch in the automatic position and under the direction of the modulating control. The manual position is provided for initial adjustment of the burner over the entire firing range. If operated in the manual position at other than low fire, the pressure vessel metal and refractory are subjected to undesirable conditions. The effectiveness of nozzle purging is lost on a No. 6 oil burner.

This is the end of the burner starting cycle. The 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 modulated firing, the modulating 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:

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 load demand light and fuel valve light are turned off. The timer begins rotating.

On a No. 6 oil burner the air purge valve (APV) is

powered from terminal 8 via the contacts of the air purge relay (APR).

Terminals 10-11 open and 10-16 close. The damp motor returns to the low fire position if it is not ready in that position.

At the end of the operating cycle, terminal 8 circuit opens and de-energizes the blower motor. The air purge valve is closed on a No. 6 oil burner. 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 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) — (F.I.A.)

Low oil pressure switch (LOPS)

High oil temperature switch (HOTS) —
(F.I.A.)

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 1-7) 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 in this manual 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 and the timer motor. When firing oil, the air pump motor starter is also powered.

Programmer terminals 10 and 13 are powered 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.

NOTE: When terminals 10 and 13 are powered, the R-B (high fire) potentiometer circuit is completed and the damper motor will drive to its open or high fire position. When terminals 10 and 16 are powered the R-W (low fire) potentiometer circuit is made and the motor will return to its closed or low fire position. In either instance, neither the manual flame control, the modulating control nor the manual - automatic switch have any effect on the damper motor.

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 oil is fired the atomizing air proving switch (AAPS) must be closed to indicate the presence of air from the air compressor.

The oil drawer switch (ODS) must be made when firing on oil to prove that the burner gun is in its proper position. The low oil pressure switch (LOPS) must be closed to indicate that sufficient fuel supply pressure exists. The low oil temperature switch (LOTS) (and high oil temperature switch (HOTS), if used) must be closed to prove that heavy oil is heated to, but does not exceed, the desired temperature range.

On a gas fired burner, the low gas pressure switch (LGPS) and the high gas pressure switch (HGPS) must be closed to prove sufficient but not excessive gas fuel pressure.

Toward the end of the purging period, terminals 10-13 open and 10-16 close. The motor and damper return to the closed or low fire position.

NOTE: Extended pre-purge period.

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 instruction bulletin in the rear of this manual 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"

The ignition transformer (IT) and gas pilot valve (GPV) are energized from terminal 6 (or 5). The

pilot flame is ignited and as soon as it is detected, flame relay 2K is energized.

NOTE: Depending upon the requirements of regulatory or insurance body applicable to the installation, terminal 5 may be used instead of terminal 6. Both provide the same function but differ in time interval allowed for proving main flame ignition. Refer to the boiler wiring diagram.

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.

With a proven pilot, the main fuel valve(s) (OV or MGV) is energized from terminal 7. The fuel valve light is also energized. Main flame is ignited.

The trial period for the proving of main flame now begins. It lasts for 15 seconds if the pilot system is connected to terminal 6, or 10 seconds if connected to terminal 5. At the end of the proving period, the ignition transformer and the pilot valve are de-energized. The 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 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.

Dial at "Main Burner"

With the main flame established, terminals 10 and 11 are powered to transfer the modulating motor circuit to either the manual flame control (MFC) or to the modulating control (MC) depending upon the setting of the manual-automatic switch (MAS). This allows operation in ranges above low fire.

With the manual-automatic switch set at automatic, subsequent modulation will be at the command of the modulating control which governs the position of the modulating motor. The air damper and the cam controlled metering valve are actuated by the motor through a linkage and cam assembly to provide modulated firing rates.

NOTE: Normal operation of the burner should be with the switch in automatic position and under the direction of the modulating control. The manual position is provided for initial adjustment of the burner over the entire firing range. If operated in the manual position at other than low fire, the pressure vessel metal and refractory are

subjected to undesirable conditions. The effectiveness of nozzle purging is lost on a No. 6 oil burner.

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 modulated firing, the modulating 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 load demand light and fuel valve light are turned off. The timer begins rotating.

On a No. 6 oil burner the air purge valve (APV) is powered from terminal 8 via the contacts of the air purge relay (APR).

Terminals 10-11 open and 10-16 close. The damper 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 air purge valve is closed on a No. 6 oil burner. 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. Depending upon the length of the trial-for-ignition period, the pilot flame will be extinguished 10 or 15 seconds later — consult wiring diagram to determine whether pilot circuit is connected to terminal 5 or 6. 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.

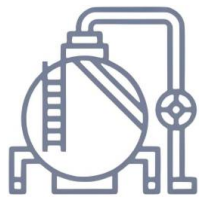
If a flame outage occurs during normal operation and/or the flame is no longer sensed by the detector, the flame relay 2K will trip within 4 seconds to de-energize the fuel valve circuit and shut off fuel flow. The blower motor continues operation. Approximately 30 seconds later the lockout switch will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



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CHAPTER 4

STARTING AND OPERATING INSTRUCTIONS

- A. GENERAL PREPARATION FOR START-UP—ALL FUELS
- B. CONTROL SETTINGS—STEAM AND HOT WATER
- C. GAS PILOT
- D. ATOMIZING AIR
- E. FIRING PREPARATIONS FOR NO. 2 OIL SERIES 100-200
- F. FIRING PREPARATIONS FOR NO. 5 OIL SERIES 400-600
- G. FIRING PREPARATIONS FOR GAS SERIES 200-400-700
- H. START-UP, OPERATING AND SHUTDOWN—ALL FUELS
- J. CONTROL OPERATIONAL TESTS AND CHECKS

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

Instructions in this chapter assume that installation is complete and that all electrical, fuel, water and vent stack connections have been made.

The operator should have familiarized himself with the burner, boiler, and all controls and components. To quickly locate and identify the various controls and components mentioned in the following paragraphs refer to call-out photographs and the contents of Chapter 1. Adjustment of the major components are given in Chapter 5 and this should be reviewed prior to firing. The wiring diagram should also have been studied along with the sequence in Chapter 3.

It is recommended that these starting instructions be read through completely until they are thoroughly understood, **BEFORE ATTEMPTING TO OPERATE THE BOILER**, rather than performing each operation as it is read for the first time.

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

The boiler should be filled with water to the proper operating level using water of ambient tem-

perature. Make sure that treated feedwater is available and used. In heating applications the entire system should be filled and vented. Refer to Chapter 2 for water requirements. On a steam boiler open the test valve (figure 1-1) to vent air displaced during filling. Leave test valve open until escape of steam is noted after burner is operating.

CAUTION

Prior to firing a boiler make sure that discharge piping from safety valves or relief valves; and discharge piping from all blowdown and 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.

Check all linkage for full and free movement of the damper and metering valves and cams. This can be done by loosening the linkage at the damper motor connecting arm and manipulating linkage by hand.

Check for rotation of all motors by momentarily closing the motor starter or relay. Blower impeller rotation is counter-clockwise when viewed from front of boiler. Air pump rotation is clockwise when viewed from its drive end.

Before operating boiler feed pump or oil supply pump be sure all valves in the line are open or properly positioned.

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

CAUTION

Note that the pressure vessel support legs are welded to mounting skids in front and secured by bolts at the rear of the pressure vessel. These bolts are tightened for shipment but when the boiler is installed, and prior to initial firing, the bolts securing the rear legs to the skid must be loosened to allow for expansion and contraction caused by differences in temperature between pressure vessel and skids.

B. CONTROL SETTINGS—STEAM AND HOT WATER

See Chapter 5 for adjustment instructions for following controls.

Inspect operating limit control for proper setting.

- (a) The pressure control on a steam boiler should be set slightly above the highest desired steam pressure, but at least 10% lower than the setting of the safety valves.
- (b) 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.

- (a) 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.
- (b) On a hot water boiler the temperature control should be 5 to 10° above the operating limit temperature control setting.

Inspect the modulating control for proper setting.

This control must be set and adjusted so that the modulating motor returns to low fire position before the operating limit control opens. It is further desirable to have its low point setting somewhat below the cut-in setting of the limit control so that burner operates in low fire position for a brief period on each start rather than immediately driving to a high fire position.

NOTE: The settings of all the above controls may require some re-adjustment after boiler is

started and running for a short period. The scale settings on the controls are relatively accurate, but are principally for use as guides. Final adjustment should be based on and agree with the reading of the steam pressure gauge or the water temperature thermometer.

Inspect the low water cut-off and pump control as well as the auxiliary low water cut-off (if equipped with this optional device). Normally no adjustment is required since these controls are pre-set by the original manufacturer. Check for freedom of float movement. Float movement can be verified by observing the level of the water in the gauge glass when the water supply has been cut-off either by the stopping of the feed pump or by the closing of a valve, and the restarting of the pump or opening of the valve when water is drained from the pressure vessel. The importance of proper functioning of low water controls cannot be over-emphasized. Make sure that the control and the piping is plumb.

The settings of controls relating to fuel, either oil or gas, are covered in subsequent sections.

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

On initial start-up or whenever the boiler is placed into operation from a "cold" start, the manual-automatic selector switch should be set at "manual" and the manual flame control set at "close". After boiler is in operation and thoroughly warmed the selector switch should be turned to "automatic", so that the burner firing rate may be controlled by the modulating control in accordance with load demands.

Close all power entrance switches (supplied by others).

C. GAS PILOT

The gas pilot should be checked for satisfactory performance prior to initial firing. Follow the pilot flame adjustment instructions given in Chapter 5.

On initial starting attempts several efforts might be required to accomplish bleeding time of pilot line. While checking pilot adjustment observe whether pilot flame is extinguished promptly when burner switch is opened. Lingering flame is indicative of a leaking gas pilot valve and a condition requiring correction before proceeding.

D. ATOMIZING AIR

The supply and pressure of the atomizing air on an oil fired burner should be checked. Before starting, inspect the oil pump lube oil level. Add oil if neces-

sary to bring the level to the mid point or slightly higher of the sight glass. Use SAE 20 detergent oil of a grade mentioned in Chapter 7 and fill in accordance with instructions given there.

Check the oil level of the air intake strainer.

To verify air flow and pressure, flip the burner switch "on" to energize the programming relay. Immediately turn the switch off. The programmer will continue thru its cycle, however, without ignition or energizing the fuel valves. Observe the reading on the air pressure gauge (figure 4-1). With no oil flow the pressure should be a minimum of 7 psi.

If there is no pressure determine the cause and correct it before proceeding. Check for obstructions in the air inlet line, incorrect rotation (air pump rotation is clockwise), or a loose oil nozzle or other leaks. If pressure is much higher without any oil flow, check for obstruction in the discharge line or at the oil nozzle.

The air pressure will increase when an oil flow exists. At low firing rate, the air pressure may rise to 12 psi or more. At high fire **THE AIR PRESSURE SHOULD NOT EXCEED 30 PSI**. Greater air pressure causes excessive wear of the air pump, increases lube oil usage and can overload the motor.

NOTE: Abnormally high pressure indicated on the nozzle air pressure gauge is an indication that the burner nozzle has become clogged. In this event, check the nozzle and clean as necessary.

E. FIRING PREPARATIONS FOR NO. 2 OIL (SERIES 100-200)

Prior to initial firing, oil flow and pressure should be established and verified. Atomizing air pressure should also be established as outlined in section D. The schematic flow diagram (figure 1-11) indicates the flow of fuel and atomizing air.

If the burner is a combination fuel model, make certain that the main gas shutoff cock is closed and set the gas/oil selector switch to "oil". Insert the burner drawer gun into its most forward position and latch it in place. See Figure 4-1.

Oil Flow

Open all valves in the oil suction and oil return lines.

If the oil supply tank is located above the level of the pump and flow to the pump is by gravity, then it will usually be necessary to vent the suction line to allow oil to fill the line. This can generally be accomplished by cracking a union fitting, or by opening the cap of the oil strainer using care to

prevent spillage of oil. Tighten fitting or cap as soon as oil flow appears.

If the oil supply tank is below level of oil pump, it is **MANDATORY** that suction line to pump mu-

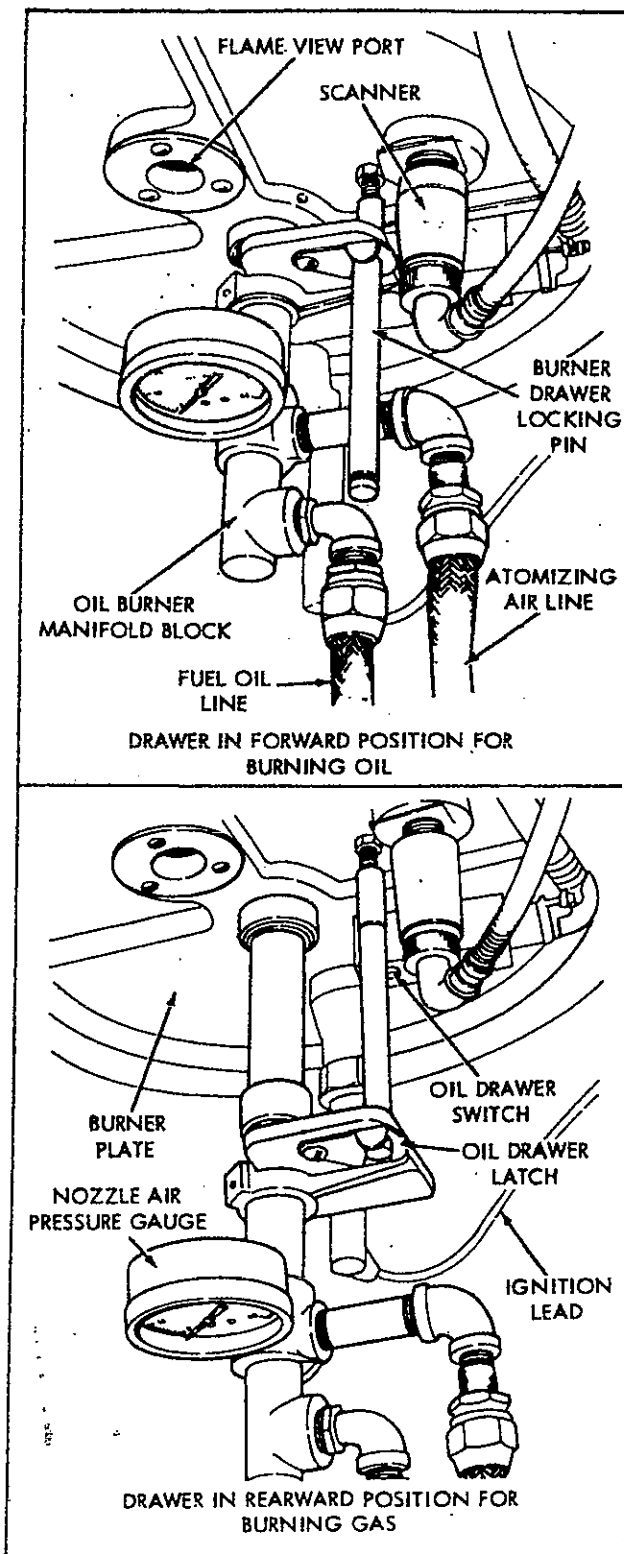


FIGURE 4-1. POSITIONS OF BURNER DRAWER FOR OIL AND GAS

be completely filled with oil prior to starting the pump to avoid possibility of damage to the pump gears through operation without the lubrication afforded by the fuel oil. Non-lubricating fluids such as kerosene should not be used for priming.

Prior to priming the suction line and the initial start, check to make certain that all plugs, connections, etc., have been securely tightened to prevent leaks.

If the fuel oil supply originates from a pressurized loop, it is assumed that the pressure of the loop will be at a minimum of 75 psi. Boilers would not then have individual pumps furnished as standard equipment. Under these conditions the relief valve at the terminal block should be adjusted to the point where it becomes inoperative.

A standardly equipped boiler has a selector switch incorporated in the oil pump motor starter. Momentarily energize the starter to check for proper pump rotation. With the rotation verified operate the pump to determine that oil circulation exists. Observe the oil burner pressure gauge for indication that flow is established. If no pressure shows on this gauge after a few moments stop the oil pump and re-prime. If the supply tank is lower than the pump, it is possible that the initial priming of the suction line, followed by operation of the pump, will not establish oil flow. This might be caused by obstruction in the suction line, excessive lift, inadequate priming, suction line leaks, etc. If oil flow is not readily established, avoid prolonged operation of the pump to minimize risk of damage to internal parts of the pump. If oil flow is not established after a second or third priming attempt, a full investigation is required to determine the cause.

A vacuum (or a compound pressure-vacuum) gauge should be installed at the suction port of the pump and its reading observed and recorded for future guidance. If a vacuum condition exists, this reading will reveal the tightness of the system. It is advisable to maintain the vacuum reading at less than 10" W.C. A vacuum in excess of this may allow oil to vaporize causing cavitation, loss of prime and unstable firing condition.

Oil Pressure

Oil supply pressure is regulated by adjusting the pressure relief valve at the oil terminal block, (figure 1-1). A pressure gauge should be installed in the terminal block and the relief valve adjusted to obtain a minimum reading of 75 psi when the burner is firing at maximum rate.

When oil is supplied from a pressurized loop to a multiple boiler installation, the relief valve in the loop should be properly adjusted to provide this reading. In this circumstance, the relief valve at the terminal block should be adjusted to the point

where it will be inoperative (or removed and openings plugged). To render inoperative, turn adjusting screw in as far as possible.

Adjustment may also be required to the regulator on the fuel oil controller (Figure 1-5). This pressure regulating valve is equipped with tubing that directs and adds atomizing air pressure to the adjustable spring pressure. Since air pump is not running at this time only tentative adjustment can be made. Without this air supply, adjust the fuel oil pressure regulator so that the oil burner gauge registers approximately 35 psi.

The pressure gauge will indicate a higher reading when flame is present. The pressure will increase as the firing rate increases and vice versa. After the burner is firing and when the air pump is running, final adjustment can be made to this valve.

Final regulation of oil flow to the nozzle can be done later, if necessary, by adjusting the metering cam screws as outlined in Chapter 5.

Suggested oil pressures at high fire operation:

| | |
|---------------------------|-----------|
| Oil Supply | 75 psi |
| Oil Burner Pressure | 30-45 psi |

Starting

When all the conditions covered above and in sections A, B, C and D are assured the burner is ready for firing. Refer to section H of this chapter for further starting and operating information.

F. FIRING PREPARATIONS FOR NO. 6 OIL (SERIES 400-600)

Prior to initial firing, oil flow, pressure and temperature should be established and verified. Atomizing air pressure should also be established as outlined in Section D. The schematic flow diagram (figure 1-12) indicates the flow of fuel and atomizing air.

If the boiler is a combination fuel model, make certain that the main gas shut off cock is closed and set the gas/oil selector switch to "oil". Insert the burner drawer gun into its most forward position and latch it in place. See Figure 4-1.

Oil Flow

Open all valves in the oil suction and oil return lines. Open the by-pass valve on the fuel oil controller (figure 1-6) until oil flow is established. Normally the orifice valve is left in a closed position. However, on cold starts it may be opened for brief periods to aid in establishing oil flow. The by-pass and orifice valves must be returned to closed position as soon as proper oil flow is established as indicated by a reading on the oil supply pressure gauge (figures 1-2 and 1-8). Do not attempt to set pressures while valves are open.

Momentarily energize fuel oil pump starter to check for proper pump rotation. With the rotation verified, prime the suction line strainer with oil and start the fuel oil pump by closing its power entrance switch. Observe the oil supply pressure gauge for indication that oil flow is established. If no pressure shows on gauge after a few moments stop the oil pump and re-prime. Heavy oil in the storage tank must be at a temperature to provide oil viscosity to permit flow through the oil pump and suction line. If oil flow is not established after priming pump on one or more occasions, conditions preventing oil flow must be determined and corrected to avoid damage to the pump's internal mechanism.

A vacuum (or a compound pressure-vacuum) gauge should be installed in the oil suction line and its reading observed and recorded for future guidance. This gauge reveals the tightness of the system.

Oil Pressure

Oil pressure is regulated in several areas. The first is at the relief valve at the oil heater (figures 1-2 and 1-8). This should be set so that at maximum firing rate a minimum reading of 75 psi is obtained on the oil supply pressure gauge.

The other pressure adjustments are to the regulators on the fuel oil controller (figure 1-6). Both the pressure regulating and the back pressure relief valves are equipped with tubing that directs and adds atomizing air pressure to the adjustable spring pressure. Since air pump is not running at this time only tentative adjustments can be made. Without this air supply, adjust the fuel oil pressure regulator so that the burner oil gauge registers approximately 35 psi. Adjust the back pressure relief valve so that its gauge reads about 10 psi less than the burner gauge.

After the burner is firing further adjustments can be made if necessary to these valves.

The pressure gauges will indicate higher readings when flame is present. The pressure will increase as the firing rate increases and vice versa. The pressure reading on the two gauges on the controller will, despite this fluctuation, retain a nearly constant difference of 10 psi.

Final regulation of oil flow to the nozzle can be done, if necessary, by adjusting the metering cam screws as outlined in Chapter 5:

Suggested oil pressures at high fire operation:

Oil supply pressure gauge 75 psi (minimum at maximum firing rate).

Oil burner pressure gauge 40-50 psi.

Oil return pressure gauge 10 psi less than oil supply pressure.

Oil Temperature

CAUTION

Before turning on electric oil heater switch, make certain that the heater shell is filled with fuel oil as indicated by proper pressure reading on fuel oil pressure gauge.

After determining that heater shell is filled and that fuel oil circulation exists, turn the oil heater switch to "on". Adjust the electric oil heater thermostat (Figures 1-2 and 1-8) to maintain oil temperature at approximately 200°F.

The electric heater on burners equipped for No. 6 fuel oil is sized so that it is capable of supplying heated oil at a rate no greater than that required for low fire operation and is primarily supplied for convenience on cold starts. Heating coils utilizing either steam or hot water are supplied to provide sufficient quantities of oil so that higher rates of firing can be accomplished once steam pressure or hot water is available. In normal operation the thermostat governing the electric heating element is kept at a lower setting than the thermostat governing admission of steam to the heater, or of hot water circulation, so that heating is not performed electrically except when steam or hot water is not available.

Set the steam thermostat (Figure 1-8) or the hot water thermostat (Figure 1-2) to maintain an oil temperature of 220-230°F. The electric heater will be turned off automatically as soon as steam or hot water provides heat.

NOTE: The temperatures listed are tentative. The composition of the fuel oil in a given grade can vary necessitating a higher or lower preheating temperature. The viscosity of the oil at the nozzle should be less than 300 SSU and preferably less than 150 SSU. The actual temperature of the oil at the burner should be determined by flame appearance and good combustion based on a stack analysis. See Chapter 5 for additional information.

Close the manual by-pass valve after temperature rise on the fuel oil controller thermometer is noted. Make certain that hot oil is moving through the controller. The orifice gate valve must also be closed. If temperature drops, open the orifice gate valve until a rise is noted, then close it.

Once the correct setting of the heater thermostats has been established, set the low oil temperature switch (Figures 1-2 and 1-8) at a point approximately 30° lower than the normal burning temperature. If the system is equipped with a high oil temperature switch this should be set to open at 20 to 30° higher than normal burning temperature.

Starting

When all the conditions covered above and in sections A, B, C and D are assured the burner is ready for firing. Refer to section H of this chapter for further starting and operating information.

G. FIRING PREPARATIONS FOR GAS (SERIES 200-400-700)

Prior to initial starting check the linkage attached to the gas butterfly valve to see that movement is free from binding.

Verify the presence and availability of gas. On a new installation, representatives of the gas utility should be present when gas is first turned into the system to supervise purging of the new gas line unless they have already done so.

Determine that pilot is operating properly as outlined in Section C of this chapter.

Determine that sufficient pressure exists at the entrance to the gas train. This can be done by installing a test gauge downstream of the regulator.

The gas pressure regulator must be adjusted to the proper pressure level. Since this regulator is generally supplied by others, adjustment should proceed according to instructions supplied by its manufacturer.

It is necessary for the operator to know the burner requirements in gas quantity and pressure. This information can generally be found on the dimension diagram supplied for the particular installation. Should this information not be readily available, consult the Cleaver-Brooks Service Department giving boiler serial number. Chapter 5 contains additional information along with standard gas flow and pressure requirements. This section should be completely reviewed prior to start-up.

If the burner is a combination fuel model, set the gas/oil selector switch to "gas". Withdraw the oil burner gun and latch it in its rearward position.

On initial start-up it is recommended that the main gas shut-off cock (figure 1-3) remain closed until the programmer has cycled through pre-purge and pilot sequences. Then as dial indicates "main burner" observe the action of the motorized gas valve stem to determine that it opens when energized. As soon as this is confirmed, turn the burner switch "off" and let programmer finish its cycle. Check to see that gas valve has closed. Again turn burner "on" and when dial indicates "main burner" slowly open the main gas cock. Main flame should ignite unless there is air present in the line. If flame is not established within about 5 seconds turn the burner switch "off" and allow programmer to re-cycle normally for a new lighting trial. Several efforts may be necessary to "bleed" air from the line.

CAUTION

Do not repeat unsuccessful lighting attempts without re-checking burner and pilot adjustments if lighting does not occur within 5 seconds after fuel introduction is verified or can be reasonably assumed.

NOTE: 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 or to take any action that might circumvent this feature.

Once main flame is established observe that it is extinguished promptly when burner is shut down. Flame may continue to burn for a second or two after normal shutdown due to the gas remaining downstream from the fuel valve. If flame continues to burn for a longer period or during blower motor spindown, immediately turn burner switch off and close main gas cock. Investigate and correct the cause of valve leakage before relighting 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 and purging.

When the conditions covered above and in Sections A, B and C are assured the burner is ready for firing. Refer to Section H of this chapter for further starting and operating information.

H. STARTUP, OPERATING AND SHUTDOWN—ALL FUELS

Depending upon fuel being burned, the applicable previous sections in this chapter should be reviewed for preliminary instructions.

When firing with oil make certain that the burner gun is in its most forward position and latched in place. See figure 4-1. When firing with gas the burner gun should be properly withdrawn and latched in place. The fuel selector switch should be accordingly set to either "oil" or "gas".

Set the manual-automatic switch (figure 1-7) to "manual" and turn manual flame control to "close".

Turn burner switch to "on". Load demand light should glow. Low water level light should remain out indicating safe water level in boiler.

The programmer is now sequencing. See Chapter 3 for sequence details.

NOTE: On an initial starting attempt, several efforts might be required to accomplish "bleeding" of fuel lines, main or pilot. If

ignition does not then occur, do not repeat unsuccessful attempts without rechecking burner and pilot adjustment.

On ignition failure the flame failure light will glow and the blower will purge the boiler of unburned fuel vapors before stopping. After ignition failure wait a few moments before re-setting the lockout switch.

CAUTION

Do not re-light the pilot or attempt to start the main burner, either oil or gas, if combustion chamber is hot and/or if gas or oil vapor combustion gases are present in the furnace or flue passages. 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 or take any action that might circumvent this feature.

After main flame ignition the burner should be left on manual control at its low fire setting (that is, with manual flame control at "close") for about 30 minutes or until boiler is properly warmed, unless it reaches its normal operating pressure or temperature sooner.

In the case of a steam boiler, **CLOSE THE TEST VALVE** when steam begins to appear

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

If flame at low fire setting is insufficient to reach normal operating pressure or temperature after 30 minutes, *gradually* increase the firing rate by turning the manual flame control in one point increments to no higher than the midpoint between close and open. Operate at this increased fuel input rate for a period of time until an increase is noted in pressure or temperature. Sustained operation of the boiler should never be maintained when the manual control is set beyond midpoint.

After unit is thoroughly warmed, turn the manual flame control to high fire. At this point a combustion analysis should be made, with instruments, and fuel flow regulated as required. Refer to adjustment procedures in Chapter 5. After making the high-fire adjustment manually position the burner over the range from high to low fire stopping at intermediate points, analyzing combustion gases and adjusting as required.

To properly perform this testing and adjusting, it is necessary that burner be allowed to fire at maximum rate sufficiently long enough to achieve desired results.

Operating

Normal operation should be with the manual-automatic switch set at "auto" and under the control of the modulating pressure or temperature control. If operated in the manual position at other than low fire, the pressure vessel metal and refractory are subjected to undesirable conditions.

With the switch set at "auto", burner will operate on a modulating basis according to the load demand.

The burner will continue to operate with modulated firing until operating limit pressure or temperature 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 (or atomizing) air drops below minimum level.

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

When the burner is shut down normally, by either the operating limit control or by manually switching burner off, the load demand light no longer glows.

Shutdown through conditions causing safety or interlock controls to open will actuate the flame failure light (and alarm if so equipped) and the load demand light will remain lit. The cause of this type of shutdown will have to be located, investigated, and corrected before operation can be resumed. Refer to the "trouble-shooting" section.

Shutdown

When the operating limit control setting is reached to open the circuit or if the burner switch is turned "off", the following sequence occurs:

The fuel valve(s) is de-energized and flame extinguished. The timer begins operation and the blower motor continues running to force air through the furnace in the post-purge period.

At the end of the programmed post-purge period the blower motor is de-energized. The air pump motor of an oil-fired burner is also de-energized. The timer has returned to its original starting position and stops. Unit is ready to re-start.

CAUTION

It is advisable to check for tight shutoff of fuel valves. Despite precautions and strainers, foreign material in either new or renovated fuel lines may lodge under a valve seat preventing tight closure. This is especially true in new installations. Promptly correct any conditions causing leakage.

J. CONTROL OPERATIONAL TEST AND CHECKS

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 thereafter 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 modulating control for desired operating pressure range. See Chapter 5 for instructions on the adjustment of controls.

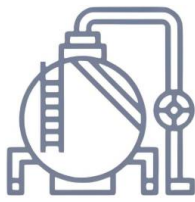
Water temperature, on a hot water boiler that may be operating at less than full load, may be raised by manually increasing the firing rate until the burner shuts down thru the action of the operating limit control. Observe the thermometer to verify the desired settings at the point of cut-out and again when burner restarts. Return the manual automatic switch to "automatic" and check the modulating control for the desired temperature range. See Chapter 5 for instructions on the adjustment of the controls.

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 Chapter 7 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.

Refer to adjustments procedures and maintenance instructions, given in Chapter 5 and 7.



CHAPTER 5

ADJUSTMENT PROCEDURES

- A. GENERAL
- B. LINKAGE—MODULATING MOTOR AND AIR DAMPER
- C. MODULATING MOTOR
- D. MODULATING MOTOR SWITCHES—LOW FIRE AND HIGH FIRE
- E. OPERATING CONTROLS—GENERAL
- F. MODULATING PRESSURE CONTROLS—(Steam)
- G. OPERATING LIMIT PRESSURE CONTROL—(Steam)
- H. HIGH LIMIT PRESSURE CONTROL—(Steam)
- I. MODULATING TEMPERATURE CONTROL—(Hot Water)
- J. OPERATING LIMIT TEMPERATURE CONTROL—(Hot Water)
- K. HIGH LIMIT TEMPERATURE CONTROL—(Hot Water)
- L. LOW WATER CUT-OFF DEVICES
- M. COMBUSTION AIR PROVING SWITCH
- N. ATOMIZING AIR PROVING SWITCH
- O. GAS PILOT FLAME ADJUSTMENT
- P. GAS PRESSURE AND FLOW INFORMATION
- Q. GAS FUEL COMBUSTION ADJUSTMENT
- R. LOW GAS PRESSURE SWITCH
- S. HIGH GAS PRESSURE SWITCH
- T. FUEL OIL PRESSURE AND TEMPERATURE—GENERAL
- U. FUEL OIL COMBUSTION ADJUSTMENT
- V. BURNER DRAWER ADJUSTMENTS
- W. OIL DRAWER SWITCH
- X. LOW OIL TEMPERATURE SWITCH
- Y. HIGH OIL TEMPERATURE SWITCH
- Z. LOW OIL PRESSURE SWITCH
- AA. ELECTRIC OIL HEATER THERMOSTAT
- BB. STEAM OIL HEATER THERMOSTAT
- CC. HOT WATER OIL HEATER THERMOSTAT
- DD. STEAM HEATER PRESSURE REGULATOR

A. GENERAL

While each boiler is tested for correct operation before shipment from the factory, variable conditions such as burning characteristics of the fuel and operating load conditions may require further adjustment after installation to assure maximum operating efficiency and economy.

A combustion efficiency analysis made during the initial start-up will help to determine what additional adjustments are required in a particular installation.

Prior to placing the boiler into 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 misadjustments occurred during shipment and installation.

The adjustment procedures in this chapter apply to standard components furnished on steam or hot

water boilers fired with gas and/or the various grades of oil.

The descriptive heading will aid in readily determining those procedures that are applicable to your boiler. Wherever practical, the heading contains the manufacturer's name and model and the boiler series. Contact your Cleaver-Brooks representative or the Cleaver-Brooks Service Department for recommendations covering special adjustments that are not included in this chapter.

B. LINKAGE—MODULATING MOTOR AND AIR DAMPER

The linkage consists of the various arms, connecting rods, and swivel ball joints that transmit motion from the modulating motor to the metering cam(s), to the rotary air damper, and to the gas butterfly valve, if used.

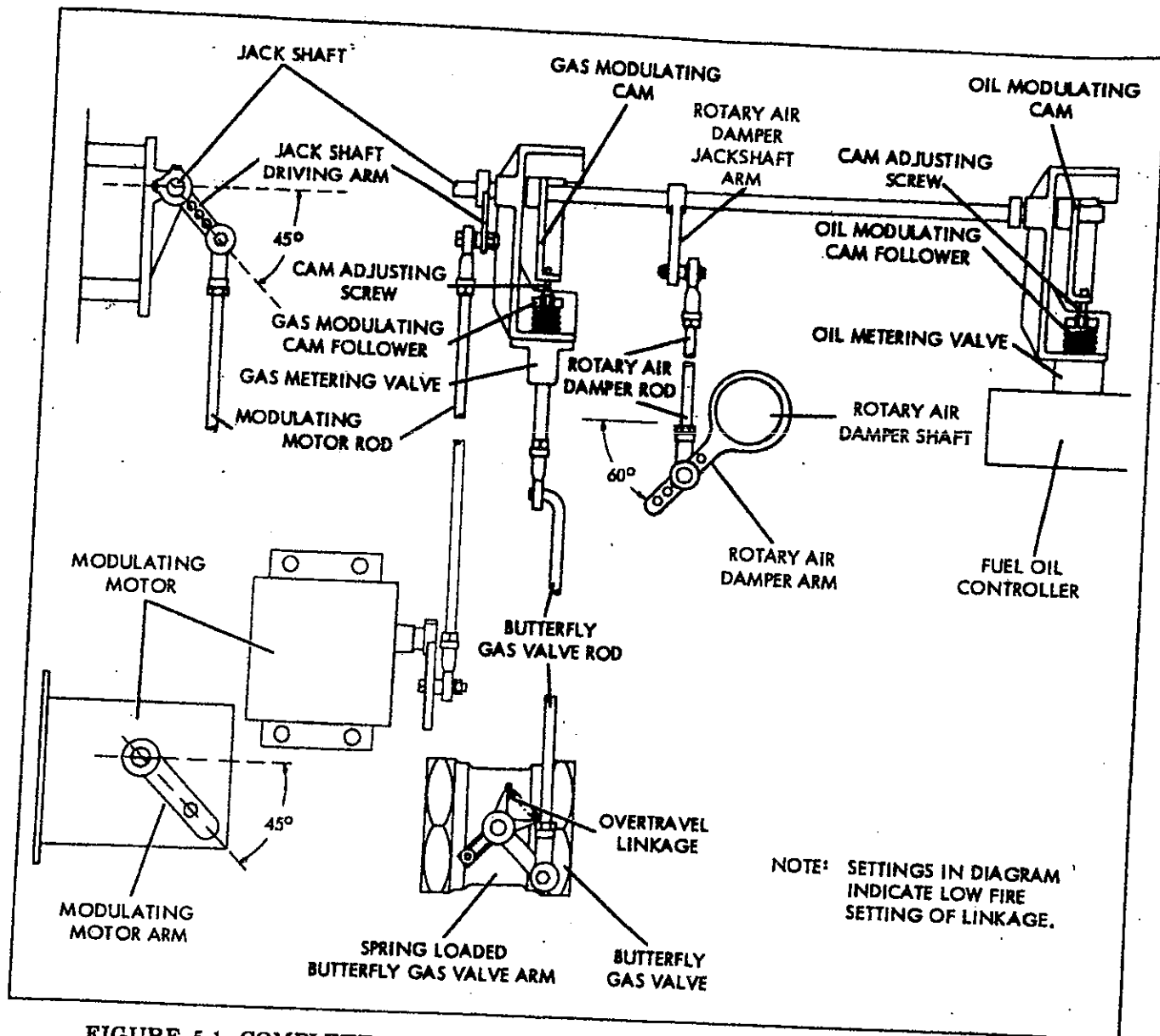


FIGURE 5-1. COMPLETE LINKAGE ASSEMBLY - COMBINATION GAS AND OIL

When properly adjusted a co-ordinated movement of the damper and metering cams within the limits of the modulating motor travel is attained to provide proper fuel-air ratios through the firing range.

In linkage adjustments there are several important factors that must serve as guides.

- (a) The modulating motor must be able to complete its full travel range. Restrictions will cause definite damage to this motor.
- (b) Initial adjustment should be made with the motor in a full closed position, that is with the shaft on the power end of the motor in its most counterclockwise position.
- (c) The closer the connector is to the drive shaft the less the arm will travel, while the closer

the connector is to the driven shaft the farther that arm will travel.

- (d) Over-travel linkage, where used, should not be required to extend its spring to fullest stretch.

With the modulating motor in the low fire position, the arm on its shaft should be at an angle of 45° below the horizontal. The driven arm on the jack shaft should be parallel to this. Secure both arms and fit the connecting linkage rod in place between them. Refer to Figure 5-1.

Position the oil and/or gas modulating cams (Figures 5-3 and 5-4) on the jack-shaft so that the cam follower assembly is at its lowest point.

In this position fuel delivery is at low fire rate. Secure cams with the setscrews.

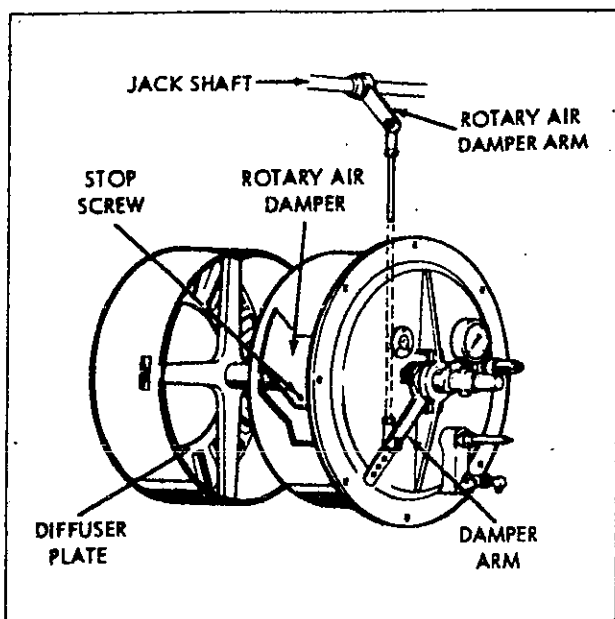


FIGURE 5-2. ROTARY AIR DAMPER
3/4 VIEW

Refer to Figure 5-2. The stop screw in the rotary air damper limits damper travel at both closed (low fire) and fully opened (high fire) positions. This screw is provided so that it is possible to tell, even with the burner in place, whether the damper rotor is in fully opened or closed position by rotating the damper open and closed by means of the damper arm. Normally, the rate of flow of air through the damper with the rotor in low fire position is about one-third of maximum.

The amount of angular movement controlling the rate of air flow is determined by the location of the ends of the rotary air damper rod in both the jack shaft arm and the air damper arm.

When the air damper is in low fire position, both the jackshaft arm and the rotary air damper arm should make an angle of approximately 60° below the horizontal (Figure 5-1). This is to insure that the angular movement of the damper starts slowly, increasing in speed as the high fire position is approached.

Prior to initially firing a boiler it is advisable to check for free movement of the linkage. The damper motor must be allowed to complete its full stroke and the damper must move from low to high fire position.

Adjustment of linkage connected to a gas butterfly valve is described in Section Q of this chapter.

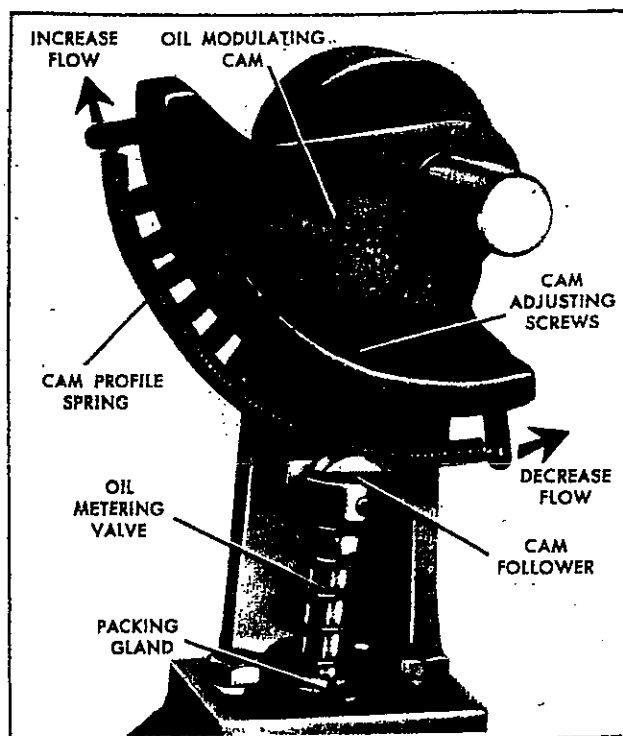


FIGURE 5-3. OIL MODULATING CAM

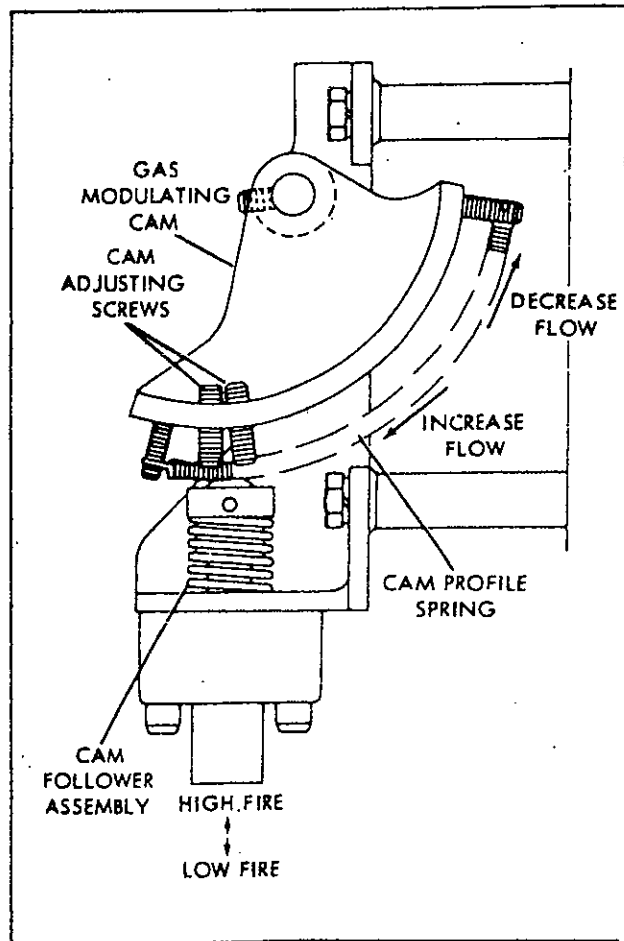


FIGURE 5-4. GAS MODULATING CAM

C. MODULATING MOTOR (HONEYWELL M954B OR M954C)

The modulating motor used in this application has a 90° shaft rotation. The motor manufacturer also provides a 160° stroke model for other applications. If a replacement is not obtained from a Cleaver-Brooks Service-Parts Agency, it may have an incorrect stroke. To prevent damage, determine the 90° stroke prior to installing a replacement.

This may be determined either by visual inspection of the power end shaft or by powering the motor and connecting terminals R-B to actually determine the stroke as motor drives to an open position.

The closed position of the motor (normal condition of replacement motor) is the limit of counterclockwise rotation as viewed from the power end of the motor. In this position the flat part of the shaft is

45 degrees from the horizontal on 90 degree stroke motors and 10 degrees from horizontal on 160 degree stroke motors.

D. MODULATING MOTOR SWITCHES— LOW FIRE AND HIGH FIRE

The modulating motor contains either one or two internal switches depending upon application. These single pole double throw micro-switches are actuated by adjustable cams attached to the motor shaft.

Factory replacement motors have the cams pre-set. The low fire start switch is set to make the red and yellow leads at approximately 8 degrees on motor closing. The high fire purge air proving switch (M954B motor) is set to make red and blue tracer leads at approximately 60 degrees on motor

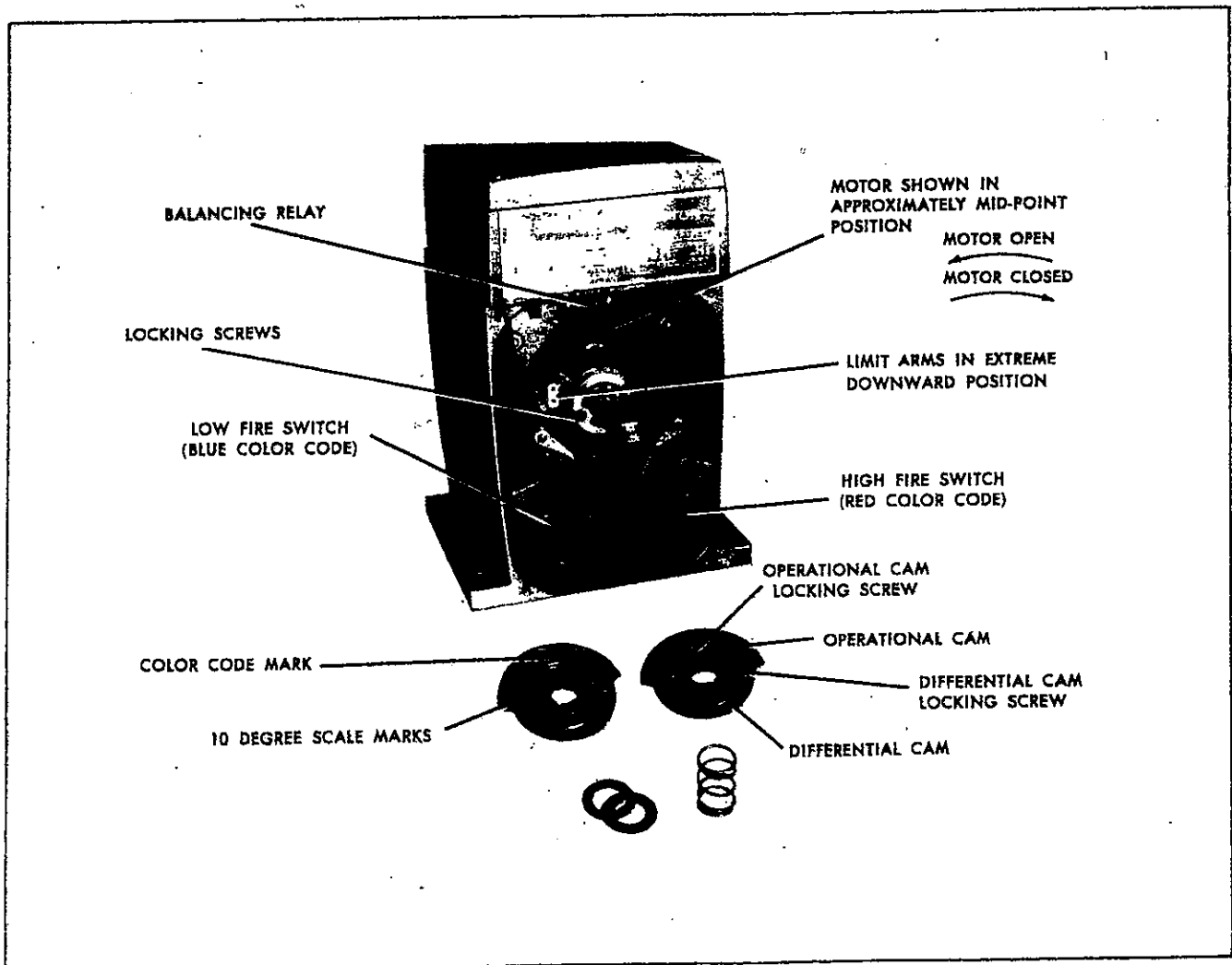


FIGURE 5-5. DAMPER MOTOR MODEL M954B DISASSEMBLED AUXILIARY END VIEW

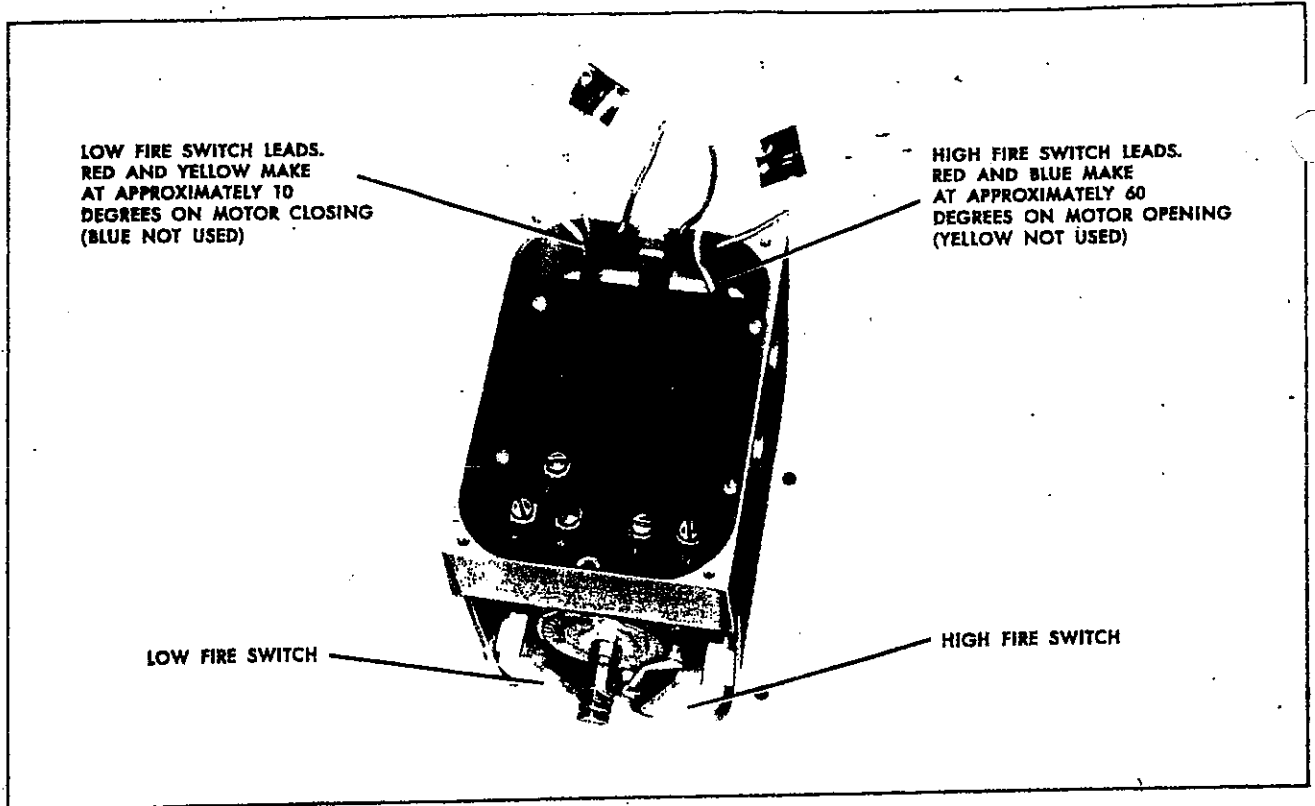


FIGURE 5-6. MODULATING DAMPER MOTOR MODEL M954B

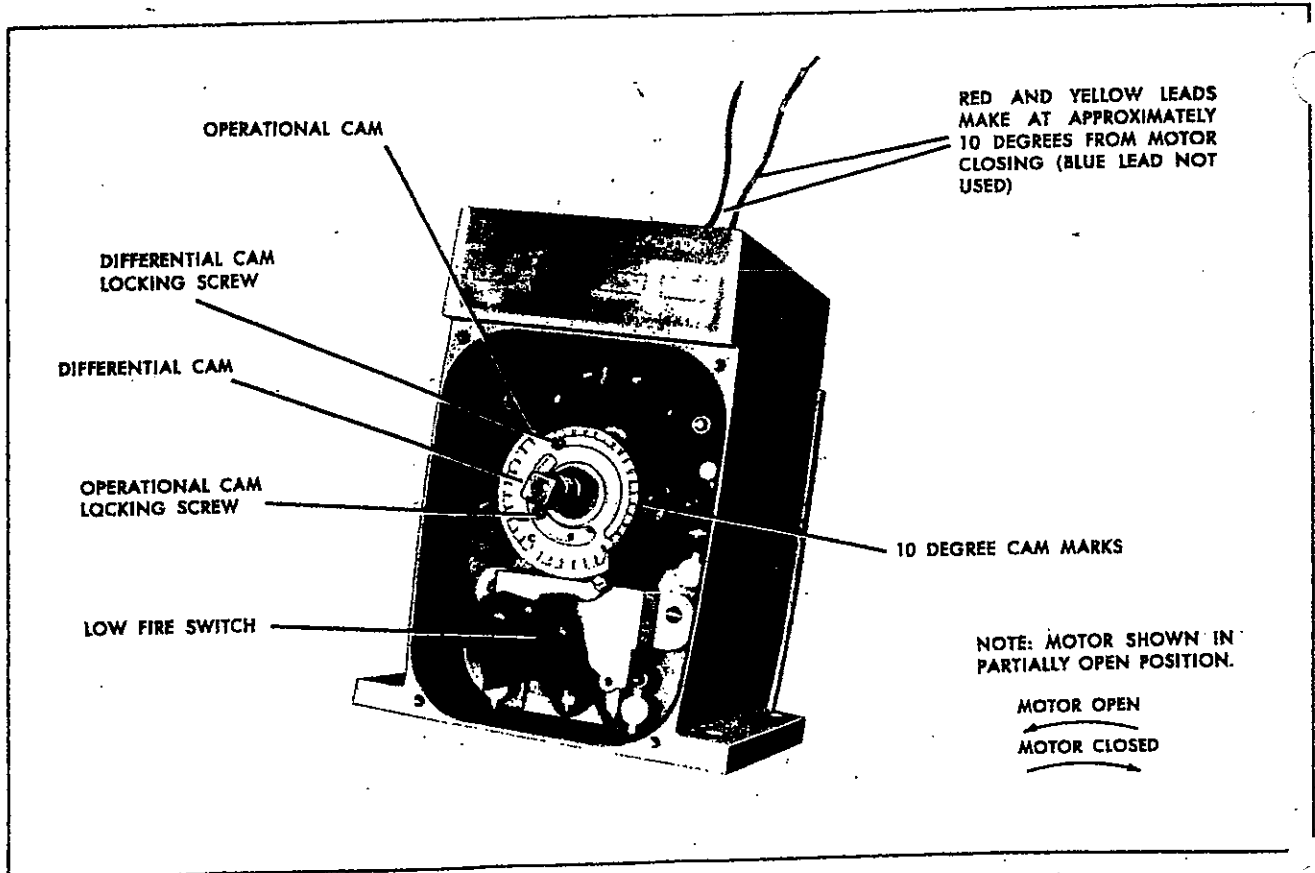


FIGURE 5-7. MODULATING DAMPER MOTOR MODEL M954C

opening. Normally these settings are left as is but job conditions may require re-adjustment.

If cams require adjustment or re-setting proceed as follows:

**M954C Motor (One switch)
(Figure 5-7)**

The following approximate method, not requiring running the motor, is suggested.

- (a) Remove the auxiliary end cover. Be careful not to lose the spring and two washers.
- (b) With the motor in a closed position loosen the operation cam lock screw. **DO NOT** loosen the locking screw on the differential cam as this is a factory-set adjustment.
- (c) Using the 10 degree marks and the cam roller as a guide, rotate the cam clockwise through an arc equal to the number of degrees the motor should travel before the switch operates.
- (d) When used for low fire start purposes this setting can be slightly before the first 10 degree mark. When properly adjusted, the switch should make—red to yellow—when the cam is approximately 10 degrees from reaching closed position.
- (e) Tighten the operational cam locking screw and replace the two washers, spring and auxiliary end cover.

**M954B Motor (Two switches)
(Figure 5-5)**

The following approximate method, not requiring running the motor, is suggested. The switches and their cams are color coded as follows: inner cam and left switch - blue dots; outer cam and right-hand switch - red dots.

- (a) Remove the auxiliary end cover. Be careful not to lose the spring and two washers.
- (b) Remove the outer cam assembly (red dot) and set it aside. Note that both cams have two parts; an operational cam and a differential cam. The differential cam is not utilized in our application.
- (c) With the motor in a closed position loosen the operational cam locking screw on the remaining cam (blue dot).
- (d) Using the 10 degree marks and the cam roller as a guide, rotate cam clockwise through an arc equal to the number of degrees the motor should travel before the switch operates.
- (e) When this switch is used for low fire start purposes the setting can be slightly before the first 10 degree mark. When properly adjusted, the switch should make - red to yellow

- when the cam is approximately 10 degrees from reaching closed position.

- (f) Tighten the operational cam locking screw.
- (g) Replace the outer cam (red dot) making sure that driving dogs are engaged.
- (h) Loosen the operating cam locking screw. Using the 10 degree marks and the cam roller as a guide rotate cams clockwise through an arc equal to the number of degrees the motor should travel before the switch operates.
- (i) When this switch is used for high fire air proving purposes, the setting can be approximately 60 degrees. When properly adjusted, the switch should make - red to blue - when the cam is approximately 60 degrees towards the open position.
- (j) Tighten the operational cam locking screw.
- (k) Before replacing the two washers, spring and auxiliary cover, run the motor and check operation of the low fire switch and high fire switch to see if they open and close at the required setting.

**E. BURNER OPERATING CONTROLS—
GENERAL**

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 and that connecting tubing is not kinked.

Controls are carefully calibrated during their manufacture and do not normally require recalibration. 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 re-adjust control setting to agree with these readings. This is predicated, however, on pressure gauges and thermometers being accurate.

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.

Figure 5-8 depicts a typical relationship of the setting of the operating limit control and the modulating control. Please note that this is *not* drawn to any scale. The burner will be "on" whenever the pressure or temperature is below point B and "off"

whenever pressure or temperature is above point A. The distance between points A and B represents the "on-off" differential of the operating limit control.

In normal operation, the burner will shut down whenever the pressure or temperature reaches setting A. The switch in the operating limit control will open. As the pressure or temperature drops back to B, the switch makes and the burner will restart. The modulating control will be calling for modulating motor to be in a low fire position at this point. If the load exceeds this low fire input, the modulating control will respond to increase the firing rate proportionately as pressure or temperature falls toward the point D. The modulating motor will stop at any intermediate point between C and D whenever the fuel input balances the load requirement. As the load requirement changes, the firing rate will change accordingly. This is referred to as modulated firing.

Point D represents the maximum firing rate of the burner. In the event pressure or temperature drops while burner is firing at its maximum input, this is indicative that the load exceeds the generating rate of the boiler.

Although a gap is shown between B and C, these points may well coincide if required by load conditions. When set as shown, the burner will be in a low fire position upon a restart and will fire at that rate for a short period of time before falling pressure or temperature requires an increase in the firing rate. From this illustration it can be seen that this desirable objective will not be attained if

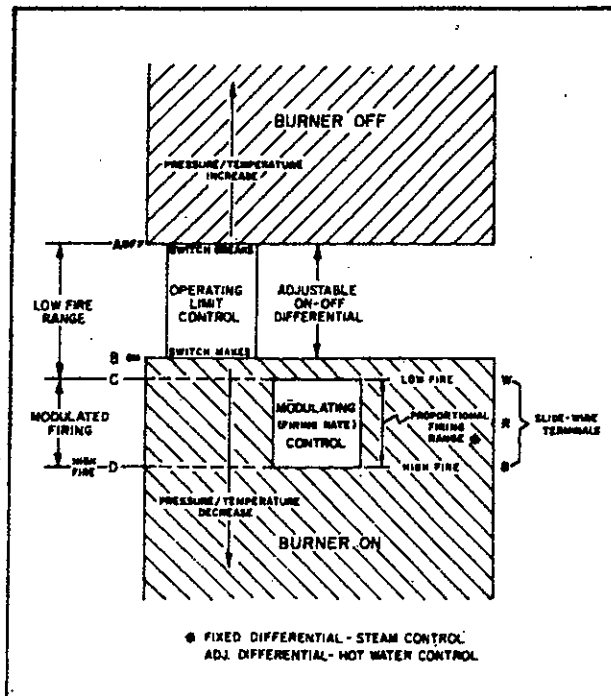


FIGURE 5-8. OPERATING CONTROL AND MODULATING CONTROL ACTIONS

setting C overlapped point B. In that event, upon a restart, the burner would drive to a higher firing position immediately after main flame was proven, and the brief period of low heat input would not occur. Actual settings will, of course, depend greatly upon load conditions which will affect the amount of differential permitted the operating limit control and to the gap, if any, between B and C.

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. The size of the flame may be manually and gradually increased to build up pressure or temperature. 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 modulating control will be calling for higher 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 modulating firing system.

To accomplish this, and assuming that air/fuel combustion ratios have been set, make approximate adjustments to the controls to bring the boiler pressure or temperature up to meet the load requirements.

To properly set the modulating control, carefully adjust it under load conditions, until the load is maintained with the burner firing at a steady rate. The firing rate at that point may be full high fire or slightly less, depending upon the relationship of the boiler size to the load.

When the modulating control is set in this manner and if the burner is in full high fire, the scale setting of the modulating pressure control on a steam

boiler will have a reading that indicates the *low* point of the modulating range. This fixed differential range is described later in this section. The scale setting of the modulating temperature control on a hot water boiler will have a reading that indicates the midpoint of the modulating range. This is also described later.

The operating limit control should now be adjusted and its differential established. See directions later in this section for the mechanics of adjusting. In an installation that does not require a very close control of steam pressure or water temperature this adjustable differential should be set as widely as conditions permit, since this will provide less frequent burner cycling.

The high limit control provides a safety factor to shut the burner off in the event the operating limit control should fail to do so. The setting of this control should be sufficiently above the operating limit control to avoid nuisance shutdowns. The setting, however, must be within the limits of the safety valve settings and preferably not exceed 90 percent of the valve setting. The control requires manual resetting after tripping.

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 1/2 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:

F. MODULATING PRESSURE CONTROL (Steam) (Honeywell L91A)

Turn adjusting screw until the indicator is opposite the low point of the desired modulating range. Modulated firing will range between this point and a higher point equal to the modulating range of the particular control. In 0-15 psi controls the range is 1/2 lb.; in 5-150 psi controls the range is 5 lbs.; in 10-300 psi controls the range is 12 lbs.

NOTE: To prevent burner shutdown at other than low fire setting adjust modulating pressure control to modulate to low fire **BEFORE** operating limit pressure control shuts off burner.

G. OPERATING LIMIT PRESSURE CONTROL (Steam) (Honeywell L404A)

Set "cut-out" (burner off) pressure on the main scale using the large adjusting screw. Set dif-

ferential 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.

H. HIGH LIMIT PRESSURE CONTROL (Steam) (Honeywell L404C)

Set "cut-out" (burner off) pressure on scale using adjusting screw. The control will break a circuit 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 pressure to return to normal and then press the reset button.

I. MODULATING TEMPERATURE CONTROL (Hot Water) (Honeywell T991A)

Turn knob on front of case until pointer indicates desired set point temperature. This is the center point of a proportional range. The control has a 3 to 30 degree differential and may be adjusted to vary the temperature range within which modulating action is desired. With cover off, turn adjustment wheel until pointer indicates desired range.

NOTE: To prevent burner shutdown at other than low fire setting, adjust modulating temperature control to modulate low fire **BEFORE** operating limit temperature control shuts off burner.

J. 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 adjusted from 5 to 30 degrees F.

K. HIGH LIMIT TEMPERATURE CONTROL (Hot Water) (Honeywell L4008E)

Set the "cut-out" (burner off) temperature on scale using adjusting screw. This control will break the

circuit and lock out on a rise in water temperature above the setting. The setting should be sufficiently above the operating limit temperature to avoid unnecessary shut-downs. On a 30 lb. hot water boiler 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.

L. LOW WATER CUT-OFF DEVICES (Steam and Hot Water)

No adjustment is required since these controls are pre-set by the original manufacturer. However, if water level is not maintained as shown in Figure 2-3 inspect devices immediately and replace as required.

M. COMBUSTION AIR PROVING SWITCH (Honeywell C645A)

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.

NOTE: On an oil fired boiler, the atomizing air proving switch (AAPS) must also be made. On a combination fuel fired burner, the fuel selector switch could be set at "gas" to eliminate the atomizing air proving switch from the circuitry.

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. Make a further adjustment to the air switch so that proper operation is obtained.

N. ATOMIZING AIR PROVING SWITCH (Dietz 161 P15)

Air pressure against the diaphragm actuates the switch which, when made, completes a circuit to prove the presence of atomizing air. Since the pressure of the atomizing air is at its minimum value when there is no fuel present at the nozzle, adjustment of the switch should be done while the unit is running but not firing. The control should be set to actuate under a condition of minimum pressure, but not too close to that point to cause nuisance shutdowns.

The control adjustment may be made during the prepurge period of operation by stopping the programmer timer during the prepurge period through the use of the TEST switch. Refer to the control instruction bulletin for details.

The adjustment screw of the atomizing air proving switch can then be adjusted until it breaks the circuit. At this point, the timer will begin rotating. The CB-20 relay will recycle and return to the stop point of the prepurge provided that the air switch adjustment screw is made so that relay 1K pulls in. The CB-40 control will lock out and must be manually reset before it can again be started.

Since the adjustment of the air switch may be made either during the damper closed or damper open position of prepurge, it is also possible to make the adjustment with the timer stopped in the damper open position in a similar manner to the adjustment of the combustion air proving switch described in the previous section.

After making the adjustment, recycle the control to be sure that normal operation is obtained. The TEST switch must be set to the NORM position.

O. GAS PILOT FLAME ADJUSTMENT

The size of the gas pilot flame is regulated by adjusting the gas flow through the pilot gas regulator and the adjusting cock. 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.

Although it is possible to visibly adjust the size of the pilot flame, it is preferable to obtain a micro-amp reading of the flame signal. The amplifier has a meter jack for this purpose. This reading may be measured with a good quality micro-ammeter or a suitable multi-meter with a 0 to 25 micro-amp DC rating.

The meter is connected to the jack using 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.

To Measure and Adjust Pilot:

(1) When making a pilot adjustment turn the manual-automatic switch to "manual" and the manual flame control to "close". Open both the pilot shutoff cock and the pilot adjusting cock. The main gas cock should remain closed.

The regulator in the pilot line, if provided, is to reduce the gas pressure to suit the pilot's requirement of between 5 to 10" W.C. Regulator adjustment is not critical, however, with a lower pressure the final adjustment of the pilot flame with the adjusting cock is less sensitive.

(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, and with the pilot adjusting cock wide open, remove the flame detector from the burner plate. The pilot flame can then be observed through 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 adjusting cock until the flame can no longer be seen through the sight tube. Then slowly open the cock 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 5.

(7) When a suitable flame as indicated in paragraph 6 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 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.

P. 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 (Figure 1-3) 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.) | Two Gas Valves 4" Pipe Size |
|--------------------|--------------------------------|
| 400 | 18.5" W.C. |
| 500 | 29.5" W.C. |
| 600 | 42.0" W.C. |
| 700 | 58.5" W.C. |
| 800 | 75.5" W.C. |

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

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 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 |

TABLE 3

| Boiler Horsepower | Maximum Input BTU/Hr |
|----------------------|-------------------------|
| 400 | 16,750,000 |
| 500 | 20,925,000 |
| 600 | 25,100,000 |
| 700 | 29,100,000 |
| 800 | 32,200,000 |

Pressure Correction

The flow rate outlined in the previous section 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.

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 | | |

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.

As an example: assume that a 600 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 42" 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 47.5" 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

$$\frac{25,100,000}{1,000} = 25,100 \text{ CFH (At 14.7 lb. atmospheric "base" pressure)}$$

THEN

$$\frac{25,100}{1.18} = 21,271 \text{ CFH}$$

This is the CFH (at line pressure) which must pass through the meter so that the equivalent full input requirement of 25,100 CFH (at base pressure) will be delivered.

Checking Gas Flow

Your gas supplier can generally furnish a gas meter flow chart from which gas flow can be determined. After a short observation period, this information aids in adjusting the regulator to increase or decrease flow as required to obtain rating.

Final adjustment of gas fuel is carried out by means of the adjusting screws in the gas modulating cam while performing a combustion efficiency analysis. See Section Q for details.

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.

Q. GAS FUEL COMBUSTION ADJUSTMENT

After operating for a sufficient period of time to assure a warm boiler, adjustments should be made to obtain efficient combustion.

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 (CO₂), oxygen (O₂), and carbon monoxide (CO) in the flue gas.

Burner efficiency is measured by the amount or percentage of CO₂ present in the flue gas. The theoretical maximum CO₂ percentage for natural gas is approximately 11.7%. As shown in Chart 5-9, this is attained when there is no excess oxygen (O₂) or carbon monoxide (CO). A definite percentage of excess air (oxygen) is required by most

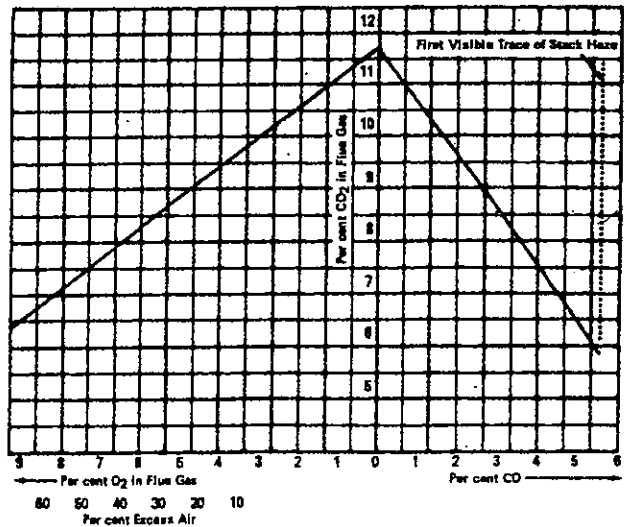


FIGURE 5-9. FLUE GAS ANALYSIS CHART FOR NATURAL GAS

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 CO₂ readings of between 9-1/2 and 10-1/2% be attained with corresponding O₂ readings of 2 to 4%.

From information in section P of this chapter determine the standard conditions of gas pressure and flow for the size of boiler and the gas train on it. Calculate the actual pressure and flow through the use of correction factors that compensate for incoming gas pressure and altitude.

Basically, gas adjustments are made with a gas pressure regulator (Figure 1-15) which controls the pressure and with the butterfly gas valve (Figure 1-3) which directly controls the rate of flow.

In initially setting the linkage, back off the low fire stop screw on the butterfly valve so that valve is closed. Then run screw out to touch the arm and give it two complete turns. Adjust the connecting rod so that over-ride tension is released and so that arm is now just touching the stop screw. Tighten the lock nuts on all ball joints. See Figure 5-10.

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

To do this, turn manual flame control switch to "high." 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. See section P of this chapter. With the butterfly valve open and with regulated gas pressure set at the calculated pressure, the actual flow rate should be quite close to the required input. If corrections are necessary, increase or decrease the gas pressure by adjusting the gas pressure regulator, following manufacturer's directions for regulator adjustment.

When proper gas flow is obtained take a flue gas analysis reading. The CO₂ should be between 9-1/2 and 10-1/2% and the corresponding O₂ reading should be 2 to 4%.

With the high fire air-fuel ratio established the gas pressure regulator needs no further adjusting.

After making certain that the air control damper and its linkage are correctly adjusted to provide the proper amount of secondary air and after adjusting the gas pressure regulator, final adjustment can be made, if necessary, to the gas modulating cam to obtain a constant air-fuel ratio throughout the entire firing range.

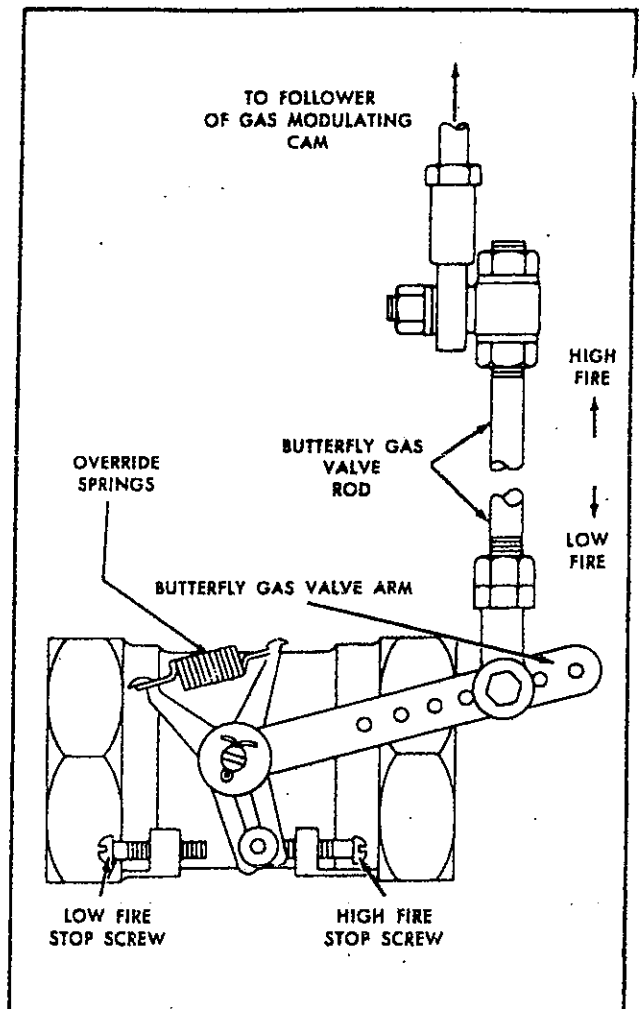


FIGURE 5-10. BUTTERFLY GAS VALVE

Since the input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of gas fuel at that setting. This adjustment is made to the metering cam by means of adjusting screws (Figure 5-4) which are turned out (counter-clockwise from the hex-socket end) to increase the flow of fuel, and in (clockwise from the hex-socket end) to decrease it. Flow rate is highest when cam follower assembly is closest to jack-shaft.

Through the manual flame control switch, position the cam so that the adjusting screw adjacent to the end or high fire screw contacts the cam follower. Make a combustion analysis at this point. If an adjustment to that cam screw is necessary follow this recommended procedure.

Mark the point requiring adjustment, using a piece of chalk on the side of the cam. See Figure 5-11. Then rotate the cam to move the screw requiring adjustment sufficiently away from contact with the cam follower and adjust to increase or decrease fuel flow.

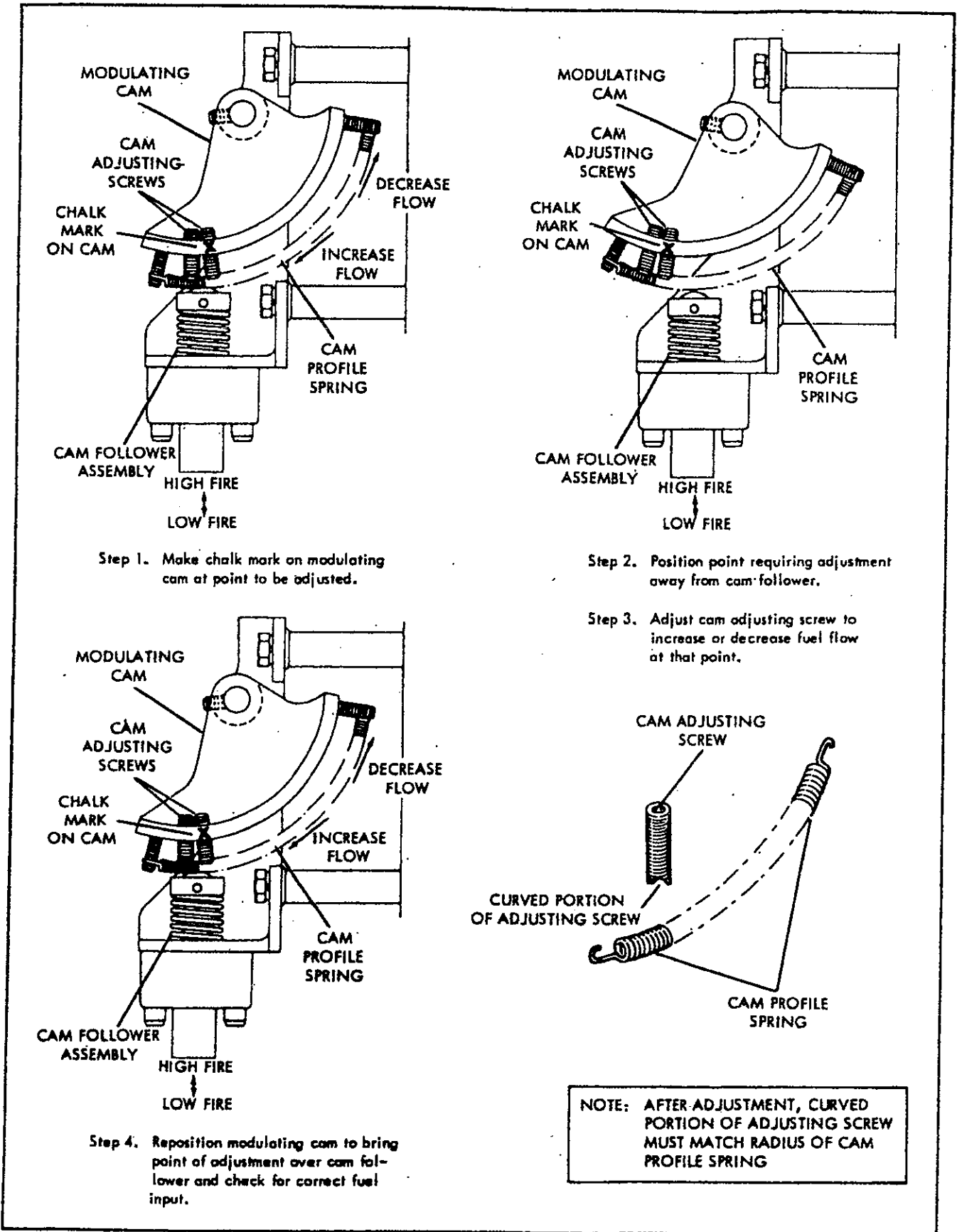


FIGURE 5-11. MODULATING CAM ADJUSTMENT PROCEDURE

NOTE: The adjustment screws are curved on the bottom to match the radius of the cam profile spring. If adjusting screws are turned when the cam follower is pressing against the lower surface of the spring then it is possible the edges of the adjusting screws may score the spring, leading to premature spring breakage. After completing adjustment **MAKE CERTAIN THAT CAM ADJUSTING SCREW CONTOUR MATCHES SPRING RADIUS.**

Return the cam to the point at which the adjustment was required and re-check input.

Repeat this process, stopping at each adjusting screw until low fire position is reached. If all screws are properly adjusted, none will deviate from the general overall contour of the cam face. It may be necessary to re-adjust the setting of the low fire stop screw in order to obtain the proper air-fuel ratio at low fire burning rate. To insure that the low fire position of the butterfly valve is always the same, allow one turn of stop screw for over-travel.

CAUTION

Failure to release pressure of cam follower against cam profile spring before or while adjusting the cam contour or adjusting screws will result in scored or weakened springs. Replace these springs immediately to avoid breakage.

R. LOW GAS PRESSURE SWITCH

Adjust the scale setting to slightly below the normal burning pressure. The control circuit will be broken when pressure falls below this point. Since gas line distribution pressure may decrease under some conditions, shutdowns may result if the setting is too close to normal. However, regulations require that the setting may not be less than 50% of the rated pressure downstream of the regulator.

Manual resetting is necessary after a pressure drop. Press the reset lever after pressure is restored. Make sure that a mercury switch equipped control is level.

S. HIGH GAS PRESSURE SWITCH

Adjust the scale setting to slightly above the normal burning pressure. The control circuit will be broken when pressure exceeds this point. Unnecessary shutdowns may result if the setting is too close

to normal, however, regulations require that the setting may not be greater than 50% of the rated pressure.

Manual resetting is necessary after a pressure rise. Press the reset lever after pressure falls. Make sure that a mercury switch equipped control is level.

T. FUEL OIL PRESSURE AND TEMPERATURE - GENERAL

Variations in burning characteristics of the fuel oil may require adjustments from time to time to assure highest combustion efficiency. The handling and burning characteristics may vary from one delivery of oil to another. For this reason it is recommended that the oil system be inspected from time to time to verify that pressures and viscosity are at the proper operating levels.

Because of variation in oils including chemical content, source, blends and viscosity characteristics, the temperatures and pressures listed in Chapter 4 and mentioned in the adjusting of the controls in the following paragraphs will vary and thus may be regarded as tentative and to be changed to provide best firing conditions. Figure 5-12 is an oil viscosity-temperature chart. This may be used as a guide although your oil supplier will be able to give you more exacting information based on an analysis of the oil.

Review of the applicable maintenance instructions given in Chapter 7 will aid in maintaining an efficient fuel system.

NOTE: To prevent oil heater coking, the fuel oil pump must be in operation during all times that an oil heater is in service. During any time that the oil pump is not operating, the oil heating system must be electrically shut down by manually turning the oil heater switch "off."

When the boiler is shut down, or switched over to gas firing, the pump must operate for a sufficient period of time to cool the oil heater. Similarly, if an electric, steam, or hot water oil heater is removed for servicing, the temperature of the heater should be reduced by circulating oil until it is.

U. FUEL OIL COMBUSTION ADJUSTMENT

After operating for a sufficient period of time to assure a warm boiler, adjustments should be made to obtain efficient combustion.

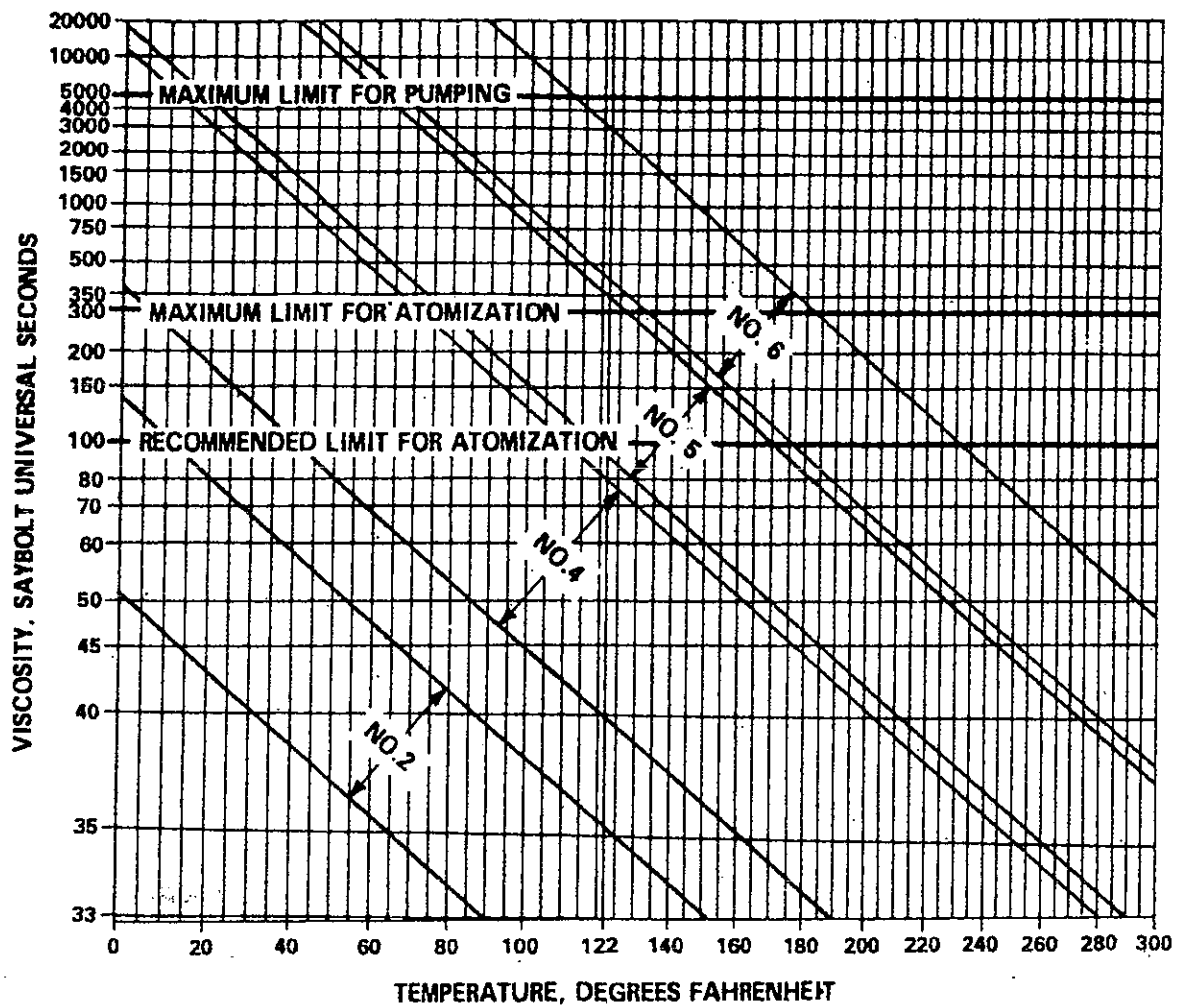


FIGURE 5-12. OIL VISCOSITY CHART

Efficient combustion cannot be solely judged by flame condition or color, although they may be used in making approximate settings. This should be done so that there is a bright sharp flame with no visible haze.

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 (CO₂), oxygen (O₂) and carbon monoxide (CO) in the flue gas.

Burner efficiency is measured by the amount or percent of CO₂ present in the flue gas. The ideal setting from a standpoint of efficiency is reached when the percentage of oxygen in the flue gas is zero. 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, temperature, or burning properties of oil. 15 to 20% excess air is considered reasonable and this should result in an approximate CO₂ reading of 12-1/2 to 13%.

The burner should never be operated with an air-fuel ratio that indicates a detectable percentage of carbon monoxide.

Through the use of the manual flame control slowly bring the unit to high fire by stages. At the high fire position the air damper should be fully opened and the air and oil pressure readings should be on the order of those given in Chapter 4.

Take a flue gas analysis reading at this point. If necessary make adjustments to the fuel oil controller to increase or decrease oil pressure. This should be done before making any effort to adjust the screws in the metering cam. Ideally, the cam profile spring should be as close to the cam casting as practical and it is more desirable to lower the oil pressure to reduce flow, if necessary, than to extend adjusting screws to an extreme position in an effort to cut-back on flow.

After making certain that the air control damper and its linkage are operating properly to provide the proper amount of secondary air and that fuel

oil pressure settings are correct, final adjustment can be made, if necessary, to the oil modulating cam to obtain a constant fuel-air ratio through the entire firing range.

Since the input of combustion air is ordinarily fixed at any given point in the modulating cycle, the flue gas reading is determined by varying the input of fuel at that setting. This adjustment is made to the metering cam by means of adjusting screws (Figure 5-3), which are turned out (counterclockwise from the hex-socket end) to increase the flow of fuel and in (clockwise from the hex-socket end) to decrease it. Flow rate is highest when cam follower assembly is closest to jack-shaft.

If oil pressure, primary air pressure, and linkages are properly adjusted the metering cam should require minimal adjustment.

If adjustment is necessary follow this recommended procedure.

Through the flame control switch, position the cam so that the adjusting screw adjacent to the end or high fire screw contacts the cam follower. Make a combustion analysis at this point. If an adjustment to that cam screw is necessary proceed as follows:

Mark the point requiring adjustment, using a piece of chalk on the side of the cam. See Figure 5-11. Then rotate the cam to move the screw requiring adjustment sufficiently away from contact with the cam follower and adjust to increase or decrease fuel flow.

NOTE: The adjustment screws are curved on the bottom to match the radius of the cam profile spring. If adjusting screws are turned when the cam follower is pressing against the lower surface of the spring then it is possible the edges of adjusting screws may score the spring leading to premature spring breakage. After completing adjustment **MAKE CERTAIN THAT CAM ADJUSTING SCREW CONTOUR MATCHES SPRING RADIUS.**

Return the cam to the point at which the adjustment was required and re-check input.

Repeat this process, stopping at each adjusting screw until low fire position is reached. If all screws are properly adjusted none will deviate from the general overall contour of the cam face.

CAUTION

Failure to release pressure of cam follower against cam profile spring before or while adjusting the cam contour or adjusting screws will result in scored or weakened springs. Replace these springs immediately to avoid breakage.

V. BURNER DRAWER ADJUSTMENT

There are relatively few adjustments that can be made to the burner, however, a check should be made to see that all components are properly located and that all holding screws are properly tightened. Figures 5-14 and 5-16 show various views or portions of the burner.

The diffuser location on gas fired boilers is quite important. There should be one quarter inch distance between the inside edge of the gas exit holes in the burner tube and the skirt of the diffuser (see Figure 5-15). The setting of an oil fired burner is less exacting and the diffuser should be located with the skirt approximately 1-1/8" from the end of the burner tube.

When the proper diffuser location is ascertained, the setting of the oil nozzle in relation to the diffuser should be checked. This is generally set at time of manufacture and seldom needs altering. It is most important that oil spray does not impinge upon the diffuser. The distance that the nozzle is behind the diffuser has some latitude and individual installations may require a slight deviation. The spacing which is indicated by dimension A in Figure 5-14 is 2".

Check the setting of the ignition electrode(s) for proper gap and position. See Figure 5-14 for the gas pilot electrode and Figure 5-13 for the light oil pilot. Make sure that the porcelain insulator is not cracked and that ignition cable connections are tight.

The oil nozzle tip should be seated tightly in the body with the swirler and the seating spring in place. See Section G in Chapter 7 for additional nozzle tip information.

Check to see that the flame detector sight tube and the gas pilot tube extend thru their respective openings in the diffuser face.

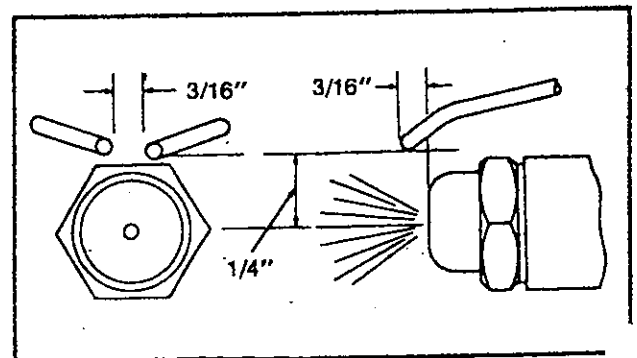


FIGURE 5-13. ELECTRODE SETTING - OIL PILOT

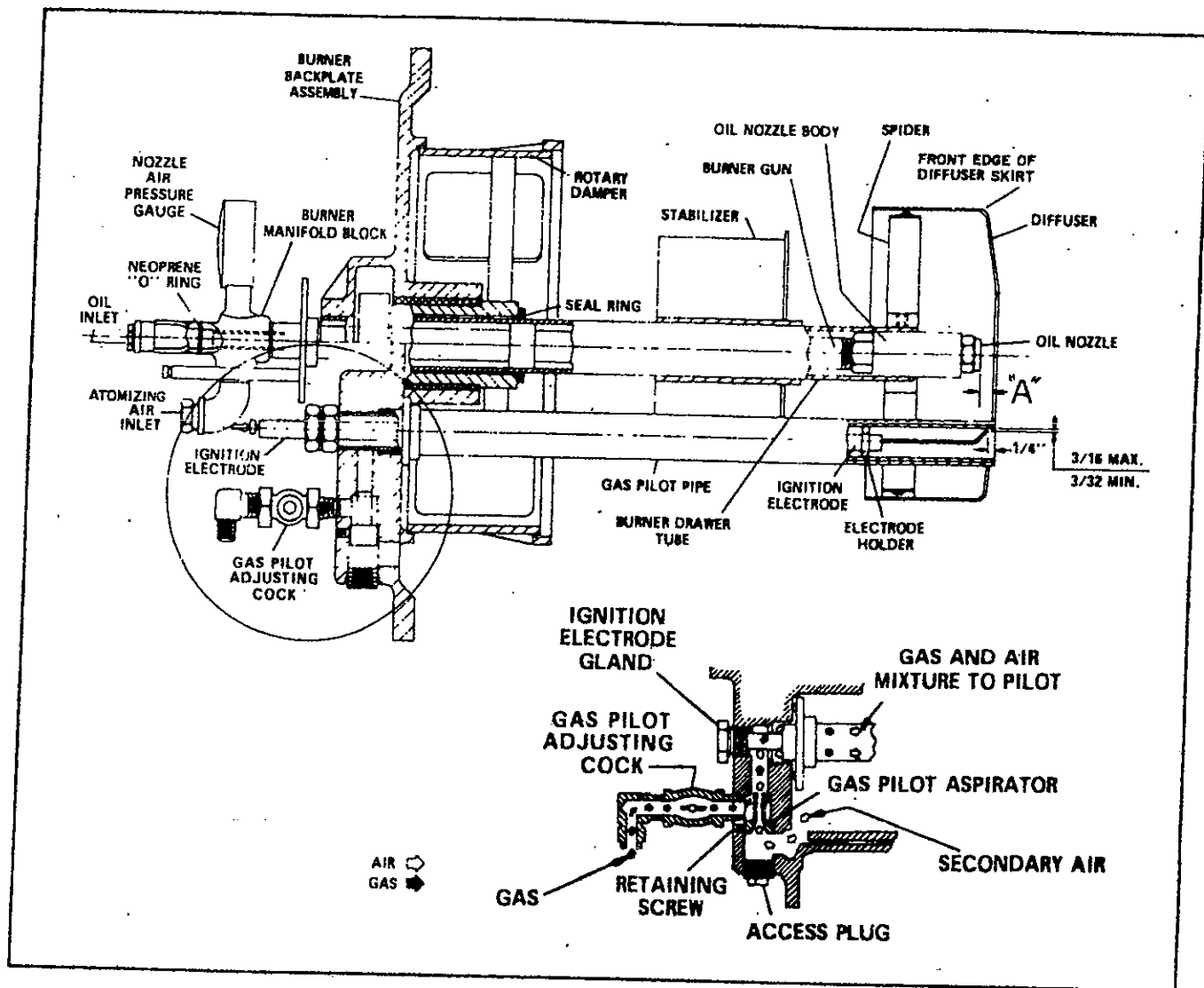


FIGURE 5-14. BURNER DRAWER WITH GAS PILOT

W. OIL DRAWER SWITCH

The integral contacts of this control are closed by proper positioning and latching of the oil drawer in its forward position. Adjustment of switch must be such that its contacts open if oil drawer is not properly positioned for oil firing. The switch is electrically removed from the circuit when a combination fuel burner is fired on gas.

X. LOW OIL TEMPERATURE SWITCH

This control prevents the burner from starting, or stops its operation, if the temperature of the oil is below normal operating temperature.

A No. 6 oil burner standardly uses a White-Rodgers 11B05-1 control. To adjust, insert screwdriver into center slot in control cover and

turn dial until fixed (center) pointer is approximately 30 degrees F lower than oil heater thermostat setting. Turn differential adjusting screw (located above dial) until movable indicator is approximately 5 degrees F above the setting on the main scale.

On a No. 6 oil burner installed on a hot water boiler, the low oil temperature switch is an integral part of the electric oil heater. The switch is nonadjustable and is factory set at approximately 40 degrees F below the maximum operating temperature of the heater.

An optionally equipped burner complying with insurance group requirements can be equipped with the White-Rodgers thermostat—or may be equipped with Mercoid FM437-3 or Honeywell L6008C controls. All of these are readily adjusted and should be set approximately 30 degrees F lower than the oil heater thermostat.

Y. HIGH OIL TEMPERATURE SWITCH (OPTIONAL - F.I.A. Only)

This control prevents the burner from starting, or stops its operation, if the temperature of the oil exceeds the normal operating temperature.

A! White-Rodgers 11B18-1 control is used. To adjust, turn the dial until the pointer is approximately 25° above normal operating temperature. These controls generally have a set differential and will close 5° below the set point.

Z. LOW OIL PRESSURE SWITCH (Optional)

This control prevents burner ignition, or stops its operation, when the oil pressure is below a set point. Adjust the control by turning the screw on top of control case to an indicated pressure 10 psi below the established primary oil pressure setting indicated on the oil supply pressure gauge. The switch will remain in a closed position as long as

the oil pressure exceeds this setting. The control normally used automatically resets when pressure is restored after a drop.

AA. ELECTRIC OIL HEATER THERMOSTAT (FENWAL) (400 and 600 Series - Steam)

The maximum temperature setting of the control is stamped on the dial. This is attained with the adjusting knob turned to the "high" end of the scale. Lower settings are obtained by turning the adjusting knob clockwise using the thermometer in the fuel oil controller as a guide.

The final setting of this thermostat should be at a sufficiently lower temperature (approximately 15 degrees) than the steam heater thermostat. This eliminates the electric heater from operation when the steam heater is functioning. The electric heater is sized to provide sufficient heated oil for low fire operation on cold starts before steam is available.

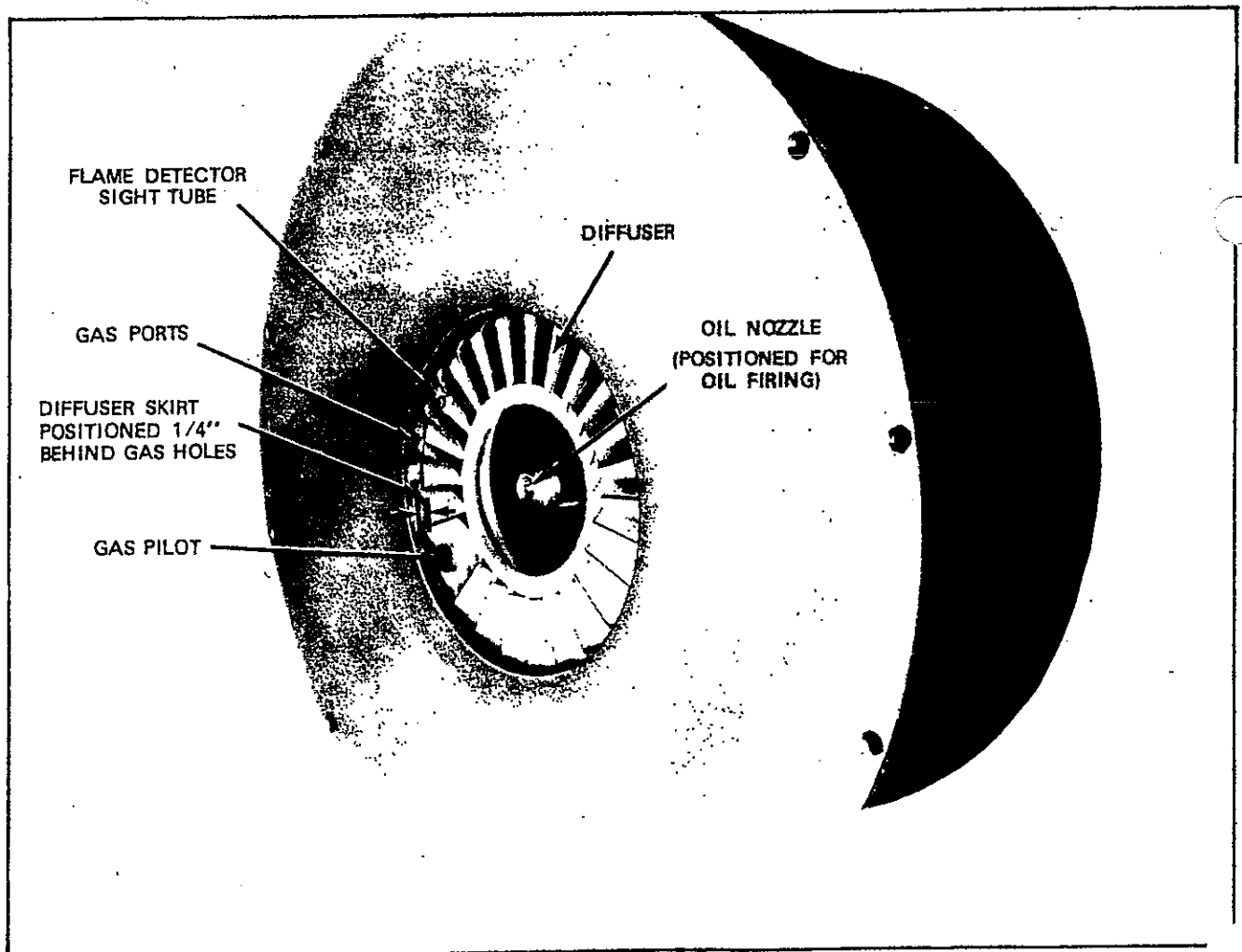


FIGURE 5-15. BURNER HOUSING

A 0.005 MFD capacitor is wired in parallel with the thermostat lead connections to prevent contact bounce and arcing. The control differential is non-adjustable.

BB. STEAM OIL HEATER THERMOSTAT (FENWAL) (No 6 Oil) (400 and 600 Series - Steam)

The maximum temperature setting of the control is stamped on the dial. This is attained with the adjusting knob turned to the "high" end of the scale. Lower settings are obtained by turning the adjusting knob clockwise using the thermometer in the fuel oil controller as a guide.

The final setting of this thermostat should provide oil at a sufficient temperature for efficient combustion based on flue gas analysis. There is no need to heat the oil in excess of this temperature.

A 0.005 MFD capacitor is wired in parallel with the thermostat lead connections to prevent contact bounce and arcing. The control differential is non-adjustable.

CC. HOT WATER OIL HEATER THERMOSTAT (400 and 600 Series)

The thermostat normally supplied is a White Rodgers 11B18-1. To adjust, insert screwdriver into center slot in control cover and turn dial until pointer is at desired temperature level. This control generally has a set differential and will close 5° below the set point.

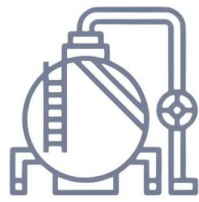
The thermostat contacts close to energize the booster water pump which pumps water from the boiler through the heater. On cold starts it is normal practice to manually close the valve in the pump discharge line until boiler water temperature exceeds the temperature of fuel oil entering the heater.

The electric oil heater on a hot water boiler burning No. 6 oil and equipped with a hot water oil heater has a built-in adjustable thermostat. The maximum temperature setting is stamped on its dial. Desired temperature can be obtained by turning the adjusting screw. The thermostat should be set at a sufficiently lower temperature (approximately 15°) than the hot water heater thermostat. This eliminates the electric heater from operation when the water heater is functioning. The electric heater is sized to provide sufficient heated oil for low fire operation on cold starts before hot water is available.

DD. STEAM HEATER PRESSURE REGULATOR (400 and 600 Series - Steam)

This regulator is provided on a boiler designed to operate at pressures above 15 psi for the purpose of reducing boiler steam pressure to the level necessary for proper operation of the steam oil heater. This pressure should be reduced to a point that permits sufficient temperature to heat the oil while allowing as continuous a steam flow as possible. Reduced pressure that is too high will result in frequent cycling of the steam solenoid valve.

It is best to adjust the regulator under typical flow conditions. To do this it is suggested that the globe valve in the steam supply line be closed so that there is no pressure on the regulator. Turn out the adjusting screw fully to relieve compression on the regulator spring thus closing the regulator. With steam at normal pressure, open the globe valve and then set the secondary pressure by turning the adjusting screw or handle until the downstream gauge shows the desired pressure.



CHAPTER 6

TROUBLE SHOOTING

- A. BURNER DOES NOT START
- B. NO IGNITION
- C. PILOT FLAME, BUT NO MAIN FLAME
- D. BURNER STAYS IN LOW FIRE
- E. SHUTDOWN OCCURS DURING FIRING
- F. MODULATING 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 connection.
3. Combustion control safety switch requires setting
 - 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 (terminal board 2)
 - d) Check that appropriate relay contacts are closed (see programmer bulletin)
4. Limit circuit not completed - no power to programmer terminal 3. (TB6)
 - a) Pressure or temperature is above setting of operating control. (Load demand light will not glow)
 - b) Water below required level
 - 1) Low water light (and alarm horn) should indicate this condition
 - 2) Check manual reset button, if provided, on low water control
 - c) Fuel pressure must be within settings of low pressure and high pressure switches
 - d) Oil fired unit — burner gun must be in full forward position to close oil drawer switch
 - e) Heavy oil fired unit — oil temperature below minimum setting
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 on 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
 - c) Insufficient or no voltage to gas pilot solenoid valve. Check power at terminal 5 or 6
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 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) Supply pump inoperative
 - c) No fuel
 - d) Inoperative solenoid valve
 - e) Check oil nozzle, gun 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 (TB 14). If no voltage check contacts. (See bulletin)

D. BURNER STAYS IN LOW FIRE

1. Pressure or temperature above modulating control setting
2. Manual-automatic switch in wrong position
3. Inoperative modulating motor (See Section F)
4. Defective modulating control

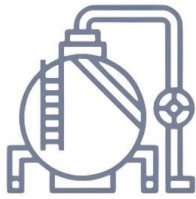
5. Binding or loose linkage, cams, setscrews, etc.
6. Check appropriate relay contacts

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.
 - a) The flame failure light (and alarm horn) are energized by ignition failure, main flame failure, inadequate flame signal, or open control in the non-recycling interlock circuit
 - b) The light (and horn) will not be energized by the opening of any control in the limit circuit
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
 - a) 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 line
 2. Temporary drop in gas pressure
 3. Orifice gate valve accidentally opened (heavy oil)
8. Interlock device inoperative or defective

F. MODULATING MOTOR DOES NOT OPERATE

1. Manual-automatic 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) Manual-automatic switch in wrong position
 - b) Modulating control improperly set or inoperative
 - c) Check appropriate contacts (See bulletin)
5. Motor inoperative
 - a) Loose electrical connection
 - b) Faulty damper motor transformer



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CHAPTER 7

INSPECTION AND MAINTENANCE

- A. GENERAL
- B. FIRESIDE CLEANING
- C. WATER LEVEL CONTROLS AND WATERSIDE
- D. WATER GAGE GLASS
- E. ELECTRICAL CONTROLS
- F. PROGRAMMING CONTROL
- G. OIL BURNER MAINTENANCE
- H. GAS BURNER MAINTENANCE
- I. MOTORIZED GAS VALVE
- J. SOLENOID VALVES
- K. CAM SPRING
- L. FORCED DRAFT FAN
- M. SAFETY VALVES
- N. FUEL OIL VALVES
- O. AIR PUMP AND COMPONENTS
- P. REFRACTORY
- Q. DOOR CLOSING AND SEALING
- R. LUBRICATION
- S. OIL HEATERS—ELECTRIC, STEAM, HOT WATER

A. GENERAL

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 of daily, weekly and monthly and yearly maintenance activities 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 should be repaired as soon as they are noticed. Leaks are wasteful as well as hazardous. Include in the program preven-

tive maintenance measures such as regularly checking the tightness of connections, locknuts, set-screws, 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 change. 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.

Periodic Inspection

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

Section I of 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 and check of all components of the boiler including piping, valves, pumps, gaskets, refractory etc. Comprehensive cleaning, spot painting or re-painting 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 many years of performance.

B. 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 the tube sheets.

Refer to Section Q 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.

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.

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 7-1 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.

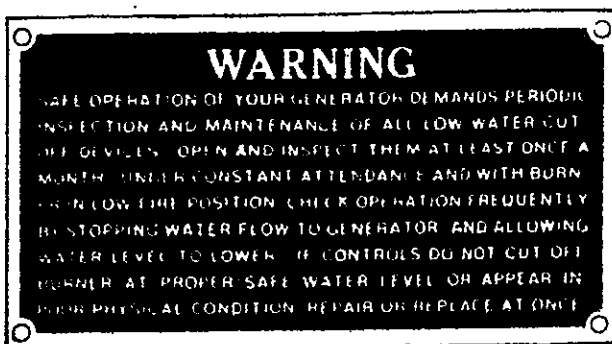


FIGURE 7-1. LOW WATER PLATE

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. ELECTRICAL CONTROLS

Most of the operating controls require very little maintenance beyond occasional inspection. Examine tightness of electrical connections. Keep the controls clean. Remove any dust that accumulates in the interior of the control using a low pressure air hose and taking care not to damage the mechanism.

Examine any mercury tube switches for damage: 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. The piping leading to those 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 it 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 cause of excessive current draw.

RECOMMENDED MAXIMUM "FUSETRON" FUSE SIZES

| ELECTRICAL LOAD | SINGLE PHASE 50/60 HERTZ | | THREE PHASE 50/60 HERTZ | | | | | |
|--|--------------------------|-------------|-------------------------|--------------|-----------------------|--------------|---|--|
| | 110-120 V | 220-240 V | 200-208 V | 220-240 V | 348-416 V | 440-480 V | 550-600 V | |
| 1/4 HP MOTOR | FRN - 8 | FRN - 4-1/2 | FRN - 1-8/10 | FRN - 1-8/10 | | FRS - 1 | FRS - 8/10 | |
| 1/3 HP MOTOR | FRN - 9 | FRN - 4-1/2 | FRN - 1-8/10 | FRN - 1-8/10 | | FRS - 1 | FRS - 8/10 | |
| 1/2 HP MOTOR | FRN - 12 | FRN - 6-1/4 | FRN - 2-8/10 | FRN - 2-8/10 | FRS - 1-8/10 | FRS - 1-4/10 | FRS - 1 | |
| 3/4 HP MOTOR | FRN - 17-1/2 | FRN - 9 | FRN - 4-1/2 | FRN - 4-1/2 | FRS - 2-1/4 | FRS - 1-8/10 | FRS - 1-4/10 | |
| 1 HP MOTOR | FRN - 20 | FRN - 10 | FRN - 5 | FRN - 5 | FRS - 3-2/10 | FRS - 2-1/4 | FRS - 1-8/10 | |
| 1-1/2 HP MOTOR | FRN - 25 | FRN - 12 | FRN - 7 | FRN - 7 | FRS - 4-1/10 | FRS - 3-2/10 | FRS - 2-1/2 | |
| 2 HP MOTOR | FRN - 30 | FRN - 15 | FRN - 9 | FRN - 9 | FRS - 5-8/10 | FRS - 4-1/10 | FRS - 3-1/2 | |
| 3 HP MOTOR | FRN - 40 | FRN - 20 | FRN - 12 | FRN - 12 | FRS - 8 | FRS - 6-1/4 | FRS - 5 | |
| 5 HP MOTOR | | FRN - 35 | FRN - 20 | FRN - 20 | FRS - 12 | FRS - 10 | FRS - 8 | |
| 7-1/2 HP MOTOR | | | FRN - 30 | FRN - 30 | FRS - 17-1/2 | FRS - 15 | FRS - 12 | |
| 10 HP MOTOR | | | FRN - 40 | FRN - 35 | FRS - 20 | FRS - 17-1/2 | FRS - 15 | |
| 15 HP MOTOR | | | FRN - 60 | FRN - 50 | FRS - 30 | FRS - 25 | FRS - 20 | |
| 20 HP MOTOR | | | FRN - 70 | FRN - 70 | FRS - 40 | FRS - 35 | FRS - 25 | |
| 25 HP MOTOR | | | FRN - 90 | FRN - 80 | FRS - 50 | FRS - 40 | FRS - 35 | |
| 30 HP MOTOR | | | FRN - 100 | FRN - 100 | FRS - 60 | FRS - 50 | FRS - 40 | |
| 40 HP MOTOR | | | FRN - 150 | FRN - 150 | FRS - 80 | FRS - 70 | FRS - 50 | |
| 50 HP MOTOR | | | FRN - 175 | FRN - 175 | FRS - 100 | FRS - 80 | FRS - 70 | |
| 60 HP MOTOR | | | FRN - 200 | FRN - 200 | FRS - 125 | FRS - 100 | FRS - 80 | |
| 75 HP MOTOR | | | FRN - 250 | FRN - 250 | FRS - 150 | FRS - 125 | FRS - 100 | |
| 100 HP MOTOR | | | FRN - 350 | FRN - 300 | | FRS - 150 | FRS - 125 | |
| 125 HP MOTOR | | | FRN - 450 | FRN - 400 | | FRS - 200 | FRS - 150 | |
| 150 HP MOTOR | | | FRN - 500 | FRN - 450 | | FRS - 225 | FRS - 200 | |
| 200 HP MOTOR | | | | FRN - 600 | | FRS - 300 | FRS - 250 | |
| 2 KW HEATER | FRN - 20 | FRN - 12 | FRN - 7 | FRN - 7 | | FRS - 4-1/10 | FRS - 3-2/10 | |
| 3 KW HEATER | FRN - 30 | FRN - 15 | FRN - 10 | FRN - 10 | FRS - 6-1/4 | FRS - 5-8/10 | FRS - 4-1/10 | |
| 5 KW HEATER | FRN - 50 | FRN - 25 | FRN - 15 | FRN - 15 | FRS - 10 | FRS - 8 | FRS - 6-1/4 | |
| 7-1/2 KW HEATER | | | FRN - 25 | FRN - 25 | FRS - 15 | FRS - 12 | FRS - 10 | |
| 10 KW HEATER | | | FRN - 30 | FRN - 30 | FRS - 25 | FRS - 17-1/2 | FRS - 12 | |
| 15 KW HEATER | | | FRN - 45 | FRN - 45 | FRS - 35 | FRS - 25 | FRS - 20 | |
| CONTROL CIRCUIT SERVICE VOLTAGE | 1/2 KVA MAX. | | 1 KVA MAX. | | 1-1/2 KVA MAX. | | | |
| 110-120 | FRN - 10 | | FRN - 12 | | FRN - 15 | | | |
| 208-240 | FRN - 6-1/4 | | FRN - 7 | | FRN - 8 | | | |
| 348-416 | FRS - 4-1/10 | | FRS - 6 | | FRS - 7 | | | |
| 440-480 | FRS - 3-2/10 | | FRS - 4-1/10 | | FRS - 5 | | | |
| 550-600 | FRS - 3-2/10 | | FRS - 4-1/10 | | FRS - 5 | | | |
| CONSULT CLEAVER-BROOKS ELECTRICAL ENGINEERING DEPT. FOR "FUSETRON" FUSE SIZE FOR POWER SYSTEMS WITH VOLTAGE, FREQUENCY OR PHASE NOT MENTIONED ABOVE. | | | | | | | DWG. NO. 830-1253 (REVISED 1/8/75) C18-9077 | |

FIGURE 7-2. RECOMMENDED MAXIMUM "FUSETRON" FUSE SIZES

Power supply to the boiler must be protected with dual element fuses (fusetrans) or circuit breakers. Similar fuses should be used in branch circuits and standard one-shot fuses are not recommended. Information given in Table 7-2 is included for guidance to fuse requirements.

F. 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 in rear of this manual. Do not use abrasive materials. Keep the control cabinet door 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 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 (figure 1-3). 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 activating the flame failure light (and optional alarm).

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 prepurge period. The main fuel valve(s) will be energized but there should be no main 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. The flame failure light (and optional alarm) will be activated.

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. The flame failure light (and optional alarm) will be activated.

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.

G. OIL BURNER MAINTENANCE

The burner should be inspected for evidence of damage due to improperly adjusted combustion. The setting of the oil nozzle in relation to the diffuser and other components is important for proper firing and should be checked. See Section V in Chapter 5.

The seal between the burner housing and the oven liner is extremely important. Its condition should be checked periodically and repairs made as necessary.

Oil Strainers

Oil strainers should be cleaned frequently to maintain a free and full flow of fuel.

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.

Heavy Oil Strainer

Keep the cartridge of the Cuno strainer clear by regularly giving the exterior handle one complete turn in either direction. Do this often until experience indicates cleaning frequency necessary to maintain optimum conditions of flow. If handle turns hard, through occasional neglect, rotate back and forward until handle can be turned through a complete revolution. Do not force with a wrench or other tool.

Drain sump as often as experience indicates the necessity. Remove sump, or head and cartridge assembly for thorough cleaning and inspection at frequent intervals. Exercise care not to damage cartridge discs or cleaner blades. Wash cartridge in solvents. Do not attempt to dis-assemble cartridge.

Fuel Oil Treatment

Conditions and the quality of the fuel oil being supplied to the burner may vary to the extent and degree that the use of fuel oil additives may be advisable to obtain proper combustion and to aid in pumping of the oil. The fuel oil storage tank(s) should be checked periodically and cleaned of any sludge deposits.

Cleaning Oil Nozzle

The design of the burner, together with the oil purge system on a heavy oil burner, make it unnecessary to clean the oil nozzle during periods of operation. A routine check should be made during off periods or when the burner is firing on gas and any necessary cleaning performed.

If at any time the burner flame appears "stringy" or "lazy" it is possible that the nozzle tip or swirler has become partially clogged or worn. Any blockage within the tip will cause the air pressure gauge to increase above its normal value.

To disassemble, unlatch and withdraw the burner gun. Insert the nozzle body into the hanger vice

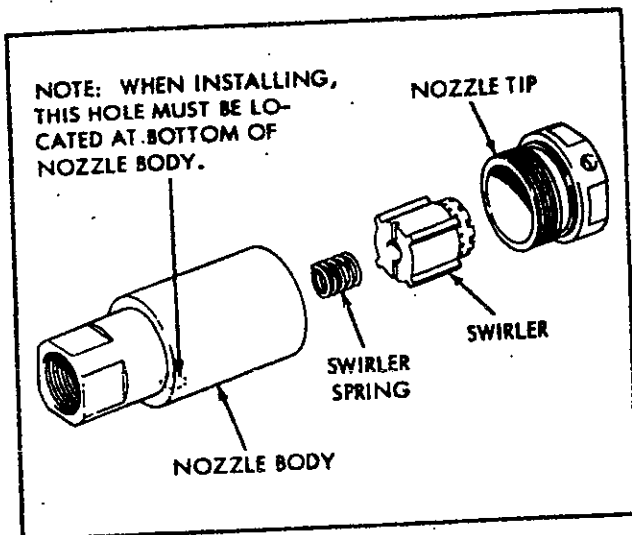


FIGURE 7-3. EXPLODED VIEW OF BURNER NOZZLE

and use the spanner wrench to remove the tip. Carefully remove the swirler and seating spring being careful not to drop or damage any parts. See figure 7-3.

Perform any necessary cleaning with a suitable solvent. Use a brush or pointed piece of soft wood for cleaning rather than wire or a sharp metallic object which is apt to scratch or deform the orifices as well as the precision ground surfaces of the swirler and tip. Inspect for scratches or signs of wear or erosion which may make the nozzle unfit for further use. Take the necessary precautions in working with solvents.

The tip and swirler are a matched set which was precision lapped at time of assembly. Do not interchange parts if a spare is kept. In reassembling, make certain that the seating spring is in place and that it is holding the swirler tightly against the tip. The swirler is stationary and does not rotate but rather imparts a swirling motion to the oil.

Note the o-ring in the burner manifold block (figure 5-14) which serves as a seal for the internal oil tube. It is well to replace this item during the annual inspection. At the same time inspect the internal surface of this oil tube. See that the plugged hole is at the bottom of the nozzle body when the gun is installed. (See figure 7-3).

Air Purge Nozzle (No. 6 Oil)

Back Pressure Orifice Nozzle (No. 2 Oil)

The nozzle and its strainer should be inspected periodically and cleaned. The nozzle consists of a

tip and internal core. Clean all internal surfaces of the tip and the slotted parts of the core using a wood splinter to avoid damage from scratching. Replace core, setting it tightly but not excessively so.

Clean the strainer screen carefully to remove any foreign matter. Use suitable solvents in cleaning. Extremely hot water at high velocity is also helpful in cleaning. Replace strainer by screwing it into the nozzle body only finger tight. Do not use an orifice of a size other than originally installed.

Ignition System

Maintain the proper gap and dimensions of the ignition electrode(s) for best ignition results. Figures 5-13 or 5-14 show the correct settings.

Inspect electrode tip for signs of pitting or combustion deposits and dress as required with a fine file. Inspect the porcelain insulator for any cracks that might be present. If there are, replace electrode since they can cause grounding of the 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.

Periodically remove the access plug from the gas pilot aspirator (figure 5-14) and clean out any accumulated lint or other foreign material.

H. GAS BURNER MAINTENANCE

There is little maintenance required on the gas burner itself beyond checking the burner components for evidence of damage due to improperly adjusted combustion.

Check periodically for a proper seal between the end of the burner and oven refractory. See figure 7-9. Also check to see that the diffuser is not covering the gas exit holes in the burner housing. See figure 5-15.

Check the electrode setting and for any cracks that might be present on the porcelain insulator. If there are, replace electrode since they can cause grounding of the ignition voltage. Inspect the tip of electrode for signs of pitting or combustion deposits and dress as required with a fine file. See figure 5-14 for electrode settings.

Periodically remove the access plug from the gas pilot aspirator (figure 5-14) and clean out any accumulated lint or other foreign material.

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

I. MOTORIZED GAS VALVE

The motorized gas valve (Hydramotor) has its operating mechanism completely immersed in oil and because of the sealed design little maintenance is required. However, proper operation should be checked on a routine periodic basis.

Keep outer parts of the valve clean especially the stem between the operator and the valve. The packing gland is of the o-ring type and a nicked, scored or otherwise damaged valve stem can cause leakage. Do not remove dust covers if installed.

If oil is noticed around operator base or if leakage occurs repair by replacing any leaking o-rings and re-filling actuator with oil.

The manufacturer's recommendations for re-filling are as follows:

- (a) Unscrew filler plug from top of unit. Use care so that dirt, dust and lint do not enter during refilling.
- (b) Fill power unit with "AA" Capella refrigerant oil. Capacity is 1 pint for H10 actuator and 4 pints for H30 actuator.

NOTE: If nameplate has designation "F5" use Dow-Corning DC510 Silicon Oil. Do not intermix with "AA" Capella Oil.

- (c) Power actuator "on and off" for 15 to 20 minutes to release air from cylinder and bring oil temperature to 68° F or above. Add enough oil to fill container to base of filler tube.
- (d) Replace plug and tighten.

If actuator is sluggish or fails to operate, even after oil level is checked, replace entire operator portion. Follow the manufacturer's recommendation for replacement as follows:

- (a) Loosen lock screw on the union nut immediately below the indicator plate on the actuator shaft. Unscrew union nut to detach valve stem from actuator shaft. Do not remove or alter the stem nut on the end of valve stem.

CAUTION

Do not use pliers on polished surfaces of valve stem or actuator shaft.

- (b) Energize actuator to relieve pressure of closing spring.
- (c) Remove mounting bolts holding actuator to valve bonnet.

- (d) De-energize actuator and lift off of valve body.
- (e) Replace actuator with unit having same actuator catalog number. Re-assembly is the reverse of dis-assembly.
- (f) Energize new actuator and secure to valve.
- (g) Line-up prongs of stem head nut with slot in actuator shaft.
- (h) De-energize actuator.
- (i) Make sure prongs are in slot. Tighten union nut. Tighten lock screw.

CAUTION

If upper valve stem nut has been removed or its position changed see "Stem Nut Adjustment" instructions supplied with replacement actuator.

- (j) Test for proper operation.

J. 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 re-assembled. 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 re-installed in proper order.

K. CAM SPRING

The fuel cam profile spring should be inspected frequently for wear, scoring, or distortion. If any of these questionable conditions are found the spring must be replaced immediately to avoid the possibility of breakage in service. Use care to avoid damaging the spring during installation.

Lubricate occasionally with a non-gumming dripless high temperature lubricant, such as graphite or a silicone derivative.

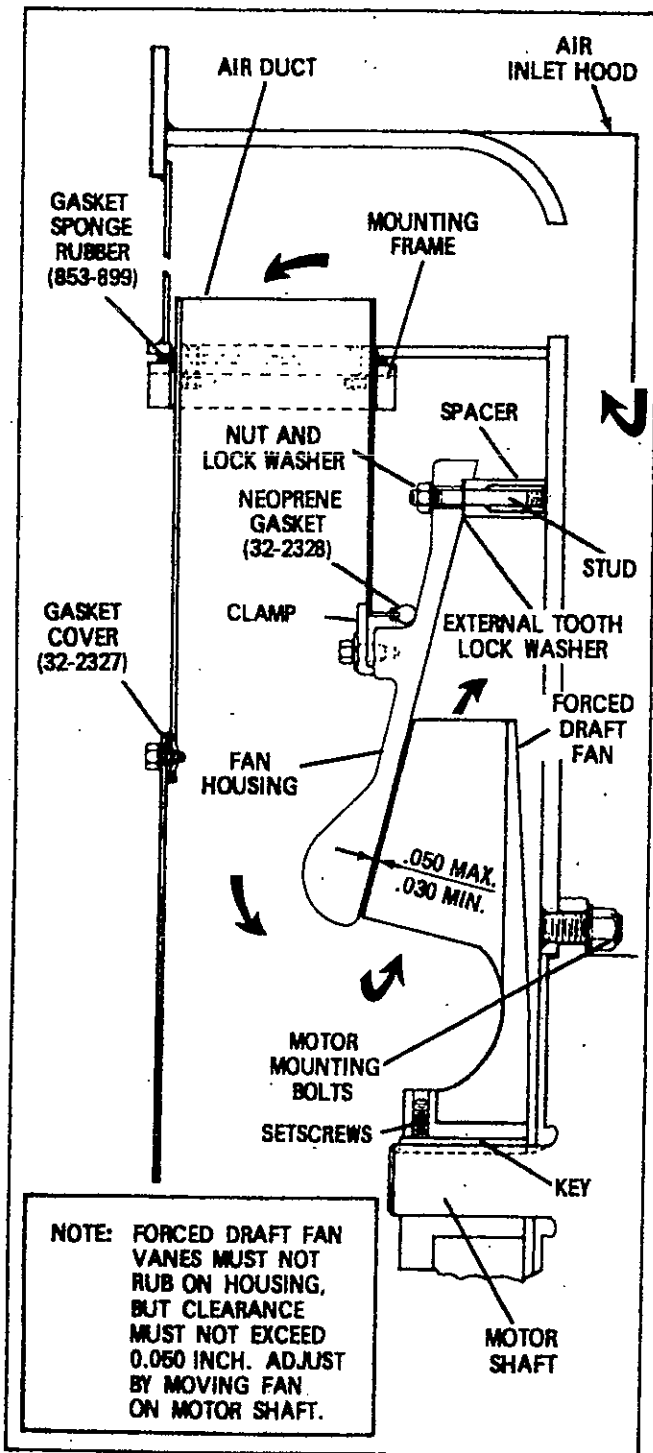


FIGURE 7-4.
FORCED DRAFT FAN MOUNTING
AND FLOW OF SECONDARY AIR

NOTE: Failure to follow instructions in Chapter 5 pertaining to the adjustment of the modulating cam will result in wear, scoring or distortion. Although these springs are specially manufactured with flat contact surfaces, any of the above conditions may lead to breakage causing excess fuel input.

L. FORCED DRAFT FAN

Figure 7-4 illustrates the forced draft fan and motor mounting in relation to the fan housing. The position of the fan housing and the clearance between it and the fan (impeller) is extremely important to the output capacity of the fan.

The procedure for installing and adjusting is as follows:

1. Bolt the motor securely to the head.
2. Slide fan onto the shaft, but do not tighten setscrews.
3. Turn spacers on studs until they contact headplate.
4. Install the fan housing on studs after placing an external tooth lock washer next to the spacer. Hold the fan housing in place with nuts and lock washers. Tighten only finger tight.
5. Slide fan until its vanes touch the fan housing. All blades must be against the housing. If necessary, adjust spacers until housing is evenly against all blades. Tighten nuts to secure housing in place.
6. Slide fan toward motor and use a feeler gauge to obtain .030 — .050" clearance.
7. Tighten setscrew on key first and then tighten the setscrew at 90° from key.
8. Install air duct assembly through opening in head. Tighten the screws securing the air duct to the fan housing only enough to create a seal between the neoprene gasket and the housing.
9. After connecting motor leads check rotation of the impeller to be sure that it is counter-clockwise when viewed from the motor end.

Check occasionally to see that fan is securely tightened to motor shaft. Check the clearance between the fan vanes and housing as outlined above. If the boiler is installed in a dusty location, check 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.

M. 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 1-9. 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 reseal 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.

N. FUEL OIL METERING VALVE, ADJUSTING, AND RELIEF VALVES

If there are indications that the oil metering valve has become clogged at its orifice, it will be necessary to dis-assemble the affected control to remove the obstruction. Clean the slotted stem of the oil metering valve with suitable solvent and blow dry with an air line.

In the event that a leak occurs in the packing of the metering valve, the packing nut should be snugged gradually to stop the leak. **EXCESSIVE TIGHTENING OF METERING VALVE PACKING NUT PREVENTS FREE MOVEMENT OF THE METERING STEM.**

If replacement of metering valve packing is required, follow procedure for installation given in bulletin that accompanies the kit or see page 8-10.

If pressure adjusting or relief valves become clogged, dis-assemble by releasing lock-nut and backing off screw to relieve tension on diaphragm. Remove valve cover and diaphragm. This will expose any dirt or foreign material which may have entered the valves. Clean out carefully and re-assemble. It is recommended that the diaphragms be replaced annually.

O. THE AIR PUMP AND LUBRICATING SYSTEM

Air Pump

The air pump itself requires little maintenance, however, the life of the pump is dependent upon a sufficient supply of clean cool lubricating oil. The oil level in the air-oil tank must be observed closely. Lack of oil will damage the pump making replacement necessary. Dis-assembly or field repairs to the pump are not recommended.

Lubricating Oil

Lubricating oil must be visible in the gauge glass at all times. There is no specific level required as long as oil is visible. Do not operate if oil is not visible.

Oil with proper viscosity must be used. SAE20 detergent is recommended although SAE10 detergent is also permissible. Name brands known to perform satisfactorily include Havoline (Texaco), Mobil Oil (Mobil), Shell X100 and Permalube (American).

Follow this procedure when adding oil:

Remove the cover from the fill pipe and add oil through the conical strainer in this pipe *with the unit running*. Oil must NEVER be added unless the pump is in operation and the strainer screen in place.

The oil and its containers should be clean. Although there is a strainer in the lube oil line its purpose is to remove any unwanted materials rather than to act as a filter for unclean oil.

LUBRICATING OIL STRAINER AND COOLING COIL

Air pressure from the pump forces lubricating oil from the tank to the pump. The oil lubricates the pump bearings and also provides a seal and lubrication for the pump vanes.

Earlier models have an oil strainer in the oil line between the cooling coil and the pump. The screen in this strainer must be removed and cleaned at regular intervals. See instructions in a later paragraph.

Current models direct the oil flow from the cooling coil to the filler pipe. The strainer screen in this pipe strains the oil as it flows to the pump. With this system it is possible to visually verify oil flow during operation by removing the filler cap and checking the flow. If necessary, the strainer may be cleaned during operation.

In the event that it is necessary to clean the strainer during operation, clean it and replace immediately. It can be cleaned by immersing in solvent and blowing it dry with compressed air. Do not operate without the strainer any longer than necessary and never add new oil unless it is in place. A spare strainer basket can be obtained, if desired, and used on a rotating basis while the other is serviced.

LUBE OIL STRAINER (EARLIER MODELS)

The lube 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 basket. Re-assemble in reverse order.

AIR CLEANER

Never operate the air pump without the air cleaner in place. The cleaner itself must be periodically checked and its element flushed and cleaned. The correct level of oil must be maintained in the cleaner.

AIR-OIL TANK

Pads of steel wool are used in this tank as a filtering medium to separate the lube oil from the compressed air. Figure 7-5 shows a cross section of a tank and the location of the steel wool.

These pads play a very important role and should be replaced periodically. It is also important that a proper grade of steel wool be used. We recommend No. 3 coarse grade American steelwool or equal (CB919-124). Do not substitute other grades! 3 pads are required. When replacing the wool, insert 2 pads into the cylinder. Alternate the grain of the pads. Install the spacer with its stub end toward the opening and fit one pad over the stub. Be careful not to over-compress the wool and be sure that it is fluffed out to fill all available space. Improper packing can

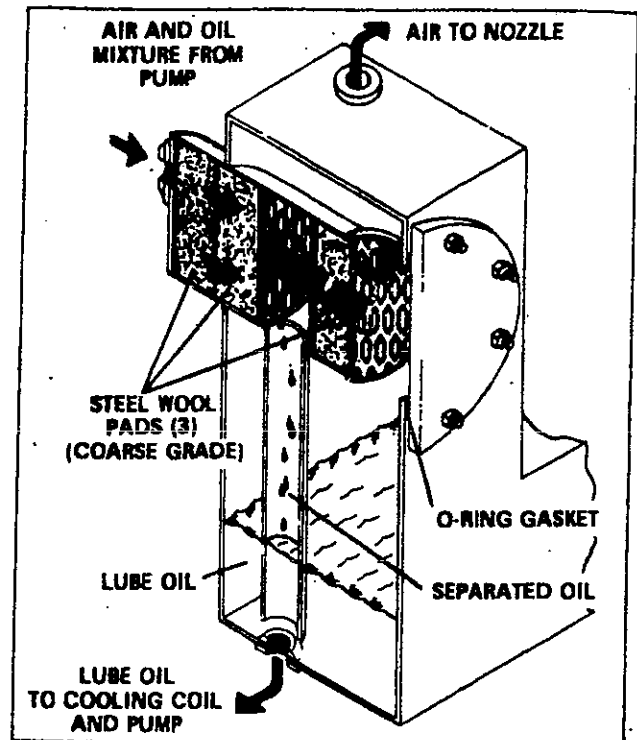


FIGURE 7-5. AIR-OIL RECEIVER TANK

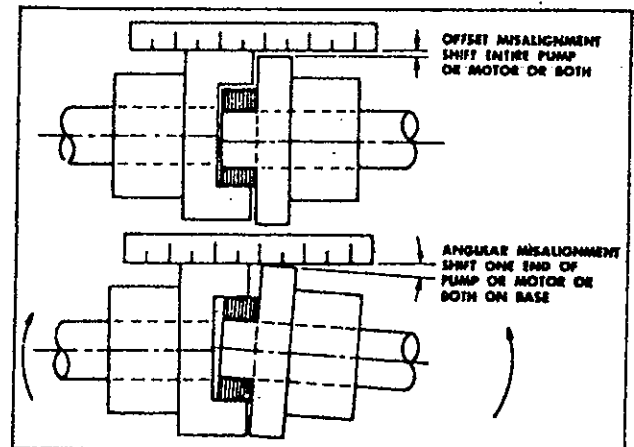


FIGURE 7-6

cause high oil consumption. After the last pad is in place, slip retainer screen onto the cylinder. Be sure to fit o-ring gasket under the cover so that a tight seal is obtained.

Follow previous instructions for oil replacement.

LUBE OIL COOLING COIL

The fins on the tubing must be kept clean and free of any dust or dirt that would impede air flow and cause overheating. Use an air hose to blow away debris. Internal cleaning of the tubes is seldom required if a good quality lube oil is used.

FLEXIBLE COUPLING ALIGNMENT

Alignment of the pump and motor through the flexible coupling is of extreme importance for trouble free operation. Check coupling alignment frequently

and replace coupling insert as required. Keep coupling guard in place.

The most commonly used tools for checking alignment are a small straightedge and a thickness gauge.

The coupling must be checked for both parallel (offset) alignment and angular (gap) alignment. Parallel misalignment exists when shaft axes are parallel but not concentric (see figure 7-6). Angular misalignment is the reverse situation - shaft axes concentric but not parallel.

Checking parallel alignment, both horizontal and vertical, can be accomplished by laying a straightedge across the coupling halves and checking with a thickness gauge to obtain the amount of misalignment. This check should be done on the top of the coupling and at least at one 90° intervals. A useful hint is to hold a flashlight behind the straightedge so that any gap can readily be seen.

Shim stock of appropriate thickness and area is then used under either the feet of the pump or the motor to establish parallel alignment. .008" tolerance is a permissible limit.

After parallel alignment is established, check for angular alignment. This is done by checking the gap between coupling halves. The coupling should have a minimum gap of 1/16" and a maximum of 3/32".

Set the spacing between the halves at one point by

using a thickness gauge and then rotate the coupling slowly to be sure that the halves are the same distance apart at all points. Adjust to obtain proper gap by loosening the hold down bolts and shifting either the pump or the motor as required. Generally a slight tapping on either the front or rear legs is all that is needed to obtain lateral adjustment. Rear legs may require shimming for vertical correction. Tighten the hold down bolts after adjustments are made.

Calipers can also be used in checking angular alignment. Measure the overall distance of the outer ends of the coupling halves at 90° intervals. Shift the pump or motor as required so that the ends of the coupling are the same distance apart at all points. The coupling will then have proper angular alignment.

Remember that alignment in one direction may alter the alignment in another. Recheck thoroughly both angular and parallel alignment procedures after making any alteration.

A properly aligned coupling will last a long time and will provide trouble-free mechanical operation.

AIR PUMP REPLACEMENT

Refer to Figure 7-7 for identification of various components and use the following procedures in replacing the pump. Be sure to tag the motor leads, if disconnected, to simplify reconnection.

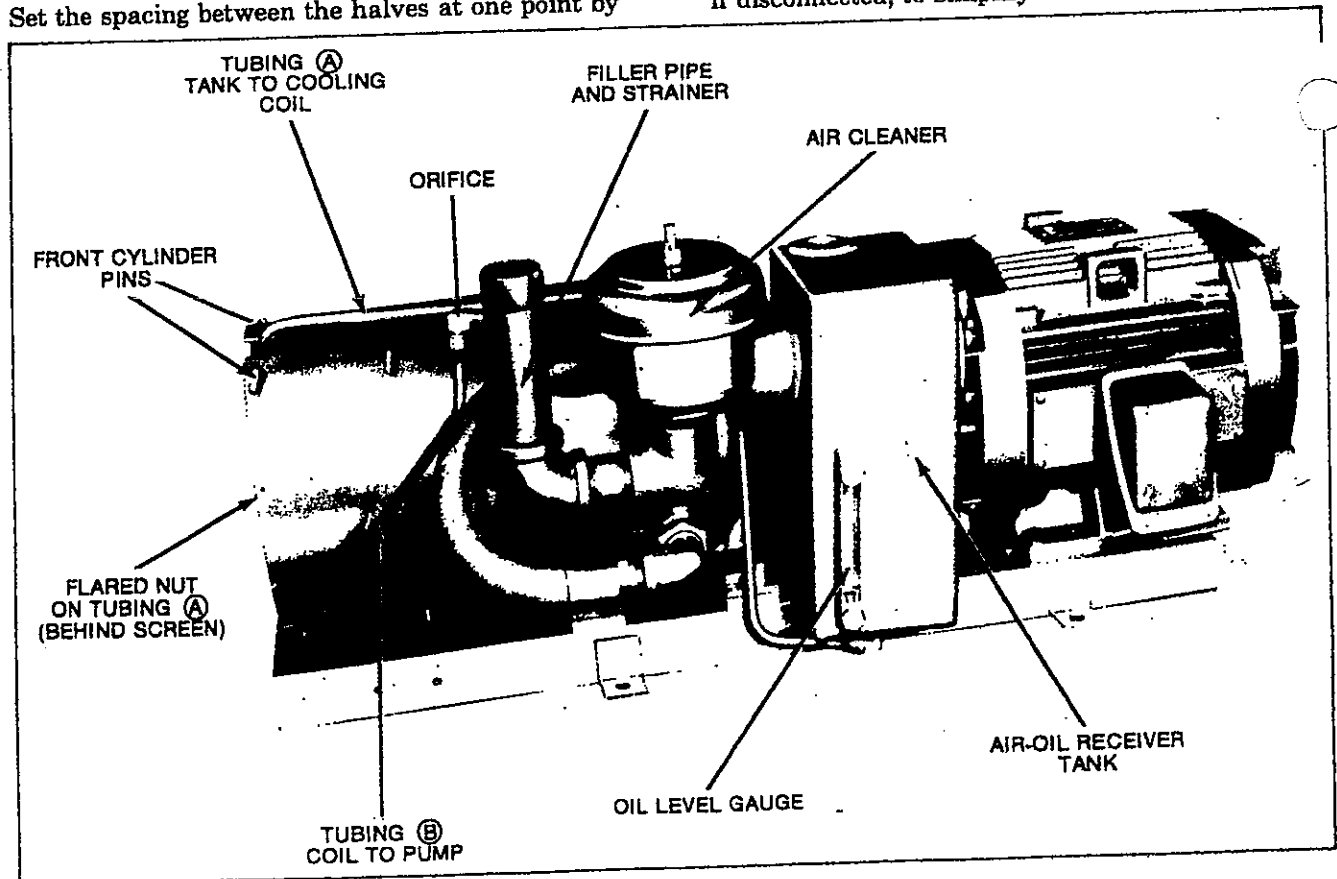


FIGURE 7-7. AIR PUMP MODULE

DIS-MANTLING

1. Lift out the two front cylinder pins that hold screen and remove screen.
2. Disconnect the flared nut on tubing "A" (behind screen) and lift tubing "A" high enough to prevent drainage of lubricating oil from the tank.
3. Disconnect the flared nut at the orifice fitting.
4. Remove the two sheet metal screws that hold cylinder in place. One screw is located at the top rear of cylinder, the other is at the bottom front.
5. Remove entire heat exchange assembly consisting of the cylinder, the finned tubing, and the oil line "B".
6. Remove fan from air pump.
7. Disconnect flexible air line from the lube tank.
8. Remove coupling guard by pushing in on both sides until it clears clamp.
9. Loosen clamp at rear of tank and remove tank with copper tubing "A" attached.
10. Leave the rear pump bracket (coupling end) in place to aid in re-alignment of replacement

pump. Do this by removing the two cap screws that extend through the bracket into the pump housing. Temporarily leave the front bracket attached to pump.

11. Remove screws holding front bracket to base and lift off the pump with its attachments. Note location of the pipe fittings and brackets prior to removing for installation on replacement pump. If piping is dismantled be sure that the check valve is re-installed so that the gate swings towards pump.

REASSEMBLY

Reassembly should take place in reverse order of dis-assembly. With the rear pump bracket left in place, re-alignment and spacing between the pump shaft and the motor shaft is greatly simplified.

There should be approximately 7/8" space between the two shafts. Place the coupling insert between the coupling halves prior to reassembly. Check to see that both shafts rotate freely.

Refer to section on coupling alignment instructions.

If shims were used originally under either pump brackets or motor feet be sure that they are correctly re-installed.

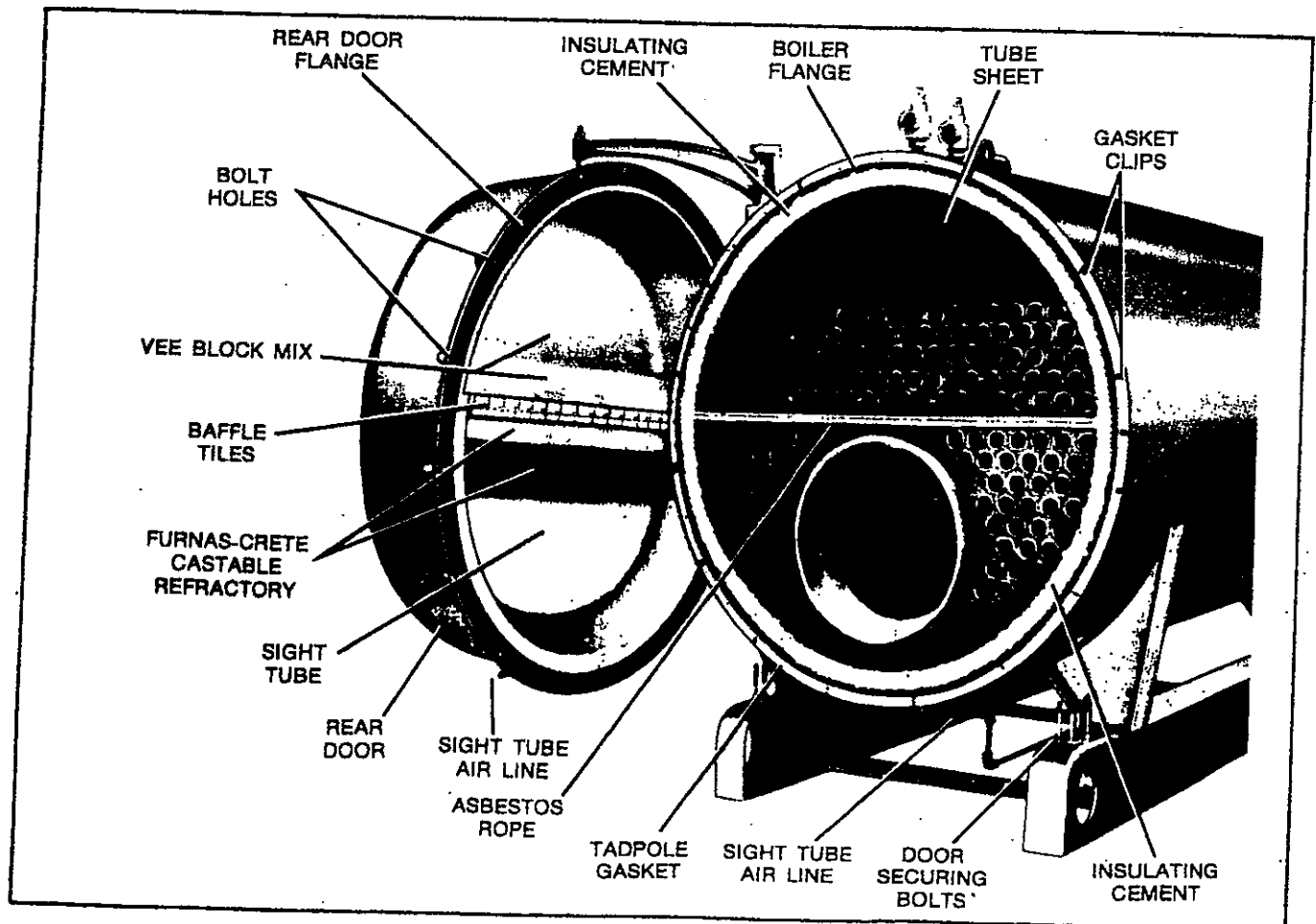


FIGURE 7-8. REAR DOOR OPEN

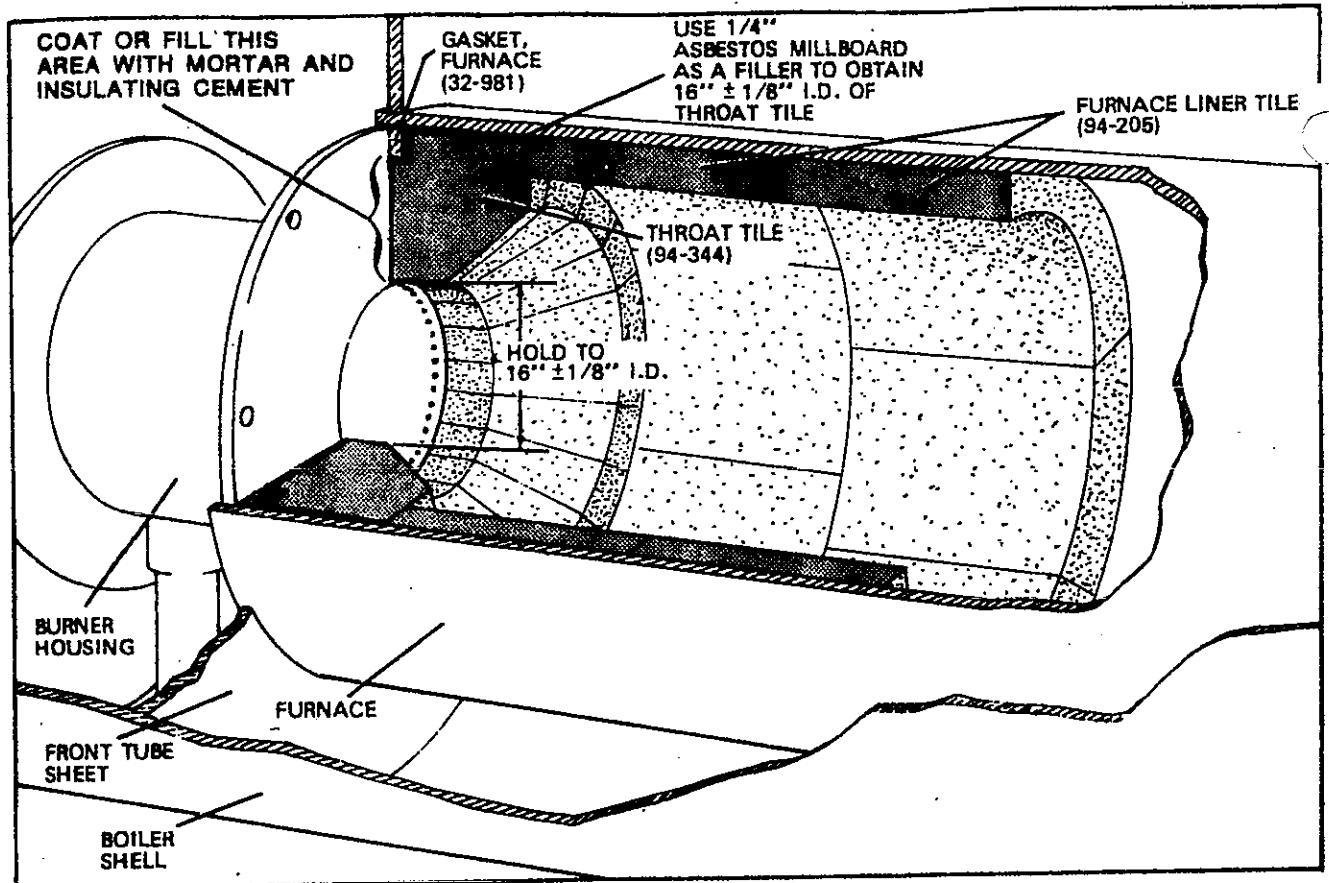


FIGURE 7-9. FURNACE LINER REFRACTORY - 400-800 HP

When re-installing the fan, slide the hub on the pump shaft so that it is bottomed. Tighten the set screw and cap screws. If the fan blades were removed from the hub, make sure that the side of the blade marked "Blower" faces the hub when re-assembling. When tightening the coupling halves or the fan hub, tighten the setscrew against the key first then tighten setscrew against the shaft. Clean or remove any dust or grime from blades prior to re-installing.

When replacing retainer screen a slight force may be required to push the cooling coil into the air cylinder so that pins may be fitted into place.

Make sure that all piping connections are tight.

If motor was replaced or if motor leads were disconnected, make sure that pump rotation is proper before starting operation. The air pump should rotate in a clockwise direction viewed from the drive shaft end.

GENERAL

Keep the motor and other components free from dust and dirt to prevent overheating and damage. Motor lubrication should follow manufacturer's recommendations.

P. REFRACTORY

The boiler is shipped with completely installed refractory. This consists of the rear head (figure 7-8), the inner door and the furnace liner (figure 7-9). 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.

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 or 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 flame.

If replacement is necessary refer to Chapter 8 and order proper replacement materials. Remove existing refractory. Thoroughly clean the furnace to remove all old refractory cement or other foreign material to insure new liner seating firmly to the steel. Inspect furnace metal for soundness. There may be metal clips welded in the furnace at the extreme end of the liner. These were installed to prevent shifting during original shipment and serve no other purpose. They are tack welded and can be removed when installing the new liner. If not removed, leave clearance between the clips and the refractory to allow for expansion in this direction.

Depending upon the design pressure of the boiler, the furnace may be of the corrugated type. Although it is not necessary to fill in the depressions, for convenience of installation some or all of the corrugation valleys may be filled with insulating cement. The liner tile should be fitted tightly against the crown of the corrugations.

Liner Installation

The furnace lining is shown in figure 7-9. The throat tile must be installed to maintain an approximate 16 inch inside diameter and be centered in the furnace. Since the thickness of the furnace metal varies with the boiler design pressure, a shim of appropriate thickness must be used to compensate for this variance. A layer or two of asbestos millboard or a bed of refractory material may be used to center the ring. The liner tile can be fitted tightly against the furnace since the inside diameter of these is not an objective.

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.

It is important to have a good seal between the burner housing and the front face of the liner. When installing the housing, liberally coat this surface with refractory cement.

Allow refractory to air dry as long as possible. If immediate use is required, fire intermittently at low rate for several hours to thoroughly dry the refractory.

For detailed information request Bulletin C10-5921.

Rear Door

The rear door is a steel shell containing horizontal

baffle tiles and lined with insulation material and castable refractory (See figure 7-8).

Burned or discolored paint on the outer surface of the door does not necessarily indicate refractory trouble, but may be an indication of other conditions 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 the flange 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. 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 a bulletin 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.

Q. 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 doors should be clean and free of any hardened cement, scale etc.

Check the condition of the asbestos 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 asbestos 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 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 7-8. 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.

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 the top and bottom bolts until both are tight. Do not overtighten. Tighten alternate bolts 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.

R. 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.

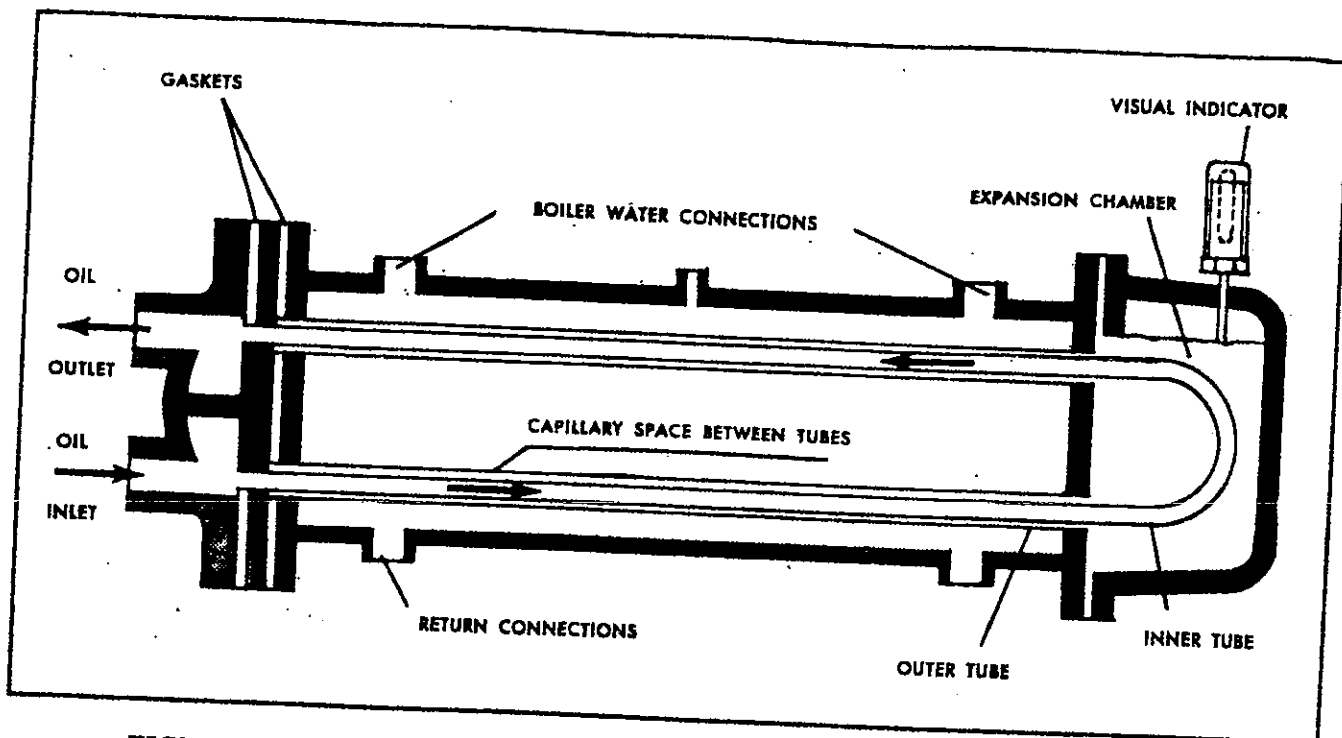


FIGURE 7-10. CIRCUIT LAYOUT OF HOT WATER OIL HEATER (ALSTROM)

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.

S. OIL HEATERS—ELECTRIC, STEAM, HOT WATER

Maintenance of these heaters consists primarily of removing the heating element from the shell and scraping any accumulation of carbonized oil or sludge deposits that may have collected on the heat exchanging surfaces.

Before breaking any of the electrical connections to the electric heating elements, mark all wires

and terminals to assure rapid and correct replacement of wires.

Finish the cleaning process with ammonia to cut all hardened deposits from the heater element. Because of the insulating effect of carbon and sludge, periodic cleaning is necessary to prevent over heating of the elements. If operation of the heater becomes sluggish examine the elements at once and clean as required.

Inspect the shell or tank each time the heater is removed. Flush all accumulated sludge and sediment from tank before re-installing the heater.

The condensate from steam oil heaters must be safely discharged to waste. This waste should be checked periodically for any traces of oil which would indicate leaking tubes within the heater.

The hot water oil heater (figure 7-10) contains a heat transfer solution. Oil flows through an inner tube while boiler water surrounds the outer tube. The space between the two tubes is filled with the heat transfer solution and is connected to a chamber on the rear of the heater. A visual indicator on this chamber reveals the presence of any oil should an oil leak occur. A 50/50 solution of permanent anti-freeze and water is generally used as the heat transfer solution, although if there is no danger of freezing, plain water may be used as a replenishment if necessary to refill.

Evidence of oil in either the steam heater condensate or in the water heater indicator demands prompt repairs.

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 boiler serial number shown on the name plate attached to the front head. Your order should state the Cleaver-Brooks part number and the name and description of the part required. State the quantity desired, and specify method of shipment. Indicate date material is required. If repair parts are required for accessory equipment, such as an electric motor, pump, etc., which may not be shown, be sure to give the complete name plate data from the item for which the parts are required.

WHERE TO ORDER PARTS — Repair or replacement parts should be ordered from your Cleaver-Brooks representative.

RETURNING PARTS FOR REPAIR — Parts to be repaired should be directed to your Cleaver-Brooks

representative. A purchase order or a letter authorizing repairs and giving complete details should be mailed to your representative. 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 stating reasons for the return and await permission and directions prior to returning the material.

Many controls and other components can be factory-rebuilt (FR) or have a trade-in value. These items are available on an exchange basis. Consult your Cleaver-Brooks representative.

Be sure to show the serial number of your unit on all parts orders and correspondence.

Cleaver Brooks®
CB® PACKAGED BOILER

MODEL SERIAL NO.

MAX. PRESSURE PSI DATE

INPUT BTU/HR GAS GPH OIL

ELECTRICAL REQUIREMENTS

MAIN POWER SUPPLY

VOLTS PH HZ AMP.

MINIMUM CIRCUIT AMPACITY AMP.

MAX. RATING OF CIRCUIT PROTECTION AMP.

BLOWER MOTOR HP

AIR COMPRESSOR MOTOR HP

OIL HEATER KW

CONTROL CIRCUIT

120 VOLTS 1 PH 60 HZ 7 AMP

OIL PUMP MOTOR

VOLTS PH HZ AMP.

CLEAVER-BROOKS DIVISION
AQUA-CHEM, INC.
MILWAUKEE, WISCONSIN, U.S.A.

118 7004

SERIAL NO. →

IT IS RECOMMENDED THAT YOUR LOCAL CLEAVER-BROOKS REPRESENTATIVE BE CONTACTED FOR PROMPT SUPPLY OF REPLACEMENT PARTS.

CB PARTS LIST

NOTE

Blank space under "Usage" indicates usage on all sizes and series covered by this manual.

| Part No. | Req. | Description | Usage |
|---------------------|------|--|-------------------|
| GASKETS | | | |
| 32-901 | 3 | Gasket, Head, Front & Rear | |
| 32-993 | 1 | Gasket, Inner Door to Housing | |
| 32-979 | 1 | Gasket, Burner | |
| 32-980 | 1 | Gasket, Support to Housing | |
| 32-981 | 1 | Gasket, Housing to Furnace | |
| 853-3 | 1 | Gasket, Rubber, 3/8" OD x 88" (Burner Support to Front Head) | |
| 853-152 | 6 | Gasket, Handhole, 3-1/4" x 4-1/2" (Asbestos) | |
| 853-618 | 1 | Gasket, Manhole, 11" x 15" (Asbestos) | |
| 853-394 | 8' | Gasket, Asbestos Tadpole (Front Baffle) | |
| 853-924 | 8' | Gasket, Asbestos Rope (Rear Baffle) | |
| 32-2327 | 1 | Gasket, Air Duct Cover | |
| 32-2328 | 8' | Gasket, Air Hood to Impeller Housing | |
| 853-899 | 9' | Gasket, Sponge Rubber, 3/4" wide x 1/2" | Air Duct |
| 841-507 | 16 | Fastener, Clip (Fastens Rear Head Gasket) | |
| 841-551 | 28 | Rivet, Split (Front Baffle and Inner Door) | |
| BURNER PARTS | | | |
| 251-75 | 1 | Nozzle, Tip and Swirler | 400 HP |
| 251-51 | 1 | Nozzle, Tip and Swirler | 500 HP |
| 251-68 | 1 | Nozzle, Tip and Swirler | 600-800 HP |
| 82-7 | 1 | Spring, Swirler | |
| 275-143 | 1 | Diffuser | |
| 435-71 | 1 | Electrode, Gas Pilot | |
| 904-36 | 1 | Grommet, Rubber, Electrode | |
| 853-1 | 1 | O-Ring, 1-1/4 OD (Electrode Gland Seal) | |
| 851-77 | 1 | Mica, Porthole | |
| 134-50 | 1 | Spider, Diffuser | |
| 90-571 | 1 | Tube, Scanner Sight | |
| 32-497 | 1 | Gasket, Scanner Tube | |
| 134-53 | 1 | Holder, Gas Pilot Electrode | |
| 435-50 | 2 | Electrode | Light Oil Pilot |
| 90-203 | 1 | Tube and Sleeve, Oil to Nozzle | |
| 853-55 | 1 | O-Ring, 5/8" OD | Oil Tube |
| 90-204 | 1 | Tube, Block to Nozzle | |
| 277-75 | 1 | Body, Nozzle | |
| 106-46 | 1 | Manifold Block | |
| 943-206 | 1 | Wrench, Nozzle | |
| 8-902 | 1 | Bracket, Light Oil Pilot Electrode | |
| 899-59 | 1 | Nozzle (Orifice) 7.0 GPH | Light Oil Orifice |
| 277-23 | 1 | Body Nozzle | Light Oil Pilot |
| 251-7 | 1 | Nozzle, Tip and Swirler | Light Oil Pilot |
| 82-34 | 1 | Spring, Swirler | Light Oil Pilot |
| 924-49 | 1' | Spring, Ignition | Light Oil Pilot |
| 94-179 | 2 | Insulator, Ignition | Light Oil Pilot |
| 40-403 | 1 | Burner Housing | Oil |
| 40-409 | 1 | Burner Housing | Gas and Gas-Oil |

| Part No. | Req. | Description | Usage |
|--|------|---|-------------------------------------|
| ELECTRICAL CONTROLS AND COMPONENTS | | | |
| 832-107 | 1 | Transformer, Ignition, 115 V/60 Hz 6,000 Sec. V | Gas Pilot |
| 832-118 | 1 | Transformer, Ignition, 115 V/60 Hz 10,000 Sec. V. | L.O. Pilot |
| 817-16 | 1 | Control, Pressure, 2-15 lb, MH L404A | L.P. |
| 817-110 | 1 | Control, Pressure, 10-150 lb, MH L404A | Power to 150 lb |
| 817-111 | 1 | Control, Pressure, 20-300 lb, MH L404A | Power Over 150 lb |
| 817-415 | 1 | Control, Pressure, 2-15 lb, MH L404C | L.P. |
| 817-109 | 1 | Control, Pressure, 10-150 lb, MH L404C | Power to 150 lb |
| 817-900 | 1 | Control, Pressure, 20-300 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 | 3 | Clip | For 817-399 |
| 904-60 | 3 | Grommet | And 817-378 Wells |
| 894-2812 | 1 | Motor, Modulating, M954C | |
| 894-2834 | 1 | Motor, Modulating, M954B | |
| 832-235 | 1 | Transformer, Damper Motor, 115/25V, 60 Cycles | |
| 836-209 | 1 | Potentiometer, MH 30112 | |
| 836-471 | 1 | Switch, Burner, DPST | |
| 836-474 | 1 | Switch, Manual-Auto, DPDT | |
| 836-223 | 1 | Switch, Oil-Gas Selector | |
| 817-436 | 1 | Switch, Air Pressure MHC645A1 | Combustion Air |
| 836-418 | 1 | Switch, Air Pressure, Dietz 161 P15 | Atomizing Air |
| 292-66 | 1 | Ignition Cable Assembly, 20" | |
| 295-94 | 1 | Ignition Cable Assembly, 23" | |
| 292-95 | 1 | Ignition Cable Assembly, 25" | |
| 836-320 | 1 | Thermoswitch, Fenwall | |
| 832-311 | 1 | Condenser, .005 MFD | |
| 836-65 | 1 | Thermostat, 100-240 degrees F, WR 11B05 | |
| 836-72 | 1 | Thermostat, 100-240 degrees F, WR 11B18 | |
| 836-89 | 1 | Switch, Micro, YZLN,RH | Burner Interlock |
| 881-226 | 2 | Neon Lamp, Clear | |
| 881-225 | 2 | Neon Lamp, Red | |
| 817-774 | 1 | Switch, Gas Pressure, C645A 3-21" WC | 400-HP LGPS |
| 817-1935 | 1 | Switch, Gas Pressure, C645B 5-35" WC | 400-HP HGPS |
| 817-751 | 1 | Switch, Gas Pressure, C437E 1/2-5 lbs. | 500-800 HP LGPS |
| 817-752 | 1 | Switch, Gas Pressure, C437D 1/2-5 lbs. | 500-800 HP HGPS |
| 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. |

| Part No. | Req. | Description | Usage |
|-------------------------------------|------|--|-----------------------|
| 833-2209 | 1 | Purge Extender - (Plug-in Module) | For CB-40 |
| | | <i>The following are used on special order or preceded the above.</i> | |
| 833-1964 | 1 | Control, Programmer, CB-2-1A | For CB-2-1A & CB-4-1A |
| 833-1965 | 1 | Control, Programmer, CB-4-1A | |
| 833-1967 | 1 | Amplifier, Infra-red, R7258A | |
| 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 | |
| 832-748 | 1 | Tube, Electron, 12BH7A | |
| | | <i>The following are factory rebuilt controls available on a trade-in exchange basis only.</i> | |
| 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) | |
| 833-1883 | 1 | Control, 6080C (FR) | |
| 833-1936 | 1 | Control, CB-3 (FR) | |
| 833-2224 | 1 | Amplifier, R7248A (FR) | |
| 833-2047 | 1 | Amplifier, R7258A (FR) | |
| 833-2225 | 1 | Purge Extender (FR) | |
| BLOWER MOTOR AND DRIVE PARTS | | | |
| 894-2626 | 1 | Motor, 10 HP, 200/3/60/3600 | 400 HP |
| 894-2627 | 1 | Motor, 10 HP, 230/460/3/60/3600 | 400 HP |
| 894-2628 | 1 | Motor, 10 HP, 575/3/60/3600 | 400 HP |
| 894-2630 | 1 | Motor, 15 HP, 200/3/60/3600 | 500 HP |
| 894-2631 | 1 | Motor, 15 HP, 230/460/3/60/3600 | 500 HP |
| 894-2632 | 1 | Motor, 15 HP, 575/3/60/3600 | 500 HP |
| 894-2634 | 1 | Motor, 20 HP, 200/3/60/3600 | 600 HP |
| 894-2635 | 1 | Motor, 20 HP, 230/460/3/60/3600 | 600 HP |
| 894-2636 | 1 | Motor, 20 HP, 575/3/60/3600 | 600 HP |
| 894-2638 | 1 | Motor, 30 HP, 200/3/60/3600 | 700 HP |
| 894-2639 | 1 | Motor, 30 HP, 230/460/3/60/3600 | 700 HP |
| 894-2640 | 1 | Motor, 30 HP, 575/3/60/3600 | 700 HP |
| 894-3193 | 1 | Motor, 50 HP, 200/3/60/3600 | 800 HP |
| 894-3173 | 1 | Motor, 50 HP, 230/460/3/60/3600 | 800 HP |
| 894-3194 | 1 | Motor, 50 HP, 575/3/60/3600 | 800 HP |
| | | NOTE: Above are normally used motors. Check name plate prior to ordering and if different than above, furnish complete data. | |
| 192-170 | 1 | Impeller, 17" | 400 HP |
| 192-171 | 1 | Impeller, 19" | 500 HP |
| 192-172 | 1 | Impeller, 21" | 600 HP |
| 192-173 | 1 | Impeller, 23" | 700 HP |
| 192-219 | 1 | Impeller, 26-3/4" | 800 HP |
| | | NOTE: Above are standard impellers. Variations may occur depending on motor selection and altitude. | |

| Part No. | Req. | Description | Usage |
|---|------|--|----------------------------------|
| WATER CONTROL PARTS | | | |
| 817-85 | 1 | Control Head Mechanism, MCD&M 150 HD | L.P. Only |
| 817-99 | 1 | Control Head Mechanism, MCD&M 150 M - HD | Power to 150 lb |
| 817-389 | 1 | Control Head Mechanism, MCD&M 194 M - HD | Power Over 150 lb |
| 836-44 | 1 | Switch, Mercury, 3 Wire, Auto Reset, SA-150-124 | L.P. |
| 836-93 | 1 | Switch, Mercury, 3 Wire, Manual Reset, SA-150M-124 | Power to 150 lb |
| 836-46 | 1 | Switch, Mercury, 2 Wire, SA-150-125 | |
| 853-268 | 1 | Gasket, Float Housing, 150-14 | |
| 851-44 | 1 | Glass, Gauge, 5/8" x 10-3/4" | Power to 150 lb |
| 851-199 | 1 | Glass, Gauge, 5/8" x 9-1/2" | Power Over 150 lb |
| 853-115 | 2 | Gasket, Gauge Glass, 5/8" | |
| 825-352 | 1 | Set, Gauge Glass Valves | |
| 825-92 | 3 | Trycock, Column, 1/2" | Power to 200 lb |
| 825-154 | 3 | Trycock, Column, 1/2" | Power Over 200 lb |
| NOTE: Above are standard controls and parts. Exceptions may exist depending on job variations. Consult local service agency or Cleaver-Brooks Parts Department, for information or exceptions and also for exchange policy on MCD&M control heads. | | | |
| GAUGES AND THERMOMETERS | | | |
| 850-3 | 1 | Gauge, 2-1/2", 0-60 lb. | |
| 850-61 | 1 | Gauge, 2-1/2", 0-100 lb. | |
| 850-237 | 1 | Gauge, 2-1/2", 0-150 lb. | |
| 850-109 | 1 | Gauge, Gas Pressure, 0-20 oz. & 0-35" | CB 400 |
| 850-580 | 1 | Gauge, Gas Pressure, 0-60" | CB 500 |
| 850-1093 | 1 | Gauge, Gas Pressure, 0-100" | CB 600-800 |
| 850-264 | 1 | Gauge, 8-1/2", 0-30 lb, 0-30" | L.P. |
| 850-104 | 1 | Gauge, 8-1/2", 0-300 lb | Power |
| 850-391 | 1 | Gauge, 3-1/2", 0-100 lb | Oil Controller |
| 937-145 | 1 | Thermometer, Stack, 5", 200-700 degrees | |
| 937-27 | 1 | Thermometer, 100-300 degrees F, 6" | Hot Water |
| 937-49 | 1 | Thermometer, 2", 50-300 degrees F | Oil Temperature |
| 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, 1/2", R400S | Gas Pilot |
| 940-648 | 1 | Valve, Gas, 4" Flanged, H118AN | |
| 945-102 | 1 | Actuator, 115 Volt, H30A | |
| 949-186 | 1 | Valve, Gas, 4" Flanged, H118AN | } Has Proof of Closure Switch |
| 945-152 | 1 | Actuator, 115 Volt, H30A | |
| 853-403 | 2 | Gasket, 4" Flange | |
| 940-165 | 1 | Valve, Gas Butterfly, 4" | Main Vent Valve (FIA) |
| 948-55 | 1 | Valve, Solenoid, 2" N.O. 821583 | For 948-55 |
| 832-895 | 1 | Coil, Solenoid, 115V | For 948-55 |
| 880-115 | 1 | Kit, Spare Parts | Main Vent Valve |
| 948-2 | 1 | Valve, Solenoid, 3/4" N.O. 8030B83 | (and FIA Pilot) |
| 832-721 | 1 | Coil, Solenoid, 115V | For 948-2 |
| 880-116 | 1 | Kit, Spare Parts | For 948-2 |
| LINKAGE PARTS | | | |
| 2-149 | 1 | Arm, Modulating Motor | |
| 10-91 | 1 | Bushing, Modulating Motor Shaft | |

| Part No. | Req. | Description | Usage |
|--------------------------------|------|---------------------------------------|--|
| 883-17 | 5 | Ball Joint | |
| 10-288 | 5 | Bushing, Ball Joint | |
| 2-160 | 2 | Arm, Jack Shaft | |
| 313-9 | 1 | Cam | |
| 82-111 | 1 | Spring, Cam | |
| 24-41 | 1 | Stem, Gas Valve Cam Linkage | |
| 82-1 | 1 | Spring, Gas Stem | |
| 287-24 | 1 | Arm, Gas Butterfly Linkage | |
| 287-5 | 1 | Arm, Gas Butterfly Actuating | |
| 82-27 | 2 | Spring, Over-Ride | |
| 882-15 | 2 | Arm, Spring Holding | |
| 2-43 | 1 | Arm, Burner Damper | |
| AIR PUMP AND LUBE PARTS | | | |
| 505-98 | 1 | Pump, Air, 5" | |
| 843-82 | 1 | Cleaner, Air | |
| 853-879 | 1 | O-Ring, Lube Tank Cover | |
| 919-124 | 3 | Pad, Steel Wool No. 3 coarse. | |
| 529-11 | 1 | Strainer | |
| 171-28 | 1 | Basket, Strainer | |
| 32-350 | 1 | Gasket, Cover | |
| 32-351 | 1 | Gasket, Cover Bolt | |
| 171-114 | 1 | Basket, Oil Inlet Filter | |
| 819-20 | 1 | Coupling, Flexible | |
| 819-56 | 1 | Insert, Flexible Coupling, L-100 | |
| 850-647 | 1 | Gauge, Oil Level | |
| 880-102 | 1 | Kit, Glass and O-Rings | |
| 894-2755 | 1 | Motor, 5 HP, 200/3/60/1750 | |
| 894-2756 | 1 | Motor, 5 HP, 230/460/3/60/1750 | |
| 894-2757 | 1 | Motor, 5 HP, 575/3/60/1750 | |
| 861-346 | 1 | Hose, Air | |
| 813-146 | 1 | Fan, Cooling | |
| 813-124 | 1 | Hub, Fan | |
| FUEL OIL COMPONENTS | | | |
| 948-155 | 1 | Valve, Solenoid, 1/2", 8266B77L | |
| 832-1066 | 1 | Coil, Solenoid, 115 V | |
| 880-107 | 1 | Kit, Spare Parts | |
| 948-153 | 1 | Valve, Solenoid, 1/4", 8262B202 | |
| 832-721 | 1 | Coil, Solenoid, 115 V | |
| 880-77 | 1 | Kit, Spare Parts | |
| 949-183 | 1 | Valve, Motorized, 1/2", HOV1A302T168 | |
| 847-1715 | 2 | Swivel Joint, 1/2" | |
| 861-226 | 1 | Hose, Oil, 1/2" x 34" | |
| 861-371 | 1 | Hose, Air, 3/4" x 39" | |
| 940-995 | 1 | Valve, Relief, 3/4", K200A | |
| 940-2296 | 1 | Valve, Relief, 3/4", VJ4 | |
| 899-51 | 1 | Nozzle, Back Pressure Orifice, 24 GPH | |
| 899-80 | 1 | Nozzle, Air Purge Orifice, 6 GPH | |
| 843-81 | 1 | Strainer, 3/4", .005" CUNO GU | |
| 853-309 | 1 | Gasket, Cover | |
| 843-13 | 1 | Cartridge, Replacement | |
| 843-244 | 1 | Strainer, 1", .008" CUNO EGU | |
| 853-310 | 1 | Gasket, Cover | |
| 843-245 | 1 | Cartridge, Replacement | |
| 923-47 | 1 | Strainer, Oil, 2" Morrison | |
| 853-316 | 1 | Gasket, Morrison Strainer | |
| 930-8 | 1 | Basket, 10 Mesh, Morrison | |
| | | | For 948-155 For 948-155 Light Oil Pilot/Air Purge For 948-153 For 948-153 FM |
| | | | Light Oil Heavy Oil Light Oil Heavy Oil Light Oil For 843-81 For 843-81 Heavy Oil For 843-244 For 843-244 Suction Line |
| | | | Heavy Oil |

| Part No. | Req. | Description | Usage |
|--|------|---|--|
| 923-290 | 1 | Basket, 40 Mesh, Morrison <i>The following 6 items are applicable to 400, 500, 600 HP boilers that had the oil valve and air purge valve built into the fuel oil controller.</i> | Light Oil |
| 940-1491 | 1 | Valve, Solenoid, Oil | 400-600 Series For 940-1491 |
| 832-297 | 1 | Coil, Solenoid, 115 V | For 940-1491 |
| 880-73 | 1 | Kit, Repair, Solenoid Valve | 400-600 Series |
| 940-1514 | 1 | Valve, Solenoid, Air Purge | For 940-1514 |
| 832-721 | 1 | Coil, Solenoid, 115 V | For 940-1514 |
| 880-77 | 1 | Kit, Repair, Solenoid Valve | For 940-1514 |
| REPLACEMENT PARTS FUEL OIL CONTROLLER (SEE FIGURES 1-5 and 1-6) | | | |
| 313-9 | 1 | Cam (Includes Spring and Setscrews) | 400 HP 500-700 HP 800 HP |
| 82-111 | 1 | Spring, Cam | |
| 24-46 | 1 | Stem, Metering Valve, No. 6 | |
| 24-44 | 1 | Stem, Metering Valve, No. 7 | |
| 24-51 | 1 | Stem, Metering Valve, No. 8 | |
| 82-1 | 1 | Spring, Stem | |
| 908-113 | 1 | Kit, Packing, Metering Stem | |
| 850-391 | 1 | Gauge, 3-1/2", 0-100 lbs. (Back Connection) | |
| 937-49 | 1 | Thermometer, 2", 50-300 degrees | |
| 945-104 | 1 | Diaphragm, Set of 2 | |
| 32-1296 | 1 | Gasket, Diaphragm | Controller Reducing Valve |
| 880-75 | 1 | Kit, Repair Parts (Includes Two Items Above) | |
| 194-80 | 1 | Diaphragm, Assembly | |
| 32-1291 | 1 | Gasket, Diaphragm | Controller Back Pressure Valve |
| 880-76 | 1 | Kit, Repair Parts (Includes Two Items Above) | |
| 48-201 | 1 | Orifice, Metering Valve | |
| 48-205 | 1 | Orifice, Metering Valve | |
| 82-72 | 1 | Spring, Orifice Retainer | |
| 32-1248 | 1 | Gasket, Orifice Spring Cover | |
| 66-113 | 1 | Packing, Manual Valve Stem | |
| REFRACTORY | | | |
| 94-344 | 35 | Tile, Throat | 400-500 HP High Pressure 400-500 HP Low Pressure 600-800 HP High Pressure 600-800 HP Low Pressure |
| 94-205 | 33 | Tile, Furnace Liner | |
| 94-205 | 35 | Tile, Furnace Liner | |
| 94-205 | 49 | Tile, Furnace Liner | |
| 94-205 | 52 | Tile, Furnace Liner | |
| 872-469 | 1 | Shim, Throat Tile, Millboard (1/4" x 7" x 24') | |
| 94-189 | 19 | Tile, Rear Baffle | |
| 872-47 | 1 | Cement, Refractory (50 lb drum) | |
| 872-96 | 1 | Cement, Furnas-Crete (100 lb bag) | |
| 872-162 | 1 | Cement, Vee-Block Mix (50 lb bag) | |
| 872-26 | 1 | Cement, Insulating (Bulk Quantity) | |
| 465-167 | 1 | Door, Front Inner, Insulated | |
| NOTE: For rear door refractory repairs consult your local service agency or Cleaver-Brooks Parts Department. | | | |

| Part No. | Req. | Description | Usage |
|--|------|---|---------------------|
| OIL HEATING EQUIPMENT | | | |
| 832-509 | 1 | Heater, Electric, 7-1/2 KW, 230 Volt | Steam Boiler |
| 832-510 | 1 | Heater, Electric, 7-1/2 KW, 460 Volt | Steam Boiler |
| 832-520 | 1 | Heater, Electric, 7-1/2 KW, 550 Volt | Steam Boiler |
| 832-981 | 1 | Heater, Electric, 10 KW, 230 Volt | Steam Boiler |
| 832-982 | 1 | Heater, Electric, 10 KW, 460 Volt | Steam Boiler |
| 832-983 | 1 | Heater, Electric, 10 KW, 550 Volt | Steam Boiler |
| 832-940 | 1 | Heater, Electric, 10 KW, 208 Volt | Hot Water Boiler |
| 832-941 | 1 | Heater, Electric, 10 KW, 240 Volt | Hot Water Boiler |
| 832-942 | 1 | Heater, Electric, 10 KW, 480 Volt | Hot Water Boiler |
| 832-943 | 1 | Heater, Electric, 10 KW, 550 Volt | Hot Water Boiler |
| 853-692 | 1 | Gasket, Electric Heater | |
| 32-2394 | 1 | Gasket, O-Ring Backup | |
| 652-24 | 1 | Heater, Steam (Less Electric Heater) | |
| 534-277 | 1 | Tube Bundle, Outer | Steam Heater |
| 191-1356 | 1 | Tube Bundle, Inner | Steam Heater |
| 32-1106 | 2 | Gasket, Tube Sheet, Outer | Steam Heater |
| 32-1105 | 1 | Gasket, Tube Sheet, Inner | Steam Heater |
| 91-45 | 8 | Washer, Copper | Electric Heater |
| 934-59 | 1 | Steam Trap, 3/4" | |
| 817-260 | 1 | Regulator, Steam, 1/2", 11-016 | 150 PSI Steam |
| 880-93 | 1 | Kit, Repair Parts, for Steam Regulator | |
| 817-330 | 1 | Regulator, Steam, 1/2", Fisher 95H | 150-250 PSI Steam |
| 948-222 | 1 | Valve, Solenoid, 1/2", Gen. Cont. S401A | High Pressure Steam |
| 948-65 | 1 | Valve, Solenoid, 3/4", Asco 8210 | Low Pressure Steam |
| 832-1123 | 1 | Coil, Solenoid, 115 Volt | For 948-222 |
| 832-779 | 1 | Coil, Solenoid, 115 Volt | For 948-65 |
| 880-80 | 1 | Kit, Repair Parts, Solenoid Valve | For 940-515 |
| 880-94 | 1 | Kit, Repair Parts, Solenoid Valve | For 948-65 |
| OIL PUMPS | | | |
| 901-204 | 1 | Pump, Tuthill2L-C | No. 2 Oil |
| 901-1340 | 1 | Pump, Viking HL-432 | No. 6 Oil |
| 819-198 | 1 | Insert, Coupling Lovejoy L075 | |
| 819-203 | 1 | Coupling Half, 7/16", Lovejoy L075 | Pump Shaft |
| 819-200 | 1 | Coupling Half, 5/8", Lovejoy L075 | Motor Shaft |
| 809-147 | 1 | V-Belt, A46S | |
| 925-155 | 1 | Seal, Mechanical, Viking | For 901-1340 |
| 529-11 | 1 | Strainer, Oil | No. 2 Oil |
| 171-28 | 1 | Basket, Strainer | For 529-11 |
| 32-350 | 1 | Gasket, Strainer Cover | For 529-11 |
| 32-351 | 1 | Gasket, Strainer Bolt | For 529-11 |
| 923-47 | 1 | Strainer, Oil, 2", Morrison | No. 6 Oil |
| 930-8 | 1 | Basket, 2" Strainer | For 923-47 |
| 853-316 | 1 | Gasket, 2" Strainer | For 923-47 |
| <p>The above are standard pumps. There are many variations and it is not practical to list exceptions or the various motors. When ordering give complete nameplate data.</p> | | | |

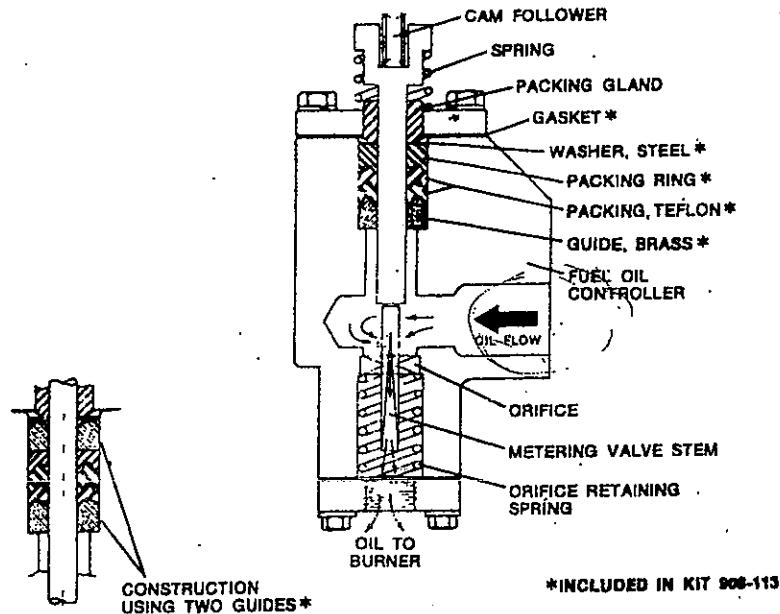
| Part No. | Req. | Description | Usage |
|------------------------------|------|---|---------------------|
| OIL HEATING EQUIPMENT | | | |
| 832-509 | 1 | Heater, Electric, 7-1/2 KW, 230 Volt | Steam Boiler |
| 832-510 | 1 | Heater, Electric, 7-1/2 KW, 460 Volt | Steam Boiler |
| 832-520 | 1 | Heater, Electric, 7-1/2 KW, 550 Volt | Steam Boiler |
| 832-981 | 1 | Heater, Electric, 10 KW, 230 Volt | Steam Boiler |
| 832-982 | 1 | Heater, Electric, 10 KW, 460 Volt | Steam Boiler |
| 832-983 | 1 | Heater, Electric, 10 KW, 550 Volt | Steam Boiler |
| 832-940 | 1 | Heater, Electric, 10 KW, 208 Volt | Hot Water Boiler |
| 832-941 | 1 | Heater, Electric, 10 KW, 240 Volt | Hot Water Boiler |
| 832-942 | 1 | Heater, Electric, 10 KW, 480 Volt | Hot Water Boiler |
| 832-943 | 1 | Heater, Electric, 10 KW, 550 Volt | Hot Water Boiler |
| 853-692 | 1 | Gasket, Electric Heater | |
| 32-2394 | 1 | Gasket, O-Ring Backup | |
| 652-24 | 1 | Heater, Steam (Less Electric Heater) | |
| 534-277 | 1 | Tube Bundle, Outer | Steam Heater |
| 191-1356 | 1 | Tube Bundle, Inner | Steam Heater |
| 32-1106 | 2 | Gasket, Tube Sheet, Outer | Steam Heater |
| 32-1105 | 1 | Gasket, Tube Sheet, Inner | Steam Heater |
| 91-45 | 8 | Washer, Copper | Electric Heater |
| 934-59 | 1 | Steam Trap, 3/4" | |
| 817-260 | 1 | Regulator, Steam, 1/2", 11-016 | 150 PSI Steam |
| 880-93 | 1 | Kit, Repair Parts, for Steam Regulator | |
| 817-330 | 1 | Regulator, Steam, 1/2", Fisher 95H | 150-250 PSI Steam |
| 948-222 | 1 | Valve, Solenoid, 1/2", Gen. Cont. S401A | High Pressure Steam |
| 948-65 | 1 | Valve, Solenoid, 3/4", Asco 8210 | Low Pressure Steam |
| 832-1123 | 1 | Coil, Solenoid, 115 Volt | For 948-222 |
| 832-779 | 1 | Coil, Solenoid, 115 Volt | For 948-65 |
| 880-80 | 1 | Kit, Repair Parts, Solenoid Valve | For 940-515 |
| 880-94 | 1 | Kit, Repair Parts, Solenoid Valve | For 948-65 |
| OIL PUMPS | | | |
| 901-204 | 1 | Pump, Tuthill2L-C | No. 2 Oil |
| 901-1340 | 1 | Pump, Viking HL-432 | No. 6 Oil |
| 819-198 | 1 | Insert, Coupling Lovejoy L075 | |
| 819-203 | 1 | Coupling Half, 7/16", Lovejoy L075 | Pump Shaft |
| 819-200 | 1 | Coupling Half, 5/8", Lovejoy L075 | Motor Shaft |
| 809-147 | 1 | V-Belt, A46S | |
| 925-155 | 1 | Seal, Mechanical, Viking | For 901-1340 |
| 529-11 | 1 | Strainer, Oil | No. 2 Oil |
| 171-28 | 1 | Basket, Strainer | For 529-11 |
| 32-350 | 1 | Gasket, Strainer Cover | For 529-11 |
| 32-351 | 1 | Gasket, Strainer Bolt | For 529-11 |
| 923-47 | 1 | Strainer, Oil, 2", Morrison | No. 6 Oil |
| 930-8 | 1 | Basket, 2" Strainer | For 923-47 |
| 853-316 | 1 | Gasket, 2" Strainer | For 923-47 |
| | | The above are standard pumps. There are many variations and it is not practical to list exceptions or the various motors. When ordering give complete nameplate data. | |

| Part No. | Req. | Description | Usage |
|----------------------|------|---|--|
| SAFETY VALVES | | | |
| | | Because of the many variations in pressure settings and sizes, it is impractical to list safety or relief valves. Furnish nameplate data of existing valve when ordering replacement. | |
| MISCELLANEOUS | | | |
| 814-7 | 1 | Brush, Flue, 2-3/8" | Rear Door |
| 550-42 | 1 | Window, Observation | |
| 851-26 | 1 | Glass, Pyrex | Head Bolts |
| 853-213 | 2 | Gasket, Sight-Hole | |
| 868-819 | 27 | Capscrew, 7/8" x 6" | |
| 51-162 | 27 | Nut, Headbolt, 7/8" | |
| 317-60 | 6 | Cover, Handhole, 3-1/4" x 4-1/2" | |
| 104-449 | 6 | Yoke, Handhole | 15 PSI and Hot Water Power Boiler (U.S.) Power Boiler (Canada) |
| 958-48 | 6 | Yoke, Handhole | |
| 958-49 | 6 | Yoke, Handhole | |

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.

| <u>CONTROL MODEL</u> | <u>CLEAVER-BROOKS BULLETIN NO.</u> | <u>MANUFACTURER'S BULLETIN NO.</u> |
|----------------------|------------------------------------|------------------------------------|
| CB-20 | C9-767 | — |
| CB-40 | C9-768 | — |
| CB-3 | C9-758 | — |
| 4580 | — | C-60 |
| 5022 | — | C-14 |
| 6080, 6580 | — | C-30 |



OIL METERING VALVE

INSTRUCTIONS FOR REPLACING OIL METERING VALVE PACKING

- A. Shut off the oil flow. Be sure no pressure shows on gauge.
- B. Match mark the cam hub and drive shaft. This will enable replacement of the cam in the original position and result in a minimum of cam adjustment when burner is refired.
- C. Clamp or hold the metering stem in the down position.
- D. Loosen the setscrews in the cam hub and rotate cam to a position where it does not interfere with stem removal; or, remove the cam from the shaft.
- E. Withdraw metering valve stem and spring. Do not drop or mis-handle. Check for nicks or scratches. Ensure that pin holding metering portion is not protruding. Back off the packing gland.
- F. To replace packing, it is necessary to remove the jack shaft support bracket. In most instances, the removal of the two cap screws will permit the bracket to be moved, although it may be necessary to loosen the securing bracket on the opposite end of the shaft.
- G. Remove existing packing rings and guide. (Note that either one (1) or two (2) guides are used depending upon construction.)
- H. Lightly coat the stem with grease or lubricating oil. Place new packing and guide(s) fully onto the stem, in the sequence shown on the reverse. The beveled face of the guide and teflon rings must face upward.
- I. Using the stem as a guide, insert the assembled packing into the cavity; then withdraw the stem.
- J. Replace steel washer and gasket. Put support bracket in place and secure all fastenings.
- K. Replace metering stem and spring. Lightly coat the stem with grease or lubricating oil to facilitate insertion and easy movement. Use care when inserting so that the orifice and the stem are not damaged.
- L. Snug the packing gland, but only sufficiently to place slight tension on the packing. The stem must move freely from the force of the spring:
- M. Work the stem up and down several times to insure that it is free.
- N. Depress the valve stem and replace the cam. Mate the match marks and secure the setscrews. Make sure the cam spring is centered in the roller.
- O. Restore oil flow. Test fire the burner at various firing rates making certain that the metering stem freely follows the cam.
- P. Tighten the packing gland after a period of operation, if required, to maintain proper tension on the packing. Do not overtighten.