$30.00 U.S.

OPERATING INSTRUCTIONS

CB burner®
model CN

FUEL: LIGHT OIL, HEAVY OIL, GAS OR COMBINATION

SERIES 100-200-400-600-700

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. 750-308

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. Only trained and authorized personnel should be allowed to operate, adjust or repair this equipment.

Cleaver-Brooks products are 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 standardly equipped burner 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.

Cleaver-Brooks Service Engineers, or Cleaver-Brooks authorized service representatives, present for start-up or service are present only in an advisory capacity. The operation of the burner or boiler is under the scope of work to be performed by the owner's operating personnel at the owner's risk, and under the owner's insurance protection. Recommendation for proper adjustments required to make the equipment perform can be made by these Service Engineers.

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CHAPTER 1

CHAPTER DESCRIPTION

A. THE BURNER AND CONTROL SYSTEM

The information in this manual applies to the Cleaver-Brooks Model CN burner whether it is mounted on a Cleaver-Brooks watertube boiler or installed as a conversion burner on a watertube boiler manufactured by others. In either instance the burner is functionally the same although slight modifications or piping arrangement may be required in some conversion installations.

When provided as a part of a Cleaver-Brooks watertube boiler, and on some conversions, the burner is fired into a boiler having a positive furnace pressure. The conversion burner may be installed on a boiler with a negative furnace pressure. The basic difference is in the BTU input which is somewhat greater on a negative pressure furnace.

The burner is made in seven sizes with the following input capacities:

BTU MAXIMUM INPUT

Burner Model	CB Watertube Boiler Pressurized Furnace	Negative Pressure Furnace
CN-1	52,000,000	58,000,000
CN-2	58,000,000	65,000,000
CN-3	65,000,000	72,000,000
CN-4	69,000,000	79,000,000
CN-5	76,000,000	N.A.
CN-6	82,000,000	90,000,000
CN-7	90,000,000	100,000,000

The type of fuel determines the series classification.

Series 100 — equipped to burn No. 2 oil only
Series 200 — equipped to burn No. 2 oil or gas
Series 400 — equipped to burn No. 6 oil or gas
Series 600 — equipped to burn No. 6 oil only
Series 700 — equipped to burn gas only

NOTE: Although the Series 400 or 600 burner is designed and designated to burn No. 6 oil (CS12-48) it must be recognized that the burner will handle grades 4 and 5 equally well. While this manual contains pertinent information on No. 6 fuel oil, all references to this fuel should be considered equally applicable to all grades of heavy oil.

The oil burner is of the low pressure, air atomizing (nozzle) type. The gas burner is of the nonpremix 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.

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 thru potentiometer type positioning controls. The standard control system utilizes electric positioning controls. A switch is provided to permit changeover from automatic fully modulated firing to continuous firing at any desired rate between minimum and maximum. In either case, additional safeguards

assure that the burner always returns to the minimum firing position for ignition.

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 or excess steam pressure.

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 low fire pressure switch holds the burner in the low fire position until the boiler is properly warmed up.

Combustion air is provided by a centrifugal blower mounted in the wind box of the burner. Combustion air delivery to the burner is under the control of a damper motor. This same motor regulates the flow of gas fuel thru a linkage system connected to a gas butterfly valve and the flow of oil thru a cam operated metering valve. Fuel input and air are thus properly proportioned for most efficient combustion.

For an oil fired boiler, filtered primary air for atomizing the fuel oil is furnished independently of the combustion air by a motor driven air compressor. The fuel oil pump may be mounted near the burner or at some remote location.

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

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.

The function of individual components is outlined in this chapter and the electrical sequence is covered in chapter 2.

B. CONTROLS AND FUNCTIONS

The term "control" as used here 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 function of all controls, whether or not outlined, before he can understand the burner's operation or follow the procedures outlined in this manual.

Identify and locate each item using the figure callout. A non-standard burner or one having specially ordered features may have components not listed here.

The actual controls furnished will depend upon the type of fuel for which the burner is equipped. Refer to the following applicable group or groups listed below that apply to your burner.

C. Controls common to all burners.

D. Controls for gas firing (including combination)

E. Controls for oil firing (No. 2, No. 6 oil and combination)

F. Additional controls for heavy oil

C. CONTROLS COMMON TO ALL BURNERS

(1) Forced Draft Fan (figure 1-1): Furnishes all air, under pressure, for combustion of pilot fuel and main fuel and provides purge air.

(2) Forced Draft Fan Motor (figure 1-1): Drives forced draft fan directly to provide combustion air. Also referred to as a blower motor.

(3) Forced Draft Fan Motor Starter (figure 1-4): Energizes forced draft fan (blower) motor.

(4) Ignition Transformer (figure 1-2): Provides high voltage spark for ignition of gas pilot.

(5) Modulating Motor (figure 1-2): Operates the rotary air damper and fuel valves through a cam and linkage system to provide proper air-fuel rations under all boiler load conditions.

(6) Low Fire Switch (figure 1-2): Actuated by rotation of the modulating damper motor shaft. In order for the burner to start firing in a low fire position, this switch must be closed. This is a feature which prevents burner ignition unless the modulating motor has returned the rotary air damper and modulating fuel valve to the low fire position. This switch is an integral part of the motor.

(7) Burner Switch (figure 1-4): A manually operated start-stop switch for directly starting and stopping operation of burner.

(8) Manual-Automatic Switch (figure 1-4): 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 ration through the entire firing range.

(9) Manual Flame Control (figure 1-4): A manually operated potentiometer that permits the

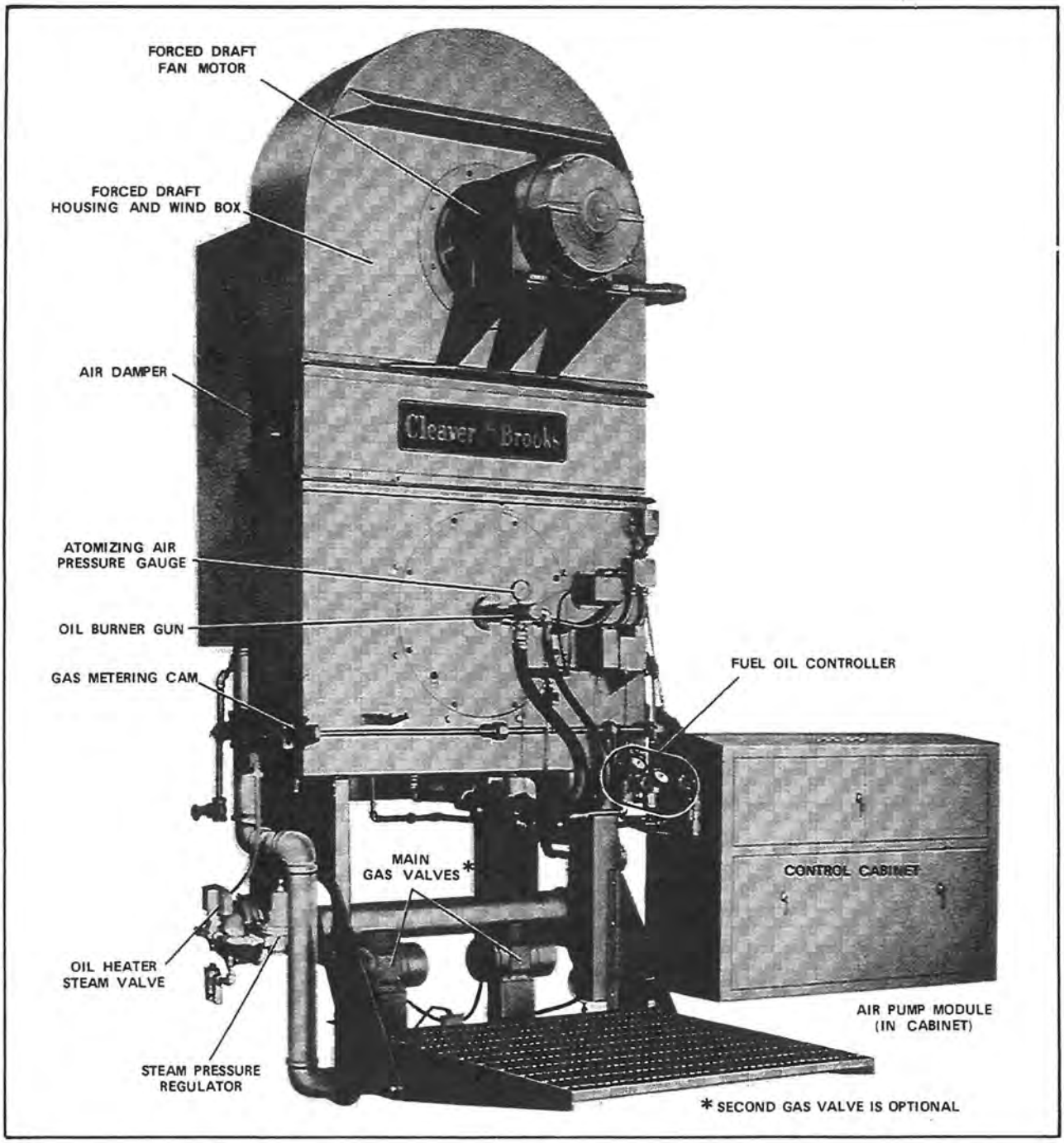


FIGURE 1-1 TYPICAL MODEL CN BURNER - NO. 6 OIL AND GAS FIRED

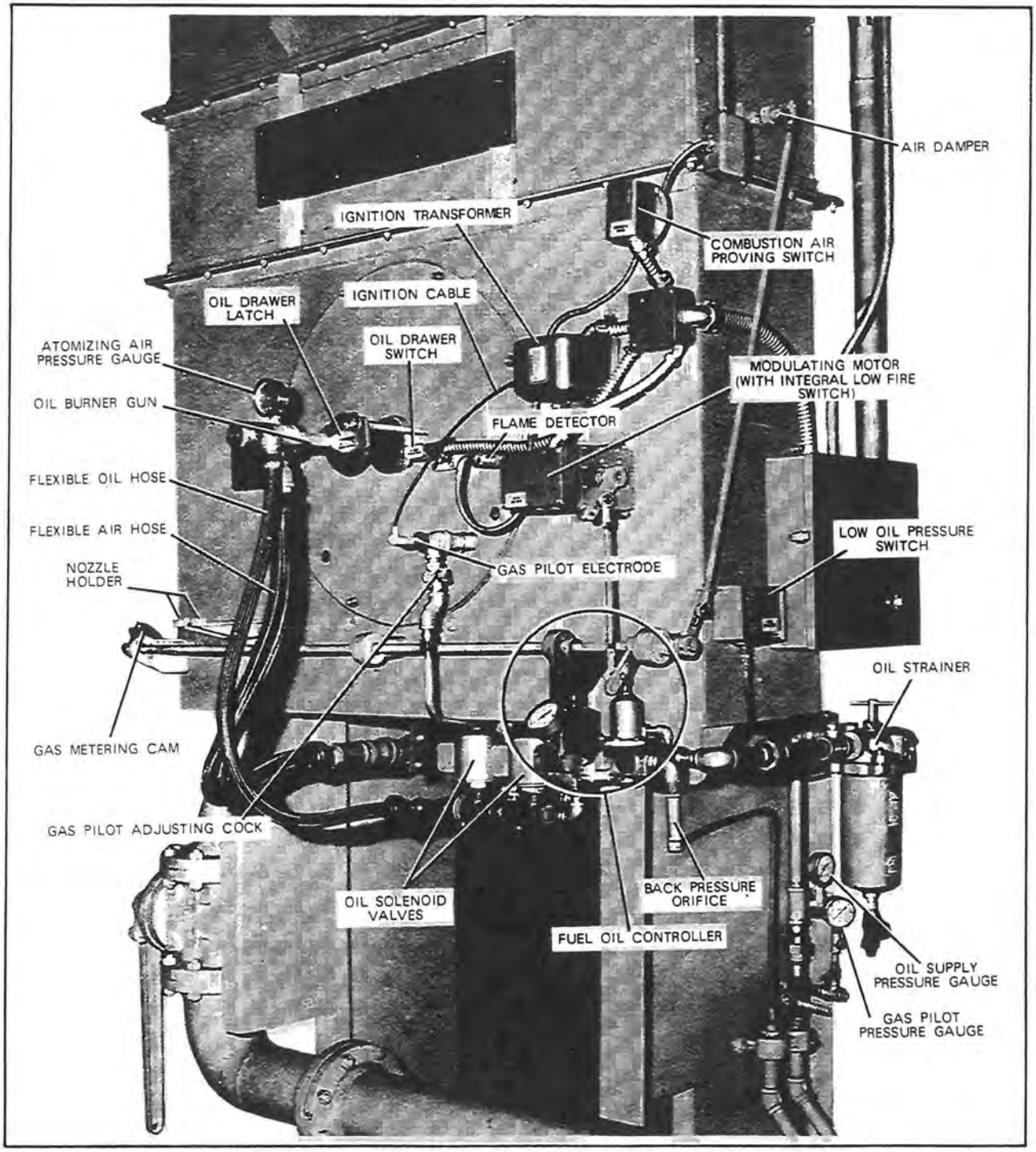


FIGURE 1-2 OIL BURNER COMPONENTS - NO. 2 OIL

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 (not shown): Reduces control circuit voltage (115VAC) to required voltage (24VAC) for operation of the modulating motor.

(11) Indicator Lights (figure 1-4): Provide visual information on operation of boiler as follows:

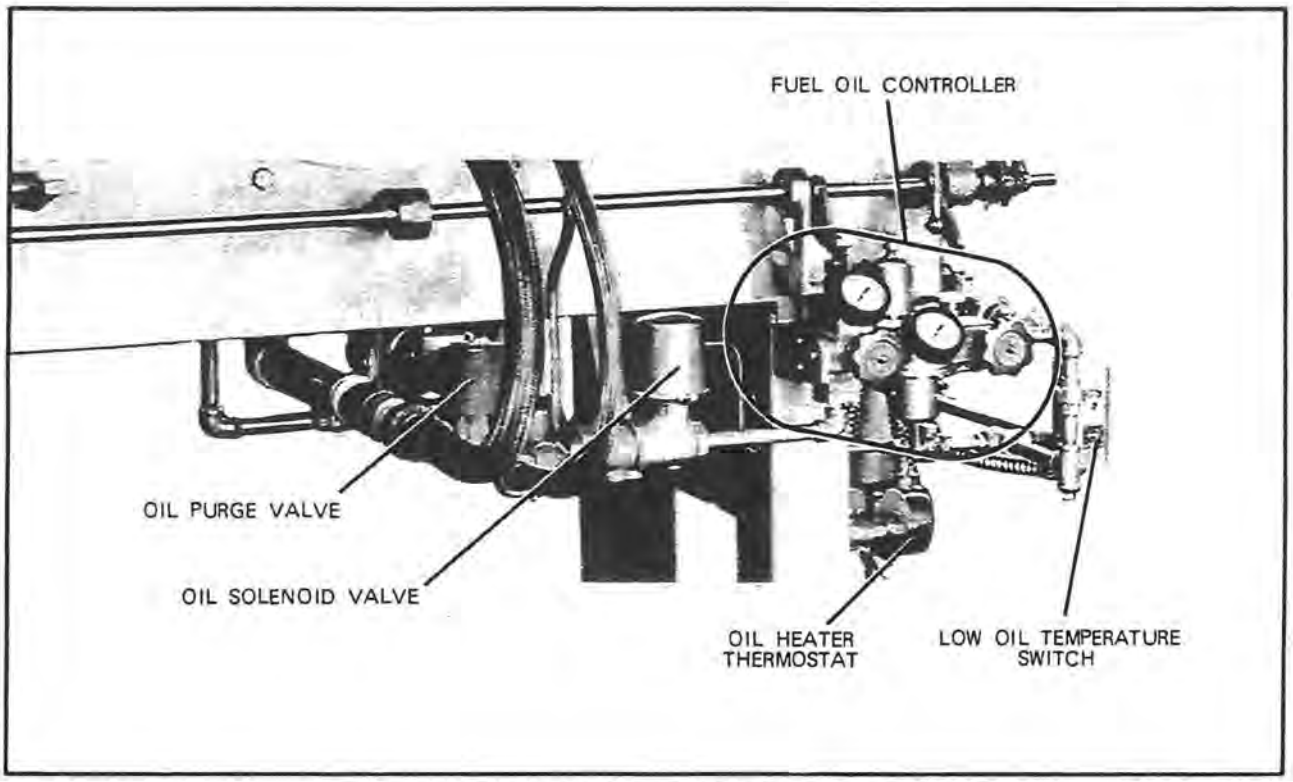


FIGURE 1-2(A) OIL BURNER COMPONENTS - NO. 6 OIL

Flame Failure
Steam Demand
Low Water
High Water

(12) Combustion Air Proving Switch (figure 1-2): A pressure sensitive switch actuated by air pressure from the forced draft fan. Its contacts close to prove presence of combustion air.

(13) Operating Limit Pressure Control (figure 1-8): 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.

(14) High Limit Pressure Control (Optional) (figure 1-8): 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. The high limit pressure control is equipped with a manual reset.

(15) Modulating Pressure Control (figure 1-8): 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.

(16) Low Fire Pressure Switch (figure 1-8): Senses boiler pressure and limits the burner to low fire operation until boiler and casing is properly warmed and pressure reaches a pre-set point.

(17) Alarm Horn (not shown): Sounds to notify the operator of a condition requiring attention.

(18) Alarm Test Switch (figure 1-4) Used to check alarm wiring system during normal operation.

(19) Rotary Air Damper (figure 1-1): This damper provides accurate control of combustion air in proportion to fuel input for various load demands.

(20) Diffuser (figure 1-3): 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.

(21) Gas-Oil Switch (figure 1-4): To manually select circuitry for either oil firing or gas firing. (combination burner only)

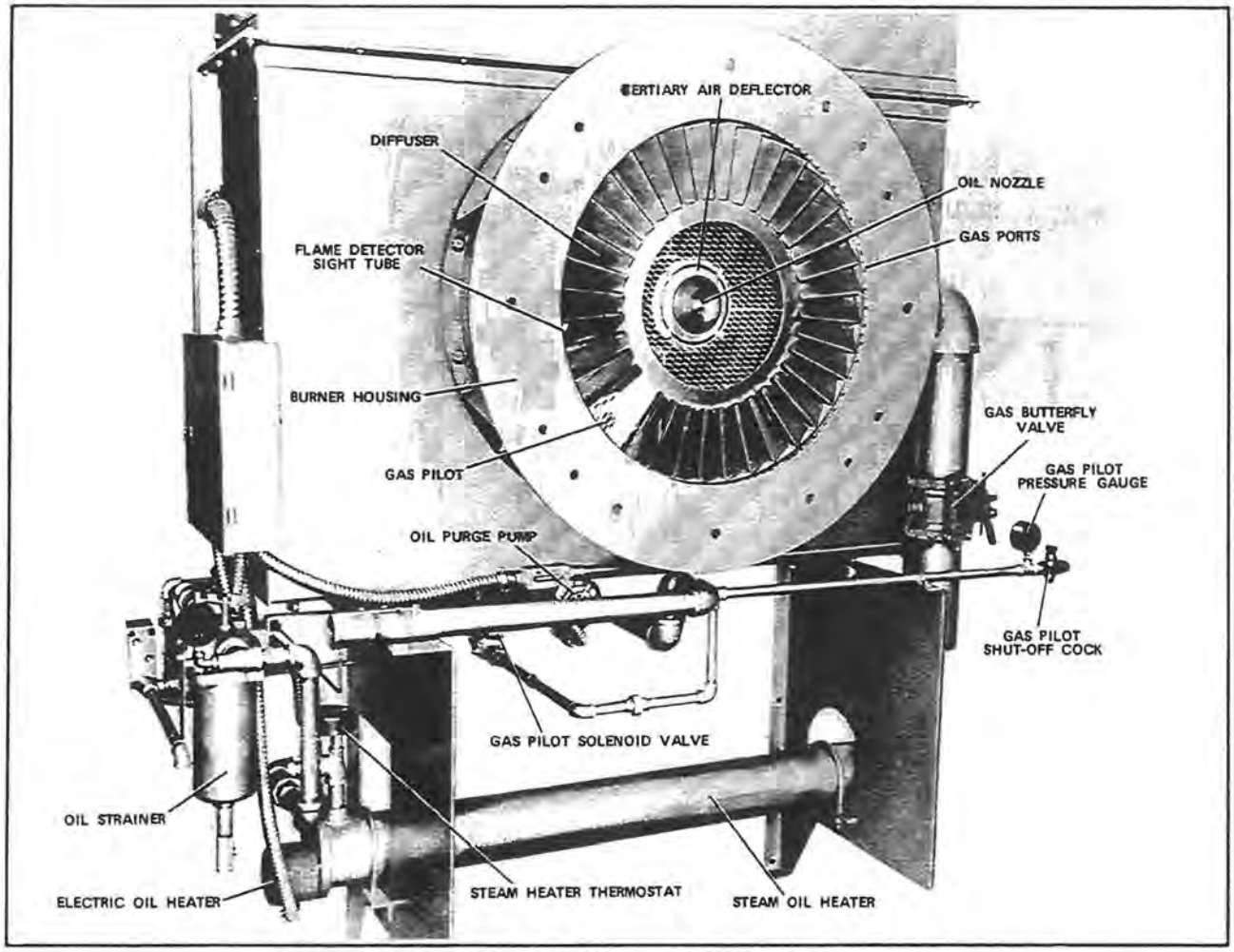


FIGURE 1-3 REAR VIEW — MODEL CN BURNER

(22) Programming and Flame Safe Guard Control (figure 1-4): 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 supervises both oil and gas flames and provides ignition and flame failure protection in the event of loss of a flame.

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 which causes a safety lockout 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:

(a) Master Relay (RL1): 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.

(b) Flame Relay (RL2): 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.

(c) Non-recycling Relay (RL3): Held in by the airflow switch(es) which must be closed during the prepurge and firing cycle. A safety lockout will occur if a control in this circuit opens during operation.

(d) Lockout Switch (LS): Trips following a loss of flame, ignition failure, or failure of the flame relay to remain in its de-energized position during the programmer's checking period. A short cooling period is required before

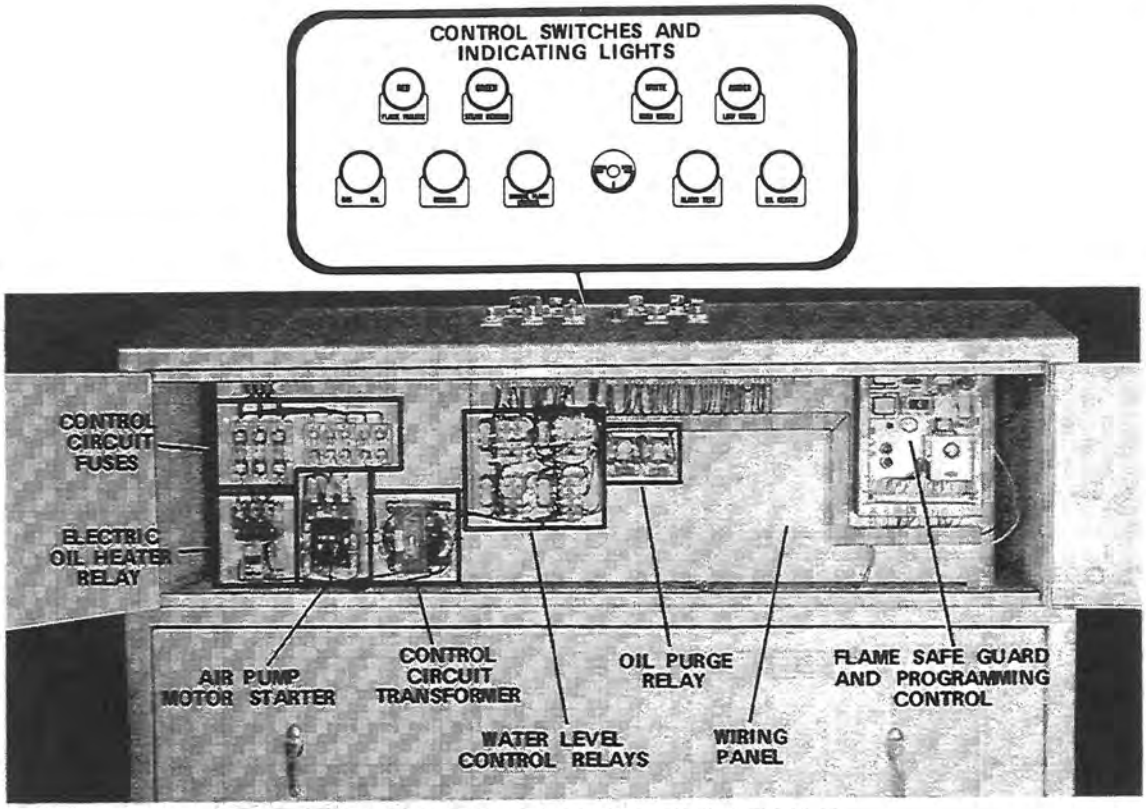


FIGURE 1-4 TYPICAL CONTROL PANEL

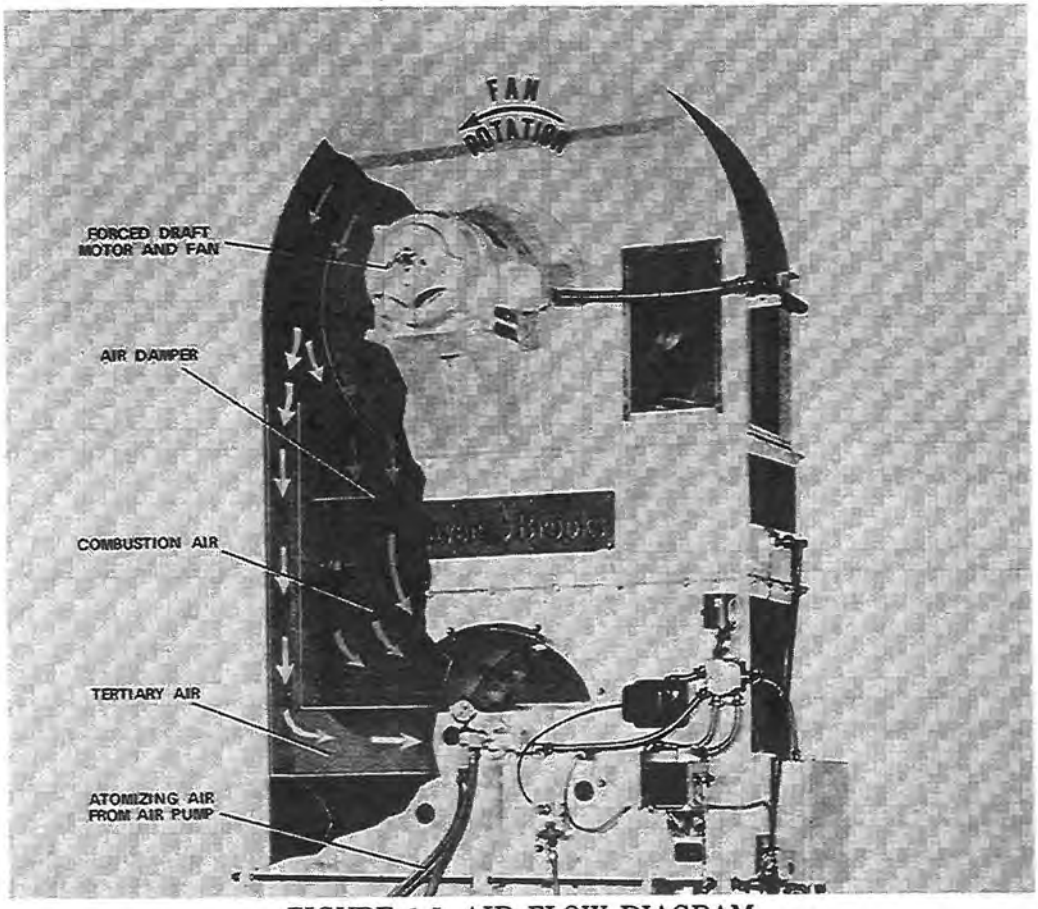


FIGURE 1-5. AIR FLOW DIAGRAM

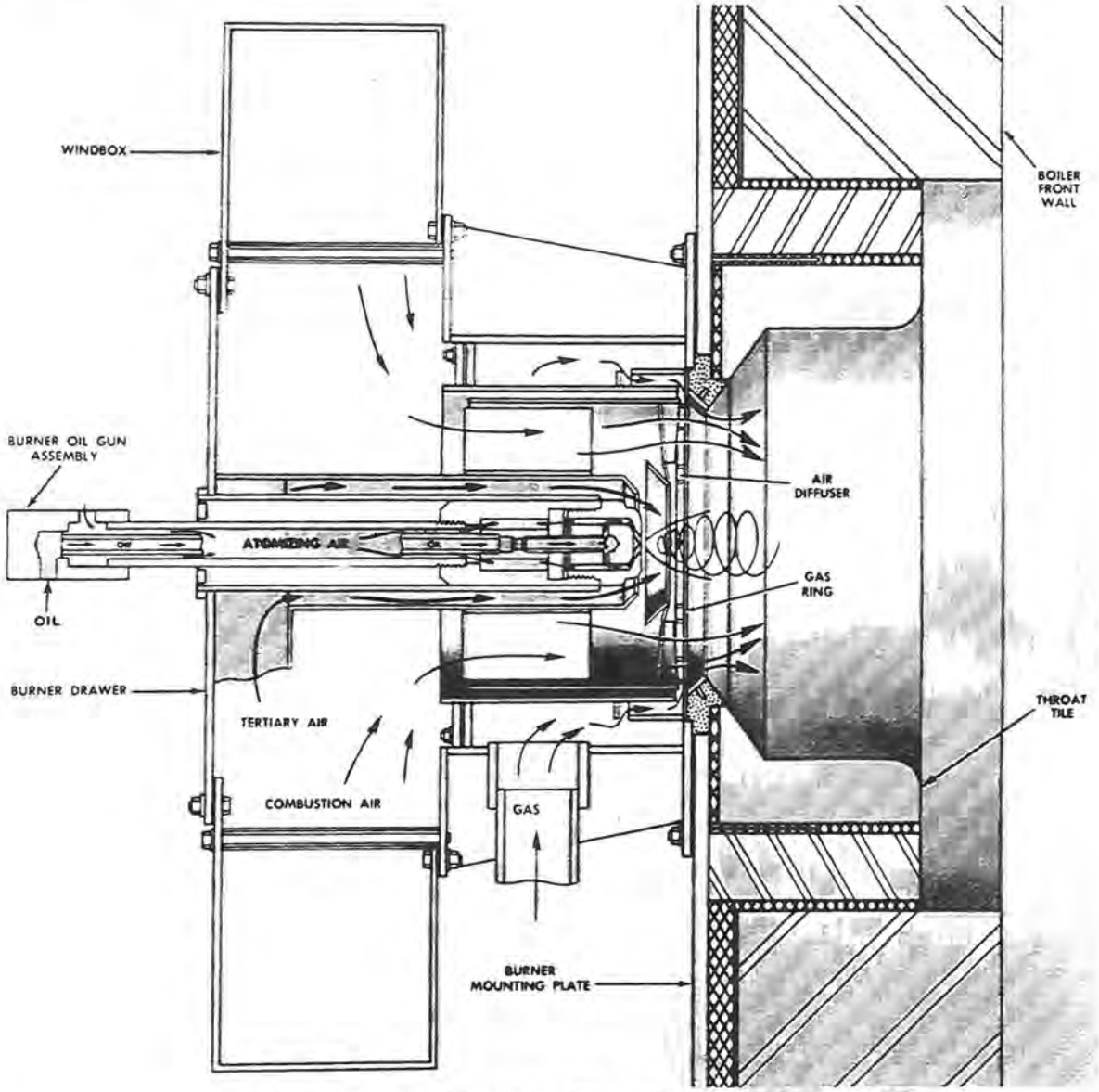


FIGURE 1-6. FUEL AND AIR FLOW DIAGRAM

it can be reset. CAUTION. The reason for any lockout should be determined and checked before the burner is again placed into operation.

(e) 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.

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

(23) Flame Detector (figure 1-2): 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 burner has a lead sulfide (infra-red sensitive) detector.

D. CONTROLS FOR GAS FIRING (INCLUDING COMBINATION)

(1) Gas Pilot Valve (figures 1-3): A solenoid valve energized to open during ignition period to admit fuel to pilot. It is closed after main flame is established. The sequence of energizing and de-energizing is determined by the timing of the programming control.

(2) Gas Pilot Shutoff Cock (figure 1-3): For manually opening or closing the pilot gas supply.

(3) Gas Pilot Adjusting Cock (figure 1-2): Provided to regulate the size of gas pilot flame.

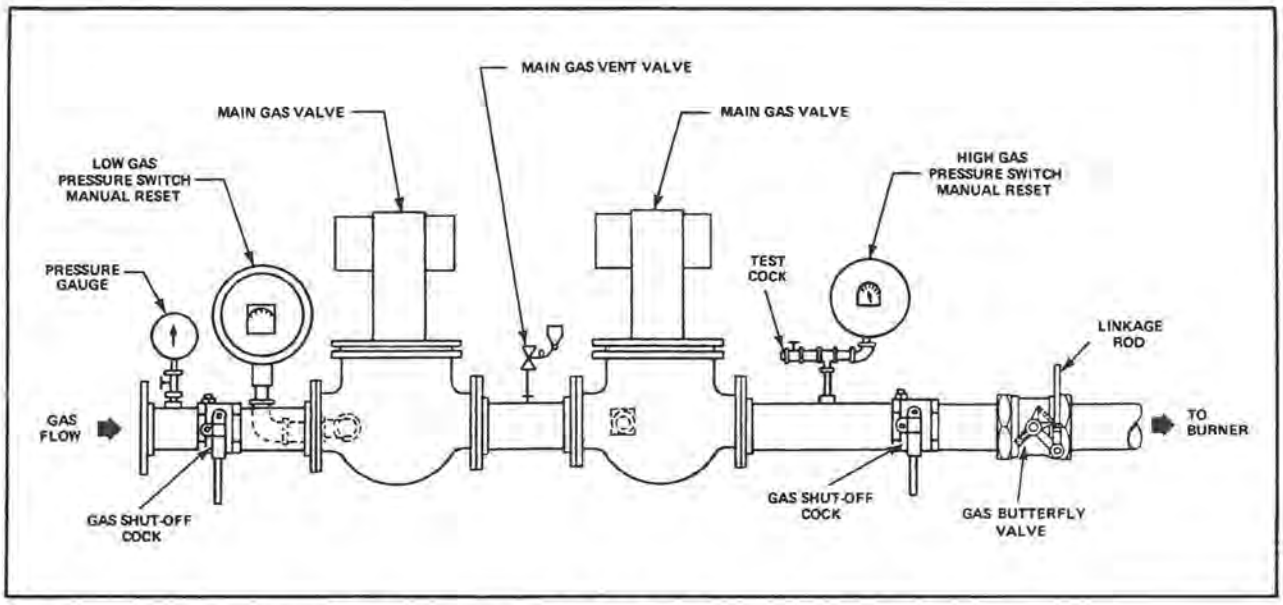


FIGURE 1-7. TYPICAL GAS TRAIN—TWO GAS VALVES

(4) Gas Pilot Pressure Gauge (figure 1-3): Indicates gas pressure to pilot.

(5) Main Gas Valve (figure 1-1): An electrically actuated shut-off valve. When opened, this motorized valve admits main flame gas through the butterfly (modulating) gas valve.

(6) Butterfly Gas Valve (figure 1-3): Valve's butterfly disc is operated by a connecting linkage actuated by the gas modulating cam to regulate the rate of gas flow to the burner.

(7) Gas Modulating Cam (figure 1-1): Assembly consisting of 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.

(8) Main Gas Cock (figure 1-7): For manual opening or closing the main fuel gas supply downstream of main gas line regulator.

OPTIONAL GAS TRAIN: (Figure 1-7)

Insurance carrier requirements may require optional equipment and additional controls for the operation of a gas-fired burner. In addition to the items listed above, the following components may be included:

(a) Additional Main Gas Cock (figure 1-7).
(b) Additional Main Gas Valve (figure 1-7).
(c) Additional Gas Pilot Valve (figure 1-7).
(d) Pilot Line Vent Valve (figure 1-7): A normally open solenoid valve for venting gas should any be present in pilot line when pilot valves are de-energized. Vent valve closes when gas pilot valves are energized.
(e) Main Gas Line Vent Valve (figure 1-7): A normally open solenoid valve for venting gas should any be present in main gas line when main gas valves are de-energized. Vent valve closes when main gas valves are energized.
(f) Low Gas Pressure Switch (figure 1-7): 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 breaking a circuit causing main gas valves to close.
(g) High Gas Pressure Switch (figure 1-7): Pressure actuated switch that is closed whenever main gas line pressure is below a preselected pressure. Should the pressure rise above this setting the switch contacts will open breaking a circuit causing main gas valves to close.
(h) Test Cocks (figure 1-7): Allow testing for leakage across main gas valve.

E. CONTROLS FOR OIL FIRING (INCLUDING COMBINATION)

(1) Oil Drawer Switch (figure 1-2): Breaks 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 4-7): 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 4-7): 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 4-7): 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 4-7): Provides air for atomization of fuel oil.

(6) Air Filter (figure 4-7): An oil bath type strainer to clean the air supply prior to entering air pump.

(7) Check Valve (figure 4-7): Prevents lubricating oil and compressed air from surging back through the pump and air filter when pump stops.

(8) Air-oil Receiver Tank (figure 4-7): 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 4-7): Indicates the level of lubricating oil in the air-oil receiver tank.

(11) Lube Oil Cooling Coil (figure 4-7): 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 4-7): 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 (not shown): 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 1-2): 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 1-9): 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 F.

(a) Oil Metering Valve: Valve metering stem moves to increase or decrease the orifice area to regulate the supply of fuel oil to the burner nozzle in accordance with boiler load variances. Movement of metering stem 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.

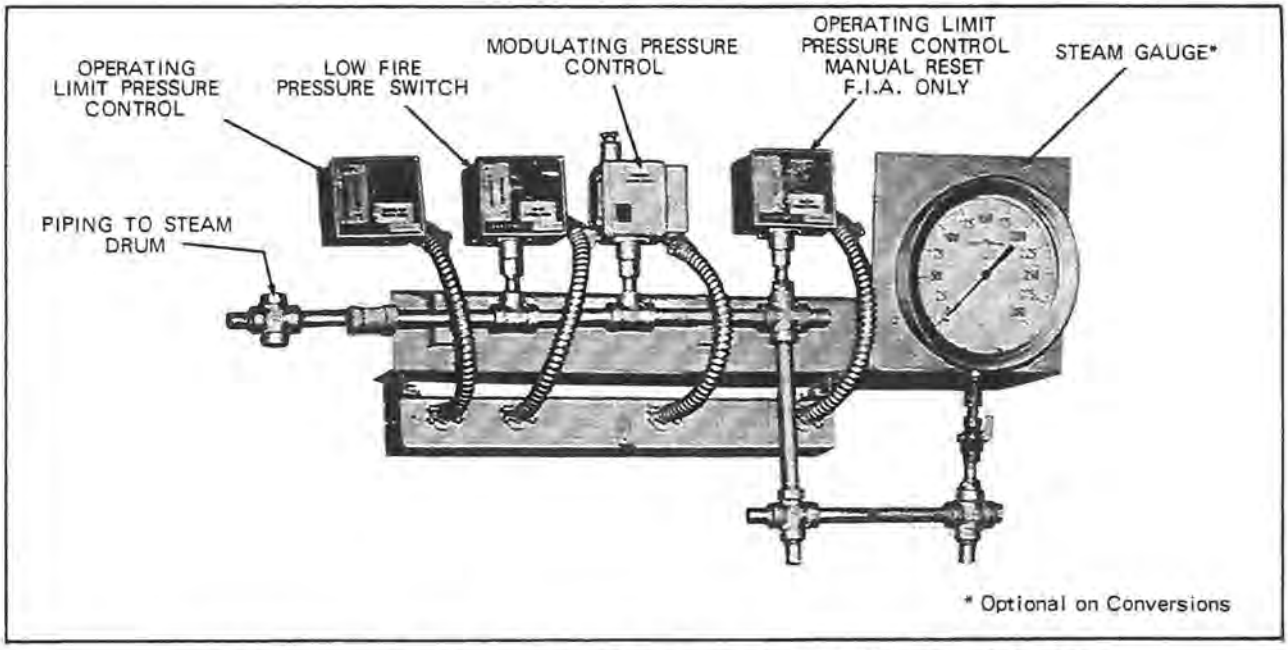


FIGURE 1-8 TYPICAL ARRANGEMENT OF PRESSURE CONTROLS

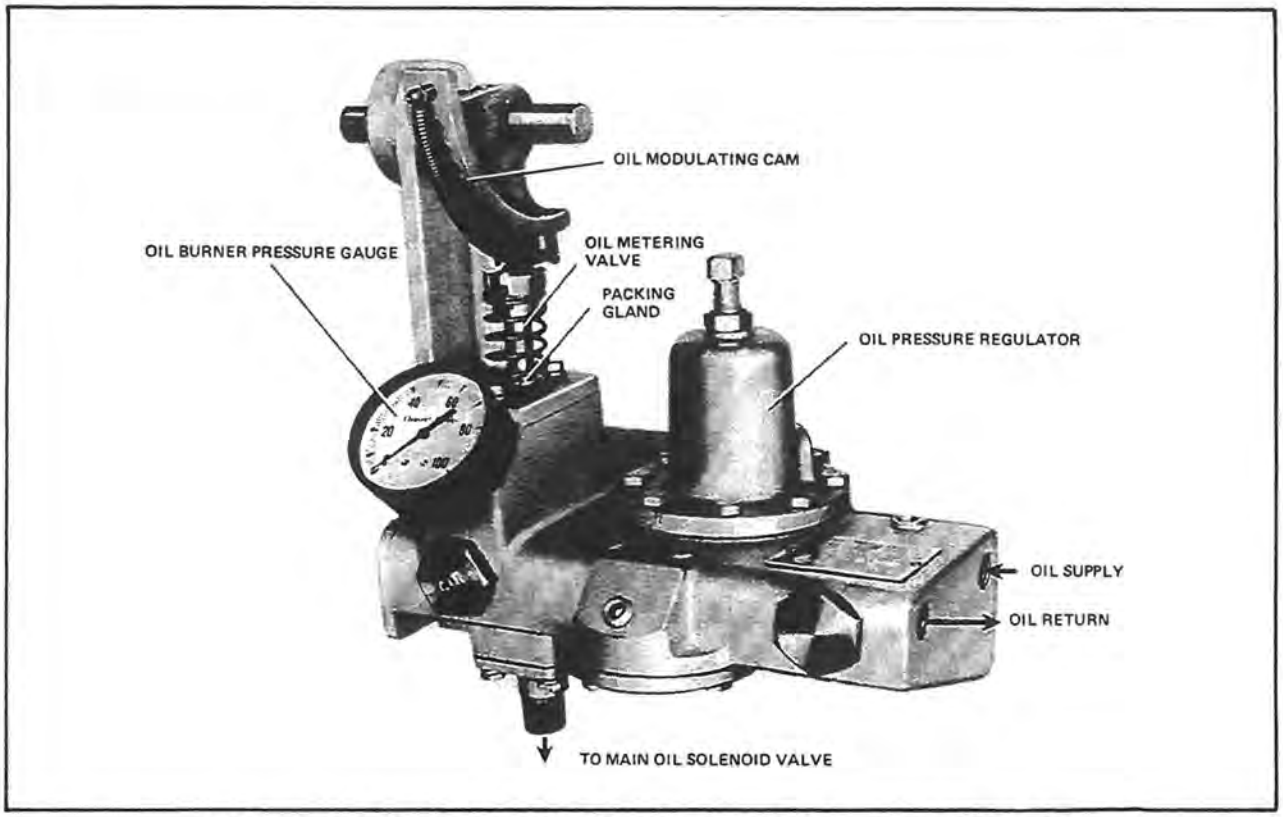


FIGURE 1-9. OIL CONTROL VALVE ASSEMBLY—FOR LIGHT OIL

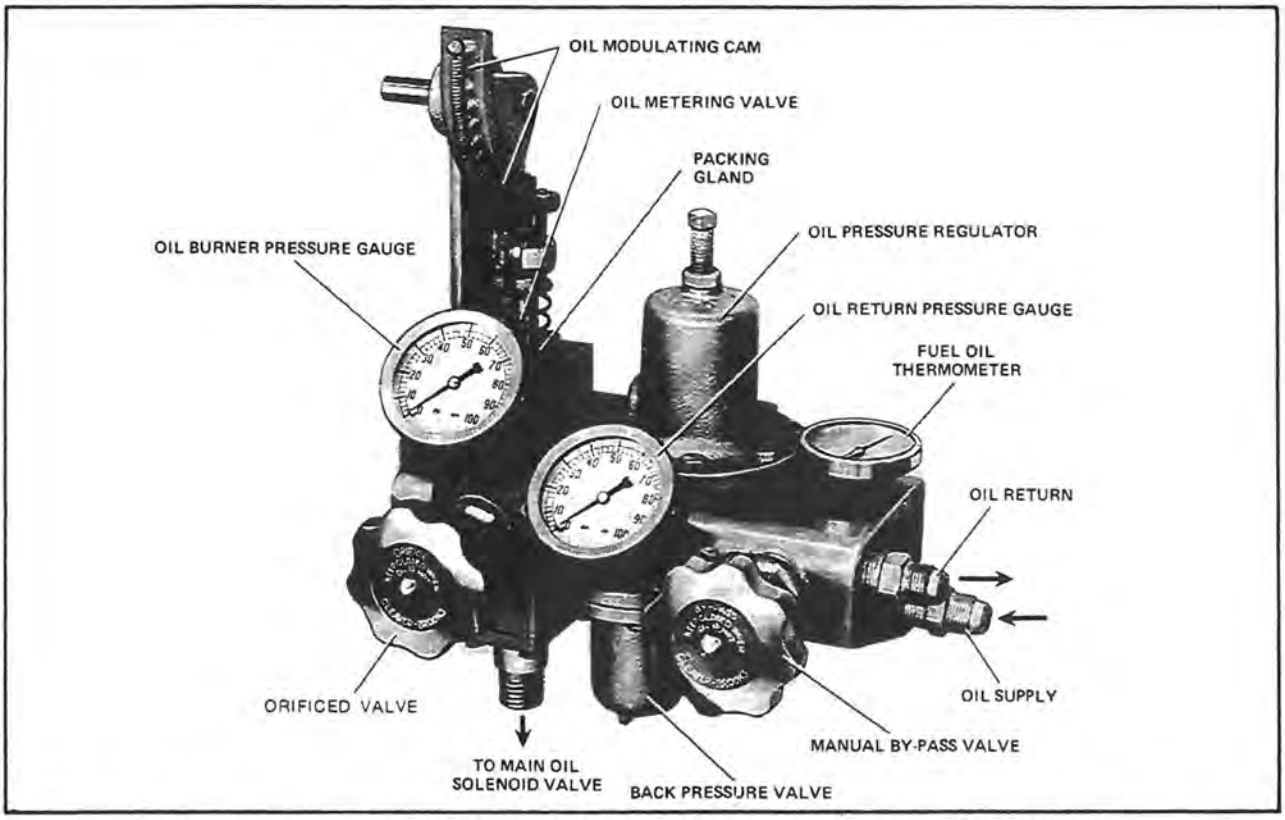


FIGURE 1-10. OIL CONTROL VALVE ASSEMBLY — FOR HEAVY OIL

(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 Strainer (figure 1-3): Provided to prevent foreign matter from entering the burner system.

(18) Oil Supply Pressure Gauge (not shown): Indicates fuel oil pressure in the oil heater and supply pressure to the fuel oil controller's pressure regulator.

(19) Gas Pilot: See Section D for description of the various components.

F. ADDITIONAL CONTROLS FOR HEAVY OIL

(1) Oil Heater Switch (figure 1-4): Manually provides power to oil heater system.

(2) Oil Heater (Electric) (figure 1-3): Used for heating sufficient fuel oil for low fire flow during cold starts before steam is available for heating. It is housed in the steam heater.

(3) Oil Heater (steam) (figure 1-3): Heats oil with steam from boiler.

(4) Oil Heater Thermostat—Electric (figures 1-2A): Senses fuel oil temperature and energizes or de-energizes the electric oil heater to maintain required temperature.

(5) Oil Heater Steam Thermostat (figure 1-3): Senses fuel oil temperature and controls the opening and closing of the steam heater valve to maintain the selected temperature.

(6) Low Oil Temperature Switch (figure 1-2A): Thermostatic switch that prevents burner from starting, or stops burner firing if fuel oil temperature is lower then required for oil burner operation.

(7) 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.

(8) Oil Heater Steam Valve (figure 1-1): A normally closed solenoid valve opened by the oil heater steam thermostat to allow flow of steam to the steam heating assembly to maintain temperature of fuel oil.

(9) Steam Heater Check Valve (not shown): Prevents oil contamination of the waterside of pressure vessel should any leakage occur in the oil heater.

(10) Steam Heater Pressure Regulator (figure 1-1): Provides means of adjusting and regulating steam pressure to the heater to properly maintain the required fuel oil temperature.

(11) Steam Trap (figure 1-12): 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 1-12): Prevents air entry during shutdown periods when cooling action may create vacuum within steam heater.

(13) Purge Solenoid Valve (figure 1-2A): This valve opens when oil solenoid closes. Purge pump then delivers oil from nozzle and hose through this valve to return line.

(14) Purge Pump (figure 1-3): A low capacity pump which runs each time the oil solenoid valve cuts off supply to the nozzle. It clears the nozzle and lines to the nozzle clear of fuel oil.

(15) In addition to the components of the fuel oil controller mentioned in Section E, the following are used with a heavy oil fired burner (See Figure 1-10).

(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.

G. AUTOMATIC IGNITION

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

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

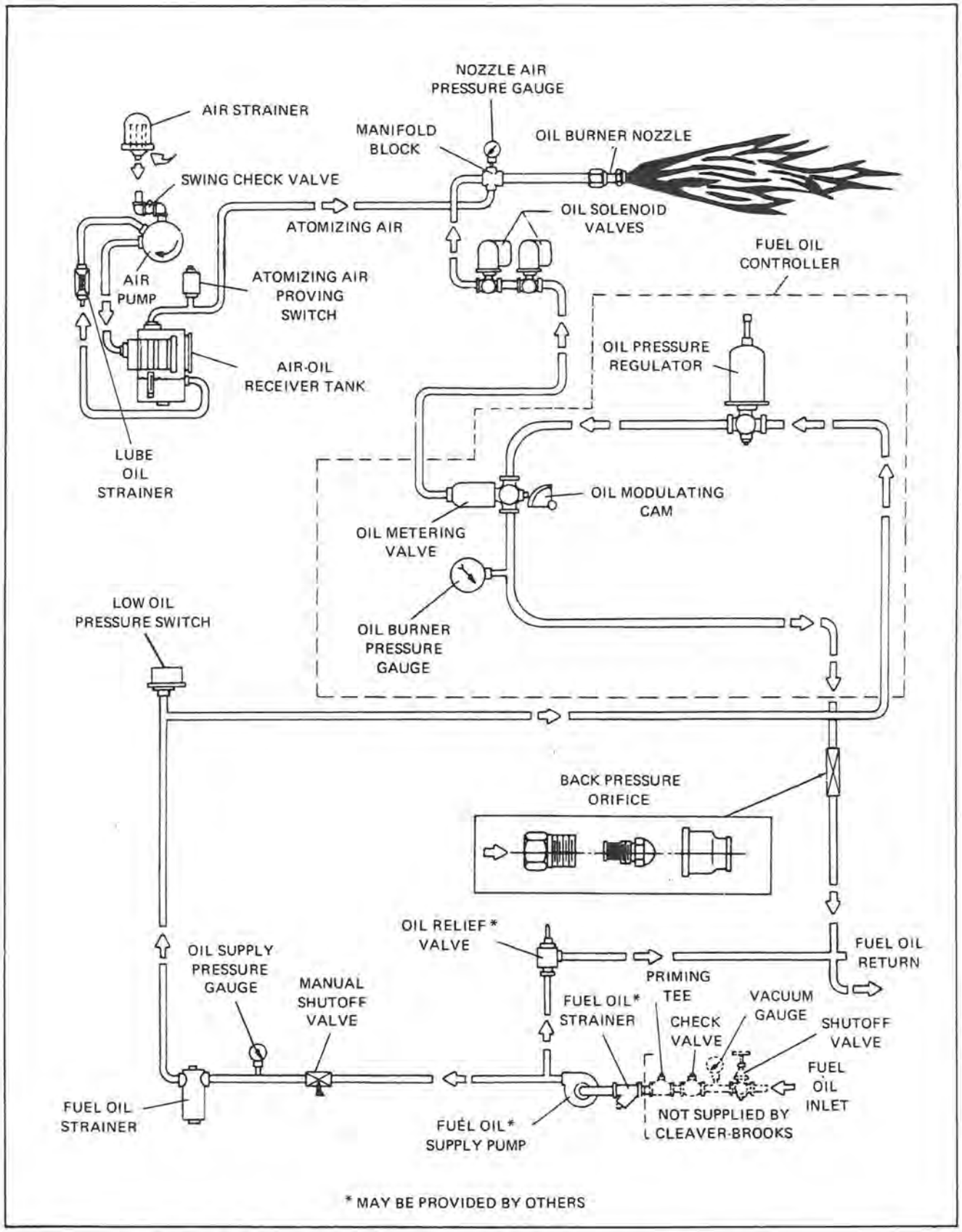


FIGURE 1-11. SCHEMATIC DIAGRAM FOR LIGHT OIL FLOW

supplies high voltage current for the igniting spark. The gas pilot has a single electrode and a spark arcs between the tip of the electrode and the wall of the tube surrounding it. 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.

Optionally equipped burners have 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.

H. COMBUSTION AIR

Air for combustion of fuel (often referred to as "secondary" air) is furnished by the forced draft fan mounted in the fan housing. In operation, air pressure is built up in the wind box and is forced through a diffuser plate for a thorough mixture with the fuel for proper combustion. See Figures 1-5 and 1-6.

The supply of secondary air is governed by automatically throttling the output of the fan to the burner 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.

At low firing rates the flame shape and stability is greatly assisted by the addition of a "tertiary" air supply. A small quantity of secondary air is by-passed around the damper and directed to encircle the burner nozzle at high velocity. This insures good directional turbulence at low firing rates to maintain flame stability and pattern. Additionally, it keeps the nozzle cool and clean. This supply of air is not adjustable.

I. 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 3.

J. MODULATING FIRING

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

The modulating motor's operation is controlled automatically by a modulating pressure control. A manually operated potentiometer is also provided to permit the positioning of the motor to a desired burner firing rate when the manual-automatic switch is set on manual. 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 (also referred to as a damper motor) is a 24 volt, reversible type motor with a built-in speed reducer gear train. An internal limit switch limits the turning angle of the motor arm to 90° of arc. During normal operation the motor stops in any position within this range. The motor arm must be free to operate through the full 90° rotation. Permanent damage to the motor will be caused if the linkage is misadjusted or the motor arm prevented from traveling to the position corresponding to the demand of the pressure or temperature control.

The modulating pressure control contains a potentiometer which is electrically connected to a matching potentiometer in the modulating motor. Changing steam pressure alters the electrical resistance of the modulating controller's potentiometer. This change in resistance compels an integral balancing relay to operate an internal switch to start, stop, or reverse the motor rotation. Rotation in either direction continues until the resistance ratio of the motor's potentiometer

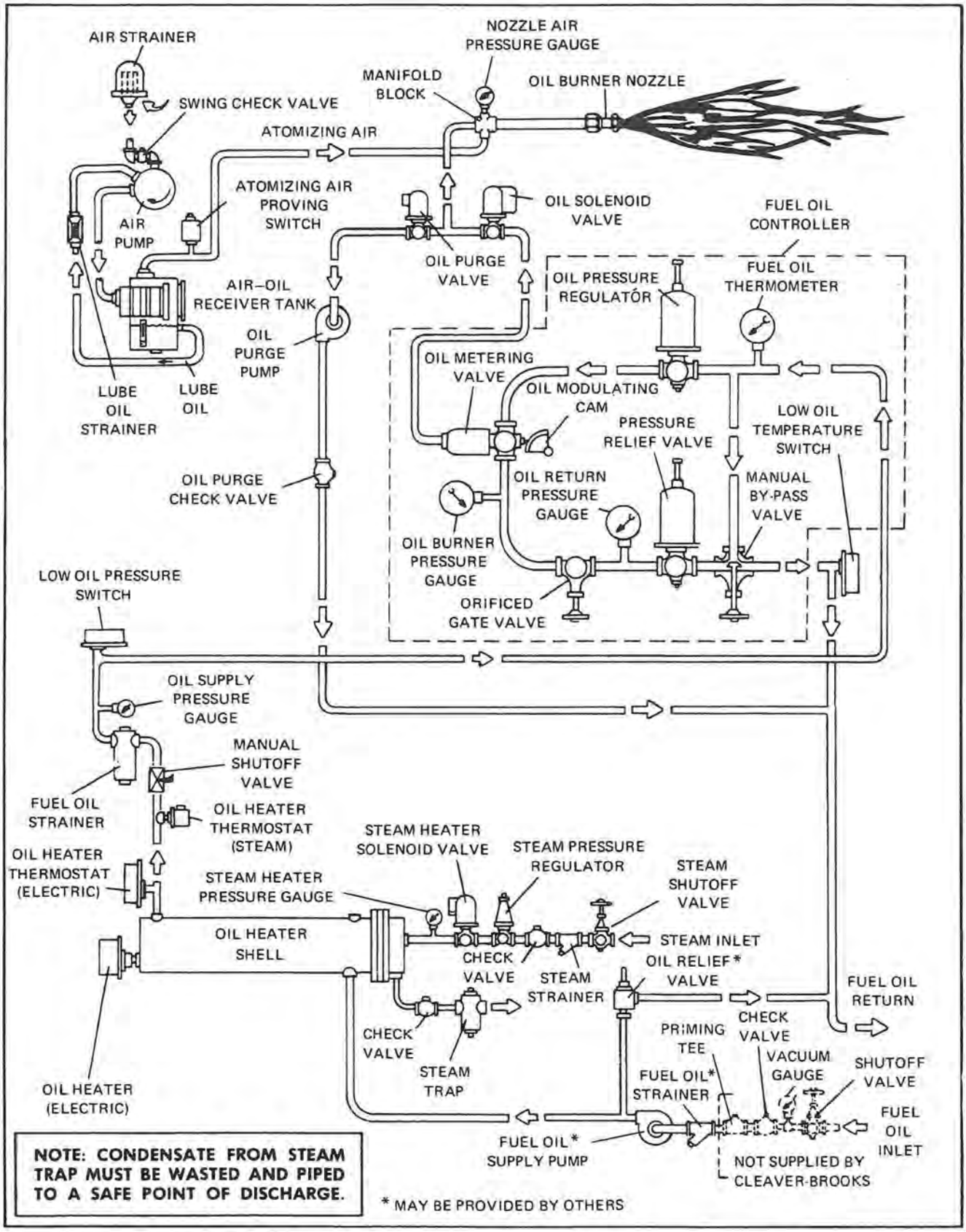


FIGURE 1-12. SCHEMATIC DIAGRAM FOR NO. 6 HEAVY OIL FLOW (STEAM-ELECTRIC HEATED

and the controller potentiometer are equal. When this balancing 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 a 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. This 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 pressure control has any control over the damper motor, regardless of their setting.

Optionally equipped burners use a second integral switch to establish that the motor has driven the damper to high fire position during the pre-purge period. This switch closes as high fire position is approached and completes an internal circuit in the programmer allowing continuation of the programming cycle.

K. GAS FUEL FLOW

The gas flow system is shown in Figures 1-6 and 1-7. Gas flow is indicated by arrows and the pertinent controls 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 valve cannot be energized (opened) unless the combustion air proving switch is closed to indicate a sufficient supply of combustion air. Optionally equipped burners have low gas pressure and high gas pressure switches which must be closed to prove sufficient, but not excessive, gas fuel pressure.

When two main gas valves are supplied, a normally open vent valve is placed between them. This valve is shut when the main gas valves are opened. When they are closed the vent valve is open for venting gas should any be present.

L. OIL FUEL FLOW - LIGHT OIL

The oil fuel flow and circulating system is shown in schematic diagram form in Figure 1-11. 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 burner. The remainder of the fuel oil returns to the oil storage tank thru a fuel oil relief valve and oil return line.

A lever operated valve is provided to permit the quick shut off of oil flow should this be necessary. The oil flows thru a fuel oil strainer to prevent any foreign matter from entering the control valves and nozzle. A low oil pressure switch prevents the burner from operating unless a definite flow of oil exists.

The fuel oil controller contains in a single unit the necessary valve, regulator and gauge 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 normally closed when de-energized. They can not be opened (energized) unless the combustion air proving switch, the atomizing air proving switch, and the low oil pressure switch 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 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.

M. 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. The system has a low oil pressure switch which prevents the heaters from operating unless a definite flow of oil exists. This reduces the possibility of coking the heater elements.

A lever operated valve is provided to permit the quick shut off of oil flow should this be necessary. 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 normally 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 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 oil purge valve and the oil purge pump are energized when the oil solenoid valve closes and the oil from the nozzle and adjacent piping is pumped back into the return line This assures a clean nozzle and line for the subsequent restart.

N. STEAM ATOMIZATION OF FUEL OIL

When specified, CB Model Burners are equipped to utilize steam — rather than air — for the atomization of the fuel oil. This feature is provided either with steam as the only atomizing media or, in some instances, as a stand-by for normal air atomization. When both are available, disconnect couplings or a valving arrangement is provided to permit the use of either.

If steam, at a minimum of 50 PSI, is not available from another boiler, air from either the Cleaver-Brooks air pump or from an alternate air supply must be used for atomization during a cold start and until the boiler is able to provide its own steam. On a combination gas-oil fired burner, gas can be burned until steam is raised.

The accompanying schematic diagram (Figure 1-13) indicates the flow of oil and atomizing steam (and air). While this diagram shows heavy fuel oil, the principle for steam atomization of light oil is essentially the same with the exception that oil preheating equipment is not generally required. If No. 2 fuel oil from a low ambient temperature source is supplied, preheating the oil may be necessary to accomplish proper atomization.

The oil flows from the pumping system through the steam-electric fuel oil heater. The electric heater, housed in the steam heater, is used primarily to heat sufficient oil for low fire flow during a cold start before steam is available for heating. The operation of the electric oil heater is controlled by the electric oil heater thermostat. A low oil temperature switch must be closed to indicate the availability of properly heated oil before the burner can be started. Steam, at a properly reduced pressure, enters the heater when the steam heater solenoid valve is opened. This valve is energized by the thermostatic action of the steam heater thermostat.

The oil flows from the heater through a strainer to the fuel oil controller. A low oil pressure switch assures that sufficient oil pressure exists. The oil burner valve cannot open if the oil pressure is below the setting of the switch or it will close if the pressure drops during operation.

The fuel oil controller contains, in a single assembly, the various regulators, valves, and gauges required to regulate the flow of fuel oil. The controller has a by-pass valve and an orificed valve which are closed during normal operation. They may be opened on a cold start to aid in establishing oil flow through the controller. The orifice valve has a small opening in it's disc to permit a continuous circulation of hot fuel oil through the controller. A temperature gauge is

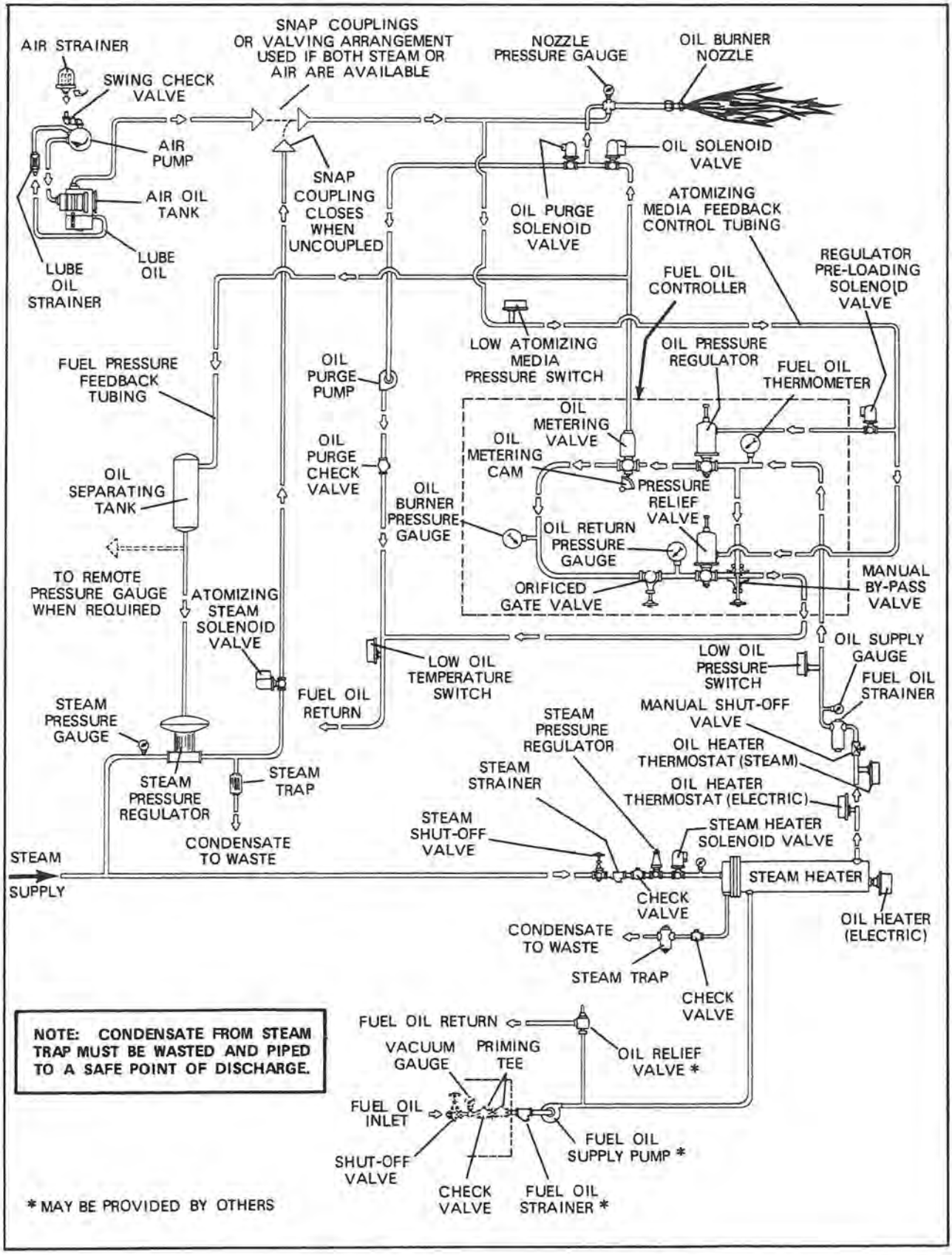


FIGURE 1-13. STEAM ATOMIZATION DIAGRAM

provided to indicate the temperature of the oil at the controller.

A pressure regulator adjusts the oil pressure at the metering valve to the desired level. The oil metering valve stem moves to increase or decrease the orifice area to regulate the supply of fuel oil through the burner nozzle in accordance with load demand. The movement of the metering stem is controlled by a cam driven by the modulating mechanism. Oil in excess of that required by the burner flows through a back pressure regulator and is returned to the oil supply tank.

During the firing cycle the main fuel oil valve, or valves, open to allow the flow of oil to the burner nozzle.

A regulator in the atomizing steam line reduces the boiler steam pressure to a level that is suitable for atomizing the oil. The atomizing steam solenoid valve is energized upon the burner start and steam flows during the entire burner operating cycle. Steam flow, prior to ignition, serves to heat the line and to prevent condensation from causing poor atomization. (Steam lines must be insulated.) The valve closes when the burner shuts down.

The final adjustment of the steam reducing valve and of the regulators in the fuel oil controller must be done under actual firing conditions when combustion efficiency can be determined. The pressure of the atomizing steam while the unit is not firing, or with no oil passing through the nozzle, should be a minimum of 7 PSI. At low fire, the pressure may rise to 12 PSI or more, and at high fire to approximately 30 PSI. The exact adjustment of the atomizing pressure should be done during a prolonged high fire run and should be determined by the results of a combustion analysis.

In order to vary the atomizing pressure as the firing rate increases or decreases, a pressure sensing line is connected between the fuel oil line and the spring chamber portion of the steam regulator. The pressure changes as the oil flow changes and the sensing line increases or decreases the set pressure of the steam pressure reducing valve. As fuel flow increases with an increased firing rate, the pressure at the oil nozzle increases. The steam reducing valve would normally react to this additional resistance and close on the assumption that sufficient downstream pressure exists. However, the additional force provided to the regulator spring tension by the feed-back line prevents this reducing valve from closing and cutting down the supply of atomizing steam.

There is a small oil separating tank in this sensing line which is filled with an ethylene glycol solution. This provides a means of allowing the fuel oil to provide the back pressure required yet prevents the heavy fuel oil from filling the line to the steam reducing valve.

Oil flow to the nozzle is controlled by a solenoid oil valve which is energized or de-energized through contacts in the programmer control. The metering valve delivers to the burner nozzle the exact quantity of fuel oil that the boiler demands. A portion of oil is by-passed through the orificed gate valve and the back pressure return valve into the return line.

To maintain a pressure drop across the orificed valve and to assure a constant and reasonable flow of heated oil back to the tank, a feed-back system is incorporated to add the pressure of the atomizing steam to the adjustable spring pressure of the regulating valve and the back pressure valve. This feature facilitates the opening of the oil valve at a reduced pressure and at the same time gives a greater pressure drop across the metering valve at high firing rates.

The rate of fuel delivery through the metering valve is dependent upon the size of the opening in that valve and the pressure difference indicated by the readings of the oil pressure gauge and the atomizing steam gauge on the burner gun. The steam gauge actually indicates atomizing media pressure at that point, but this is very nearly the same as the oil pressure at the nozzle.

Under normal operating conditions the readings of the oil burner pressure gauge and the oil return pressure gauge on the fuel oil controller will vary with the burner load. However, the pressure difference between the two gauges will remain relatively constant. A 10 PSI difference is desirable.

As the area of opening in the metering valve increases, the oil flow changes (increases). With this flow change, pressure as indicated by the gauge on the burner gun, is fed back to the regulating valves on the controller, thus again increasing the pressure reading of the controller gauges. As the rate of flow of fuel oil to the burner increases, the natural characteristic of the regulating valve is to drop. This would normally indicate a lowering pressure on the oil pressure gauge. The feed-back system, however, adds the pressure of the atomizing steam to the back pressure regulator valve and to the pressure regulator to compensate for this.

A solenoid valve installed in the feed-back line to the oil pressure regulator is energized to open whenever the main oil valve is energized. This permits feed-back only when the oil valve is opened.

A low atomizing media pressure switch must be closed to prove that sufficient atomizing pressure exists. Insufficient pressure during operation will cause the burner to shut down.

Upon a burner shut down, the oil valve closes to shut off the flow of oil. At the same time, the oil purge valve is energized to open and the oil pump operates to withdraw the oil remaining in the line down stream from the oil valve to the nozzle. This purged oil is returned to the oil supply tank. The purpose of this is to remove oil from this line so that the line is open for the flow of heated oil on a subsequent burner restart.

A similar system of sensing lines is used on burners fired with No. 2 fuel oil. Nozzle air purging is not required with light oil and a slightly different system is used to control the flow of returned oil. The light oil flow text in Chapter 1 of the Operating Manual can be referred to for an explanation of the oil flow.

CHAPTER 2

SEQUENCE OF OPERATION

A. GENERAL

This chapter outlines the electrical sequencing of the various controls from the beginning of the starting cycle, through the ignition cycle, the operating period and normal shutdown.

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. For purposes of this outline, it is assumed that the fuel system, oil or gas, and the feedwater system is functioning. Chapters 3 and 4 contain operating instructions and specific information on setting and adjusting the 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.

In the schematic type wiring diagram provided for the burner 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 the switches or contacts that permit the component to function when required. The timer in the programming control sequences the operation of all other controls and components to provide an overall operating sequence. Abbreviations for the various electrical components are listed in Figure 2-1. The sequences outlined in this chapter also employ these designations to aid in applying the text to the wiring diagram.

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

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

Boiler water is at correct level. Neither the low water nor high water indicator light glows. The operating limit pressure control is below it's cut-off setting. The steam demand indicator light is on.

Burners equipped for oil firing have a separate air pump motor and an oil pump motor. Power must also be present to the starters for these motors. When the fuel is heavy oil, power must also be present at the relay terminals of the oil heater.

B. CIRCUIT AND INTERLOCK CONTROLS

Control circuit power is extended to programmer terminals 2 and 4 and to the damper motor transformer (DMT). The hot line is extended to programmer terminals 3, FV, and R thru limit and interlock devices. The controls used vary depending upon the fuel — oil or gas — and the specific requirements of applicable regulatory bodies. Refer to the burner wiring diagram to determine the controls provided. Those normally used are listed below and are referred to in the following sequence.

Burner switch (BS)

Operating pressure control

Normally identified as HLPC. On an F.I.A. approved burner, the operating pressure control is identified as OLPC. In addition, this burner has a high limit pressure control identified as HLPC.

Low water cut outs (LWCO-1 LWCO-2)

Gas/oil switch (GOS) — combination burner only

	A
A	Amber (Color of Pilot Light)
AAFL	Atomizing Air Failure Light
AAPS	Atomizing Air Proving Switch
AB	Alarm Bell
ACMCB	Air Compressor Motor Circuit Breaker
ACMS	Air Compressor Motor Starter
AFSV	Air Flow Solenoid Valve
AGV	Auxiliary Gas Valve
AH	Alarm Horn
ALWCO	Auxiliary Low Water Control
AM	Ammeter
AMS	Atomizing Media Switch
AOV	Auxiliary Oil Valve
APR	Air Purge Relay
AR	Alarm Relay
AS	Auxiliary Switch (Mounted on Damper Motor)
ASS	Alarm Silencing Switch
ASV	Atomizing Steam Valve
ATS	Alarm Test Switch
	B
B	Blue (Color of Pilot Light)
BDCS	Breeching Damper Closed Switch
BDOS	Breeching Damper Open Switch
BHS	Boiler – Header Switch
BIOL	Boiler In Operation Light
BM	Blower Motor
BMCB	Blower Motor Circuit Breaker
BMF	Blower Motor Fuses
BMS	Blower Motor Starter
BMSI	Blower Motor Starter Interlock (included in BMS)
BMSS	Blower Motor Selector Switch
BS	Burner Switch
BSS	Boiler Selector Switch
BWPM	Booster Water Pump Motor
BWT	Booster Water Thermostat
	C
CAAL	Combustion Air Adequate Light
CAFL	Combustion Air Failure Light
CAP	Capacitor: 0.005 MF, 600 Volts
CAPS	Combustion Air Proving Switch
CAPR	Combustion Air Proving Relay
CCCB	Control Circuit – Circuit Breaker
CCF	Control Circuit Fuse
CCT	Control Circuit Transformer
CL	Canopy Light
CLS	Canopy Light Switch
CPOL	Control Power on Light
CR	Control Relay
CWPS	Circulating Water Pump Switch
CWPM	Circulating Water Pump Motor
	D
DISC	Disconnect (Entrance) Switch
DMT	Damper Motor Transformer

	E
EDS	Emergency Door Switch
	F
FCIPL	Fuel Changeover In Progress Light
FD	Flame Detector
FDPS	Flow Differential Pressure Switch
FFL	Flame Failure Light
FON	Fan On
FOFF	Fan Off
FOL	Flame On Light
FPM	Feed Pump Motor
FPMS	Feed Pump Motor Starter
FS	Flow Switch
FVEL	Fuel Valve Energized Light
FVL	Fuel Valve Light
	G
G	Green (Color of Pilot Light)
GCAS	Gas Cock Auxiliary Switch
GCS	Gas Cock Switch
GGL	Gauge Glass Light
GGLS	Gauge Glass Light Switch
GOS	Gas – Oil Switch
GOV	Gas Oil Valve
GPV	Gas Pilot Valve
GPVV	Gas Pilot Vent Valve
GVEL	Gas Valve Energized Light
	H
HATC	High Ambient Temperature Control
HFAV	High Fire Automatic Valve
HFOV	High Fire Oil Valve
HFS	High Fire Switch
HFS-A	High Fire Switch – Air
HGPL	High Gas Pressure Light
HGPS	High Gas Pressure Switch
HLC	High Limit Control
HLPC	High Limit Pressure Control
HLTC	High Limit Temperature Control
HMC	Header Modulating Control
HOPL	High Oil Pressure Light
HOPS	High Oil Pressure Switch
HOLC	Header Operating Limit Control
HOLT	High Oil Temperature Light
HOTS	High Oil Temperature Switch
HSPC	High Steam Pressure Control
HSPL	High Steam Pressure Light
HWAR	High Water Alarm Relay
HWC	High Water Control
HWL	High Water Light
	I
(I.C.)	Instantaneously Closed
(I.O.)	Instantaneously Open
IL	Ignition Light
IRL	Ignition Ready Light
IT	Ignition Transformer

ELECTRICAL NOMENCLATURE USED IN WIRING DIAGRAMS
FIGURE 2-1

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

ELECTRICAL NOMENCLATURE USED IN WIRING DIAGRAMS
FIGURE 2-1A

Oil drawer switch (ODS) — oil fired burner
Low oil pressure switch or relay (LOPS/LOPR) — oil fired burner
Low oil temperature switch (LOTS) — No. 6 oil fired burner only
High oil temperature switch (HOTS) — F.I.A. — No. 6 oil fired burner
High gas pressure switch (HGPS) — F.I.A. — FM gas fired burner
Low gas pressure switch (LGPS) — F.I.A. — FM gas fired burner

The non-recycling interlocks include:
Combustion air proving switch (CAPS)
Blower motor starter interlock (BMSI)
Atomizing air proving switch (AAPS) — oil fired burner

Low fire and purge air flow interlocks include:
Low fire switch (LFS)
High fire switch (HFS) — F.I.A. and FM only
Purge timer (PT) — F.I.A. only

NOTE: A FM approved burner requires proof that the main fuel valve is closed and has the following interlock switch as an integral part of the fuel valve:
Oil valve auxiliary switch (OVAS) — oil fired burner
Main gas valve auxiliary switch (MGVAS) — gas fired burner

C. WATER LEVEL INDICATING SYSTEM

The water level alarm system employs electrodes or probes mounted in a water column. These are electrically connected to relays in the limit and alarm circuits. The action of the relay depends on electrode immersions to complete each circuit. See Figure 2-2.

A minimum of 4 circuits is always provided although individual installations may have additional. The four circuits are comprised of two low water cut-off circuits, a low water alarm circuit, and a high water alarm circuit.

Electrodes numbered 1 and 4 serve as low water cut-offs. Each of these is connected to an individual relay. A third electrode, identified as C, is a common electrode wired to all relays.

As long as these three are immersed, the water level is considered suitable for operation and the relay contacts are closed to complete the limit circuit. Should the water level lower to the point where these are no longer immersed, the limit circuit will be interrupted and the burner will shut down or be prevented from operating.

To assure adequate water level above the cutoff level, a shorter electrode identified as No. 2 is wired to a low water alarm relay. This electrode is normally immersed. Should this electrode be exposed by lowering water level, the alarm horn (AH) will sound and the low water light (LWL) will glow to alert the operator to this condition. This protection occurs while the burner is in operation or when the burner switch is closed in anticipation of operation.

Normally electrode No. 3, which is connected to a high water alarm relay will not be immersed. If the water level reaches the height of this electrode, the relay will be energized to sound the alarm horn and light the high water light. (HWL)

An alarm test switch (ATS) is provided to simulate alarm conditions when depressed so that a check may be made to determine that the alarm signal devices are in working order without disturbing burner operation.

While not a part of the water level system, flame loss will also sound the alarm horn. In this event the flame failure light (FFL) glows to alert the operator to this condition.

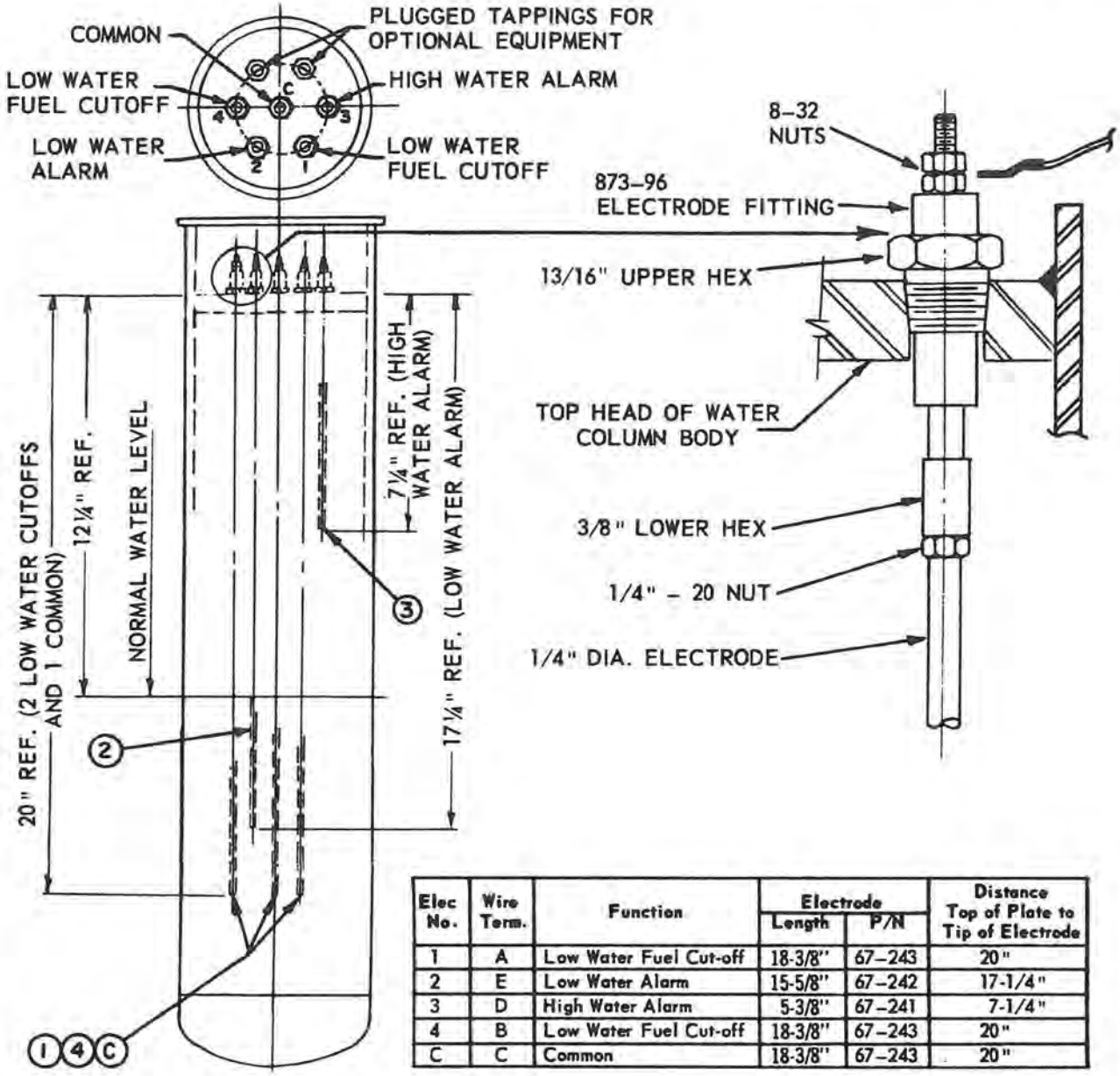
D. SEQUENCE OF OPERATION
(Electric Positioning)

This sequence is applicable to a standardly equipped burner with a Fireye Model CB-3 or 6080 flame safeguard and programming control and an electric positioning system.

The legend on the timer dial indicates the position of the timer and the stage reached in the burner operating cycle. The bar-graph shown in Figure 2-3 or on the wiring diagram relates the dial indicator to the timing of dial rotation. The sequence makes reference only to the dial indication and not to the timing involved. These timings do not represent elapsed time, since timer is interrupted and governed by other components during a normal cycle. The technical bulletin with this manual contains a schematic wiring diagram that details the timing sequence of the various programmer contacts.

On a combination fuel burner, the gas/oil switch must be set for the proper fuel. All of the controls in the limit circuit must be made to show that their operating conditions are satisfied. Refer to the burner wiring diagram to determine the controls provided.

These controls essentially include the oil drawer switch (ODS) which must be made when firing on oil to prove that the burner gun is in its proper position. The low oil pressure switch (LOPS) is closed to prove that sufficient fuel oil pressure exists. The low oil temperature (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.



Elec No.	Wire Term.	Function	Electrode		Distance Top of Plate to Tip of Electrode
			Length	P/N	
1	A	Low Water Fuel Cut-off	18-3/8"	67–243	20"
2	E	Low Water Alarm	15-5/8"	67–242	17-1/4"
3	D	High Water Alarm	5-3/8"	67–241	7-1/4"
4	B	Low Water Fuel Cut-off	18-3/8"	67–243	20"
C	C	Common	18-3/8"	67–243	20"

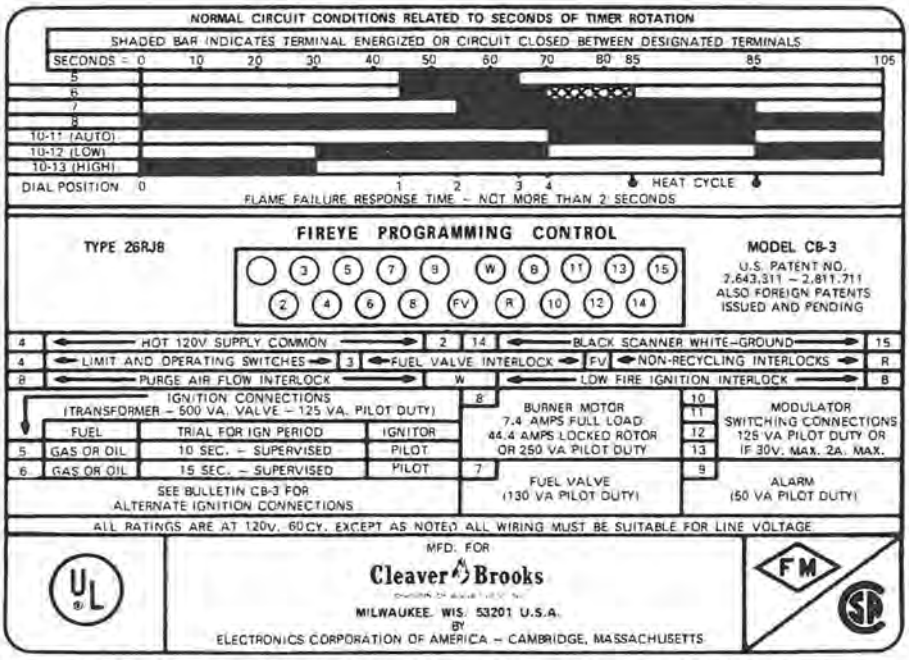
INSTALLATION INSTRUCTIONS

Thread electrode probe into holder finger tight. Lock in place using a wrench on lower hex and another on the lock nut. Do not use a wrench on the upper hex while installing the probe.

Clean the female threads in the water column plate. If they require chasing, use a 3/8" SAE DRY SEAL (**PTF**) tap. Do not use a standard 3/8" NPT tap. Teflon tape or a small amount of pipe dope may be used on the male threads. Use a 13/16" deep socket wrench on upper hex to tighten electrode holder. Take care not to crack the insulator.

When attaching the wire lug use proper wrenches on both lug nuts so that no torque is applied to the electrode holder. Do not use a knurled nut or lock washer.

STANDARD WATER COLUMN ASSEMBLY
FIGURE 2-2



PROGRAMMING SEQUENCE FOR FIREYE MODEL CB-3
FIGURE 2-3

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.

Pre-purge Period

DIAL AT 0

When the burner switch is turned "on", power is routed thru the limit controls to terminal 3. Non-recycling relay RL3 and master relay RL1 are energized. Power is routed to the blower motor starter, and the air compressor motor starter if firing on oil.

The timer will begin operation unless the burner is equipped with a purge air flow interlock. In this case the timer motor will not start until the high fire switch (HFS) is closed a short while later.

Programmer terminals 10-12 break and 10-13 make to energize the damper motor which begins driving the damper to the open or high fire position. This allows a full flow of purging air thru 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 12 are powered the R-W (low fire) potentiometer circuit is made and the motor will return to its closed or low fire position. Under both of these conditions the manual automatic switch, the modulating pressure control, and the manual flame control have no control over the modulating motor regardless of their setting.

The completion of the interlock circuit to terminal R must be made within 8 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 RL3 will be de-energized. The timer will complete its revolution to the starting position and the programmer will lock out.

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.

As high fire position is approached, the contacts of the high fire switch, (HFS) (if burner is so equipped) close completing internal circuitry in the programmer proving that the high fire position was reached. When this switch closes the timer is energized and begins rotation.

NOTE: Extended pre-purge period

Existing F.I.A. requirements and/or others require additional pre-purge time beyond that provided by the programmer. This is accomplished by the use of a separate time delay relay. The timing of the relay is adjustable from 1 to 200 seconds and it is field set according to code or insurance requirements.

The purge timer (PT) is energized thru the contacts of the high fire switch (HFS) as the damper approaches the high fire position. At the completion of the set timing of the relay, the programmer timer is energized and begins operation. The damper motor and air damper remain in the high fire position since terminals 10-13 are still closed. They remain closed for 30 seconds to provide the programmer's normal pre-purge period.

Toward the end of the purging period terminals 10-13 open and 10-12 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 B. 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.

Ignition Period

DIAL AT I

The ignition transformer (IT) and gas pilot valve (GPV) are energized from terminal 6 (or 5). With combustion air, ignition spark, and pilot fuel present the pilot flame is ignited. As soon as pilot flame is detected, flame relay RL2 is energized.

NOTE: Depending upon the requirements of regulatory or insurance body applicable to 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 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.

CAUTION

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

DIAL AT 2

With a proven pilot, the main fuel valve(s) is energized from terminal 7. 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, (Dial at 4 or 3 respectively) 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 RL2 will drop out causing the fuel valve(s) to close. The safety switch will trip to lockout the control. Refer to flame loss sequence section for description of action.

CAUTION

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

NOTE: A gas fired burner equipped to comply with F.I.A. requirements has two gas shutoff valves with a normally open vent valve between them. When the gas valves are energized to open, the vent valve is also energized and closes. When the valves are de-energized, the vent valve opens to vent gas should any be present.

It also has a second pilot shutoff valve and a normally open vent valve in the gas pilot line. The vent valve closes when it and the pilot solenoid valves are energized at the beginning of the ignition cycle. At the end of the ignition period, when the valves are de-energized, the vent valve is opened to vent gas should any be present.

DIAL AT •

With the main flame established, terminals 10 and 11 are powered transferring 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 when sufficient steam pressure is reached to satisfy the setting of the low fire pressure switch (LFPS).

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 and for maintenance purposes.

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

Burner Shutdown

DIAL AT •

The burner will fire until steam pressure in excess of demand is generated or unless manually turned off. With modulated firing, the modulating motor should return to the low fire position before the operating limit control opens. Terminal 3 is de-energized when the operating limit control is opened and the following sequence occurs:

Relays RL1 and RL3 drop out. The main fuel valve(s) is de-energized and closes. Flame is extinguished and flame relay RL2 drops out. The blower motor continues operation forcing air through the boiler in a post-purge period. The steam demand light is turned off. The timer begins rotating.

Terminals 10-11 open and 10-12 close, driving the modulating motor to low fire position, if not already in that position.

A burner fired with heavy oil has an oil purge system to remove oil from the burner nozzle and adjacent piping. The oil purge motor (OPM) is now energized and withdraws oil thru the oil purge valve (OPV).

DIAL AT •

At the end of the operating cycle, terminal 8 circuit opens and de-energizes the blower motor. When firing with oil the air compressor motor is also de-energized. The timer stops as it reaches its original position.

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

E. SEQUENCE OF OPERATION
(Pneumatic Positioning)

This sequence is applicable to a standardly equipped burner with a Fireye Model CB-3 or 6080 flame safeguard and programming control and a pneumatic positioning system.

The legend on the timer dial indicates the position of the timer and the stage reached in the burner operating cycle. The bar-graph shown on the wiring diagram relates the dial indicator to the timing of dial rotation. The sequence makes reference only to the dial indication and not to the timing involved. These timings do not represent elapsed time, since timer is interrupted and governed by other components during a normal cycle. The technical bulletin with this manual contains a schematic wiring diagram that details the timing sequence of the various programmer contacts.

On a combination fuel burner, the gas/oil switch must be set for the proper fuel. All of the controls in the limit circuit must be made to show that their operating conditions are satisfied. Refer to the burner wiring diagram to determine the controls provided.

These controls essentially include the oil drawer switch (ODS) which must be made when firing on oil to prove that the burner gun is in its proper position. The low oil pressure switch (LOPS) is closed to prove that sufficient fuel oil pressure exists. The low oil temperature (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.

Pre-purge Period

DIAL AT 0

When the burner switch is turned "on", power is routed thru the limit controls to terminals 3, 10 and FV. Non-recycling relay RL3 and master relay RL1 are energized. Power is routed to the blower motor starter, and the air compressor motor starter if firing on oil.

The timer will begin operation unless the burner is equipped with a purge air flow interlock. In this case the timer motor will not start until the high fire switch (HFS) is closed a short while later.

Programmer terminal 13 is powered to energize the high fire auto valve (HFAV) which begins driving the damper to the open or high fire position. This allows a full flow of purging air thru the boiler prior to ignition.

The completion of the interlock circuit to terminal R must be made within 8 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 subse-

quently open, relay RL3 will be de-energized. The timer will complete its revolution to the starting position and the programmer will lock out.

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.

As high fire position is approached, the contacts of the high fire switch, (HFS) (if burner is so equipped) close completing internal circuitry in the programmer proving that the high fire position was reached. When this switch closes the timer is energized and begins rotation.

NOTE: Extended pre-purge period

Existing F.I.A. requirements and/or others require additional pre-purge time beyond that provided by the programmer. This is accomplished by the use of a separate time delay relay. The timing of the relay is adjustable from 1 to 200 seconds and it is field set according to code or insurance requirements.

The purge timer (PT) is energized thru the contacts of the high fire switch (HFS) as the damper approaches the high fire position. At the completion of the set timing of the relay, the programmer timer is energized and begins operation. The air damper remain in the high fire position since terminal 13 is still powered. It remains powered for 30 seconds to provide the programmer's normal pre-purge period.

Toward the end of the purging period terminal 13 is de-energized. The damper returns 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 B. The timer will stop until the damper has returned to the low fire position and the contacts of the low fire switch are closed.

Ignition Period

DIAL AT I

The ignition transformer (IT) and gas pilot valve (GPV) are energized from terminal 6 (or 5). With combustion air, ignition spark, and pilot fuel present the pilot flame is ignited. As soon as pilot flame is detected, flame relay RL2 is energized.

NOTE: Depending upon the requirements of regulatory or insurance body applicable to 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 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.

CAUTION

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

DIAL AT 2

With a proven pilot, the main fuel valve(s) is energized from terminal 7. 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, (Dial at 4 or 3 respectively) 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 RL2 will drop out causing the fuel valve(s) to close. The safety switch will trip to lockout the control. Refer to flame loss sequence section for description of action.

CAUTION

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

NOTE: A gas fired burner equipped to comply with F.I.A. requirements has two gas shutoff valves with a normally open vent valve between them. When the gas valves are energized to open, the vent valve is also energized and closes. When the valves are de-energized, the vent valve opens to vent gas should any be present.

It also has a second pilot shutoff valve and a normally open vent valve in the gas pilot line. The vent valve closes when it and the pilot solenoid valves are energized at the beginning of the ignition cycle. At the end of the ignition period, when the valves are de-energized, the vent valve is opened to vent gas should any be present.

DIAL AT •

Programmer terminal 11 is powered to allow the system to modulate as required to maintain the steam load. The low fire pressure switch (LFPS) will prevent the modulating control from driving to high fire until a minimum boiler pressure is reached.

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

Burner Shutdown

DIAL AT •

A pressure limit shut down, or the manual opening of the burner switch, or any abnormal limit condition will result in the de-energization of terminals 3, 10 and FV. This immediately de-energizes terminal 7 causing the fuel valves to close. The timer motor resumes operation. Terminal 11 is de-energized causing the low fire auto valve (LFAV) to vent system air causing the blower damper to drive to low fire position, if it is not already in that position. The blower motor continues running to post purge the boiler.

A burner fired with heavy oil has an oil purge system to remove oil from the burner nozzle and adjacent piping. The oil purge motor (OPM) is now energized and withdraws oil thru the oil purge valve (OPV).

DIAL AT 0

At the end of the operating cycle, terminal 8 circuit opens and de-energizes the blower motor. When firing with oil the air compressor motor is also de-energized. The timer stops as it reaches its original position.

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

The burner will restart after a normal shutdown as soon as the steam pressure drops to close the contacts of the operating limit pressure control.

If the shutdownwas caused by some other limit condition, the condition will be indicated by the appropriate annunciator light. The condition will have to be corrected and the limit control reset before a restart can be accomplished.

F. FLAME LOSS SEQUENCE

The programming and flame safeguard control recycles automatically each time the operating control closes or after a power failure. It will lockout and must be manually reset following a safety shutdown caused by failure to ignite or by loss of flame or upon any abnormal condition affecting fuel or air supervisory controls.

The safety switch must be manually reset following a safety shutdown. A short cool down period is necessary before the safety switch 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 ignition system is energized for the 10 second period between 45 and 55 seconds of timer operation (Dial indication 1 and 2). If the pilot flame is not established within that time, flame relay RL2 will not be energized preventing the fuel valve from opening. The lockout switch is energized and trips within 60 seconds de-energizing master relay RL1. The forced draft fan motor will continue to operate until the timer is de-energized at 105 seconds. The flame failure light and alarm horn are energized. The safety switch must be manually re-set before operation can be resumed. (Refer to caution above.)

B. NO MAIN FLAME

If the pilot flame is proven, the main fuel valve circuit is energized from terminal 7. (Dial at 2) 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. If main flame was not established within these intervals, the flame detecting circuit will break within 1 to 2 seconds dropping out the flame relay RL2. The main fuel valve circuit is de-energized to close the fuel valve(s). The blower motor continues running. Approximately 60 seconds later the lockout switch will trip de-energizing master relay RL1. The forced draft fan motor continues to operate until the timer is de-energized at 105 seconds. The flame failure light and alarm horn are energized. The safety switch must be manually reset before operation can be resumed. (Refer to caution above.)

C. LOSS OF FLAME

If there is a flame outage during normal operation and/or the flame is no longer sensed by the

detector, flame relay RL2 trips within 1 to 2 seconds de-energizing the fuel valve circuit. The fuel valve(s) closes. The blower motor continues operation. Approximately 60 seconds later the lockout switch will trip de-energizing master relay RL1. The timer is energized and the forced draft fan continues to operate until the timer is de-energized at 105 seconds. The flame failure light and alarm horn are energized. The safety 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 are recommended.

CHAPTER 3

STARTING AND OPERATING INSTRUCTIONS

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

Instructions in this chapter assume that installation is complete and that all electrical, fuel, and water connections have been completed and are functionable.

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 4 and this should be reviewed prior to firing. The wiring diagram should also have been studied along with the sequence in Chapter 2.

It is recommended that these starting instructions be read through completely until they are thoroughly understood, BEFORE ATTEMPTING TO OPERATE THE BURNER, 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 lockout switch on the programmer and reset if necessary. The timer dial should be at the "0" position.

The boiler should be filled with water to the proper operating level using water of ambient temperature. Make sure that treated feedwater is available and used.

CAUTION

Prior to firing the burner 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. If loosened, be sure to secure tightly.

Check for rotation of all motors by momentarily closing the motor starter or relay. Blower impeller rotation is counter-clockwise when viewed from the front. 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 lines are open or properly positioned. Verify proper pump rotation.

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

B. CONTROL SETTINGS

See Chapter 4 for adjustment instructions for following controls.

Inspect operating limit control for proper setting.

The pressure control should be set slightly above the highest desired steam pressure, but at least 10% lower than the setting of the safety valves.

Inspect the high limit control, if installed, for proper setting.

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.

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.

Inspect the low fire pressure switch.

This control should be set to close at 50 PSI. It's purpose is to limit the burner to low fire until the boiler is properly heated.

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.

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.

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

The programmer's timer dial should indicate "0".

Close all power entrance switches (supplied by others).

Burner switch should be in the "off" position.

In the event the burner 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 service representative or contact the Cleaver-Brooks service department.

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 4.

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 necessary 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 4 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 1-1). 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 at its drive end), 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 approximately 12 psi or higher. At high fire THE AIR PRESSURE SHOULD NOT EXCEED 30PSI. 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. The oil drawer switch must be closed.

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 must 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.

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

The oil supply pressure should be adjusted to provide a minimum reading of 100 psi on the oil supply pressure gauge at the burner when the burner is at maximum firing rate. (125 psi on CN6 & CN7)

The low oil pressure switch should be set so that it opens at approximately 90 psi. The reset lever must be set and released before circuit can be completed.

Adjustment may also be required to the regulator on the fuel oil controller (Figure 1-9). 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 main flame is ignited. 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 4.

Suggested oil pressures at high fire operation:

Oil Supply .....100 psi CN1-5
125 psi CN6-7
Oil Burner Pressure .....approx. 40-60 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 burner 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. The oil drawer switch must be closed.

Oil Flow

Open all valves in the oil suction and oil return lines. Open the by-pass valve on the fuel oil controller (Figure 1-10) 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. 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 reprime. 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

The oil supply pressure should be adjusted to provide a minimum reading of 100 psi on the oil supply pressure gauge when the burner is at maximum firing rate. (125 psi on CN6 and CN7)

The low oil pressure switch should be set so that it opens at approximately 90 psi. The reset lever must be set and released before circuit can be completed.

The other pressure adjustments are to the regulators on the fuel oil controller (Figure 1-10). 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 main flame is ignited. 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 4.

Suggested oil pressures at high fire operation:
Oil supply pressure gauge (minimum at maximum firing rate) .....100 psi - CN1-5
125 psi - CN6-7
Oil burner pressure gauge .....approx. 40-60 psi
Oil return pressure gauge - 10 psi less than oil supply pressure.

Oil Temperature

CAUTION

The oil heater system can not be activated unless oil circulation exists. The low oil pressure switch must be closed before the system can be electrically energized. This prevents operation of the heater should the flow of oil be interrupted. When it is determined that the heater shell is filled and that fuel oil circulation exists, turn the oil heater switch on.

Adjust the electric oil heater thermostat (Figure 1-2) to maintain oil temperature at approximately 200° F.

The electric heater on a burner 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. A steam heater is supplied to provide sufficient quantities of oil so that higher rates of firing can be accomplished once steam pressure 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, so that heating is not performed electrically except when steam is not available.

Set the steam thermostat (Figure 1-3) to maintain an oil temperature of 220-230° F. The electric heater will be turned off automatically as soon as steam 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 pre-heating 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 deter-

mined by flame appearance and good combustion based on a stack analysis. See Chapter 4 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 (Figure 1-2) 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. 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 and also listed on the cover page of the manual. Should this information not be readily available, consult the Cleaver-Brooks Service Department giving burner serial number. Chapter 4 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 combustion fuel model, set the gas/oil selector switch to "gas". Retract the oil burner gun and latch it in its rearward position.

On initial start-up it is recomended that the main gas shut-off cock (Figure 1-7) remain closed until the programmer has cycled through prepurge and pilot sequences. Then as dial indicates "2" 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 and in providing a suitable strainer.

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. 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 1-4) to "manual" and turn manual flame control to "close."

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

The programmer is now sequencing. See Chapter 2 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 until the low fire pressure control is made assuring that the boiler is properly warmed.

When the pressure vessel and the casing around it is properly warmed the manual flame control can be turned to high fire. On initial start-up and before final combustion adjustments are made be sure that flame is stable as higher firing rate is reached. At this point a combustion analysis should be made, with instruments, and fuel flow regulated as required. Refer to adjustment procedures in Chapter 4. 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 control.

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 is reached, unless:

(a) burner is manually turned "off."

(b) low water condition is detected.

(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 shuts down normally, either thru action of the operating limit control or by turning the burner switch off, the steam demand light no longer glows. This light will remain on if the shutdown is due to a condition causing a limit circuit control other than the operating limit control to open. The flame failure light will glow if the shut down is due to the opening of a non-recycling interlock during operation or the loss of flame signal. The cause of an abnormal shut down should be investigated and corrected prior to resuming operation.

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.

The nozzle oil purging system of a heavy oil burner is activated as the oil purge solenoid valve

opens and the purge pump withdraws oil from the nozzle and adjacent piping.

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.

I. CONTROL OPERATIONAL TEST AND CHECKS

Proper operation of the various controls should be verified and tested when the burner 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 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 4 for instructions on the adjustment of controls.

Observe the ignition and programming control operations to make sure that they are correct. Check the alarm system for low water and high water alerting.

Proper operation of the flame failure device should be checked at time of starting and at least once a week thereafter. Refer to Chapter 4 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 later.

CHAPTER 4

ADJUSTMENT — MAINTENANCE — SERVICE

A. GENERAL

This chapter details adjustment and inspection procedures plus specialized maintenance where required. It can not cover all the phases involved in a complete maintenance program.

Prior to placing the burner into initial service, a complete inspection should be made of all controls, connecting piping, wiring and all fastenings such as nuts, bolts, and set screws to be sure that no damage occurred during shipment and installation.

The controls and components must be set and adjusted under actual firing conditions to assure maximum operating efficiency and economy. Variable conditions such as burning characteristics of the fuel and the operating load contribute to the need for adjustment. The combustion efficiency analysis made during the initial start up helps to determine the additional adjustments required in a particular installation.

A well planned maintenance program avoids unnecessary down time or costly repairs, promotes safety and aids boiler code and local inspectors. An inspection schedule with a listing of procedures should be established. It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, 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 burner 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. These are wasteful as well as hazardous. Include in the program preventive 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.

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

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

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

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

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

B. BURNER OPERATING CONTROLS

a. GENERAL

In general, when adjusting controls check to see that they are level, especially those containing mercury switches.

Controls are carefully calibrated during their manufacture and do not normally require re-calibration. The dial settings are generally accurate although it is not unusual to have a slight variation between a scale setting and an actual pressure gauge or thermometer reading. Readjust the control setting to agree with the reading. 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 4-1 depicts a typical relationship of the setting of the operating limit control and the modulating control. Please note that this is *not*

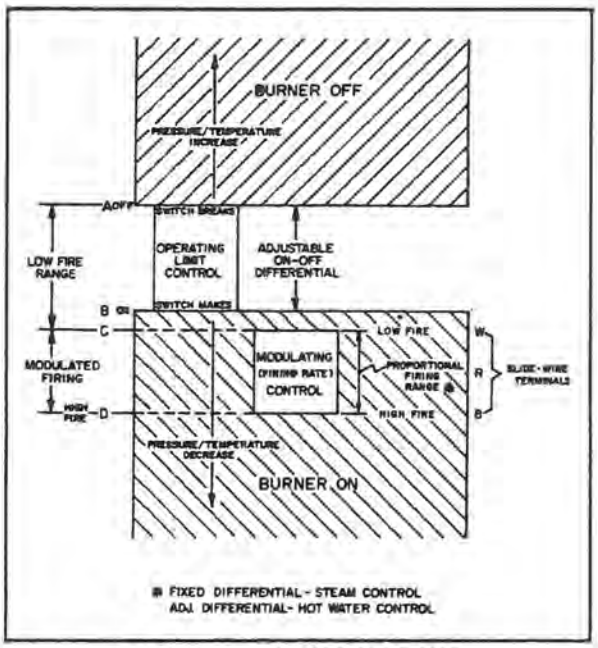


FIGURE 4-1 OPERATING CONTROL AND MODULATING CONTROL ACTIONS

drawn to any scale. The burner will be "on" whenever the pressure is below point B and "off" whenever pressure 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 reaches setting A. The switch in the operating limit control will open. As the pressure 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 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 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 requires an increase in the firing rate. From this illustration it can be seen that this desirable objective will not be attained if 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.

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.

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 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 will have a reading that indicates the *low* point of the modulating range. This fixed differential range is described later in this section.

The operating limit control should now be adjusted and it's 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, 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 total elapsed time plus approximately 1-1/2 minutes required for damper motor travel from low to high fire may allow pressure to drop below desirable limits.

The mechanics of setting the controls are:

b. MODULATING PRESSURE CONTROL (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 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.

c. OPERATING LIMIT PRESSURE CONTROL (Honeywell L404A)

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

d. HIGH LIMIT PRESSURE CONTROL (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.

e. LOW FIRE PRESSURE SWITCH (Honeywell L404B)

Set "cut-in" pressure on the main scale using the large adjusting screw. Set the differential on the short scale by turning the small adjusting screw until the indicator points to the desired difference between cut in and cut out pressures. The cut-out pressure is the cut-in pressure MINUS the differential. Actually in this application the differential is of little importance. The purpose of the control is to prevent the burner from firing at other than low fire rate until the boiler is thoroughly warmed after a cold start. The cut-in pressure is usually set at approximately 50 psi although it may be set higher depending upon the normal operating pressure.

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 furnished with 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 is not practical or recommended.

CAUTION

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

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

Checking Pilot Flame Failure

Close the gas pilot shutoff cock. Also shut off the main fuel supply. Turn the burner switch "on". The pilot system will be energized at the end of the prepurge period. Since there is no pilot flame to be detected, the pilot valve will be de-energized and the main fuel valves will not be energized. Check to see that ignition spark exists but that there is 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 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 reestablish 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 RL2 should drop out within 2 seconds after main burner ignition trial ends. The safety switch should trip and lock out about 60 seconds after end of the ignition trial. The flame failure light and 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 RL2 should drop out within 2 seconds after flame is extinguished. The blower motor will spin down in a post purge. The lock out switch will trip approximately 60 seconds later de-energizing master relay RL1. The flame failure light and 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. 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. The switch should be set to actuate under a condition of minimum pressure but not close enough to that point to cause nuisance shutdowns.

The switch should be adjusted as follows:

Disconnect its wires.

Connect the leads from an ohmeter, or a test light or bell with power source, across the switch so that a completed circuit will be indicated when the switch is closed.

Place the test switch in the programming control in the "check" position to electrically disconnect the timer motor. Turn the burner switch on. The blower motor will run. The timer will not start, but the damper motor will begin to operate. The damper motor will stop when the high fire position is reached.

The air pressure is at its minimum value when the damper is open. At this point, turn down the adjustment so the switch is open; that is until no current is indicated on the test instrument. Slowly turn the adjusting mechanism until the switch just closes and then add an additional half turn.

Turn the burner switch off and place the test switch in the "run" position.

h. ATOMIZING AIR PROVING SWITCH (Dietz 161P1.5)

Air pressure against the diaphragm actuates the switch, which when made completes a circuit to prove the presence of atomizing air. The switch should be set to actuate under a condition of minimum pressure but not close enough to that point to cause nuisance shutdowns.

The switch should be adjusted as follows:

Disconnect its wires.

Connect the leads from an ohmeter, or a test light or bell with power source, across the switch so that a completed circuit will be indicated when the switch is closed.

Place the test switch in the programming control in the "check" position to electrically disconnect the timer motor. Turn the burner switch on. The blower motor will run. The timer will not start, but the damper motor will begin to operate. The damper motor will stop when the high fire position is reached.

The air pressure is at its minimum value since no fuel is present. Turn down the adjustment so the switch is open; that is until no current is indicated on the test instrument. Slowly turn the adjusting mechanism until the switch just closes and then add an additional half turn.

Turn the burner switch off and place the test switch in the "run" position.

i. MODULATING MOTOR (Honeywell M941C or M941D)

The modulating motor must be set to provide a 90° shaft rotation. These motors have a dual stroke option and replacement motors, if not obtained from Cleaver-Brooks or its representatives, may be set to provide a 160° stroke. Ascertain a 90° stroke *before* installing a replacement motor.

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.

If adjustment to the stroke is required, refer to the manufacturer's Technical Bulletin provided with this manual. The motor may be damaged if it is unable to complete its full stroke.

j. MODULATING MOTOR SWITCHES — LOW FIRE AND HIGH FIRE

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

Factory replacement motors have the cams preset. The low fire start switch is set to make at approximately 8° on motor closing. The high fire air proving switch (M941D motor) is set to make at approximately 60 degrees on motor opening. Normally these settings are left as is but job conditions may require adjustment.

If the cams require adjustment or resetting, follow the instructions in the manufacturer's Technical Bulletin provided with this manual.

k. 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 air dampers, and to the gas butterfly valve, if used.

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 a rod fastened to the shaft arm is to the hub the less distance it will travel and vice-versa.

It is not practical to list any specific dimensions or angles, since adjustment tolerances must exist to enable exact settings. Once set, linkage should not require further adjustment. When burners are started by factory trained service engineers, fine adjustments are made and the arms are drilled and pinned in place. The operator should observe any adjustments made so that he is completely familiar with the working of the linkage. It is important that this be comprehended so that it may be properly maintained and to enable the recognizing and correcting of any looseness, slippage, etc. Set screws and lock nuts should be periodically checked. Free movement must always exist.

l. 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.

Although these springs are specially manufactured with flat contact surfaces, any of the above conditions may lead to breakage causing excess fuel input.

m. CONTROL MAINTENANCE

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

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

Dust and dirt can cause excessive wear and overheating of motor starter and relay contacts and maintenance of these is a requirement. Starter contacts are plated with silver and are not harmed by discoloration and slight pitting. Do not use files or abrasive materials such as sandpaper on the contact points since 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 overloads trip out repeatedly when motor current is normal replace them with new overloads. If this condition continues after replacement it will be necessary to determine the cause of excessive current draw.

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

C. GAS PILOT FLAME ADJUSTMENT

Although it is possible to visibly adjust the size of pilot flame it is preferable to determine the signal voltage of the flame. This may be measured with a suitable DC voltmeter having a resistance of at least 1000 ohms per volt.

When making pilot adjustments turn the manual - automatic switch to "manual" and the manual flame control to "close". Open the pilot shut off cock. The pilot adjusting cock and the main gas cock should be closed.

Normally a regulator is not provided in the pilot line unless incoming pressure exceeds 5 psi. If a regulator is installed, its adjustment is not critical, however, with a lower pressure the final adjustment of the pilot flame with the adjusting cock is less sensitive.

To measure and adjust pilot:

1. "Optional". Ground the antenuator pin to the chassis. This will reduce the sensitivity of the flame signal amplifier 40% for test purposes. See Manufacturer's Bulletin.

2. Plug DC voltmeter into test jacks on control chassis (red - plus; black - minus).

3. Turn burner switch on. Let the timer progress normally thru the pre-purge period. As timer reaches dial "1", place the test switch in the "check" position to stop the timer. Slowly open the adjusting cock until flame relay RL2 pulls in to indicate a pilot flame.

4. If pilot flame is not established within 15 seconds turn the burner switch off. Return the test switch to the "run" position and repeat from step 3. Repeat as necessary until pilot flame is established.

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.

5. If pilot flame is not detected within about 60 seconds the control will lock out making it inoperative. It will be necessary to allow several moments for the thermal element to cool and then manually reset. Repeat from step 3.

6. With pilot flame established, remove the flame detector from the burner plate. The pilot flame can then be observed thru this opening.

7. Slowly close the gas pilot adjusting cock until the pilot flame can no longer be seen thru the detector hole. Then slowly open it until a flame providing full sight tube coverage is observed. This adjustment must be accomplished within the time limit of the lockout switch or approximately 60 seconds after the detector is removed.

8. Replace the detector. Observe the reading on the voltmeter. The reading should be steady between 90 and 110 volts DC. If the reading fluctuates, recheck the adjustment. Make sure that the detector is properly seated and clean.

9. Turn burner switch to "off". Return test switch to "run" position and remove grounding wire if used.

10. Turn burner switch to "on" and let control cycle to starting position.

D. THE GAS BURNER

a) COMBUSTION ADJUSTMENT

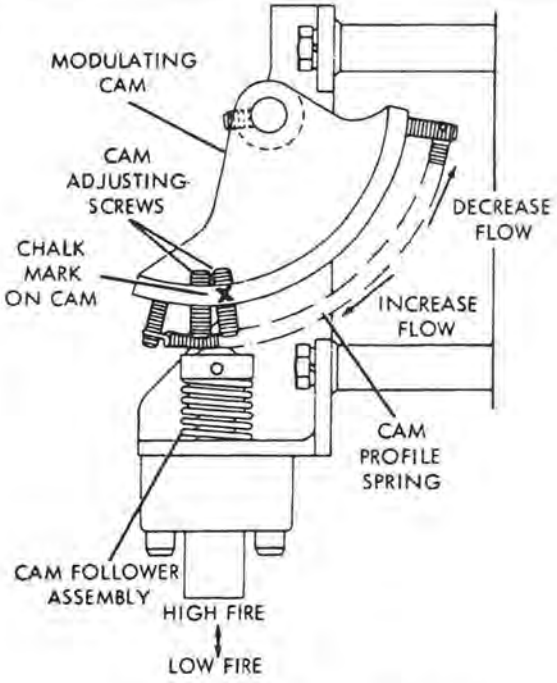
After operating for a sufficient period of time to assure a warm boiler, adjustments should be made to obtain efficient combustion.

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. Flame color is a poor guide although it can help in making approximate and tentative settings.

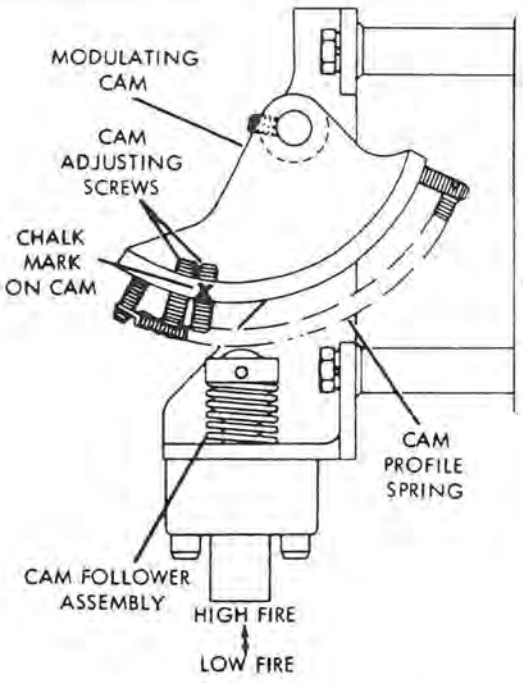
Proper setting of the air/fuel ratios at all rates of firing must be established by the use of a combustion gas analyzer. This instrument measures the content, by percentage, of carbon dioxide (CO_2), oxygen (O_2), and carbon monoxide (CO) in the flue gas.

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

Subject to local regulations pertaining to specific amounts of excess oxygen, it is generally recom-

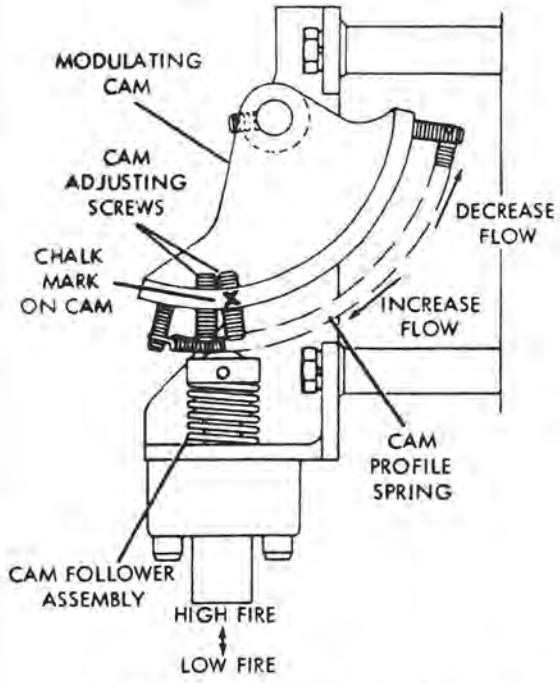


Step 1. Make chalk mark on modulating cam at point to be adjusted.

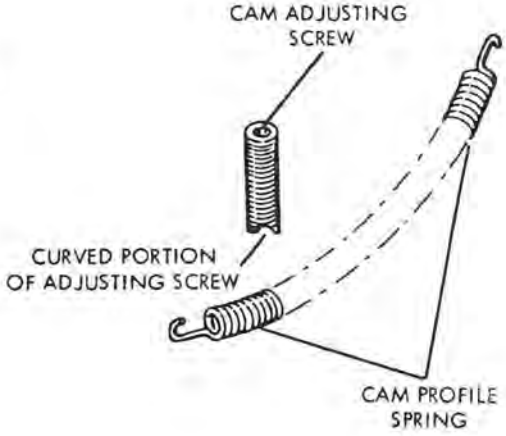


Step 2. Position point requiring adjustment away from cam follower.

Step 3. Adjust cam adjusting screw to increase or decrease fuel flow at that point.



Step 4. Reposition modulating cam to bring point of adjustment over cam follower and check for correct fuel input.



NOTE: AFTER ADJUSTMENT, CURVED PORTION OF ADJUSTING SCREW MUST MATCH RADIUS OF CAM PROFILE SPRING

FIGURE 4-2. MODULATING CAM ADJUSTMENT PROCEDURE

mended that CO_2 readings of between 9-1/2 and 10-1/2% be attained with corresponding O_2 readings of 2 to 4%.

From information in this section determine the standard conditions of gas pressure and flow for the size of burner 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 which controls the pressure and with the butterfly gas valve 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 override tension is released and so that arm is now just touching the stop screw. Tighten the lock nuts on all ball joints.

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. 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 CO_2 should be between 9-1/2 and 10-1/2% and the corresponding O_2 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.

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 4-2) 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 jackshaft.

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 4-2. 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. Ideally, the cam profile spring should be as close to the cam casting as practical and it is more desirable to lower the gas pressure to reduce flow, if necessary, than to extend adjusting screws to an extreme position in an effort to cut-back on 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 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.

b. 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 (Table 1) for rated burner 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 burner size, altitude, and type of gas train. Refer to Table 1 for pressure requirements.

TABLE 1
Minimum Net Regulated Gas Pressure For Rated Burner Output

(Required at Gas Train Entrance)

For Model CN burner mounted on Cleaver-Brooks boiler.

		Gas Pressure in Inches H_2O					
		4" Gas Train with Gen. Control Gas Valve			4" Gas Train with Maxon Gas Valve		
Burner	MBTU Max. Input	Standard	FM	FIA	Standard	FM	FIA
CN-1	52	49	56	79	29	36	39
CN-2	58	61	70	98	36	45	48
CN-3	65	77	88	123	46	57	62
CN-4	69	86	99	137	56	68	77
CN-5	76	107	125	—	68	84	88
CN-6	82	—	—	—	77	98	101
CN-7	90	—	—	—	91	115	120

TABLE 1A

For Model CN conversion burners only when used on 0" W.C. pressure furnaces.

		Gas Pressure in Inches H_2O					
		4" Gas Train			6" Gas Train		
Burner	MBTU Max. Input	Standard	FM	FIA	Standard	FM	FIA
CN-1	58	61	70	98	38.4	47.4	51.8
CN-2	65	77	88	123	48.0	58.5	64.0
CN-3	72	95	108	—	56.8	69.8	76.6
CN-4	79	117	134	—	73.1	89.3	97.5
CN-6	90	—	—	—	91.0	112.0	123.0
CN-7	100	—	—	—	113.0	139.0	153.0

The pressures listed are based on 1000 BTU/CU. FT. natural gas and elevations up to 1500 feet above sea level. For installation at higher altitudes, multiply the selected pressure by the proper factor from Table 2.

TABLE 2

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

Gas Flow

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

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

See Table 1 for input requirements.

Pressure Correction

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

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

To express the volume obtained from an actual meter reading into cubic feet at base pressure it is necessary to multiply the meter index reading by the proper pressure factor obtained from Table 3.

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

TABLE 3
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		

EXAMPLE

As an example: assume that a Model CN-2 burner on a Cleaver-Brooks 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 61" 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 69" 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 1) and "correct" this answer by applying the correction factor for 3 psig (Table 3).

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

OR

$$\frac{58{,}000{,}000}{1{,}000} = 58{,}000 \text{ CFH (At 14.7 \# atmospheric "base" pressure)}$$

THEN

$$\frac{58{,}000}{1.18} = 49{,}152 \text{ CFH}$$

This is the CFH (at line pressure) which must

pass through the meter so that the equivalent full input requirement of 58,000 CFH (at base pressure) will be delivered.

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.

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.

c. GAS BURNER MAINTENANCE

There is little maintenance required on the gas burner itself. The various components should be checked frequently to assure that they are in good working order.

The diffuser must be positioned with its skirt immediately adjacent to the gas outlet holes but it must not cover any portion of them. See Fig. 1-3. The condition of the throat tile and surrounding refractory should be inspected whenever conditions permit.

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

Periodically inspect the ignition electrode for signs of pitting or combustion deposit and dress as required with a fine file. Maintain the proper gap and dimension of this electrode within its tube. The tip should be positioned upright with a 5/32" gap approximately 1/8" into the tube. Inspect the porcelain insulator for evidence of cracks or chipping. This can cause grounding of the ignition voltage and if any are present the electrode should be replaced. Keep the insulating portion of the electrode wiped clean. Ammonia will aid in removing carbon or soot.

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

d. LOW GAS PRESSURE SWITCH (Mercoid PRL-3)

Turn adjusting screw until indicator on scale moves to a pressure setting slightly below the operating gas pressure. The control will break a circuit if pressure is below this value. The control should be finally adjusted to prevent operation with low gas pressure, but should not be set at a value close enough to normal operating pressure to cause unnecessary shutdowns. When setting this control consideration must be given to the fact that gas line distribution pressure may decrease under some conditions and it is advisable that the control does not cut out unnecessarily.

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

e. HIGH GAS PRESSURE SWITCH (Mercoid PR-2)

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

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

f. 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 refrigerent oil. Capacity is 4 pints for the 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 lockscrew 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 or 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 lockscrew.

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.

E. THE OIL BURNER

a. 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 3 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 4-3 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.

Attention to proper adjustment and to maintenance will aid in maintaining an efficient fuel system.

b. OIL BURNER ADJUSTMENTS

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 all fastenings are tight. The diffuser must be positioned with its skirt immediately adjacent the gas outlet holes but it must not cover any portion of them. See Fig. 1-3.

The oil burner gun has a definite insertion length. This is carefully set at the factory and should not change. The distance between the rear edge of the nozzle body and the stop plug should be 22-19/32" $\pm$ 1/32". This will properly locate the nozzle tip in the tertiary air sleeve which has a fixed position. The stop plug must fit tightly against the tube protruding from the burner plate when the gun is inserted.

The locking plate and the locking pin must be positioned so that the gun is held in place and the oil drawer switch actuated.

The nozzle body has the word "top" stamped on it and must be inserted accordingly. The oil nozzle tip should be seated tightly in the body with the swirler and seating spring in place.

Check to see that the gas pilot tube and the scanner sight tube extend thru their respective openings in the diffuser face. The gas pilot tube should protrude 1/4". The sight tube is not adjustable.

Make certain that the flexible oil line and air line hoses are properly reconnected if unfastened. See Figure 1-2.

Periodically inspect the ignition electrode tip for signs of pitting or combustion deposits and dress as required with a fine file. Maintain the proper gap and dimension of this electrode within its tube. The tip should be positioned upright with a 5/32" gap approximately 1/8" into the tube. Inspect the porcelain insulator for evidence of cracks or chipping. This can cause grounding of the ignition voltage and if any are present the electrode should be replaced. Keep the insulating portion of the electrode wiped clean and remove

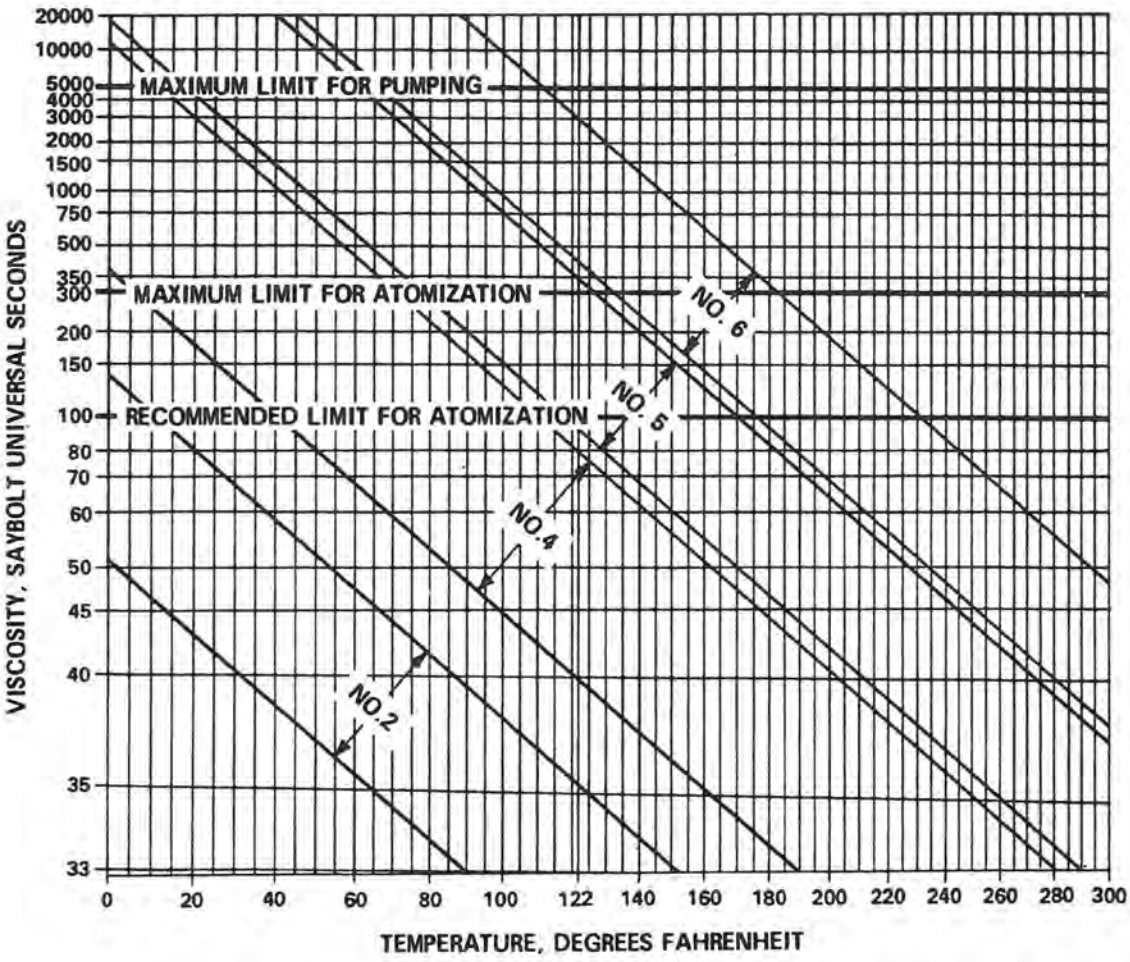


FIGURE 4-3 OIL VISCOSITY CHART

any carbon if present. Ammonia will aid in removing carbon or soot.

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

c. COMBUSTION ADJUSTMENT

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

Efficient combustion cannot be solely judged by observing flame condition. Flame color is a poor guide although it can help in making approximate settings. These 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 (CO_2), oxygen (O_2) and carbon monoxide (CO) in the flue gas.

Burner efficiency is measured by the amount of percent of CO_2 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

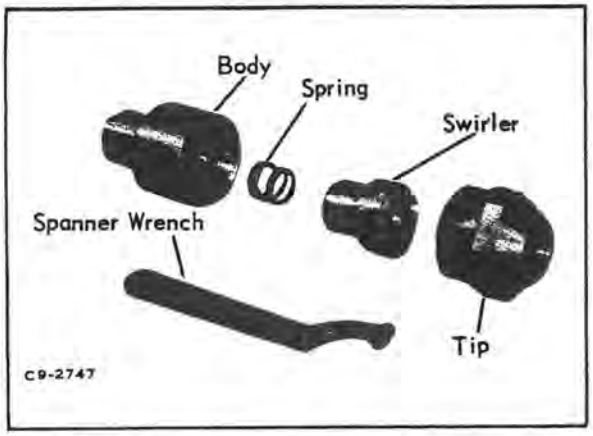


FIGURE 4-4 BURNER NOZZLE ASSEMBLY

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 CO_2 reading of 13 to 14% depending upon the grade of fuel.

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. The air and oil pressure readings should be on the order of those given in Chapter 3.

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 4-2), 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 jackshaft.

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 4-2. 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.

D. CLEANING THE OIL NOZZLE

The design of the burner and the use of tertiary air, 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 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.

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 are 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 is 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. An o-ring in the burner manifold block serves as a seal for the internal oil tube. It is well to replace this item during the annual inspection period.

E. BACK PRESSURE ORIFICE NOZZLE (100 and 200 Series only)

In the oil return line on the down stream side of the fuel oil controller there is a fixed orifice nozzle installed to create a back pressure. This nozzle and its strainer should be inspected periodically and cleaned. The nozzle consists of a tip with an 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 the core, setting it tightly but not excessively so.

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

f. LOW OIL PRESSURE SWITCH (Honeywell L404Y)

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.

This switch must be manually reset after tripping, on a drop of fuel oil pressure. To reset, allow oil pressure to build up then press down the reset lever on top of control.

g. ELECTRIC OIL HEATER THERMOSTAT (400 and 600 Series) (Fenwal 47800-529)

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.

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.

h. STEAM OIL HEATER THERMOSTAT (400 and 600 Series) (Fenwal 47800-529)

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.

i. LOW OIL TEMPERATURE SWITCH (400 and 600 Series) (WR 11B05-1)

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

To adjust, insert screwdriver into center slot in control cover and turn dial until fixed (center) pointer is approximately 30 degrees F lower than the steam 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.

A burner equipped to comply with FM requirements will be equipped with a Mercoid FM437-3 control. This should also be adjusted and set at approximately 30° F. lower than the oil heater thermostat.

j. HIGH OIL TEMPERATURE SWITCH (400 and 600 Series - F.I.A. Only) (WR 11B18)

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

To adjust this control, 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.

k. OIL DRAWER SWITCH

The locking plate on the burner gun and the locking pin must be adjusted so that the integral contacts of this micro-switch are closed when the gun is inserted and locked in its forward position for oil firing. The adjustment must not allow the contacts to close unless the gun is properly positioned. The switch is electrically removed from the circuit when a combination fuel burner is fired on gas.

l. OIL STRAINERS

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

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.

A quick opening valve is provided on the strainer of a No. 6 oil burner to facilitate draining. Use caution in handling heated oil.

Drain sump as often as experience indicates is necessary. 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.

m. FUEL OIL TREATMENT

Conditions and quality of 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 aid in pumping of the oil. The fuel oil storage tank(s) should be checked periodically and cleaned of any sludge deposits.

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

Normally these valves do not require any specialized maintenance. 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 leaks occur in the packing of the metering valve, the packing nut should be snugged gradually to stop leaks. EXCESSIVE TIGHTENING OF METERING VALVE PACKING NUT PREVENTS FREE MOVEMENT OF THE METERING STEM.

If replacement of metering valve packing is required, obtain packing kit from Cleaver-Brooks or its representatives and follow procedure for installation given in bulletin that accompanies the kit.

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.

o. OIL HEATERS—ELECTRIC, STEAM, (HEAVY OIL)

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.

Evidence of oil in the steam heater condensate demands prompt repairs.

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 burner 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, or steam oil heater is removed for servicing the temperature of the heater should be reduced by allowing oil flow from the pump until it is.

p. STEAM HEATER PRESSURE REGULATOR

This regulator is provided for the purpose of reducing steam pressure from the boiler to the level necessary to 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. Pressure that is too high will result in frequent cycling of the steam solenoid valve. The final setting should be made during operation at normal load level.

r. THE AIR PUMP AND LUBRICATING SYSTEM

Air Pump

The air pump itself requires a 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. Disassembly 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 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.

There is an orifice fitting installed at the junction of the tubing and the filler pipe. This orifice restricts the flow of lubricating oil to the pump. It must be reinstalled in the event of dismantling during pump replacement or other repair work.

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. Reassemble strainer in reverse order.

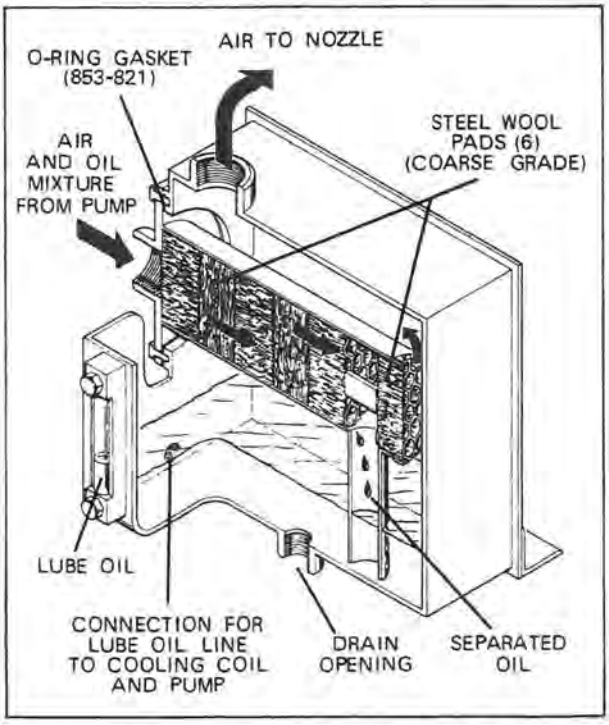


FIGURE 4-5 AIR-OIL RECEIVER TANK

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 4-5 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 steel wool (CB919-124). Do not substitute other grades! 6 pads are required. When replacing the wool, insert 5 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 overly compress the wool and be sure that it is fluffed out to fill all available space. Improper packing can 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 SYSTEM

The fins of the heat exchanger 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 tool for checking alignment is a small straightedge. While some can gauge the amount of misalignment by eye, it is better to use 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 4-6). 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° interval.

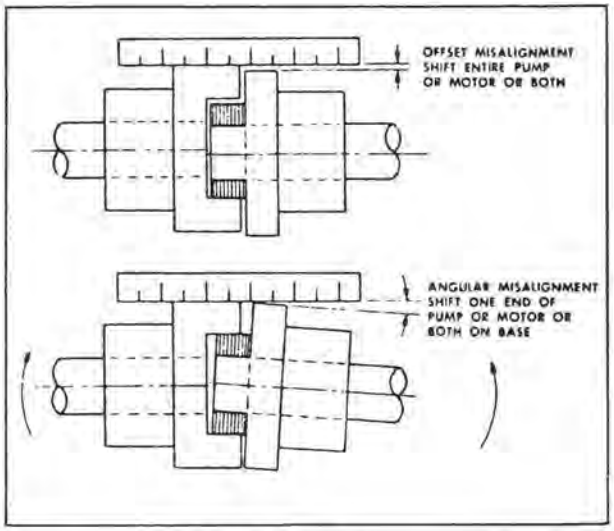


FIGURE 4-6

If possible, checking at four 90° intervals is best. 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 4-7 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.

DIS-MANTLING

1. Disconnect union in pump discharge line. See Figure 4-7.

2. Remove coupling guard and fan guard.

3. Disconnect the flared nut closest to the cooling coil on the tubing between the coil and the fill pipe. Be alert to possible spillage of lube oil.

4. Remove capscrews holding pump to base and remove pump and attachments.

5. Remove fan from pump.

6. Remove inlet casting and piping from pump.

7. Install removed components on replacement pump. If piping was dismantled be sure that the check valve is reinstalled so that the gate swings toward the pump.

When re-installing fan slide it on to the compressor shaft until the hub is bottomed. 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.

8. When reinstalling pump on base, carefully check the spacing between shafts and the coupling alignment. 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.

9. To prevent a piping strain on the pump, slots are provided in the mounting base of the air-oil tank to provide the necessary adjustment for the mating parts of the union to touch. Make sure that all piping connections are tight.

10. Replace coupling and fan guards.

11. If motor was replaced or if 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 manufacturers' recommendations.

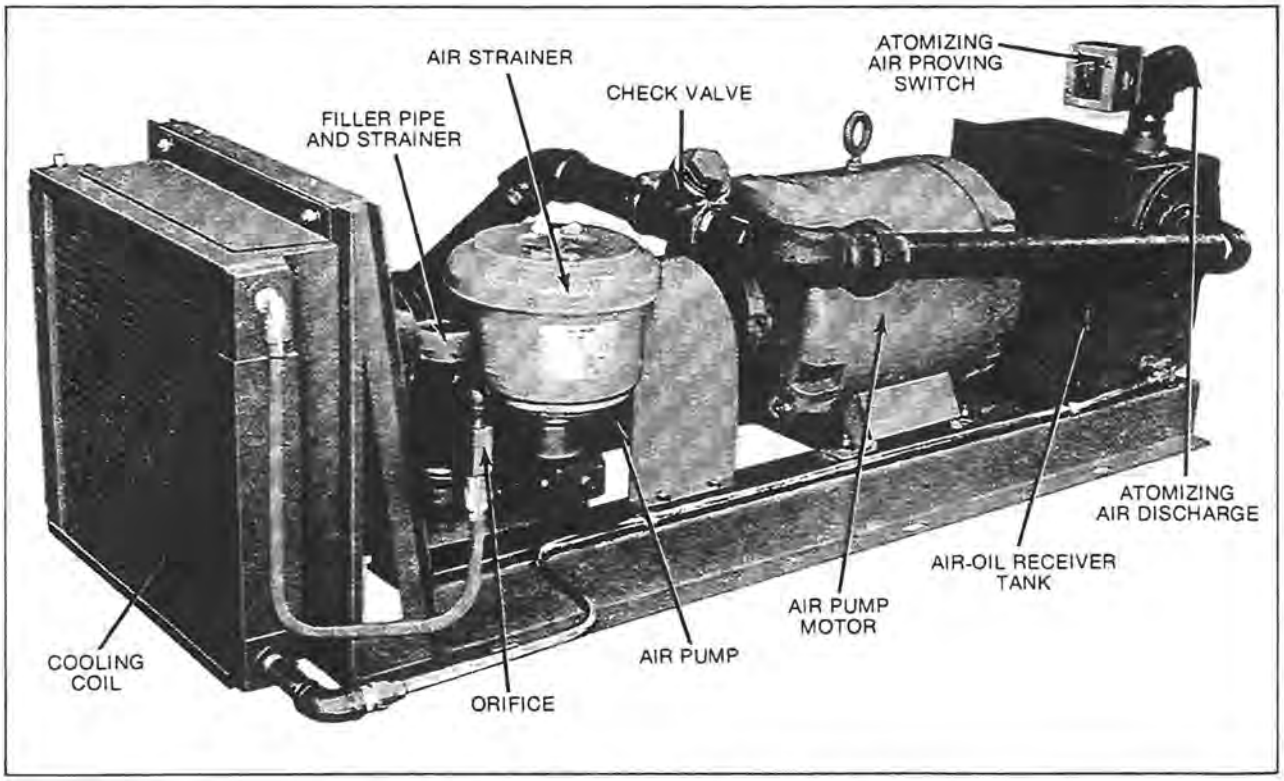


FIGURE 4-7 AIR PUMP MODULE

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

These valves will operate for long periods without trouble. However, foreign matter between the valve seat and seat disc can cause leakage. Valves are readily dis-assembled, 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.

G. LUBRICATION

Electric Motors

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

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

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

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

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

Control Linkage

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

Solenoid valves and motorized valves require no lubrication.

CHAPTER 5

TROUBLE SHOOTING

If the burner will not start, or upon a safety lockout, this trouble shooting section and the technical bulletin for the programming relay 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 this manual and the 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.

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. Little effort is made to explain methods of correcting the trouble once it has been identified, since this information may be found elsewhere in this manual.

A. BURNER DOES NOT START

1. Main disconnect switch open
2. Blown fuses or tripped overloads
   a) Starter overload coils
   b) Inoperative starter or burned out coil
   c) Loose electrical connection
3. Combustion control contacts dirty or safety switch requires resetting.
   a) Refer to manufacturer's bulletin
   b) Check for power between terminals 2 and 4
   c) Check that timer contacts and relay contacts are clean. (See Bulletin)
   d) If relay RL1 pulls in, but blower motor does not start check power at terminal 8. If no power check contact RL1-1
4. Limit circuit not completed
   a) Pressure is above setting of operating control. (steam demand light will not glow)
   b) Fuel pressure must be within settings of low pressure and high pressure switches
   c) Oil fired unit — burner gun must be in full forward position to close oil drawer switch
   d) Heavy oil fired unit — oil temperature below minimum setting.
   e) Water level below proper setting
      1) Low water light and alarm horn should indicate this condition
      2) Check manual reset button, if provided, on low water control
   f) Fault is in the limit circuit if there is zero voltage between terminals 2 and 3
5. Motor defective
6. If burner starts, but shuts down after 8 seconds check the air proving switch circuit (terminal R)

B. NO IGNITION

1. Lack of Spark
   a) Electrode grounded or porcelain cracked
   b) Improper electrode setting
   c) Loose terminal on ignition cable
   d) Inoperative ignition transformer
   e) Relay contacts dirty or open (see programmer manual)
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

C. GAS 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 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 RL2 does not pull in when pilot flame lights, check contact K1-3
   b) If relay RL2 pulls in but fuel valve isn't energized, check voltage between terminals 2 and 7 when timer reaches position "2". If no voltage check contacts RL2-2 or K1-1.
5. Flame detector defective, sight tube obstructed or detector lens dirty.

D. LOW FLAME, BUT NO HIGH FIRE

1. Pressure above modulating control setting
2. Pressure below setting of low fire pressure switch
3. Manual-automatic switch in wrong position
4. Inoperative modulating motor (See Section F)
5. Defective modulating control
6. Binding or loose linkage, cams, setscrews, etc.

E. LOSS OF FLAME

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. Limit circuit or non-recycling interlock circuit open.
   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. 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)
7. Incorrect burner adjustment
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 during pre-purge
   a) Contacts RL1-5, K7-2, K5-2 dirty or open
   b) Contact RL1-6 does not open
4. Motor does not close at end of pre-purge
   a) Contacts RL1-5, K7-2, K5-1 dirty or open
5. Motor does not operate on demand
   a) Manual-automatic switch in wrong position
   b) Modulating control improperly set or in-
   c) Low fire pressure switch open
   d) Contacts K7-1, RL1-5 dirty or open
   e) Contact RL1-6 does not open
6. Motor does not close at burner shutdown
   a) Contact RL1-6 dirty or open
7. Motor inoperative
   a) Loose electrical connection
   b) Faulty damper motor transformer

CHAPTER 6

PARTS ORDERING INSTRUCTIONS AND PARTS LIST

FURNISH COMPLETE INFORMATION WHEN ORDERING PARTS — When ordering parts for your burner, be sure to include on your order the burner 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.

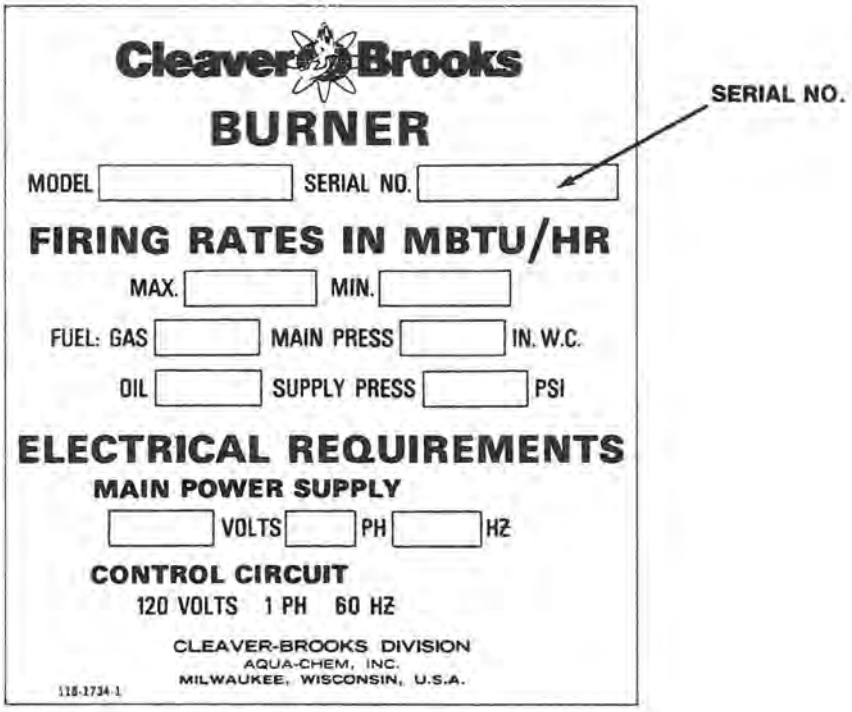
WHERE TO ORDER PARTS — Repair or replacement parts should be ordered from your Cleaver-Brooks representative.

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.



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

NOTE: Usage Column indicates parts that apply to a particular unit. If no designation is given, parts apply to all models, sizes and series covered by this manual.

Part No.	Req.	Description	Usage
		BURNER PARTS	
251-46	1	Nozzle Tip and Swirler	CN 1-5 Light Oil
251-56	1	Nozzle Tip and Swirler	CN 6-7 Light Oil
251-55	1	Nozzle Tip and Swirler	CN 1-7 Heavy Oil
82-105	1	Spring, Swirler	
32-2297	1	Gasket, Burner	
275-151	1	Diffuser	
435-71	1	Electrode, Gas Pilot	
904-36	1	Grommet, Rubber, Electrode	
134-53	1	Spacer, Electrode Holder	
853-691	1	O-ring, 1-1/16" OD 13/16" ID	Oil Tube
90-292	1	Tube and Sleeve, Oil to Nozzle	
851-77	1	Mica, Porthole	
90-307	1	Tube, Flame Detector Sight	
861-317	1	Hose, Flexible, 3/4" x 42"	Oil
861-318	1	Hose, Flexible, 1-1/4" x 42"	Air
277-136	1	Body, Nozzle	
251-45	1	Burner Gun	CN 1-5 Light Oil
251-47	1	Burner Gun	CN 6-7 Light Oil
251-59	1	Burner Gun	CN 1-7 Heavy Oil
32-497	1	Gasket, Scanner Tube	
		ELECTRICAL CONTROLS AND COMPONENTS	
832-107	1	Transformer, Ignition, 115/6000	
894-2812	1	Motor, Modulating, M941C	Integral Low Fire Switch
894-2834	1	Motor, Modulating, M941D	Integral Low and High Fire Switches
833-1921	1	Control, Fireye CB-3	
833-1814	1	Control, Fireye 6080C	
832-160	1	Cell, Flame Detector	
817-139	1	Flame Detector Cable Assembly	
832-747	1	Tube, Electron, 12AX7	
832-748	1	Tube, Electron, 12BH7A	
817-111	1	Control, Pressure, 20-300 lb., L404A	
817-900	1	Control, Pressure, 20-300 lb., L404C	
817-234	1	Control, Pressure, 10-300 lb., L91A	
817-112	1	Control, Pressure, 20-300 lb., L404B	
836-45	1	Switch, Mercury, For L404A and L404C	
836-92	1	Switch, Mercury, For L404B	
817-1265	1	Control, Pressure, L404Y	Low Oil Pressure
817-1261	1	Control, Temperature, FM-437-3	Low Oil Temperature
836-65	1	Thermostat, 100-240 Degrees F., WR 11B05	Low Oil Temperature
836-72	1	Thermostat, 100-240 Degrees F. WR 11B18	High Oil Temperature (FIA)
836-320	2	Thermoswitch, Fenwall	Oil Heaters
832-311	2	Condenser, .005 MFD	For 836-320
817-436	1	Switch, Air, C645A1	Combustion Air
836-418	1	Switch, Air, 161P15	Atomizing Air
817-1167	1	Control, Pressure, 1-30", PR-2	High Gas Pressure
817-1168	1	Control, Pressure, 1/2 to 5PSI, PR-2	High Gas Pressure
817-1169	1	Control, Pressure, 1-30", PRL-3	Low Gas Pressure
817-1170	1	Control, Pressure, 1/2 to 5PSI, PRL-3	Low Gas Pressure
832-235	1	Transformer, Damper Motor	
836-209	1	Potentiometer, 30112	
836-89	1	Switch, Micro, YZLN-RH	Burner Drawer
292-66	1	Ignition Cable, 20"	
832-764	1	Coil, Potentiometer, For L91A	

Part No.	Req.	Description	Usage
		OIL VALVES AND COMPONENTS	
940-1818	1	Valve, Solenoid, 1/2", 115V., K10A B 389	Light Oil CN 1-5
832-1078	1	Coil, Solenoid, 115V.	For 940-1818
948-43	1	Valve, Solenoid, 1/2", 115V., K10A D	Light Oil CN 6-7 Heavy Oil CN 1-7
832-1071	1	Coil, Solenoid, 115V.	For 948-43
948-154	1	Valve, Solenoid, 3/8", 115V., 8266C23	Heavy Oil Purge
832-1066	1	Coil, Solenoid, 115V.	For 948-154
880-109	1	Kit, Spare Parts	For 948-154
949-184	1	Valve, Motorized, 3/4" w/Aux. Switch. HOVIA	FM Approved
24-56	1	Stem, Metering Valve, No. 9	
908-113	1	Kit, Packing, Metering Valve	
48-301	1	Orifice, Metering Valve	
32-1248	1	Gasket, Orifice Cover	
945-104	1	Diaphragm, Set of 2	Controller Reducing Valve
32-1296	1	Gasket, Diaphragm	
880-75	1	Kit, Repair Parts (Includes Two Items Above)	
945-107	1	Diaphragm, Set of 2	Controller Back Pressure Valve
32-1291	1	Gasket, Diaphragm	
880-76	1	Kit, Repair Parts (Includes Two Items Above)	
899-51	1	Nozzle, Orifice, 24 GPH	Light Oil
		GAS VALVES AND COMPONENTS	
940-278	1	Valve, Solenoid, 1/2", 115V. K3A	Gas Pilot
832-208	1	Coil, Solenoid, 115V.	For 940-278
940-648	1	Valve, Motorized, 4", H118AN	
949-25	1	Valve, Motorized, 6" H118AQ	
945-102	1	Actuator, 115V. H30	For 940-648 and 949-25
853-403	2	Gasket, 4" Flange	
940-165	1	Valve, Gas Butterfly, 4"	
948-55	1	Valve, Solenoid, 2" N.O., 821583	Vent Valve
880-115	1	Kit, Spare Parts	For 948-55
832-1066	1	Coil, Solenoid, 115V.	For 948-55
948-66	1	Valve, Solenoid, 1/2" N.O., 8210A34	Pilot Vent Valve
880-114	1	Kit, Spare Parts	For 948-66
832-721	1	Coil, Solenoid, 115V.	For 948-66
949-186	1	Valve, Motorized, 4", w/Aux. Switch, H118AN	FM Approved
949-163	1	Valve, Motorized, 4", Maxon 4690H	F.I.A. (Optional)
949-174	1	Valve, Motorized, 2-1/2", H120	Vent Valve
		OIL HEATING COMPONENTS	
832-981	1	Heater, Electric, 10 KW, 230 Volts	
832-982	1	Heater, Electric, 10 KW, 460 Volts	
832-983	1	Heater, Electric, 10 KW, 575 Volts	
853-692	1	O-Ring Gasket, Electric Heater	
32-2394	1	Gasket, O-Ring Backup	
652-20	1	Heater, Steam (Less Electric Heater)	
534-185	1	Tube Bundle, Outer	Steam Heater
191-1810	1	Tube Bundle, Inner	Steam Heater
32-1106	2	Gasket, Tube Sheet, Outer	Steam Heater
32-1105	1	Gasket, Tube Sheet, Inner	Steam Heater
948-152	1	Valve, Solenoid, 3/4", 115V. 8222E3	Steam Heater
832-1076	1	Coil, Solenoid, 115 Volts	For 948-152
880-107	1	Kit, Spare Parts	For 948-152
918-104	1	Regulator, Steam, 3/4" 95H	To 250 PSI Steam
918-13	1	Regulator, Steam, 3/4" 95H	250-300 PSI Steam

Part No.	Req.	Description	Usage
		GAUGES	
850-547	1	Gauge, 2-1/2", 0-60 lb.	Air
850-391	1	Gauge, 2-1/2", 0-100 lb.	Back Connection
850-145	1	Gauge, 2-1/2", 0-160 lb.	Back Connection
850-237	1	Gauge, 2-1/2", 0-160 lb.	Bottom Connection
850-117	1	Gauge, 2-1/2", 0-200 lb.	Bottom Connection
850-526	1	Gauge, 3-1/2", 0-30 lb.	Main Gas
850-615	1	Gauge, 2-1/2", 0-15 oz. - 5 lb.	Pilot Gas
937-49	1	Thermometer, Oil, 2", 50-300°F	Heavy Oil
		LINKAGE PARTS	
10-91	1	Bushing, Modulating Motor Shaft	
883-17	1	Ball Joint	
10-288	1	Bushing, Ball Joint	
2-148	1	Arm, Damper Shaft	
2-149	1	Arm, Damper Motor	
2-151	1	Arm, Jackshaft to Damper	
2-142	1	Arm, Jackshaft from Motor	
313-8	1	Cam	
82-111	1	Spring, Cam	
24-41	1	Stem, Gas Valve Cam Linkage	
82-1	1	Spring, Gas Stem	
		AIR PUMP AND LUBE PARTS	
505-97	1	Pump, Air, 10"	
32-1783	1	Gasket, Inlet Manifold	
819-181	1	Coupling, Flexible, 1-3/8"x1-3/8" Lovejoy L110	
819-217	1	Insert, For L110 Coupling	
919-124	3	Pad, Steel Wool, #3 Coarse	6 Req'd
853-821	1	O-Ring, Tank Cover	
529-11	1	Strainer, Lube 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
171-114	1	Basket, Oil Inlet Filter	
919-122	1	Cap, Oil Inlet Pipe	
843-238	1	Air Filter, 1-1/2"	
813-85	2	Fan Blade, Cooling	
41-110	1	Hub, Fan	For 813-85
850-647	1	Oil Sight Gauge	
880-102	1	Glass and O-Rings, Oil Sight Gauge	For 850-647
894-2865	1	Motor, 10 HP, 230/460/3/60/1800	
894-2866	1	Motor, 10 HP, 208/3/60/1800	
894-2867	1	Motor, 10 HP, 575/3/60/1800	
		BLOWER MOTORS	
		It is not practical to list blower motors or wheels. If replacement is required, please furnish nameplate data of present motor.	