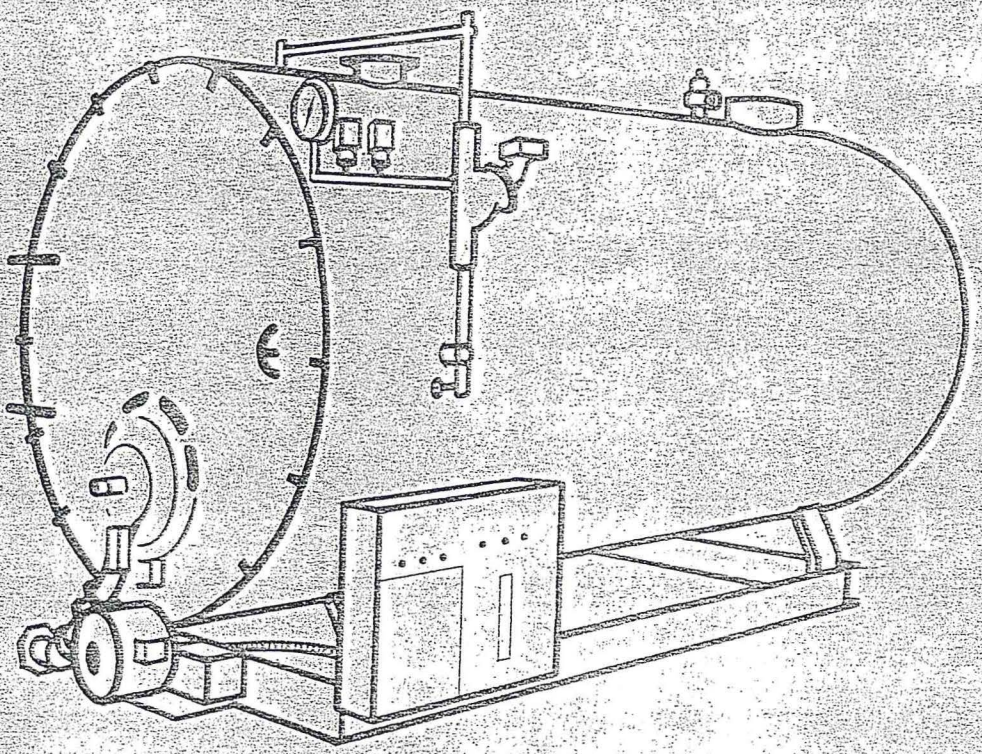
OFFICE Copy

INSTRUCTION MANUAL

RAY PACKAGED BOILERS

SERIES E



RAY BURNER COMPANY — BOILER DIVISION

1301 SAN JOSE AVENUE • SAN FRANCISCO, CALIFORNIA 94112

PLANTS IN SAN FRANCISCO, CALIFORNIA • MIDDLETOWN, PENNSYLVANIA • TORONTO, CANADA

FOR OFFICE COPY ONLY !

NB 28176

QUALITY CONTROL-FINAL BURNER INSPECTION

ORDER NO. B-7622 72-200-10

200 BHP | BNR MODEL E0R-144 | SERIAL NO 293518

5 OIL	440-60-3 MOTORS 115-60-1				CONTROLLER		
	HP	RPM	ELECT	MAKE	FRAME	MAKE	TYPE	OVERLOA
BLOWER 7.1	5	3510	---460	GE	182-T	C-H 30	9586H7154	2-----5
AIR PUMP 2.3	1½	1725	---460	GE	56C	A-H 30	34331-U	42010
OIL PUMP 7.3	½	3450	115---	Baldor	56C			
IGN PUMP								

	DRIVE PULLEY			DRIVEN PULLEY			BELTS	
	P D	BORE	GROOVE	P D	BORE	GROOVE	TYPE	QT
BLOWER	5.6	1 1/8	3	6.0	1 7/16	3	3V560	3
AIR PUMP								
OIL PUMP								

AIR PUMP COUPLING BORE- BORE | OIL PUMP COUPLING BORE BO

ELECTRIC PREHEATER- QTY 2 - KW- 5 VOLTS-440 PHASE- MAKE Wells MODEL 5442SF

PREHEATER RELAY- QTY 2 MAKE A-H 40 MODEL ACC 320-UM-20 Ser 9712647&9712169

Ser #32-72031204	MAKE	MODEL	SIZE
BURNER SAFETY	ECA	26RJ8-6070	
BURNER SCANNER	ECA	48PTL	
OIL PUMP	Ray	52060-21	
OIL STRAINER	Ray	6487	3/4
OIL FILTER	Cuno	12706-02	3/8
OIL PRESS REG			
OIL PRESS GA. 2	Ray	0-100/0-100	2
OIL TEMP GA			
LO OIL PRESS LY4	M-H	L404V1038	¼
HI OIL PRESS			
LO OIL TEMP FY24	M-H	L4007B1006	½
HI OIL TEMP FX2	M-H	L4006A1009	½
MAIN OIL VALVE LIE	G.C.	K10AB281-T	½
MAIN OIL VALVE J2E	G.C.	K10AB281-T	½
CIRC OIL VALVE			½
PURGE VALVE F2A	GC	S302AA	¼
AIR PUMP 72-139062	Ray	2065P38F	
AIR FILTER	Gast	D344B	3/4
OILER	Gast	X	½
AIR PRESS REL	Gast	X	3/8
AIR PRESS GA	Gast	0-30	2
ATOM AIR VALVE			
ATOM STM VALVE			
AIR PRESS REG			
STM PRESS REG			
ATOM AIR INTERLOCK	M-H	PA404B1007	½
STM ATOM INTERLOCK			
IGN TRANS- OIL			
IGN TRANS- GAS	Ray	7-6-372	¼
MOD MOTOR			
HI-LO MOTOR BX1	M-H	M947D1013	
MOTOR TRANS DX	M-H	AT72D1089	
MAIN GAS VALVE			
MAIN GAS VALVE			
MAIN VENT VALVE			
GAS PRESS GA			
MAIN GAS COCK			
HANDLE			
MAIN GAS COCK			
HANDLE			
MAIN GAS REG			

	MAKE	MODEL	SI
LO GAS PRESS			
HI GAS PRESS			
PILOT VALVE E2A	GC	S301AA	3/
PILOT VALVE			
PILOT VENT VALVE			
PILOT REG	Max	R500S	½
PILOT PRESS GA			
PILOT COCK	X	X	
PILOT OIL PUMP			
STM PREHEATER			
STM STRAINER			
STM STOP VALVE			
STM PRESS REG			
STM TEMP CONTROL			
STM PRESS GA			
STM TRAP			
WTR PREHEATER			
CIRCULATOR			
WTR TEMP CONTROL			
OIL TEMP CONTROL			
STOP VALVE			
TAIL PIECE HTR 2	X	X	
COMB AIR INTERLOCK	BEC	X	
TAIL PIECE SWITCH			
CONTROL CIRC FUSE	1	FRN-15	
WTR CONTROL RELAY	Warrick	IDIDO	
BLOWER WHEEL	Belt	X	
WINDBOX ASSY	X	X	
Loose (X)			
DIM DRAWING			
WIRING DIAGRAM			
INSPECTED BY	WIB		

OPERATIONAL TEST REPORT

BOILER HP	BOILER PRESS	BURNER MODEL	ALTITUDE	ORDER NO
200	SWP 150 WWP ____ PSIG	EOR-144		B-7622

FUEL OIL	GAS CHARACTERISTICS	APPROVALS
NO 5	____ BTU/CU FT ____ MIN ____ MAX PRESS	

ELECTRICAL CHARACTERISTICS

CONTROLS	115 VOLTS	1 PHASE	60 HERTZ	2 WIRES
MOTORS	440 VOLTS	3 PHASE	60 HERTZ	3 WIRES

TEST DATA

NO 5 OIL FIRED TEST				____ BTU GAS FIRED TEST			
		HI FIRE	LO FIRE			HI FIRE	LO FIRE
FIRING RATE	LBS / HR			FIRING RATE CFH			
	GALS/HR	56	16				
PLENUM PRESS IN.W.C.		4	1.5	PLENUM PRESS IN WC			
CO_2 %		12	11	CO_2 %			
SMOKE NO		1	1	CO %			
O_2 %		—	—	O_2 %			
STACK TEMP °F		350	XX	STACK TEMP °F			XX
STACK DRAFT IN WC		0	0	STACK DRAFT IN WC			
BOILER PRESS PSIG		—	—	BOILER PRESS PSIG			
COM AIR PRESS PSIG		18	15	GAS PRESS BEFORE		XX	XX
ATOM OIL PRESS PSIG		26	12	PRESS REG	IN WC PSIG		
OIL TEMP °F		130	140	BURNER	IN WC		
FURNACE PRESS IN WC		.7	.1	FURNACE PRESS	IN WC		

COMPONENT CHECK

BLR PIPING TIGHT	✓	HI OIL PRESS SWITCH		—
OIL PIPING TIGHT	✓	LO OIL PRESS SWITCH	✓	
GAS PIPING TIGHT		LO OIL TEMP SWITCH	✓	
HI LIMIT CONTROLS	✓	HI OIL TEMP SWITCH	✓	
OPERATING CONTROLS	✓	COMB AIR SWITCH	✓	
MODULATING SYSTEM	✓	ATOM AIR INTERLOCK	✓	
HI-LO SYSTEM		LO FIRE INTERLOCK	✓	
ON-OFF SYSTEM	✓	HI FIRE INTERLOCK	✓	
LWC & ALARM	✓	BNR POSITION SWITCH		
HWC & ALARM		COMBUSTION SAFETY	✓	
HI GAS PRESS SWITCH		FLAME FAILURE	✓	
LO GAS PRESS SWITCH		PILOT ADJUSTED	✓	
VENT VALVE TIGHT				

TEST AMPS

BLOWER MOTOR	OIL PUMP MOTOR	AIR PUMP MOTOR	IGNITOR MOTOR
7.3 AMPS	3.7 AMPS	8 AMPS	AMPS

R. McLauchlan F01549 28176

QUALITY CONTROL-FINAL BOILER INSPECTION

ORDER NO. B-7622 72 200 10

200 BHP | DESIGN PRESS- 150 PSIG STM/~~XXXX~~ | N.B. 28176

SUBMITTAL B0-7622-200 | APL COMM AB-7622-1 | WIRING DIA. WR-7622

	MAKE	MODEL	SIZE		MAKE	MODEL	SIZE
WATER COLUMN				HI LIMIT CONT FX9	M-H	L404A1395	1/4
TRY COCKS 3	Cons	X	1/2	AUX HI LIMIT CON'T	(FX9)M-H	L404A1395	1/4
GAUGE COCKS 2	Cons	X	1/2	OPER CONT FX9	M-H	L404A 1396	1/4
STOP COCKS				MOD CONT HX3	M-H	L91A1052	1/4
DRAIN VALVE	CBC	Apollo	1/4				
21 1/2		Auto		SURFACE B.D			
WATER LEVEL CONT	M-M	157		SPARGE PIPE			
DRAIN VALVE	N-S	T255B	3/4	SPARGE VALVE			
AUX WTR LEVEL CONT				BLOWDOWN-SLOW			
DRAIN VALVE				BLOWDOWN-QUICK			
AUX LWC-PROBE	Warrick	3EIB	X	SAF/REL VALVE	Short		
AUX HI WC-PROBE				SAF/REL VALVE	Kunkle	6000-H1	1 1/2-150 (X)
				SAF/REL VALVE			
BLR PRESS GA	Ashcroft	0-300	6				
BLR TEMP GA				STACK THERM	Weston	4303	3 (X)
GAUGE COCK	X	X	1/4				
TEST COCK	X	X	1/4	REAR PEEP			1 1/2
FEED STOP VALVE				PRESS REL. DOOR(S)			
FEED CHECK VALVE							
				FLUE BRUSH			
EJECTOR							
INJ STM VALVE				MAIN STOP VAL			
INJ STOP VALVE				MAIN NON RETURN			
INJ CHECK VALVE				MAIN ADAPTOR			
MECH FEEDER				PRI BLR CIRC			
SOLENOID FEEDER				STOP VALVE			
3 VAL BYPASS				FLOW SWITCH			
				Day-Nite Sw.	X	X	X
				Alarm Horn	F.S.S.	350	Ser#A-1
				Loose (X)			

MARKINGS		INSTRUCTION ENVELOPE	X
OILER NAMEPLATE	Rev E	WALL CARD	
SPECIAL NAMEPLATE	———	WIRING DIAGRAM	Did One
STENCILS	X	SUBMITTALS	
UL NAMEPLATE NO	L-391270	SPECIAL CONNECTIONS	
CURRENT RATING PLATE	440-60-3	FIRE TEST REPORT	X
LOAD - AMPS	115	INSPECTED BY	WJB

INSTRUCTIONS
for the
INSTALLATION, OPERATION AND MAINTENANCE
of
PACKAGED BOILERS

The information contained in this book has been prepared with a background of many years of experience and development. These recommendations should be followed to obtain the greatest satisfaction from oil and gas burning equipment.

This instruction book describes the construction and operation of a packaged boiler which is designed for automatic operation to generate high or low pressure steam or hot water, and to use heavy and light oils and natural and liquid petroleum gas as fuel.

All equipment must be installed in accordance with the Standards of the National Board of Fire Underwriters and of State and local ordinances. These recommendations should be carefully followed in all instances. All authorities having fire or safety jurisdiction should be consulted before installations are made.

Specified controls are shipped with the boilers. Some are mounted or installed on the unit, while others are shipped along with the unit in the manufacturer's original package. Instruction leaflets are usually included either in the original carton with the control components, or included with other instructions in an envelope shipped with the boiler. Should any additional information be required, please contact your dealer or the boiler manufacturer.

To obtain the most economical and satisfactory performance, it is recommended that these boilers be installed, adjusted, and serviced under the supervision of your local independent dealer.

INDEX

I. GENERAL DESCRIPTION

BOILER EQUIPMENT

These packaged boilers are 2 or 3-pass modified Scotch Marine types with integral burner and fuel handling equipment for gas, light or heavy oil or combination of gas and oil. Boilers are constructed in strict accordance with the applicable sections of the ASME Code and its latest revisions. The ASME Code stamp is located in the pressure vessel shell and covered by a removable plate in the boiler insulating protective jacket. The rear combustion chamber is either of the dry-back or water cooled type. Additional insulation of the boiler shell is not required at job site.

Boiler Saddles and Base

Each boiler is supported by a structural steel frame (four saddles) and bottom base. In the rear, the shell is attached to the two saddles by means of bolts and nuts. **IMPORTANT:** After installation, and before the boiler is placed in operation, the bolts at these locations must be loosened to allow free travel of the boiler shell on the rear saddles occasioned by thermal expansion. Failure to do so may create severe stress and cause damage to the internal parts of the pressure vessel.

Fire Tubes

Fire tubes are staggered to assure maximum heat transfer at internal circulation of the boiler water. In low pressure boilers (15 psi steam or 30 psi hot water), all tube ends at the entrance of the 2nd pass bank are rolled and beaded, rolled and flared at all other tube ends. In high pressure boilers (150 psi steam and hot water boilers in excess of 30 psi) all tube ends are rolled, flared and beaded. When re-rolling tube ends after boiler has been installed, the following procedure must be followed:

(a) Re-roll as lightly as possible to repair leaks.

(b) Re-bead any beaded tube ends which have been re-rolled.

(c) Dismount safety valves and any other boiler controls which have a maximum design pressure range below 1½ times the design pressure of the boiler. Plug or cap resulting openings in shell or piping.

(d) Submit the boiler to a hydrostatic test of 1½ times its design pressure as stamped on the boiler nameplace on the front door. While under this pressure, check for residual leaks and re-roll lightly as required.

For firetube diameters, metal thickness and replacement length, see Chart No. 1.

CHART NO. 1
(Fire Tubes)

Boiler Size	Outside Diameter In.	Metal Thickness All Pressures Ga.	Replacement Length 2nd & 3rd Pass In.
40	2	13	59
50	2	13	75
60	2	13	91
70	2	13	107
80	2½	12	95
100	2½	12	119½
125	2½	12	114½
150	2½	12	138
200	2½	12	130
250	2½	12	139
300	2½	12	167½
350	2½	12	178½
400	2½	12	143
500	2½	12	170½
600	2½	12	180½

OPERATION AND MAINTENANCE OF BOILERS

Boilers involved in this discussion are of the scotch, three-pass, type. In the operation of your new boiler, good care and attention is very important and we are listing herein some suggested matters in this respect. Authorities in your local area may have regulations governing operation of boilers and you should determine what these regulations require. In addition, you will find certain other sources of useful information, such as your boiler insurance company, state and local boiler inspector, and engineering society handbooks.

1. BOILER START-UP

See applicable instructions in Section V on Burner Operation.

Each boiler is equipped with a "low fire hold switch." With this switch in the "manual" position, the fire, when started, will remain at low setting until the switch is changed to "automatic."

In any boiler, the metal and refractory surfaces need to be heated slowly to minimize rapid local expansion especially in the areas where tubes are rolled into the tube sheets.

Therefore, it is imperative that a cold boiler be allowed to reach its operating temperature slowly by keeping the unit on low fire until steam is being generated in steam boilers and the temperature of the boiler water has reached 180° in hot water units. If this procedure is not followed, severe damage may be caused to tubes and refractories.

Important – Do not attempt to overfire any boiler. This may result in severe damage to the pressure vessel and refractories and will automatically void the standard factory warranty. In case the boiler does not keep pace with the load demand, consult the nearest factory authorized representative or service organization to determine the cause and make the necessary recommendations for remedy of this condition.

2. WATER TREATMENT – NEW BOILER (Boil Out)

It is essential to make sure the boiler is cleaned thoroughly of oil, pipe dope, etc., when it is first put in service. If you do not have the services of a firm specializing in water treatment, add one pound of caustic soda (household lye can be used, if necessary) for each 10 horsepower of boiler capacity, to the boiler water. Add the caustic soda to water in a bucket, do not pour water on caustic soda. Avoid getting the solution on hands, face or clothing, or painted surfaces, when pouring it into a boiler opening.

The sequence of boil-out procedure is as follows:

a. Isolate boiler from system by closing main stop valves.
b. Remove pop safety valve(s) from boiler and insert pipe plug in unused safety valve couplings if more than one safety valve is used. Pour caustic solution in boiler through safety valve opening.
c. Install a temporary discharge pipe from the safety valve opening to a point outside the boiler room where caustic saturated steam or vapors may be discharged safely without danger to persons or damage to surrounding structures. Do *not* attempt to relieve and discharge steam or vapors through safety valves as this will damage the safety valves beyond repair.
d. Set the pressure or temperature control of the boiler to operate the burner to a maximum boiler pressure of 5 psig or 212° F. Start the burner and maintain at low fire while boiling out the pressure vessel. Inasmuch as the boil-out procedure is effective only when the burner is in operation, the fire should be kept at a minimum to keep the unit firing as long as possible. Maintain the boil-out procedure for a period of not less than 6 hours after the burner is initially started.
e. After completion, allow unit to cool slowly overnight. Remove temporary discharge piping. Fill pressure vessel to the top with fresh clean water and drain through bottom blowoff valve. Fill and drain a second time. For boilers equipped with a top manhole, remove manhole. For those units which do not have a manhole, remove highest handhole in boiler shell. Insert a high pressure water hose in manhole or handhole and flush internal surfaces of the pressure vessel thoroughly leaving the bottom blowoff valve open.
f. After completion of flushing procedure, re-install manhole and handhole covers using new gaskets. Replace safety valve(s). Place boiler in operation and reset pressure or temperature controls for desired operation.

3. BLOWDOWN

The valves at the low points in the boiler are referred to as drain or blowdown valves. Use of these valves will result in carrying off a portion of the boiler water having a high concentration of precipitates and dissolved matter and will prevent them from building up to form salts and solids.

When a boiler is generating steam, the continued requirement for feedwater brings dissolved mineral matter into the boiler. If care is not exercised, this continued increase of mineral matter will proceed until some limit is reached, beyond which operation is unsatisfactory. Excessive concentrations of sludge, silica, chlorides, and other dissolved matter will result if boiler blowdown is not practiced.

Small boilers are generally blown down a certain number of inches, measured by the water glass gauge. The amount of blowdown, or the number of times per day or week, depends upon the concentration of solids in the boiler water. Since feedwaters differ in mineral and salt content, it is not possible to indicate any specific recommendation to cover blowdown for all boilers. A boiler water expert should be consulted for specific blowdown schedule if steam production is high and the raw water is high in mineral content. A number of feedwater experts believe a good feedwater is one with 0.5 ppm maximum total solids and 0.007 ppm maximum dissolved oxygen, with a pH of 8.8 to 9.2.

A heating boiler operated with water returning from the system normally does not need blowing down, emptying or cleaning internally during the heating season. As a general rule high pressure steam boilers are blown down once a day, while low pressure steam and hot water boilers are blown down once a week.

4. SURFACE BLOWDOWN

Grease, scum, and light solids may be removed from the surface of the boiler by means of the surface blow valve. This valve is connected to the blow pipe which extends the length of the boiler at or immediately below the waterline. The pipe is perforated on the top along its length. When the valve is opened, steam pressure forces the surface water and surface contaminants out through the pipe.

5. WATER TREATMENT – IN SERVICE

A wide fluctuation of water line may indicate that the boiler is *foaming or priming.* This may be due to a very high rate of steaming, especially at low pressure, or water line being carried too high. Dirt or oil in the boiler water, or a high concentration of solids or water treatment compounds in the water, may also cause foaming. Check by blowing down and also by surface blowdown. Sometimes by blowing down to drain two or three inches, and refilling several times, the foaming will be stopped. If foaming persists it may be necessary to take the boiler out of service, drain and wash out thoroughly and then refill and put back into service.

Almost without exception, boiler tube failure due to *pitting* is traceable to the presence of oxygen in the boiler water, introduced via raw water makeup or by infiltration through leaking valves and pumps. Low pressure steam and hot water heating boilers are more prone to oxygen attack than high pressure steam boilers.

If one boiler tube should develop a leak, due to corrosion, it is likely other tubes are affected as well. Have the boiler examined by a capable and experienced inspector before ordering replacement of one or a few tubes. If all tubes are in a state where replacement will be needed soon, it is less expensive and better to have the work done at one time.

All repair work should be done by experienced boiler mechanics. Welding should be done by ASME code certificate welders. Do not permit repairs to a boiler when it is under pressure, except when authorized by and under the supervision of a capable and responsible engineer or boiler inspector. When any repair work is required, notify the representative of the company that insures the boiler and be guided by his instructions.

For control of scale and pitting problems in regular service, it is advisable to use boiler water treatment. This should be applied as instructed by the supplier of the treatment chemicals. If the raw water is relatively free of scale-forming components and little or no makeup is used, very little treatment is necessary. However, the pitting problem is usually maximum when the scale problem is the least and it is, therefore, important to consult a specialist in order to protect your investment. A reliable concern who is familiar with local water conditions and who can give regular inspection and service should be engaged. A schedule of frequency of bottom blowoff for steam boilers should be obtained from the suppliers of boiler water treatment chemicals, and this schedule should be followed at all times.

Often oxygen scavengers or inhibitors are used in steam boilers in general and hot water boilers when first placed in operation. While not specifically an oxygen scavenger, a borate nitrite solution is the only recommended inhibitor to be used in direct fired pressure vessels. These chemicals deposit a thin, protective film on the waterside metal surfaces. This film will neither build up nor harden into damaging deposits in the high temperature areas.

The use of solutions (scavengers) containing sulphites, sulphates or phosphates are *specifically not recommended.* These constituents will build up thick crystallized deposits on waterside metal surfaces which will harden into a scale-like thermal insulating substance in the high temperature areas, causing damage to the rear tube sheets and tubes at the entrance to the 2nd pass bank.

Hot Water Heating Systems

A closed hot water heating system, operating with water returning from the radiation, should be clean, watertight and have alkaline water. If any of the following tests prove positive, the system needs cleaning:

a. Dirty, murky, discolored water.
b. Gases vented at high points in radiation system will ignite and burn with an almost invisible blue flame.
c. A pH test proves water to be acidic.

A system whose water proves acidic will usually have the following symptoms:

a. Gas formation which, if vented, will ignite.
b. Pump gland and seal troubles.
c. Air vents sticky and leaky.
d. Frequent relief valve operation.
e. Leaky pipe joints.

6. FILLING

Whenever a clean boiler is refilled with water, immediately boil the water, or heat it to at least 180° F. to drive off the dissolved gases. Add a charge of boiler water treatment, of the kind and quantity recommended for the local conditions.

7. WATER LEVEL MAINTENANCE AND CONTROL

a. Maintenance of water in the boiler is of the utmost importance. With a steam boiler, when the water is not visible in the gauge glass, open the try cocks to determine whether the level is above or below the water glass. If it is above, lower water to a proper level with the bottom drain valve. If it is below, shut off the fire immediately. Shut off feed water pumps immediately. Do *not* attempt to feed cold water into the boiler, or open the safety valves as any one of the above procedures may cause severe damage to the boiler and surrounding structures. Allow the boiler to cool slowly.

   Bring the water back to proper level only after the boiler has cooled sufficiently and then check for any possible leaks before resuming operation, and re-check for leaks after boiler is up to operating pressure.

   In the case of water boilers, see that the water pressure in the system is always at or above the minimum maintained by the line water pressure regulator. If the pressure is consistently high, the pressure regulator may be leaking or the expansion tank may be waterlogged and need recharging with air.

b. Follow the manufacturer's instructions in regard to flushing of a low water cutout. Always flush this control with the drain valve at least once each day, preferably allowing it to shut off the fire to prove it is functioning electrically. Excessive flushing merely wastes water and the makeup water necessary adds to the scaling problem. Therefore, frequent small flushings are preferable to infrequent excessive flushings. If possible, observe the water drained from this control. If water shows some dirt momentarily at first opening of the valve and then becomes clear, no additional steps need to be taken to inspect the control internally. If, however, the discharged water is intermittently or continually dirty, the boiler should be shut off and drained, the control dismantled and cleaned as required and directed by manufacturer's instructions.

   If the low water cutout incorporates the use of mercury switches, these switches should be checked visually once every three months to determine whether or not mercury separation has taken place in the mercury tubes. This separation can be observed by droplets of mercury clinging to the glass. Switches showing evidence of such separation should be replaced immediately. Each low water cutout on low as well as high pressure boilers should be inspected internally for sand or scale deposits at *least* once every year and cleaned as required.

   Check the water gauge from time to time, when there is steam pressure on the boiler. Close the lower water gauge valve, then open the drain cock and blow the glass clean. Close the drain cock and open the gauge valve. Water should return to the gauge glass immediately. If the water return is sluggish, leave lower gauge valve open and close upper gauge valve. Open the drain cock and allow water to flow until it runs clear. Then return the gauge to operating condition. If condition is not cleared, indicated by little or no water flow from the drain cock, the valves will have to be cleaned of deposits. Leaks around gauge glass or fittings should be corrected as soon as possible. Steam leaks may result in a false water line reading.

8. SCHEDULED MAINTENANCE PROGRAM

A regularly scheduled maintenance program will assure boiler and system operation at maximum performance and lowest operating costs. It will assure a minimum of costly shutdowns and major repair bills. The operator should understand all local laws relative to the duties of engineer and fireman and to safety requirements, so that protection is afforded everyone connected with its operation.

9. CLEANING

Clean boiler tubes and other heating surfaces whenever required. Frequency of cleaning cannot be predicted and must be determined by trial. The amount of soot depends upon the fuel and efficiency of combustion. If the flue between boiler and chimney becomes hotter than that found previously, it indicates that too much heat is being wasted and lost up the chimney, probably because the boiler fire surfaces are coated with soot. The furnace and fire passages should be brushed frequently to improve operating conditions and save fuel. This work should be done once a week, at a time when the load is lightest.

10. INHIBITING FIRESIDE CORROSION

Fireside corrosion of boiler tubes is traceable to moisture condensing from the atmosphere during a shutdown period or from flue gases during operation. High-sulphur fuels cause attack because of the sulphur gases produced. These gases condense on the tube or the tube surfaces, absorb moisture, and form the corrosive sulphuric acid.

Caution

Hot water boilers should not be operated at a water temperature of less than 180°, as normally determined at the top of the shell. Certain portions of the heating surface may be considerably below the indicated temperature. 180° provides a safety margin to avoid condensation and damage to heat transfer surfaces which otherwise might operate below the dew point.

When soot is dry it is not corrosive, but it will avidly pick up moisture and cause the sulphur compounds in it to become acidic and corrosive to boiler metals. For this reason be sure to have all soot removed from the fireside of boilers at the end of the operating season.

Exit gas temperatures must be watched. If soot is present in any quantity the flue temperature will rise and indicate the need to have the soot removed.

To inhibit attack by moisture and acid, the following suggestions should be followed:

a. Use fuels with low sulphur content. The best oils are those under 2 percent sulphur.
b. Operate burners efficiently, so that minimum carbon deposits result.
c. Prevent accumulation of soots and acids by inspecting and cleaning regularly.
d. For a boiler layup, follow the procedures given for long or short term layups.

11. REAR DOOR CLOSURE

In servicing boilers on which the rear door is hinged at the bottom, care must be exercised when opening for inspection or cleaning. Eye bolts are provided for use of block and tackle to lower and raise the door.

Caution

Door is refractory lined and is extremely heavy. Door should be lowered slowly.

In reclosing the door, scrape off loose cement from both sealing surfaces and apply fresh cement (such as Johns Manville Super X) to refractory contacting surfaces on the door along all surfaces to be sealed, around the circumference, and across the top. Inspect the asbestos gasket between the door plate and the jamb and recement or replace if in unsatisfactory condition. (See Item 12)

12. FRONT & REAR DOOR GASKET RESEALING INSTRUCTIONS

Materials

a. Gasket – 1/16"x 1/2" ID untreated asbestos braided tubing.
b. Adhesive – Rubber cement.

Procedure

Front Door

a. Remove lugs and swing door open.
b. Remove old gasket and scrape or steel brush bearing surface smooth.
c. Apply thin coat of rubber cement to door jamb and windbox front.
d. Apply gasket as continuously as possible to reduce joints to a minimum, make tight butt joints.
e. Apply thin coat of rubber cement to inside of front door edge.
f. Apply gasket as continuously as possible to reduce joints to a minimum, make tight butt joints.
g. Close door and tighten lugs evenly.
h. **Caution**—Door lugs on front and rear doors have ½" boss.

Rear Door

a. Remove lugs and lower door, use chain block or rope falls to lower door as it is heavy and should be handled with care.
b. Remove old gasket from door jamb, and scrape or steel brush surface.
c. Apply rubber cement on jamb. (Boiler Only)

d. Apply gasket around door jamb first and then across the horizontal door jamb on the bottom of the upper cover plate. Make sure there is good butt joint at each end. **Caution – There is only one gasket installed in rear door assembly.**

e. Raise door and secure with lugs. NOTE: **After boiler is put back in operation, check for leaks around doors and tighten lugs as needed.**

13. LOG OF OPERATING DATA

A daily log of operating conditions, with pertinent readings of burner operation, fuel pressure, air pressure, stack temperature, boiler feed temperature, and return temperature, as well as notes on boiler water treatment, will provide valuable reference relative to performance and quickly point out any trouble. Note daily, or more often, any abnormal appearance of the flame (shape, stability, etc.).

Routine checking for leaks in boiler tubes and other fittings and connections, and the regular examination of pumps, burners, air compressors, and all auxiliary equipment will enable trouble to be detected and corrected while it is in a minor state. A check of the log will indicate if a condition is worsening and repairs are required. A periodic inspection and close checking of the log for performance will determine if the water treatment is successfully preventing scale formation.

Condensation in a gas-fired cold boiler may occur to such an extent that it appears the boiler is leaking at numerous places. As soon as the boiler warms up, the condensation will stop. However, it may continue intermittently on hot water boilers operating at low temperature. Accumulation of water in the rear turnaround or leakage from the boiler may be from condensation and should not be mistaken as a sign of tube leakage.

For high pressure steam plants, inspection of water level, steam pressure, feed pump pressure, feedwater temperature, condensate temperature and fuel gas temperature should be made and logged hourly in large plants and every 4 hours in smaller installations. A test of the low water fuel cutoff should be run every 4 hours. Each shift should check on water treatment and boiler blowdown.

Pressure controls which incorporate mercury switches should be checked once every three months for mercury separation. Switches showing such defect should be replaced at once.

14. SAFETY VALVES

Pop safety valves and hot water relief valves should be operated manually once every week to insure proper operation of the mechanisms. In case such valves cannot be opened manually, the boiler should be shutdown immediately and the valves serviced or replaced.

The maximum operating pressure of a steam boiler should be 3 or 4 pounds lower than the set pressure of the safety valve. A pressure differential is required to permit the valve to close tight after it has popped. If a safety has a try lever on it, release the lever quickly to permit the valve to close tightly after testing. *Extreme caution must be exercised when lifting safety valve lever since raw steam under pressure can cause severe injury to any person in direct line of discharge.*

In addition, make a pressure safety check on each safety valve at the beginning of the heating season and then once a month if there are chemical fumes or dust; otherwise about every six months if the boiler room is clean. Safety valves are preferably tested by raising the steam pressure until the valve pops. Be sure to watch pressure gauge for pressure conditions. If pressures begin to go higher than valve setting, operate the hand lever. Test to make certain valve pops at the pressure it is set for, but if popping pressure is higher than that marked on the valve, replace it. *Do not attempt to reset it or to dismantle it except under supervision of an authorized boiler inspector.*

If the discharge side of the safety valve(s) is piped to the outside of the boiler room, such piping should not in any manner be supported by the valve as this will cause "weeping" of the valve well below its setting. The weight of the pipe will distort proper valve seating. It is also recommended that flexible connectors be used between safety valves and rigid discharge piping.

15. BOILER MAINTENANCE DURING LAYUP

Many difficulties begin during improper boiler layups, whether the periods involved be short or long. Boilers used seasonally or subject to long periods of inactivity should be laid up properly, either WET or DRY, depending upon environmental conditions. The following layup methods will add many years to the life of a boiler and aid in the prevention of corrosion.

Dry or Long Term Layup

Boilers subject to freezing conditions, or which are to remain inactive for a long time, should be laid up dry. The procedure is as follows:

a. Start work on the boiler within 72 hours after shutdown.
b. Close oil or gas valves and drain lines. Drain boiler while still warm. With a hot water heating system, valves to all radiators and other heating elements should be opened wide to allow condensate to drain back to the boiler or boiler feed pump. Drain entire system, including condensate tank, pumps and all connected piping.
c. Remove manhole and handhole plates from boiler and apply oil and graphite coating to the gaskets. Remove washout plugs and coat threads with graphite.
d. Flush waterside to remove loose scale and sediment. Use strong water pressure and start at lowest point in the boiler. Work toward top, using all washout openings. Then flush boiler from top down to lower openings.
e. Flush bottom of boiler by using make-up water. When finished flushing, make certain water valve is seated tightly and does not leak.
f. Flush out and clean water column; water column piping, gauge glass, steam gauge, pressure damper regulator and all other boiler accessories. Check and clean all automatic controls; inspect action, contacts, and wiring.
g. Boiler can be dried out completely by placing a small kerosene heater in the firebox or by means of a small wood fire. Exercise care to dry out the boiler completely, but do not overheat.
h. When boiler is dry, inspect internally. Examine tubes, stays and fittings for cracks, corrosion, or erosion. Tap with a hammer for a ringing sound. Check sections subject to heat for evidence of burning or scale blisters. Close vents and take precaution that moisture will not condense on waterside surfaces during storage or layup period if environmental atmosphere is damp. If atmosphere and boiler room are dry, leave doors, washout openings and vents open to permit free circulation of air through all parts of the boiler.
i. Clean fire and flue tubes thoroughly. Scrape to bare metal to remove all soot and deposits. Nipples, tube ends and other similar parts, corners of firebox sheets, front and rear tube sheets, and crown sheet should be freed of deposits, using a wire brush and scraper.
j. Swab fireside surfaces with neutral mineral oil to protect against rust, giving special attention to fire tubes, corners of firebox and blow-off connections.
k. Repaint exposed metal parts of boiler and associated equipment.

Wet or Short Term Layup

To protect a boiler for a short inactive period, during which it will not be subject to freezing, the following procedure should be used, assuming that the boiler has been in use for some time and is in need of a thorough cleaning and inspection.

a. Follow the suggestions given for the DRY layup, involving draining, flushing, and cleaning to remove scale and sediment from the waterside. Clean all soot and deposits from the fireside surfaces.
b. Refill boiler with clean water and add proper quantity of inhibitor advocated and supplied by a competent boiler water analyst who has checked the boiler, boiler water and boiler deposits. Bring to a boil to mix inhibitor thoroughly and to release the air from the water. Vent released air by steaming.
c. Cut off heat. Close all vents so air cannot enter the boiler as it cools.
d. If layup extends beyond the expected short-time, take periodic water samples so proper alkalinity can be maintained.

16. REAR DOOR & SHELL REFRACTORY REPLACEMENT

The following information covers the replacement of the rear door and shell refractories. (Paragraph "a" thru "s", or the shell refractories only (Paragraphs "h" thru "s". There is no separate method of replacing the door refractory only in this procedure.

a. Lower rear door (1), drawing D–1215 or D–1216, with the use of a block and tackle on to supports or horses. Make sure the door is level in all directions.

b. Remove all of the door refractory and insulation. Remove all of the old shell refractory. Clean up both door and shell surfaces.

c. Prepare door and shell for casting and new refractory. See drawings D–1215 or D–1216. Check all of the door anchors (2) and shell anchors (10) to insure that they are all there and still fastened securely. Tape or heavily grease the door anchors (2) to permit expansion in the refractory.

d. Install door form (3) consisting of two or three pieces, refer to drawing B–1217. Hold in place with metal strapping (4) on D–1215 or D–1216. Install seal edge form (5), drawing B–1218 and clamp into position with "C" clamps. Install the peep sight forming plug (6), drawing B–1219. Check to select the proper size.

e. Mix and install insulating refractory (7), D–1215 or D–1216. Install as indicated on the drawings. After installing let the refractory set-up for at least 1/2 hour.

Approximate Material Requirements:

PLIBRICO AIRLITE (used with Drawing D–1215 & D–1216)

20 – 30 HP	30 lbs.	200 HP	87 lbs.
40 – 70 HP	30 lbs.	250 – 300 HP	96 lbs.
80 – 100 HP	48 lbs.	350 HP	100 lbs.
125 – 150 HP	51 lbs.	400 – 500 HP	142 lbs.

f. Mix and install refractory (8), D–1215 or D–1216, as shown. Make sure the corners of the door are properly packed with refractory. Level the refractory to the top of the door surface with a straight edge. Do not make a smooth surface, keep the surface rough. An extremely smooth surface will not permit the refractory to cure properly. The sealing surface should be fairly smooth to permit a good joint with the shell refractory.

Approximate Material Requirements:

PLIBRICO – LWX No. 24 (used with Drawing D–1215 & D–1216)

20 – 30 HP	100 lbs.	200 HP	350 lbs.
40 – 70 HP	170 lbs.	250 – 300 HP	458 lbs.
80 –100 HP	270 lbs.	350 HP	470 lbs.
125 –150 HP	308 lbs.	400 – 500 HP	660 lbs.
		600 HP	773 lbs.

NOTE: After completely casting the door refractory do not move it. Permit the refractory to harden for a minimum of 18 to 20 hours.

g. Check door seal gasket on jamb ring to insure it is not broken and is usable. Replace if necessary. All joints to be tight seal butt type. Use masking tape at ends prior to cutting to prevent fraying of the ends.

h. Install shell refractory retaining form, drawing C–1220, into place on the shell extension as indicated and hold in place with "C" clamps. Make sure that there is approximately 1/4" interference with the door refractory if the door were closed.

i. Make sure the shell anchors (10) are greased or covered with masking tape. Adjust and lock the arch anchors (11) and make sure the locking nuts (12) are tight. Grease or masking tape the "V" portion of the anchor (11). (See D–1215 or D–1216)

NOTE: THE INSTRUCTIONS IN PARAGRAPH "j" THRU PARAGRAPH "n" MUST BE FOLLOWED CLOSELY. DO NOT PERMIT THE SHELL REFRACTORY TO SET UP OR HARDEN BEFORE THE DOOR IS CLOSED TO MAKE THE FINAL SEAL.

j. Mix and install shell refractory (15), D–1215 or D–1216, as shown. Do not close off any fire tubes. Reference drawing D–1215. Make sure the steps in the upper corners are properly formed to receive the arch refractory.

Reference drawing D–1216. Install the Monoblock expansion joint (19) at both sides of the shell. The monoblock is 1" thick by 6" wide and is to extend from the tube sheet to the rear door refractory.

Approximate Material Requirements for Shell Refractory:
(Note: This will be a mixture of two materials.)

			Later Models	
Size	Plicast No. 27	Trowl Mix No. 27	Plicast No. 27	Trowl Mix No. 27
20 – 30 HP	200 lbs.	–	–	–
40 – 70 HP	214 lbs.	54 lbs.	285 lbs.	72 lbs.
80 – 100 HP	283 lbs.	71 lbs.	378 lbs.	95 lbs.
125 – 150 HP	340 lbs.	85 lbs.	455 lbs.	114 lbs.
200 HP	445 lbs.	111 lbs	595 lbs.	148 lbs.
250 – 300 HP	544 lbs.	136 lbs	725 lbs.	181 lbs.
350 HP	620 lbs.	155 lbs.	825 lbs.	206 lbs.
400 HP	875 lbs.	218 lbs.	1000 lbs.	250 lbs.
500 HP	970 lbs.	243 lbs.	1110 lbs.	278 lbs.
600 HP	1231 lbs.	320 lbs.	1231 lbs.	320 lbs.

k. Install the arch support bars, drawing B–1221, so that they are in the fire tubes prior to closing the rear cover. Prepare the arch support plate, drawing B–1222, so it can be installed when required. The arch support plate can be made of two or more pieces as long as they fit into the boiler void formed by the door refractory, the shell refractory and the tube sheet.

l. Remove door form, B–1217, strapping (4), D–1215 or D–1216, and seal edge form, B–1218, after the refractory has set up.

m. Brush a coating of Houghton's Deep Draw Wax – No. 3320RR or equivalent (16), D–1215 or D–1216, on all sealing edges of the rear door refractory after the refractory has hardened. This is to prevent bonding of the shell refractory to the door refractory but still permit a good seal.

n. The shell refractory (15), D–1215 or D–1216, should be in a plastic state when the door is to be closed. If the unit is large enough, have some one in the furnace prior to closing the door. If the unit is too small, have available a long tamping pole to permit tamping the shell refractory around the door refractory to insure a good joint and seal. Remove the shell refractory retaining form C–1220. Clean off all loose material. Slowly close the door against the still plastic shell refractory. There should be a slight interference between the door refractory and the shell refractory. This joint must be tamped to insure a gas tight joint. When the door is closed it is important that all of the door clamps are in place and tightened to insure a gas tight joint between the door and jamb ring.

o. After the door has been closed, the top arch refractory (17), D–1215 or D–1216, can be cast into place. Install arch support plate, B–1222, into place. Make sure that the plate touches all outside edges to prevent refractory falling out of corners. Make sure the refractory support bars, B–1221, are pulled out to within 2" of the door refractory. The material should be forced into all corners and worked into all joints to insure solid refractory. Permit the arch to set up for at least 24 hours.

Approximate Material Requirements for Arch Refractory:

Size	PLIBRICO PLICAST NO. 27	
		Later Models
20 – 30 HP	170 lbs.	–
40 – 70 HP	225 lbs.	–
80 – 100 HP	410 lbs.	–
125 – 150 HP	465 lbs.	520 lbs.
200 HP	535 lbs.	590 lbs.
250 – 300 HP	570 lbs.	640 lbs.
350 HP	670 lbs.	745 lbs.
400 HP	770 lbs.	–
500 HP	850 lbs.	–
600 HP	1047 lbs.	–

p. Gently open the door, remove the arch support plate, B–1222, and the arch support bars, B–1221. Inspect the surfaces to make sure there is no loose material that could get into the joints.

q. Close the rear door and tighten clamps. The door is not required to be reopened after this step.

r. Loosen the bottom nut (12), D–1215 or D–1216, of the support rods for the arch. The bottom nut will permit the expansion in the upward direction but will support the refractory dead weight.

s. Install the rear door top section (18), D–1216, and bolt into place.

NOTE: When placing the boiler on the line after installing rear refractory, gradually heat up the boiler. It is suggested to fire the unit for a few minutes at low fire, then off, then on at low fire for at least 1/2 hour. Then permit firing at low fire until the unit is up to temperature.

17. BURNER REFRACTORY REPLACEMENT

Model	Horsepower Range	Drawing No.
E	40 to 300	C–1223

NOTE: Units 350 to 600 HP have a burner refractory that can be removed and replaced with a new assembly. The burner has to removed from the boiler.

a. Check the old refractory against the drawing to determine that you are referring to the correct figure.
b. Remove all of the old refractory. Clean surfaces and inspect burner head.
c. Check all refractory anchors. Replace if necessary. Grease or tape the anchor to permit expansion joint.
d. Make a profite template to check refractory shape as it is being installed.
e. Use a Ramming Mix Plastic Refractory – Plibrico "Pli-Ram" 80 Air Bond or equivalent.

PCE No. 40
Service Temperature . . . . . 3300° F
Composition . . . . . 80% Al_2O_3, 18% SiO_2
Fusion Point . . . . . 3425° F
Lbs/Cu.Ft. 175

f. Start installing at bottom of furnace and work up both sides. Complete the section as you proceed. Do not rough in the complete shape and then surface finish. If too much time has elapsed, a surface coat will be sult and incomplete bonding can cause refractory to disintegrate.
g. Allow openings for igniters, peepsights, etc., as required for each burner. Use greased bars or pipes to provide the core for the opening.
h. Refractory ends can be rounded off to furnace surface.
i. Carefully check refractory and all openings in refractory to eliminate all blockage.

BURNER EQUIPMENT

Oil System

The fuel burning equipment on these boilers consists of an oil pumping and metering unit plus oil heating units for heavy oil to raise the temperature of the oil from the required pumping temperature to the value necessary for atomization, all mounted on the boiler base.

The oil nozzle is a low pressure, air atomizing, nozzle-mix type which is supplied with air by a positive displacement, vane-type compressor also mounted on the boiler base. Plant air and/or high pressure steam may be used to replace, or supplement, the compressed air.

Gas System

The main gas components of the burner consist of a modulating gas butterfly valve, a gas manifold and through-tubes to convey the gas from the manifold to multiple ports at the combustion zone.

The main gas train will vary with local codes and with specifications but, in its simplest form, will consist of a lubricated shutoff cock, gas pressure regulating valve and electrically operated safety shutoff valve.

Forced Air System

Refer to K-2456 and K-3047A for sectional diagram of air atomizing burner components.

Burners for all types of fuel and for all grades of oil have combustion air handling features of similar design.

Air for combustion is supplied by a specially designed integral forced draft fan, passing through an air metering valve into a cylindrical swirl chamber. A large percentage of this air is discharged in a spiraling flame-shaping pattern, as secondary air, through the air nozzle, which surrounds the diffuser head, into the combustion zone. The remainder of the combustion air passes through air-straightening vanes, through a central primary air tube, and enters the combustion space between the diffuser head and the oil nozzle in a straight-flow pattern.

This air handling equipment is designed to deliver the required quantity of air into the combustion chamber and against normal combustion chamber pressure with maximum efficiency.

The use of the forced draft equipment eliminates the need of using mechanical draft control, with the possible exception of installations having extremely high stacks and some with multiple boilers.

Igniters

The standard fuel ignition system for units designed to operate with #2 oil only, consists of a #2 oil-electric igniter operating on an interrupted cycle. Gas-electric ignition is optional.

For all other fuels, or combinations thereof, a gas-electric igniter, operating on an interrupted cycle, is standard equipment. For oil burners operating on other than #2 oil, a #2 oil-electric ignition system is optional.

Both pilot and main flame are monitored through use of electronic type flame detector and sequencing relay.

Control Cabinet

All boiler units are designed with integrally mounted control cabinets. The cabinet contains all of the standard burner controls, including power circuit breakers or fuses, if specified, and starters for motors as well as combustion safety controls and relays.

All other burner components including the oil pumping and metering unit, the integral oil heater, air compressor and all valves and temperature and pressure interlocks are mounted on the boiler unit.

II. SEQUENCE OF OPERATING AND SAFETY FEATURES PROVIDED BY STANDARD CONTROL SYSTEM

(Heavy Oil Operation)

Refer to appropriate wiring diagram.
(Before starting the burner, read complete instructions particularly Section V, Operation.)

It is customary to manually start and stop the oil circulating unit. Circulation may be required during the entire heating period to insure oil of correct temperature at the burner. Heating elements normally provide automatic temperature control of the circulated oil.

The control components will provide for the following sequence of operation:

1. Boiler must be filled with water to correct level.
2. The control circuit must be closed. On some units the control circuit will not be energized until the power breakers are closed. (Refer wiring diagram)
3. All power circuits must be energized. CAUTION: Be sure the electric oil heaters are not energized until the heaters are filled with oil, and that the tailpiece cartridge heater is in place.

   (Check flow at a union on the discharge side of the heater.)
4. Fuel selector switch and limit selector switch must be in proper positions.
5. Burner linkage must be in low-fire position, with low-fire start switch closed.
6. Flame failure safety lockout and all power overload relays must be in reset positions.
7. Oil temperature must be at proper value and interlock switch must be made.

Closing of the pressure or other limit switch will then start the following sequence:

8. Energize the flame safeguard and programming control.
9. Start the forced draft fan.
10. Start the air compressor.
11. After prescribed pre-purge period, if the forced draft air pressure interlock is closed the ignition will be applied and checked by the flame detector.
12. Main fuel valve is then opened if the compressed air interlock is closed, and the main flame will be ignited.
13. Ignition is discontinued after appropriate trial-for-ignition period. Main flame continues if properly detected.
14. At the prescribed point in the sequence, the modulating control will bring the linkage to high-fire or to modulated position.

(Light Oil Operation)

In operating on light oil, references to oil heaters and temperature controls and interlocks will be disregarded.

(Gas and Combination)

On combination fuel equipment, the operation of the oil components follows the same sequence as outlined in the foregoing. It may be desirable to maintain circulation and heating of oil during gas firing although completion of the circuit through the oil temperature interlock is not necessary.

On gas firing, the first six steps in sequence listed in the foregoing are followed. Item 7 is not required. When pressure or other limit switches are closed, the following sequence is continued:

8. Energize the flame safeguard and programming relay.
9. The forced draft fan is started.
10. (Air compressor is not operated.)
11. After prescribed pre-purge period, if the forced draft air interlock is closed, ignition is applied and checked by the flame detector.
12. Main fuel valve is then opened and main flame established.
13. Ignition is discontinued after appropriate trial-for-ignition period. Main flame continues if properly detected.
14. At the prescribed point in the sequence, the modulating control will bring the linkage to high-fire or to modulated position.

III. BURNER COMPONENT DETAILS (Refer to K 2456 and K 3047A)

Forced Draft Air Supply

On boiler sizes from 40 through 150, and 350 through 600, the forced draft fan is a single width, single inlet, forward curved blade type, directly mounted on the shaft of the flange-type or bracket mounted motor. On boiler sizes 200, 250 and 300, the fan is double width, double inlet, forward curved, and is belt driven.

The fan is specially designed for high-speed operation with suitable reinforced plate, high-speed bracing, heavy hub, and is dynamically balanced.

A fan scroll, built integral with the windbox provides efficient generation of velocity pressure in the duct leading to the air control valve.

Fans are selected as to size and speed to produce the quantity of air required for combustion at the necessary pressure.

The fan may be disassembled by removing the motor or motor-mounting plate on direct drive design, or by removal of the front bearing plate and front fan inlet cone on the belted drive. On direct drive units not provided with front mounting plates, the fan may be removed through the air inlet opening.

All bearings of the forced draft fan and motor are grease lubricated. Motor bearings are "lifetime" lubricated. Where fan has separate bearings, these should be lubricated about every 3 months with high-grade bearing grease. Over-greasing and careless greasing with unsuitable and contaminated grease are the cause of most bearing failures. See also paragraph on "Lubrication."

If fan bearings of belted units must be removed or replaced, installation must be carefully made with particular reference to locking the inner race on the shaft. The locking eccentric ring must be tightened in the direction of the rotation.

On belt-drive units, the highest quality belts with very liberal load factor have been selected. Tension should be adjusted to avoid noticeable slippage on starting but without excessive tension which might shorten belt life or damage bearings.

All replacement belts or other parts should be procured through your boiler representative to assure correct size, type, quality and customer satisfaction.

The supply of combustion air is controlled by an *air control damper* in the fan discharge duct located within the windbox and operated by an extended shaft and lever. See drawing L-2072.

The damper may be inspected and disassembled by removing the burner head assembly.

This damper is a precision control which can be accurately adjusted and affords means of obtaining desired air-fuel ratio over a wide range. The opening is so designed that in all positions, a high speed vortex is formed in the swirl chamber.

Blower Air Interlock

This safety interlock, installed on a branch of the air line feeding the ignition on the 350-600 burners, or on the side of the fan scroll on the 40-300 burners, must be checked and properly set to shut off the fuel valve in event of blower air failure. This must be adjusted by trial just below the pressure at which it opens at any point between high and low fire.

Oil Fuel System

(Heavy Oils – No. 5 and No. 6. For standard piping arrangement, see K-3062.)

Oil, suitably preheated to pumping viscosity, is pumped from the storage tank by the primary element of a *two-stage pump* mounted on the burner or boiler. The unburned portion of the primary oil is returned to storage from the reservoir, passing through a general heating system if necessitated by the grade of oil. Oil must be available at the primary pump suction at a viscosity and temperature as listed in Chart No. 2. The oil is pumped and metered at this viscosity.

The *secondary pump* circulates the oil from the reservoir, through the Viscosity Metering Valve, through electric or steam oil heaters and either to the nozzle assembly during firing, or return to the reservoir during off-period operation. The flow is controlled through use of two magnetic valves; one normally open, and one normally closed. Temperature of the oil at the nozzle should be approximately as specified in Chart No. 2.

Where heating of the main oil supply is dependent upon circulation, the pumping unit may be continuously operated, providing flow through both the primary and secondary circuits.

The general heating system may consist of a steam or hot water heat exchanger or an additional electric oil heater, usually, in the return line, or an oil line thermal heating system.

The *pump and oil metering* component consists of a built-in motor gear drive unit on which is mounted an auxiliary reservoir, two-stage pumps and Viscosity Metering Valve assembly. The reservoir and metering valve are shown in #50274-12 to 19 and #9336-6. A diagram of the oil flow through the reservoir and the Viscosity Valve is shown in P-643A, together with a description of the metering process.

The pump, capacity (determined by the pump size and operating speed) is selected for a limited range of burner sizes. The eccentric disc, or metering plug, is also selected to match the capacity.

It will be noted that there is no pressure gauge on the metering valve and no adjustment for flow control other than position of the metering disc shaft and the control lever connected to the linkage. As long as the pump and eccentric disc are selected correctly and the oil delivered to the burner is within a reasonable viscosity range, the secondary pump pressure will be self regulating to produce the rate of flow set by the control lever.

Should an excessive pressure be generated by some malfunction or incorrect adjustment, the pump discharge will be relieved back to the reservoir through the relief valve in the pump discharge passage.

A full range of firing rate for any boiler rating will be obtained simply by moving the control lever through an arc of 60 to 90 degrees.

Adjustment of the metering control is detailed on P-647.

CHART NO. 2

The following tabulation gives the range of pumping and atomizing temperatures for the various grades of oil:

Conventional Grades of Oil***		Viscosity		Recommended Temperature	
ASTM	Pacific Coast	SSU at 100	SSF at 122	Pumping* °F. Range	Atomizing** °F. Range
#4 min.		45		–	35 to 70
#4 max		125		25 min.	75 to 110
#5L min.		150		35 min.	100 to 120
#5L max.		300		55 to 65	125 to 145
#5H min.	300 min.	350	(23)	60 to 70	135 to 155
#5H max.	300 max.	750	(40)	80 to 90	160 to 180
#6 min.	400 min.	(900)	45	85 to 95	165 to 185
#6 max.	400 max.	(9000)	300	130 to 150	230 to 250

*Temperature at which oil should be delivered to burner pump, maintained by tank-heaters, heater in circulated return line or pipe line heating system.

**Heaters on burner will raise temperature of oil from "pumping temperature"

ASTM #5 oil is divided into Heavy and Light ranges, also referred to as "Hot" and "Cold". These are indicated in the above as #5H and #5L.

***Note: The problems involved in the elimination of elements from the oil which cause air pollution, principally sulphur, have resulted in extreme variation in viscosity from the originally accepted standards. Until such variations are eliminated from the refining process, pumping and metering of heavy oils will present additional problems. Some guarantee of viscosity range must be obtained from the supplier in order to provide reasonable combustion results even though these may depart from recognized standards.

(Light Oils – No. 2 and No. 4 at 125 SSU or less)

On light oil, a conventional two-stage pump is employed for boiler sizes 40 to 300 HP. a single-stage pump is used on larger sizes. The oil pressure in two-stage pumps is regulated through an adjustable internal relief valve. When single-stage pumps are used, pressure regulation is accomplished by an externally mounted back pressure regulating valve. Oil is delivered to the nozzle through an oil metering valve and an electrically operated oil shutoff valve. When diesel or No. 2 fuel is used, the main pump may be used to furnish the fuel for ignition. A typical arrangement is shown on K-2596. Positive pressure on either suction or return lines should never exceed 5 psig.

Electric Oil Heater

If heavy oil is burned, it must be available in the suction line to the burner pump, and at the burner nozzle at viscosities and temperatures as listed in Chart No. 2. The oil temperature increase, ranging from 80 to 100 F, is provided through the use of one or more electric immersion heaters. The standard heating element is of low density construction with integral thermostat having suitable adjustable temperature range.

To adjust the standard heater thermostat, remove the cap and turn the knurled nut *counterclockwise* to increase the temperature. It is advisable to set the temperature during a low firing rate. Only a small change in adjustment should be made at a time. Observe the results of the change over several cycles of operation before making further adjustment.

From a given low-fire setting, the temperature may increase some during an "off" circulating period and decrease while firing at a high rate. A certain amount of temperature excursion is inevitable with "off-on" electric heaters but the general piping design of the heater and assembly and handling of the oil minimize the effect. The burners are not critical to temperature and will tolerate reasonable variations.

In using two electric preheaters in series, as on sizes 200 to 300, the first should be set to deliver the oil at a temperature appreciably below the final temperature so that the other heater can control the temperature at the required value. This difference between the discharge of the first heater and final temperature can be determined within sufficient accuracy by "feel" of the pipe lines. Do not judge the outgoing oil temperature by the temperature of the heater shell. For larger units using parallel heaters, both heaters should be adjusted for approximately the same "on-off" range.

Caution

In starting the system, be sure the heaters are full of oil and preferably circulating before energizing. Check at couplings or union in line between heater and nozzle manifold. Also, avoid carrying excessive temperatures that might produce gassing of the particular grade of oil being burned and which might promote formation of carbon and scale. Bear in mind that the surface of the heater element, where breakdown of oil would take place, becomes much hotter than the oil as measured by a thermometer located in the line at the discharge.

In other words, do not carry the oil temperature at a point higher than necessary to produce good atomization.

Tailpiece Heater

Boilers designed for operation with heated oils heavier than #2 are equipped with a cartridge type electric heater element in the oil nozzle tailpiece piping.

This heater is continuously energized to maintain the oil in the piping at a suitable holding temperature while the burner is shut down and/or while burning gas.

Caution

Be sure that the switch or plug which controls power to the tailpiece heater is open before removing the heater element. If voltage is applied to the heater when the element is out of the cavity, it will overheat and may be destroyed.

Air Compressor

The air compressor is a rotary vane type and has mounted on it an air filter and a lubricating reservoir in which a supply of oil recommended by the manufacturer must be maintained. See paragraph on lubrication in Section V. The compressor has a capacity adequate for atomization of the maximum oil capacity of the nozzle. The vanes take up their own wear and should last from 5,000 to 15,000 hours operation depending upon the application. Protect your pump against the entrance of dirt, lubricate it, and you will receive years of trouble-free service.

The air pressure is easily adjusted by setting the adjustable screw on the air pressure-adjusting-valve at the compressor outlet. No change in air pressure is required with changing firing rates after the initial adjustment.

Caution

Normal boiler operation should require replenishment of lubricating oil not more often than once a week, but initially, daily checks should be made until the rate of use is established and so included in the boiler room procedure. See section under "lubrication" for further details.

Burner Head

Burner head, which is described under a preceding section on Forced Air System, includes the *Fuel Tube Assembly* on oil and combination units. This assembly has a small diameter inner tube for oil and a surrounding tube for atomizing air, an aluminum tail casting and a nozzle assembly.

Oil Nozzle

The nozzle is a "unitized" combination of *cap, disc* and *metering pin* or *pintle* mounted on a concentric flow adaptor. (See typical assembly P-653, P-728 and 52699-1) Oil and compressed air are forced through tangential slots, mixed in a swirl chamber, and leave the nozzle at high velocity through the sharp-edge orifice.

Caution

The two principal nozzle parts are ground and matched at the factory and must never be interchanged with parts of other nozzles. The nozzle orifice and oil passages are very accurately machined and polished. *Under no circumstances should any abrasive or metal tools be used for cleaning the polished surfaces.*

Where uninterrupted operation is important, a spare fuel tube and nozzle assembly may be advisable for rapid replacement and to encourage more thorough cleaning. Always keep the spare nozzle clean and ready for instant use.

Gas Equipment

Gas Operation on combination equipment does not require the use of the air compressor. This is automatically discontinued with the fuel selector switch in "Gas" position. Maintenance of oil temperature may make the continued use of the oil heating and pumping system advisable. This will depend upon the grade of oil, ambient temperature and the general oil supply system. *Complete chilling of the circulating system, and particularly the reservoir and return line, should always be avoided with #6 fuel oil.*

The *gas head* is a ring type with ports which discharge gas into the air stream. The flat face of the gas head acts as a flame holding surface.

The gas fuel enters the burner through a butterfly valve in the line installed just ahead of the gas manifold and controlled through the burner linkage. The manifold is joined with the gas head by several longitudinal tubes, clustered around or inside the primary air tube. (See K-2456 and K-3047A).

Standard equipment on the boiler includes a main gas shutoff cock and automatic gas safety valve, a pilot cock, pilot pressure regulator and magnetic gas pilot valve.

This equipment meets approved safety specifications, but additional valving arrangements may be provided, if specified in the requirements of certain insurance companies. (Check current U.L. regulations and other applicable specifications.)

A main gas pressure regulator is furnished with the boiler to assure a uniform and dependable gas supply. The regulator is sized to deliver the required volume of gas at the required pressure specified in Chart No. 3.

Linkage

The firing rate of these boilers is controlled by a modutrol motor mounted on the lower, left side of the windbox. Mounted on the front shaft extension, is an adjustable slotted arm to which connecting rods are attached by means of ball and socket fittings, for operating combustion air valve and the main gas valve.

An adjustable arm is mounted on the rear shaft extension of the modutrol motor from which the connecting rod to the oil-metering Viscosity Valve is operated.

The position and throw of these three control linkage elements, on a combination gas and oil unit, must be coordinated to obtain the rate and range of firing required. Reasonable regulation of the gas supply pressure is assumed.

The linkage will usually be set during assembly at the factory and should require only final adjustments.

The low-fire start switch is incorporated within the modutrol motor and should require no adjustment after the original setting.

IV. INSTALLATION

SHIPMENT

A careful check should be made of the boiler equipment upon receipt to be certain that no damage has occurred during shipment. Any damage claim should be immediately made to the carrier.

FOUNDATION

The boiler is equipped with a steel base, making a special foundation unnecessary. However, it is usually necessary to block up the boiler and grout under the frame to level the unit and to obtain height depending upon requirements for

clearance, drainage, cleaning, etc. This may necessitate some form of concrete foundation or pad.

PIPING

All oil, gas, steam and water piping shall be made in accordance with requirements and recommendations of ASME Boiler Codes and with State and local codes.

Heavy Oil Piping

In many installations, #4 and #5 oils may be pumped and burned without any heating other than by means of electric heater on the boiler. Consult Chart No. 2 for viscosity and temperature limitations. Otherwise, preheating of the oil supply is required.

Oil suction lines must be installed absolutely air tight. Suitable tests for tightness must be applied before lines are covered or insulated.

Oil line sizes will be determined by the quantity pumped, the length of run, the grade of oil and the suction lift. The pipe size may be estimated by Chart P-355. The following tabulation gives the primary pump capacities which are the quantities involved in pipe size selection.

Boiler HP	40-50	60-100	125-175	200-300	350-500	600
Primary Pump, GPH	39	55	94	122	210	320

Caution

No shut-off valve shall be installed in the return line. A check valve may be used to isolate the boiler return connection or to prevent back flow if the storage is above the burner level, but a free flow of oil from the burner reservoir to the storage tank must be maintained at all times if damage to the burner equipment is to be avoided. Back pressure created by return line should not exceed 15 psig at the return port of the oil pump.

Gas Piping

All gas piping must be done in accordance with local and State Codes, and reference should be made to National Board of Fire Underwriters regulations.

The components included in the main gas supply system or the "gas train" normally include, as a minimum requirement, the following:

1. Manually operated lubricated plug cock.
2. Gas pressure regulating valve.
3. Motor-operated gas safety shutoff valve.
4. Automatically operated flow control valve.

This may be supplemented in accordance with local ordinances and FIA, or other specifications, to include: additional safety shutoff valve, vent valve, pressure switches, pressure gauges, additional gas cock, etc.

The pilot gas train will usually include a gas cock, pressure regulator and magnetic valve. The pilot line should be so connected upstream of the main gas regulator that the pilot can be adjusted with the main gas cock closed.

The components of the gas trains are selected to meet the requirements of the application with regard to gas pressure available, gas capacity required, pressure required at the burner inlet and governing specifications. These components may be completely or partially mounted on the boiler, but will be shown on the submittal drawings furnished with the boiler.

Gas piping usually requires some engineering considerations. The following Chart shows the approximate pressures required for natural gas at the butterfly valve on the burner. It also shows the size of the standard gas shutoff valve and the pressure required upstream of this valve. These values are based on use of natural gas of 1000 btu. Lower btu gas will require higher pressures or larger pipe and fittings.

CHART NO. 3

BOILER SIZE	CFH 1000 BTU GAS	PRESSURE AT BURNER INCHES W.C.	MAIN GAS SAFETY SHUTOFF VALVE SIZE	PRESSURE HEAD OF VALVE INCHES W.C.
40	1674	2.1	1½	4.7
50	2092	2.6	1½	5.9
60	2511	3.4	2	4.8
70	2929	4.1	2	5.9
80	3348	2.3	2	4.7
100	4184	2.9	2½	5.8
125	5230	3.9	2½	7.2
150	6276	5.1	3	7.6
200	8369	3.4	3	7.8
250	10461	5.1	3*	11.8
300	12553	7.1	3*	16.5
350	14650	5.1	3*	19.0
400	16750	6.4	3*	20.5
500	20900	9.1	3*	15.6
600	25100	12.6	3*	19.2

*3" valve standard, 4" optional.

Gas must be supplied at the safety shutoff valve at pressures shown in the last column. It is desirable to have an individual regulator as near burner as possible to avoid loss in the low pressure line. Where the regulator is some distance from the boiler, the losses through the pipeline and fittings must be calculated and a larger shutoff valve may be ordered if the pressure requirement becomes critical. With multiple main gas valves, greater pressures or larger valves will be required.

Local gas utility engineers should be consulted to determine the gas pressure and capacity limitations. Their advice in dealing with piping and pressure regulation problems will also be helpful.

More complete instructions may be procured, if necessary, by application to the Company representative.

OIL MEASUREMENT

If a check on the firing rate is considered necessary, a test oil meter installed in the line between the Viscosity Valve and the electric heater will read the actual rate of firing. Note, however, that the meter at this point will also record the circulated oil flow during shutdown. Therefore, it cannot give a correct integrated consumption over a series of starts and stops. For a permanent installation, two meters should be used, one on the suction line, and one on the return, using differential read-ins as the consumed quantity. Meters used should be calibrated for oil viscosity and temperature applicable.

WIRING

If the control cabinet is provided with circuit breakers or fuses for all main circuits, it will usually be necessary to run only one three-phase power circuit to the control cabinet. If overload protection is not included with the boiler equipment, separate power circuits with suitable overload protection will be required.

All circuits must be sized to conform with National Electric Code and other local requirements for the voltage and load of the boiler unit.

STACK REQUIREMENTS

Only a vent outlet of adequate size is required on these boilers. No negative draft at the exhaust is necessary. Draft regulation is not required except in installations involving unusually high stacks and where a multiple boiler installation on one stack may result in wide draft variations on individual units.

The minimum stack diameters required are indicated in the following Table:

BOILER HP	BOILER VENT DIAMETER (INCHES)
40	10
50	10
60	12
70	12
80	12
100	14
125	16
150	16
200	18
250	22
300	22
350	22
400	24
500	24
600	28

AIR INLET TO BOILER ROOM

The boiler room should have a permanently open air inlet of cross-sectional area equal to three times the area indicated as a stack vent requirement, or in accordance with applicable building codes.

The hazards and inefficiency of insufficient air should be impressed upon the equipment operator to discourage closing of air inlets.

V. OPERATION – GENERAL

The reliable operation of this boiler is in large part due to the following safety equipment and systems furnished:

1. Adequate water supply with suitable low-water protective equipment.
2. Pressure safety valves and reliable pressure and temperature limit controls.
3. Reliable fuel supply. Suitable oil heating control with oil temperature interlock for oil fired units. Regulated specified gas pressure supply for pilot and main flames on gas firing. Fuel selector switches.
4. Controlled compressed air supply with interlock switch on oil fired boilers.
5. Windbox combustion air pressure interlock.
6. Low-fire start interlock.
7. Flame failure safeguard detector and sequence control including:
   (a) Prepurge period.
   (b) Adequate pilot monitoring.
   (c) Approved trial-for-ignition period.
   (d) Main flame monitoring.
   (e) Approved maximum shutdown timing on flame failure.
   (f) Lockout following flame failure, with manual reset.
   (g) Shutdown on limit control and automatic reset for starting.
8. Modulating fire control.
9. Motor-starting equipment with manually reset overload relays on all circuits.
10. Circuit breakers or fused disconnect switches on control circuits.

The foregoing safety features should be checked and the linkage given a preliminary inspection to see that all connections are secure and free of "lost motion." Careful observation of the following recommendations should be made in putting the boiler unit into service.

ADJUSTING, OPERATION AND MAINTENANCE

Inspection

Persons responsible for placing this equipment into service at initial startup, normal course of operation, or after overhaul must be familiar with its functions. They should carefully trace out the wiring diagram and the flow diagrams for oil, gas, water and steam while referring to the actual equipment and by noting the foregoing descriptive paragraphs.

This inspection study should determine that the unit is lubricated, adjusted and intact, ready for operation. If details of adjustment, cleaning, repair or lubrication are not obvious, it is very important to refer to and study the instructions within this booklet and specific instructions included with each packaged boiler.

PLACING IN SERVICE

General – Check List for Heavy Oil

1. Entire unit inspected.
2. Installed: Leveled, wired, piped, vented.
3. Lubricated: Compressor, pump unit, others (check instructions).
4. Gas available up to pilot shutoff valves. Oil in tank and heating system in service if heavy oil.
5. Boiler water at proper working level.
6. Place combustion control switch in "Test" position or install test plug.
7. Lift "blue" junction in modutrol motor, or set switch, if provided, at "low fire."
8. Jumper oil temperature interlock. This permits scanner tests while the oil heaters fill.
9. Oil heater circuit "OFF" – Other power circuits "ON." Tailpiece heater (if included) in place.
10. Energize momentarily and check rotation of all motors.
11. Close control switch and allow pump unit to run and raise oil from tank and circulate it through reservoir and heaters. It may be necessary to close the manual shut-off valve in the circulating oil line between the N.O. magnetic valve and the suction line connection until circulation is established.

Caution

When starting pump unit with cold, heavy oil in the return line to the tank, excessive pressure in the auxiliary reservoir must be avoided. Under such conditions a 100 psi test pressure gauge should be installed at the ¼" tapped and plugged hole on the side of the VISCOSITY Valve near the pressure balance valve. The gauge at this point measures the pressure in the reservoir which is equal to the return line pressure. If the pressure, when the pump is started and the oil is circulating, approaches 50 psi, the pump should be stopped. It can then be restarted a number of times for short, low-pressure runs, keeping the pressure below 50 psi, until the warm oil is circulated in the return line.

12. Check operation of pilot flame and flame detector relay "PULL-IN." Observe adjustment instructions in a following section under "igniters."
13. Check electrical operation of low-water cutoff, boiler limit, low-fire start, atomizing air interlock, blower air interlock, modulating control and linkage movement.

NOTE: *On light oil disregard 8 and 9* and adjust pumping pressure to 80–90 psig at low fire except on units using diesel ignition where the pressure should be 100 psig.

Oil Start (of new factory adjusted and fired boiler)

1. The "check off" is the same as above, plus the following items:
   (a) Be sure oil piping through the entire burner system is absolutely clean of all foreign matter, as this can insure the safe and proper operation of the oil metering valve, main oil shutoff, oil recirculating valve and various check and pressure relief valves.
   Circulate hot oil for 5 to 10 minutes with the oil metering valve wide open. Inspect for and correct any leaky joints. Afterwards, stop and clean the small strainer in the hot supply line to the nozzle.
2. While oil pump is operating, bleed oil at any union downstream of oil heaters to determine if heater(s) are filled. When filled, energize electric oil heaters.
3. Remove jumper from oil temperature interlock and set approximate temperature.
4. Remove electrical covers on oil heaters and, if required, change the adjustment slowly to the approximate temperature. Wait to note effect of minor changes. (See paragraphs under ELECTRIC OIL HEATER in Section III for adjustments.)

5. Check approximate atomizing air pressure. Pressure values with air only passing through nozzles will be 10 to 15 psi. Observe factory set atomizing air-limit "cutout" pressure which should be closely below the final pressure determined.
6. With hot oil circulated up to the shutoff valve, the blower will start (See Item 3 preceding).
7. Move sequence control to "ignition point." Observe and adjust pilot if necessary.
8. Manually, slowly move the programmer to "FUEL ON" position. A few seconds after the oil valve opens, the oil should ignite and the flame be established. Observe the low-fire. Open limit switch and restart cycle.
9. Repeat (8), continuing programmer movement to normal firing "PILOT OFF" position. Observe fire and also time required for fire to develop after fuel valve is energized. On the first start, there may be some delay in getting oil to the nozzle, resulting in safety shutdown and requiring manual restarting. Restart several times.

   Normal starting may have a delay of 15 to 20 seconds after the oil valves operate until the oil is discharged from the nozzle because of the purging of the fuel tube on the previous shutdown.

   Trouble with faulty fire or slow light off indicates one or more of the following, requiring correction as explained in the text:

   (a) *Slow Start* – Back pressure on recirculation line too low; low fire set too low; oil at (high) gassing temperature.

   (b) *Ragged Fire* – Atomizing oil temperature or atomizing air pressure too low; obstructed nozzle passages; fire too low.

   (c) *Smokey or Lean Fire* – Very minor linkage readjustment (oil preferably) will correct.
10. Replace blue terminal wire at modutrol motor, set up programmer for automatic operation, start and cycle a number of times. Observe fire, oil temperature and air pressure and make refined adjustments of each if required.
11. Under operating conditions, test fuel valves, boiler safety controls, all burner safety controls.
12. Make combustion test data.

NOTE: *On light oil disregard 1, 2, 3, 4 and 6.*

Gas Start

1. Review check list under "General" with reference to igniters, pilots, and gas.
2. Be sure gas pressure is regulated within the range required. Temporarily connect a gas pressure gauge.
3. Burner Light-Off (Preliminary with pilot check).
   (a) Keep main manual gas cock closed until pilot is adjusted and checked and until operation of main electric gas valve is observed to open and close at the proper time in the control sequence.
   (b) With sequence operation under control, check performance of pilot.
   (c) *Never* allow unburned gas to accumulate in the combustion chamber.
   (d) Check automatic opening and closing of main electric gas valve (with main cock closed). Observe opening of valve only with proved pilot and closing of valve on flame failure (end of trial for ignition period).

   Remember that even the "three" valve installation will not protect against faulty wiring.
4. Burner Light-Off (With main gas)
   (a) Note that even though the indicator on the main electric shut-off valve may show "closed," the valve may be partially open due to damage or foreign material in the seat. Assume the valve is open until proved otherwise through the start-up procedure.
   (b) When the pilot is checked and with the main cock still closed, allow the sequence to proceed. With a hand on the lever handle observe the sequence and, at the time the main electric valve is energized, open the cock at about the same rate that the main electric valve opens.
   (c) When the main flame is established, adjust for stability, quality and capacity. Open the limit control circuit and make sure that the main valve closes immediately and that the flame is completely extinguished.
5. A very rich flame can be very unstable and rough. Avoid this by pressure regulation first, and gas butterfly readjustments second. The butterfly valve, normally, should be approximately 7-10° open at low-fire; the fire clean with perhaps a tongue or two of yellow with the igniter operating. Finally, the main gas pressure regulates the high-fire and the butterfly valve the lower rates. Too tight low-fire setting of the butterfly valve may cause a too rich fire when modulated just above low-fire. This is corrected by increasing the air valve opening and setting up a slightly higher low-fire.

   When altering pre-set air control damper movement, be sure to recheck the low oil fire. In all gas fire adjustments, avoid a rich, smokey fire such as would occur with inadequate main gas regulation or with the butterfly valve opening excessively, related to air opening.

6. After several manually programmed starts during which the tight closure of the main electric gas shut-off valve is checked, and the fire (fuel-air ratio) is observed and adjusted for modulation from low to high fire, setup for automatic operation.
7. If not already done, complete Items 10-13 inclusive under "Oil Start."

STARTING OVERHAULED OR NEW UNADJUSTED BOILER

1. The "check off" is the same as above, plus the following items:
   (a) Be sure oil piping through the entire burner system is absolutely clean of all foreign matter, as this can insure the safe and proper operation of the oil metering valve, main oil shutoff, oil recirculating valve and various check and pressure relief valves.
   (b) Circulate hot oil for 5 to 10 minutes with the oil metering valve wide open. Inspect for and correct any leaky joints. Afterwards, stop and clean the small strainer in the hot supply line to the nozzle.

LUBRICATION AND MAINTENANCE

Air Compressor (Lubricated Rotary Type) (See K-2557)

Instructions are on the oiler glass. Use one of the following oils, or a pure mineral oil without detergents having a viscosity equivalent of S.A.E. 10. For installation in warm climates or where room temperature is high, use S.A.E. 20.

Use GAST AD 220 (SAE 10) Oil or Equivalent as listed.

	SAE 10 FOR AMBIENT BELOW 100° F.	SAE 20 FOR AMBIENT ABOVE 100° F.
AMERICAN	S–1 10	S–1 20
CITGO	C–110	C–120
GULF	Gulflube HD 10	Gulflube HD 20
HUMBLE	Encolube HDX 10	Encolube HDX 20
MOBIL	Delvac 1110	Delvac 1120
SHELL	Rotella 10	Rotella 20
SINCLAIR	Super TBT 10	Super TBT 20
SUN	Sunvis 610	Sunvis 620
TEXACO	URSA S–1 10	URSA S–1 20
UCON	LB300–XY–26 *	LB300–XY–26 *

*Use only for high pressure requirements. See chart in section on "Compressed Air", page 23.

Detergents in some oils (especially S.A.E. automotive types) may cause corrosion of many metal parts contacted or leave a jelly-like deposit in oiler and pump chamber.

To Fill and Operate Oil Reservoir: 1. Remove filler cap and while pump is running insert slender spout of oil can through filler hole and downward at a 45 degree angle through either of two side holes in filler opening. 2. Do not fill above bottom of top flange to avoid oil reaching air equalizer hole. 3. Leave cap off a few minutes while pump is running after filling so any oil will be sucked out of equalizer passage. 4. Replace and tighten filler cap. Oil Feed Control: Simple gravity system depends upon keeping air equalizer passage open and on the choice of wicks (smokers' pipe cleaners). Slow feed with double wick, twice as fast with single wick. Standard feed is a double wick on small (4 oz.) cup, and a single wick on large (8 oz.) cup, so one filling lasts equally long. Time may vary from 50 to 200 hours operation according to application. Improper Feed may be caused by oil filled equalizer passage, loose filler cap or defective wick.

To Change Wick: 1. Unscrew oil reservoir from lubricator casting and pull old wick out of bottom using pliers. 2. Insert new wick (if double, insert doubled end first) from bottom until you feel it touch strainer felt. 3. Cut off end about 1/8 inch longer than bottom of oil cup. BE SURE WICK IS IN CENTER HOLE AND NOT SIDE HOLE. 4. Bend end at 90 degrees away from side hole.

Even though the bearings receive oil at all times directly from the pumping chamber it is suggested that 5-10 drops of oil be added in bearing oilers each time oil reservoir is filled. NEVER REPLACE BEARING OILERS WITH GREASE CUPS OR USE GREASE IN THIS COMPRESSOR.

Cleaning

Intake filter felts may be washed in solvent. Stop pump first as otherwise dirt may be sucked in. FLUSHING OF PUMP WITH KEROSENE IS MOST BENEFICIAL SEVERAL TIMES PER YEAR. Permit several table-spoonfuls to be drawn into intake while pump is running AFTER REMOVING FILTER. A more thorough flushing can be done by dis-

connecting the air pressure line and removing the bearing oiler caps. With pump running, restrict the intake and feed the kerosene directly into the bearing oilers, but remember to disconnect the pressure line. Immediately relubricate with a shot of oil.

Servicing

Most failure to build up pressure is due to leaks in pipe lines, a dirty filter, defective gauge, or sluggish vanes. Vanes may stick in slots of rotor due to lack of oil, too much oil, or too heavy oil. See "CLEANING." An experienced mechanic may remove the end plate opposite to the drive shaft end to clean or replace the vanes. The original gaskets are onion skin paper. Thicker paper will greatly reduce pump efficiency.

Inspection

Do this regularly to prevent expensive repairs. Occasionally examine shaft for side or end "play" by moving it manually while pump is idle. Do not be alarmed if pump temperature reaches 150 to 250 degrees when running continuously. If pump or motor shows evidence of overheating or excessive noise, stop immediately until repairs are made. It is quickest and cheapest to remove pump from base and return it to the factory for repair. Try to have a spare compressor on hand at all times.

Oil Pump (Two-Stage pump and reservoir unit)

Fill worm drive gear case to 1/4 inch below overflow cap. Check with pump stopped. Use high grade #30 SAE nondetergent oil. Light oil pump requires no lubrication, but extended operation without fuel oil may cause failure. Recommended light fuel oils contain adequate lubrication for light oil pumps.

Belt Drive Blower

Blower wheel shaft bearings (front and rear of windbox) pre-lubricated. Use small amount of good quality bearing grease at approximately 3-month intervals. Over-greasing will result in churning and a temporary increase in temperature from this action. *Be sure any grease added to bearings is absolutely clean,* free of dirt and dust. Keep grease supply can covered and sealed at all times. Use only high grade ball-bearing lubricant suitable for high-speed operation.

If fan bearings of belted units must be removed or replaced, installation must be carefully made with particular reference to locking the inner race on the shaft. The locking eccentric ring must be tightened in the direction of the rotation.

On belt-drive units, the highest quality matched belts with very liberal load factor have been selected. Tension should be adjusted to avoid noticeable slippage on starting but without excessive tension which might shorten belt life or damage bearings.

All replacement belts or other parts should be procured through your boiler representative to assure correct size, type, quality and customer satisfaction.

Motors

All "Permanently" lubricated. If lubricating fittings are furnished, use good grade of lubricant sparingly, at about three-month intervals after initial greasing.

Linkage Ball Joints

No lubrication required. Use a couple of drops of light machine oil annually if desired.

Combustion Air Control Valve

Shaft and two bearings bonded with permanent "Molykote" lubricant at factory assembly.

COMPRESSED AIR (for Atomization and Nozzle Purging)

See previous instructions for lubrication.

Each unit has a pressure relief valve and a pressure gauge at the pump. Additionally, there is a pressure gauge on the oil nozzle assembly which, when the oil is shut off, indicates the air purge pressure and atomizing air pressure available at the nozzle. This gauge should, during a "dry run," indicate nearly the same pressure as the one at the compressor. It thus acts to warn of any abnormal leakage or restriction between nozzle and compressor. When oil is passing through the nozzle, the "tailpiece gauge" indicates oil pressure and is then higher than the atomizing air pressure. (A check valve and magnetic valve in the air purge line prevents flow of oil into the air tubing.)

The air pump furnished with each oil fired boiler is sized for sufficient volume and pressure of air for proper atomization. The nozzles are designed for the best atomization near the upper limit of compressor pressure. Continuously operated, the manufacturer recommends certain pressure limits to increase pump "life." These are tabulated below. The pressure relief valve thus should be finally adjusted to not exceed this recommended pressure. The highest pressure results at high oil fire, but the fire is most sensitive to pressure fluctuations at low-fire. It is best to make very slow alterations of air pressure, or make alterations at low-fire with rechecks at high-fire. Tighten the lock nut after final air pressure adjustment. Recommended oils must be used to obtain satisfactory performance under maximum conditions.

BOILER HP.	COMPRESSOR NO.	APPROXIMATE PRESSURE RECIRCULATION	RPM	RECOMMENDED HIGH FIRE PRESSURE	MAXIMUM PRESSURE***
40–70	1065	15–20	1750	25	45
80–300	2065	12–14	1750	17	30
350	*2065	10–12	1750	17	30
	**4565–BD	10–12	1340	15	20
400	4565–BD	10–12	1340	15	20
500	4565–BD	10–12	1340	15	20
600	4565–BD	12–14	1750	17	20

* Burner Specification 104

** Burner Specification 134–144

*** Operation at these pressures is permissible only when using Union Carbide Corporation UCON–LB 300–XY–26 lubricant.

The air compressor is supplied with a felt type filter of a size found satisfactory for most applications. Larger filters are available upon order where required. Their need will be evident where frequent cleaning of the small filter becomes a problem.

Oil Nozzle Air Purge

On units up through 300 horsepower, a branch air line from the main atomizing air supply leading into the oil side at the tailpiece acts to "purge" the fuel tube assembly before and after each firing cycle. There is a spring-loaded check valve in this line to prevent flow of oil into the air line. On larger units, the nozzle itself is purged during the purge periods.

AIR ATOMIZING OIL NOZZLE ASSEMBLY

Refer to the sectional illustration titled "Fuel Feed Assemblies" P-653 for sizes up through 300 H.P. The nozzle itself is steel, all other parts and fuel piping back to the oil recirculating manifold are of a thermally conductive metal, brass or aluminum, which has the dual function of removing excessive heat from the nozzle tip and quickly distributing heat to avoid chilled oil on starts. The heat of compression in the atomizing air is also distributed beneficially within the nozzle assembly. The corresponding assembly for larger sizes, 350–600 H.P. is shown on drawing 52699-1.

Nozzle Tip

The frequency for inspection and servicing the nozzle assembly will depend upon the grade and quality of the fuel oil, the rate of firing and the general type of operation.

A neglected nozzle can cause irregular flame pattern, flame impingement on the refractory or in the combustion tube with formation of carbon in these areas and can result in hazardous conditions or damage to the boiler.

Important: The quickest method of determining the nozzle condition is a visual observation from the rear of the boiler. Keep the observation port clean so that the flame pattern may be inspected. An operator must know how a normal flame should appear at all rates of firing, symmetrical and free of smoke and excessive impingement.

Any departure from these normal patterns should indicate necessity of nozzle inspection.

The fuel tube assembly on sizes up through 300 horsepower may be easily removed by disconnecting the union in the oil line, just below the tailpiece casting, and the two air lines. Then remove the four machine screws in the tailpiece flange. It may be advisable to drain the small amount of oil from the plugged Tee below the tailpiece assembly before disconnecting the union.

On sizes 350 to 600 horsepower, (Refer to P-727) the fuel tube assembly may be easily removed by the following method:

1. Shut off the burner.
2. Clean while the oil is still hot to obtain better drainage.
3. Have an open waste oil can handy.
4. Back off on the fastening screw and swing the yoke clear of the tailpiece.
5. Keeping the tailpiece lightly seated, rotate it counter-clockwise until the half-moon cutout in the flange is under the keeper screw. This entraps the oil so it will not spill if the assembly is kept level.
6. Keeping it twisted as above, withdraw the unit keeping it level. A glove or rag should be used in one hand if the pipe is still hot as from recent firing.
7. Dip the nozzle end into the waste can and drain.

Replacing the Assembly

1. Guide the nozzle and nozzle adapter end quite carefully through the O-ring seating surfaces in the tailpiece support to avoid nicks which could cause loss of oil seal.
2. When approximately half way in, the nozzle passes through a support hole. The unit slips easily through if squared with the front. A slight jiggle will help.
3. When approximately 1" from seated position, the pipe sleeve enters its support hole, another slight jiggle will permit the complete seating.
4. Twist the assembly so the half-moon cutout passes over the keeper screw head, then rotate the tailpiece until the hole in its flange (at the top centerline) is concentric with a similar hole in the top centerline of the tailpiece support. This aligns oil feed holes in the two parts for proper feeding.
5. Swing the yoke over the center and lock the parts closed. Auxiliary leverage on the hand screw is unnecessary. The O-rings effect their seal upon approximately .009" of squeeze.

The nozzle tip is referred to as *unitized nozzle assembly* to emphasize the importance of keeping the cap and tangential plate unit mated. It is a jewel of precision – treat it accordingly. There should be no necessity for adjustment of the pintle (central conical pin). Should it, for any reason, become damaged or out-of-center, it should be returned to the factory for re-work. The lapped and ground conical surfaces must make a seal between air and oil slots; likewise the ground surface on the backside of the tangential slot plate must make an air and oil seal on the adapter body. Tiny scratches, dents or nicks on the pintle or at any point of the outlet orifice, from knife edge outward along the outer flaring cone, including its corner on the cap surface can completely ruin the nozzle. Be careful to prevent it striking hard surfaces. Clean it in solvents, using a paint brush or an old tooth brush, never abrasives, wire brushes or knives. Work over a pad of rags. Finally rinse the two pieces in clean solvent and re-assemble before lint can fall on the sealing surfaces.

SIZE	NOZZLE	
	RAY NO.	MONARCH NO.
40–70	51907–1	C170–W2–70°
80–150	51761–1	C169WA80–70°
200–300	51976–1	C169WA100–70°
350 (Spec. 104)	51976–1	C169WA100–70°
350 (Spec. 144)	53259–2	C169WA125–80°
400	53259–2	C169WA125–80°
500	52709–1	C169WA150–70°
600	52947–1	C169WA200–80°

The larger nozzles, 350-600, have no tangential slots for oil flow next to the nozzle caps conical face so it is less susceptible to charring temperatures internally. Larger holes and passages make clogging less likely. Sluggish operation can be cleared by feeding kerosene through the air compressor as is described under Compressor Maintenance. This operation may be used to clean the nozzle as well as the compressor.

The compressor must be lubricated immediately after kerosene flushing.

If the nozzle tip is disassembled for cleaning, follow the earlier amplified instructions explicitly.

Nozzle Adapter

The front sealing face must be treated with the same care as instructed for the nozzle. The pipe plug, covering the cross drilling in the adapter, should always be at the top of the assembly when "made up." This position prevents residual oil in the fuel tube from draining, after shutdown, into the air passages. The connected tubes have pipe threads. Adjustments for nozzle extension are made at the opposite end so it should not be necessary to break the joints at the nozzle end. If, however, the tubes are disassembled, before re-assembly, coat the threads with a good hot pipe thread sealant such as "PERMATEX." Avoid excess sealant that could obstruct nozzle ports.

Oil Nozzle Tubes

At the tailpiece end of the fuel pipe, on sizes 40 to 300 and at adapter end on larger units, the O-ring and the hole into which it seals must be protected from injury. The running thread and lock nut on the air pipe permit suitable nozzle extension. This thread also, if broken, should be made up with a hot pipe thread sealant. Be careful to maintain original nozzle extension of 3/8" to 1/2" in front of the diffuser unless there is a reason to alter the length as follows. Less extension may stabilize a fire that remains rough in spite of air and oil temperature adjustments – a very rare phenomenon; or increased extension will reduce a tendency for flame to pull back into the secondary air plenum at very low firing rates. The extention or retraction of the nozzle is limited by the length of the O-ring cylindrical sealing surface. Use "PERMA-TEX" or equal thread sealant at the threaded tailpiece connection of the air pipe. This prevents a nuisance leakage of compressor oil normally exhausted through the nozzle. When assembling the nozzle, a layer of "pipe thread sealant tape" on the adapter threads will help to prevent loosening of the nozzle due to thermal expansion and contraction.

When re-assembling the nozzle after cleaning, always make sure that the nozzle tip is centered properly through the nozzle cap opening.

"O" Ring Seal on Nozzle End of 350–600 Model Oil Feed Tube (See 52699-1)

If replacement of the O-ring at the adapter end ever becomes necessary, proper re-assembly is done this way: Before disassembly, measure and record tailpiece to nozzle tip length. After installing the O-ring on the oil feed pipe, back off the lock nut on the air pipe as far as possible. Then screw the air pipe into the tailpiece as far as possible. This makes (at the opposite end) sufficient extension on the oil pipe to start seating the O-ring before the air pipe threads start to make up. After starting the O-ring, run the air pipe threads in hand tight. Then, at the tailpiece end, unscrew the air pipe about 5/16". This prevents the O-ring from jamming into the cross drilled holes in the nozzle adapter. Next make the nozzle adapter wrench tight on the air pipe.

Finally, adjust the overall length to that recorded and tighten the lock nut against the tailpiece.

IGNITERS

Gas Igniter (Sizes 40–300)

P-654, Sheet 1, illustrates the proper assembly of the gas fueled igniter for sizes 40 to 300 and indicates suitable dimensions for length and spark gap. The amount of gas required by the igniter varies not only with the BTU of the gas but also with the "low-fire" air opening at the *combustion air control damper* and averages between 100 and 120 CFH. Reference should also be made to instructions for main air and fuel adjustments. As the entire burner was designed for, and is expected to be operated as a 4 or 5 to 1 turndown burner, the igniter also is designed to function at low-fire and blow away from the scanner at high-fire to prevent excessively high fire starts. Adjustments of the igniter flame are thus made exclusively at the low-fire setting of the air control, and this adjustment is accomplished by regulation of the gas flow through the igniter body by adjustment of the gas pressure regulator. A combustible mixture must pass through the spark gap. Thus, too much gas will as readily cause faulty ignition as too little. The scanner is focused and pre-tested to prevent starts with inadequate ignition flame.

The standard pilot gas pressure regulator furnished with the boiler is designed to operate at inlet pressures up to 5 psig. It is important that the inlet port of this regulator always be piped to a point upstream of the boiler main gas shutoff cock to avoid inlet pressure changes when the main gas valve opens. Should the available gas pressure at that point be in excess of 5 psig, the standard pilot regulator should be replaced with one rated for the higher pressure. The required discharge pressure is approximately 8" w.c.

Gas Igniter (Sizes 350–600)

P-654, Sheet 2, and P-726 show the assembly of the pressurized, pre-mix igniter and pilot.

This gas igniter incorporates the desirable features of simplified adjustments, a long stable flame and accessibility.

Utilizing the high air pressure from the burner blower to aspirate the gas, a high gas-air mixture pressure is created and this results in a hard blast finger of flame effectively penetrating into the burner fuel-air mixing zone.

When assembled in the burner the igniter tip is recessed 1-1/2" inside the hole cored through the burner entrance refractory. This shields the base of the flame against the crossing path of burner air flow.

The outer tube of the igniter, on natural and L.P. gases, supplies only 10-15% of the total air. This air has the dual function of creating a protective laminar envelope of air around the flame eliminating turbulence and increasing the penetrating ability of the flame.

The spark gap is adjusted to 3/32" directly over one of the slots in the tip. In this manner the flame holding ring of fire is reliably and quickly kindled to stabilize the flame.

Before attempting to adjust the gas flow to the igniter the burner air control valve should be set at about 1/8th open (1" open from fully closed). This opening is sufficient for a low oil fire of 28-30 GPH. Later, changes in low-fire air setting may require small igniter adjustments because the air supply pressure may change.

The main adjustment is at the gas pressure regulator. The gas supply line should be 3/4 NPT for a big flame is desirable. The gas cock is not used to regulate the mixture, it should be fully opened. A very light spring press (screwed 1/4 down) will usually permit sufficient gas flow, for a suction is created by the mixing tee.

During the above adjustments the air damper elbow screw usually should be approximately 1/3 open.

Diesel Fueled Igniter

P-654, Sheets 1 and 2, illustrates the proper assembly and indicates dimensions for length and of spark gap.

The Diesel oil igniter is also designed for the best flame and proper ignition only at low-fire of the main flame. The nozzle size and spray angle furnished with original equipment has been selected for each boiler horsepower range. If unusual conditions dictate, slightly smaller or larger capacity nozzles (commonly available) may be substituted. Also, minor capacity variations of perhaps 15 percent can be made by varying the igniter fuel pump pressure between 90-140 PSI. This assembly is easily removed for adjustment and cleaning.

VI. SERVICE HINTS

PRECAUTIONS IN ADJUSTMENT, READJUSTMENT AND MAINTENANCE

Certain precautions discussed herein are offered to installers, service men and operators in the initial burner adjustments, subsequent readjustments, and operating maintenance to prevent hazardous conditions.

WIRING AND ELECTRICAL EQUIPMENT

1. Wiring must not be altered from that installed and recommended by the manufacturer.
2. Solenoid valves must be handled carefully to avoid damage which might cause the core to stick either open or closed.
3. When replacing fuses, signal lamps, overload heaters, etc., care must be taken to use replacements of same specifications as the manufacturer's original wiring. Substitutions may cause grounds or "shorts," resulting in dangerous operation. A main fuel valve stuck open or partially open could cause a very hazardous condition by feeding fuel oil or gas into the combustion chamber BEFORE the ignition flame has been established. A relay which has been fused closed (by short-circuit or overload) could cause the same hazard.
4. None of the electrical or mechanical safety devices should be "jumpered," cut out, moved, or otherwise rendered inoperative.

OIL FIRING

Clean oil and clean piping is essential to trouble-free operation. At the manufacturer's level, and on any subsequent work or replacement involving opening the oil piping, no foreign matter should be permitted to lodge inside oil pipe or fittings.

1. In addition to the above precaution, before firing, *HOT OIL* should be circulated through the hot oil piping and drained away for a period of at least 10 minutes to purge the system of lint, scale, metal chips, etc. The strainer cannot collect this matter if it is in the line downstream of the strainer.

   This precaution is to prevent the likelihood of foreign matter lodging between the disc and seat of solenoid fuel valve, permitting entrance of fuel into the combustion chamber during recirculation and to prevent fouling of nozzle ports.

   While the burner is off and recirculating, it is good practice occasionally to disconnect the linkage from the Viscosity Valve arm (making sure to return it to the same position again) and move the arm several times through the normal operating angle to dislodge any dirt or foreign particles from the metering passages.

   Watch the fuel oil tanks for low level and loss of oil suction as the fire will be panting and puffy until finally shut off by the flame scanner in the event of loss of fuel delivery to the nozzle. Water in the fuel oil tank can cause similar problems.

   In making oil and air linkage adjustments, be doubly sure that all adjustable components are fastened tightly after *YOUR* final adjustments.

GAS FIRING

1. In making any adjustments or repairs to gas firing equipment, observe the recommendations and precautions in Section V, Gas Start. The following are supplemental to those recommendations.
2. When gas pressure must be reduced by a regulator from pounds to inches W.C. pressure required at the burner, (4" to 10" average) use gauges to be assured that *inches* of pressure will actually be delivered upon start-up. This is particularly important with regulators having "pilot" or balancing systems of piping.
3. The gas fire must always be started at low-fire, as it is designed to do. Remember, this is a 4 or 5 to 1 turn-down burner.
4. The gas-air adjustments for a modulating fire can be completed in the normal manner of adjusting air and gas flow but never flood the burner with a rich, over-supply of gas compared to the air rate.
5. Be sure to determine before finalizing gas fire adjustments, that the electrical gas valves (main and igniter) are closing completely upon shutoff. This is best checked at low-fire by simulating "limit" shutoff and "flame failure" a number of times until there is no doubt that the valve operations are correct and positive.
6. Be sure all linkage components are locked tightly on the final settings.
7. Observe all precautions listed under "Wiring and Electrical Equipment."

OIL FEED vs. AIR DELIVERY

Any air or gas trapped in the system between the Viscosity Valve and the oil nozzle acts as a compression chamber. When the pressure on this portion of the system increases, as during an increasing change of firing rate, the gas (and air) is compressed and, since the discharge from the Viscosity Valve is the controlling factor, delivery through the nozzle is below the normal increasing rate.

Conversely, on a decreasing rate, the gas in the circuit will expand and cause an excess flow of oil to the nozzle.

Apparent result is that the "air leads oil both ways" – Lean on increase, rich going down.

Therefore, it is important to avoid overheating of oil which might form vapors, particularly with an oil which might have light ends.

The equipment is designed to minimize the entrapment of air or vapor in such places as the Viscosity Valve and oil heater, but the pipe lines and magnetic valves themselves do contain some pockets.

It is, therefore, important to operate the unit at high and low rates to allow escape of entrained air before making final adjustments and to keep the electric oil heater set as low as good combustion will permit.

Tests have indicated that with a 30-second modutrol motor, this situation has not caused any concern except when extremely fine adjustments are attempted to obtain high CO_2. However, if operation on oil from certain sources becomes a problem, it may be advisable to use 60-second motors.

OIL STRAINERS

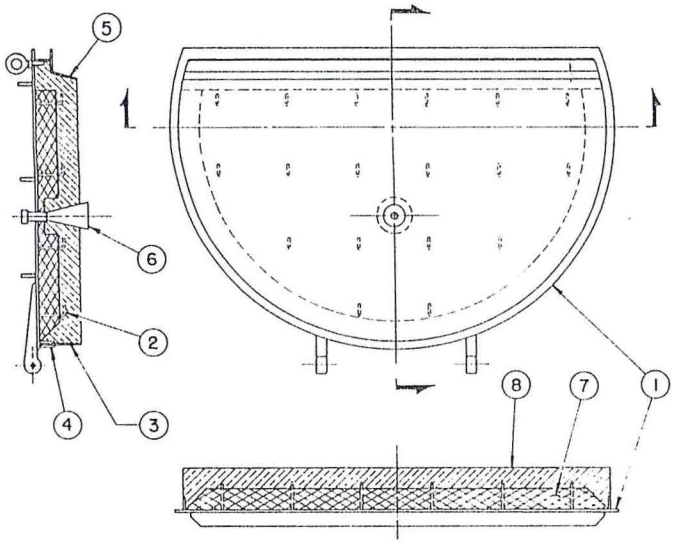
An easily-cleaned, fine-mesh strainer (Cuno type) is installed in all heavy oil, air-atomizing burners in the hot oil supply line between the electric oil heater and the nozzle piping. Keep the cartridge of this strainer clean by regularly giving the external handle one complete turn in either direction. Do this often until experience indicates cleaning frequency necessary to maintain optimum condition of flow. If handle turns hard, through occasional neglect, rotate cartridge back and forth until handle can be turned through a complete revolution. Draining and filling with solvent will assist in freeing a stiff cartridge. NEVER use a wrench or other tool to turn a filter which has become plugged. Cartridge may be removed from housing and washed in solvent. Do not try to dis-assemble cartridge. 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. A 20-mesh, #354D strainer is standard in the suction line to the primary pump for 40-300 HP units, and a double strainer, 20-mesh, #394F for 350-600 HP units.

Discussion

1. Fine straining is essential in this automatic burner, first, to assure positive seating of the electric fuel valves; second, to obtain clean tangential slots in the nozzle (the nozzle used in Sizes 40-70 BHP being most sensitive); and third, to assure proper operation of the metering valve and ball check valves.
2. Burner builders, repairmen, and piping installers can prevent much strainer grief by assuring that all piping and fittings are thoroughly clean before being made up. Any work on the oil system downstream from the last strainer must be re-assembled clean.

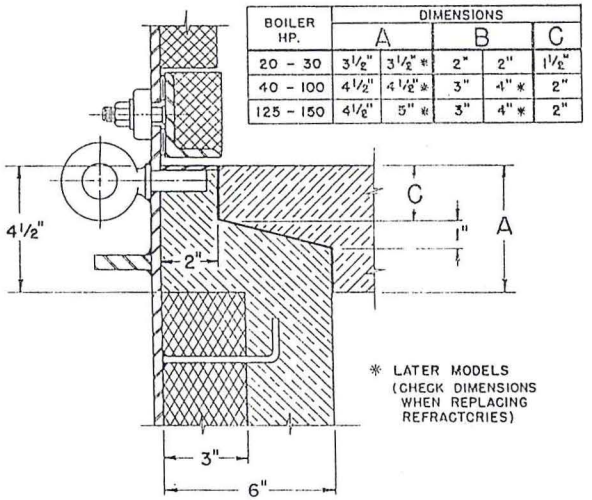
3. The required U.L. Inc., Instruction Card (for operators) reads as follows:
"During the first weeks of operation, the oil strainers should be checked frequently to remove foreign matter inherent in all new piping and to determine a cleaning schedule for the oil being used."

4. *CAUTION* – It is important that installers make certain that the magnetic oil shut-off valve positively seats before putting the burner into unattended operation. Make repeated tests to be certain.

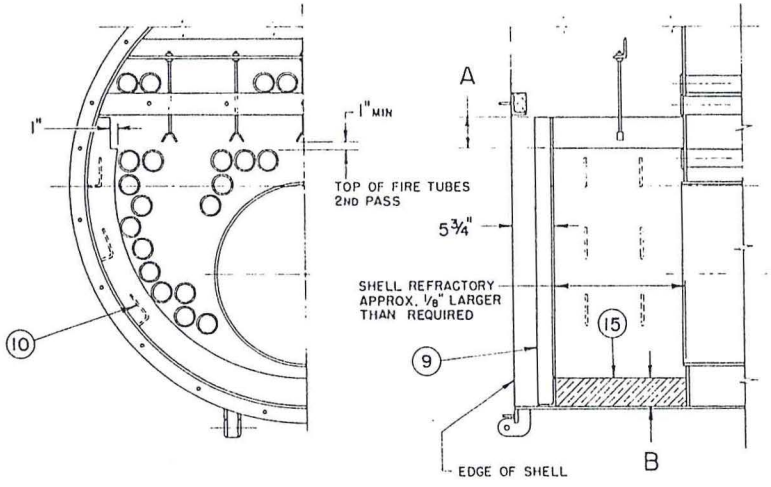


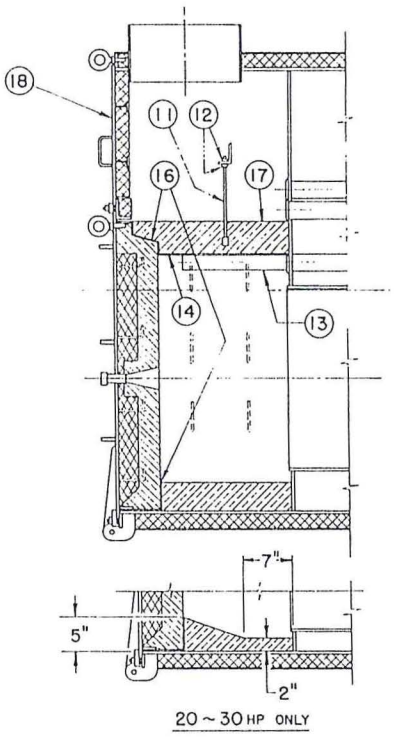
ITEM NO.	DESCRIPTION	DWG. NO.
1	LOWER REAR DOOR	
2	DOOR ANCHORS	
3	DOOR FORM	B-1217
4	METAL STRAPPING	
5	SEAL EDGE FORM	B-1218
6	PEEP SIGHT FORMING PLUG	B-1219
7	INSULATING REFRACTORY	
8	REFRACTORY	
9	SHELL REFRACTORY RETAINING FORM	C-1220
10	SHELL ANCHORS	
11	ARCH ANCHORS	
12	LOCKING NUTS	
13	ARCH SUPPORT BARS	B-1221
14	ARCH SUPPORT PLATE	B-1222
15	SHELL REFRACTORY	
16	HOUGHTON'S DEEP DRAW WAX NO.3320RR	
17	ARCH REFRACTORY	
18	REAR DOOR TOP SECTION	

BOILER HP.	DIMENSIONS				
	A		B		C
20 - 30	3½"	3½" *	2"	2"	1½"
40 - 100	4½"	4½" *	3"	4" *	2"
125 - 150	4½"	5" *	3"	4" *	2"

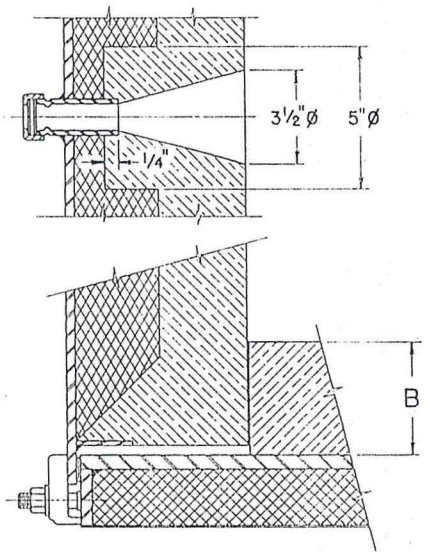


* LATER MODELS (CHECK DIMENSIONS WHEN REPLACING REFRACTORIES)





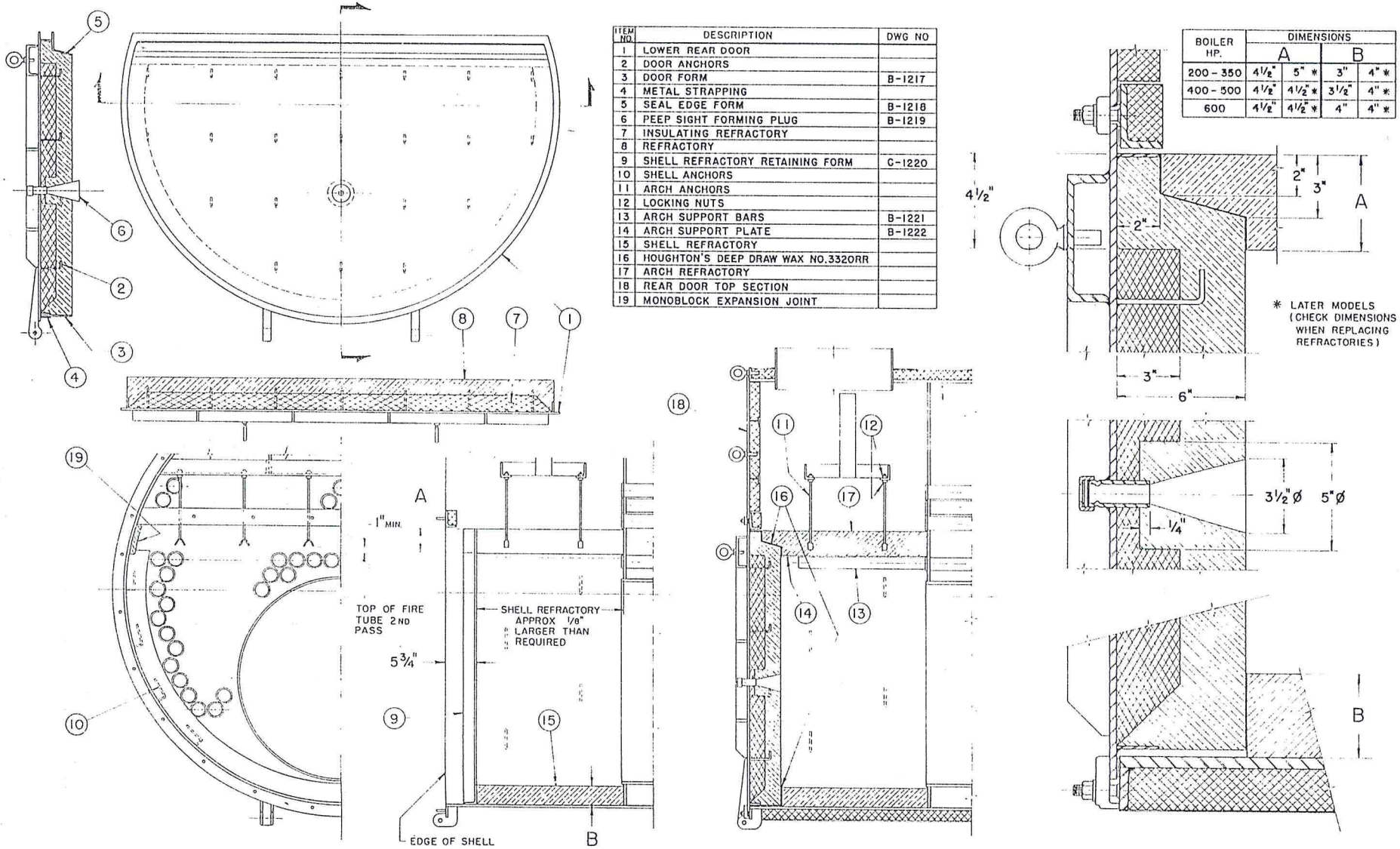
20 ~ 30 HP ONLY



REAR REFRACTORIES REPLACEMENT PROCEDURES

20—150 HP

D-1215

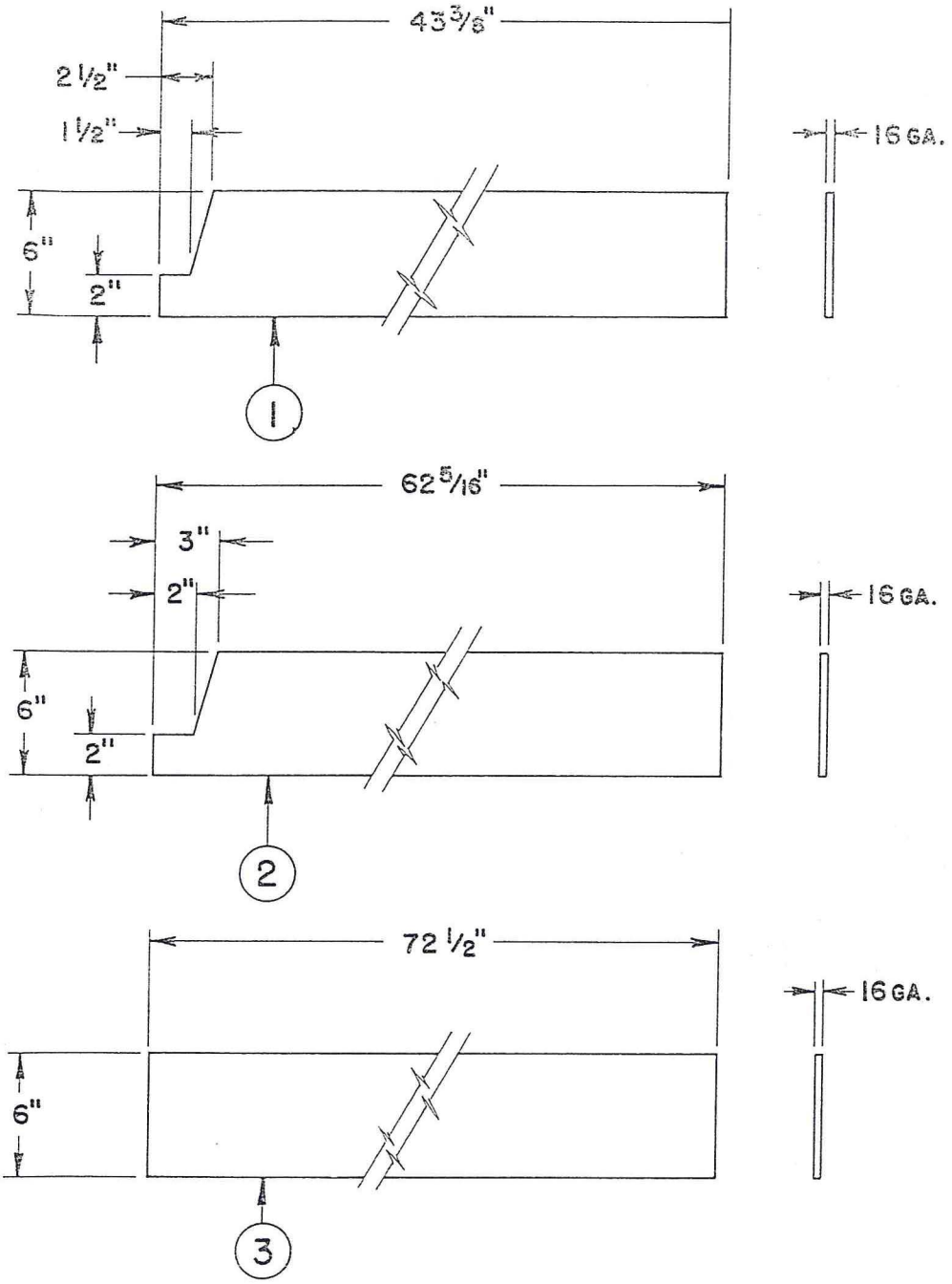


ITEM NO.	DESCRIPTION	DWG NO
1	LOWER REAR DOOR	
2	DOOR ANCHORS	
3	DOOR FORM	B-1217
4	METAL STRAPPING	
5	SEAL EDGE FORM	B-1218
6	PEEP SIGHT FORMING PLUG	B-1219
7	INSULATING REFRACTORY	
8	REFRACTORY	
9	SHELL REFRACTORY RETAINING FORM	C-1220
10	SHELL ANCHORS	
11	ARCH ANCHORS	
12	LOCKING NUTS	
13	ARCH SUPPORT BARS	B-1221
14	ARCH SUPPORT PLATE	B-1222
15	SHELL REFRACTORY	
16	HOUGHTON'S DEEP DRAW WAX NO.3320RR	
17	ARCH REFRACTORY	
18	REAR DOOR TOP SECTION	
19	MONOBLOCK EXPANSION JOINT	

BOILER HP.	DIMENSIONS			
	A		B	
200 - 350	4½"	5" *	3"	4" *
400 - 500	4½"	4½" *	3½"	4" *
600	4½"	4½" *	4"	4" *

REAR REFRACTORIES REPLACEMENT PROCEDURES
200–600 HP

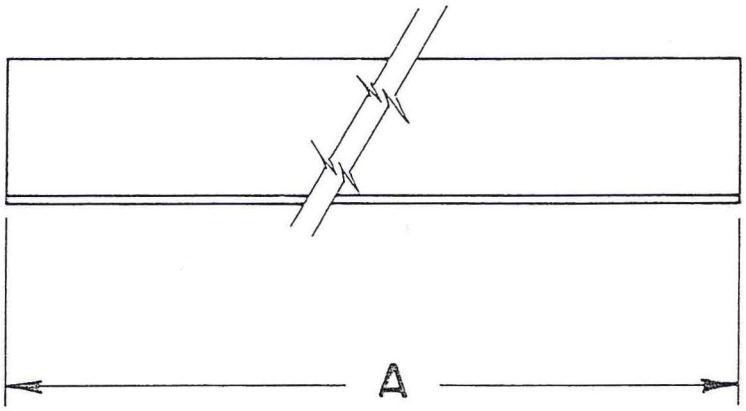
D-1216

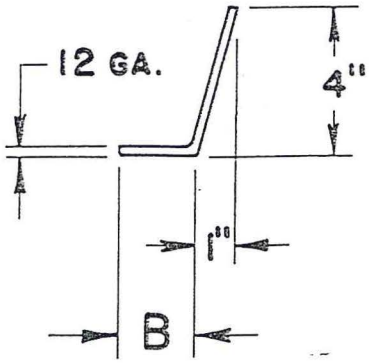


BOILER HP.	ITEM NO.	QTY.
20 – 30	1	2
40 – 150	2	2
200 – 600	2	2
	3	1

DOOR FORM
20–600 HP

B-1217



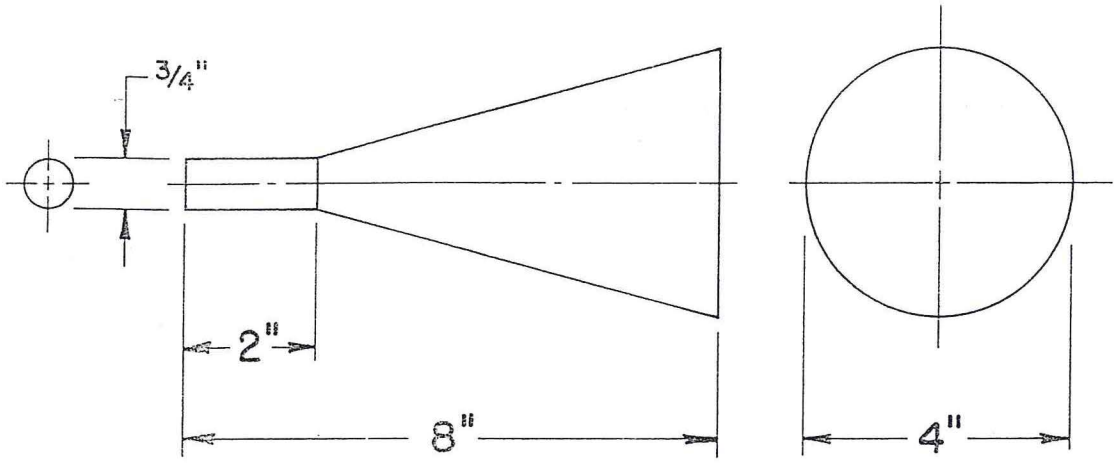


BOILER HP.	A	B
20 – 30	43 1/4"	1 1/2"
40 – 70	49 1/2"	2"
80 – 100	54 3/4"	2"
125 – 150	64"	2"
200	73 1/2"	2"
250 – 300	78"	2"
350	80 1/2"	2"
400 – 500	94"	2"
600	96"	2"

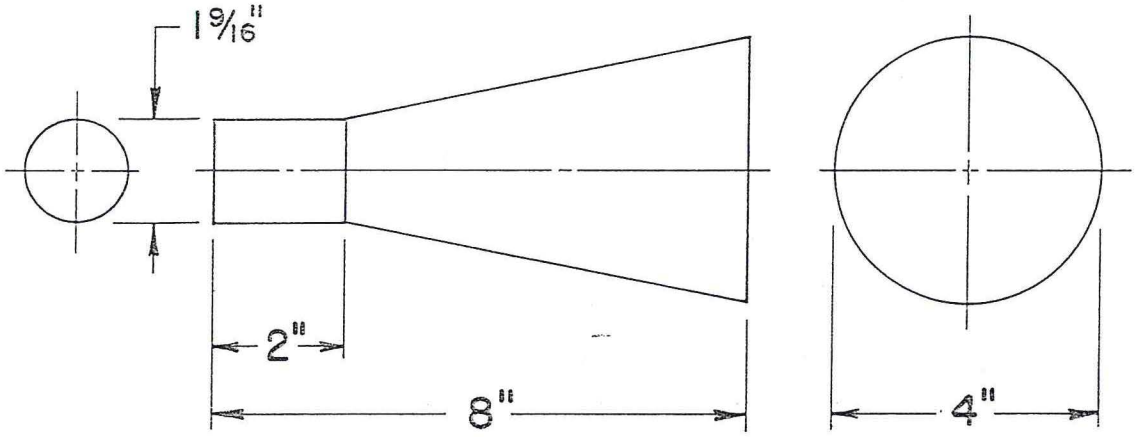
SEAL EDGE FORM

20 - 600 HP

B-1218



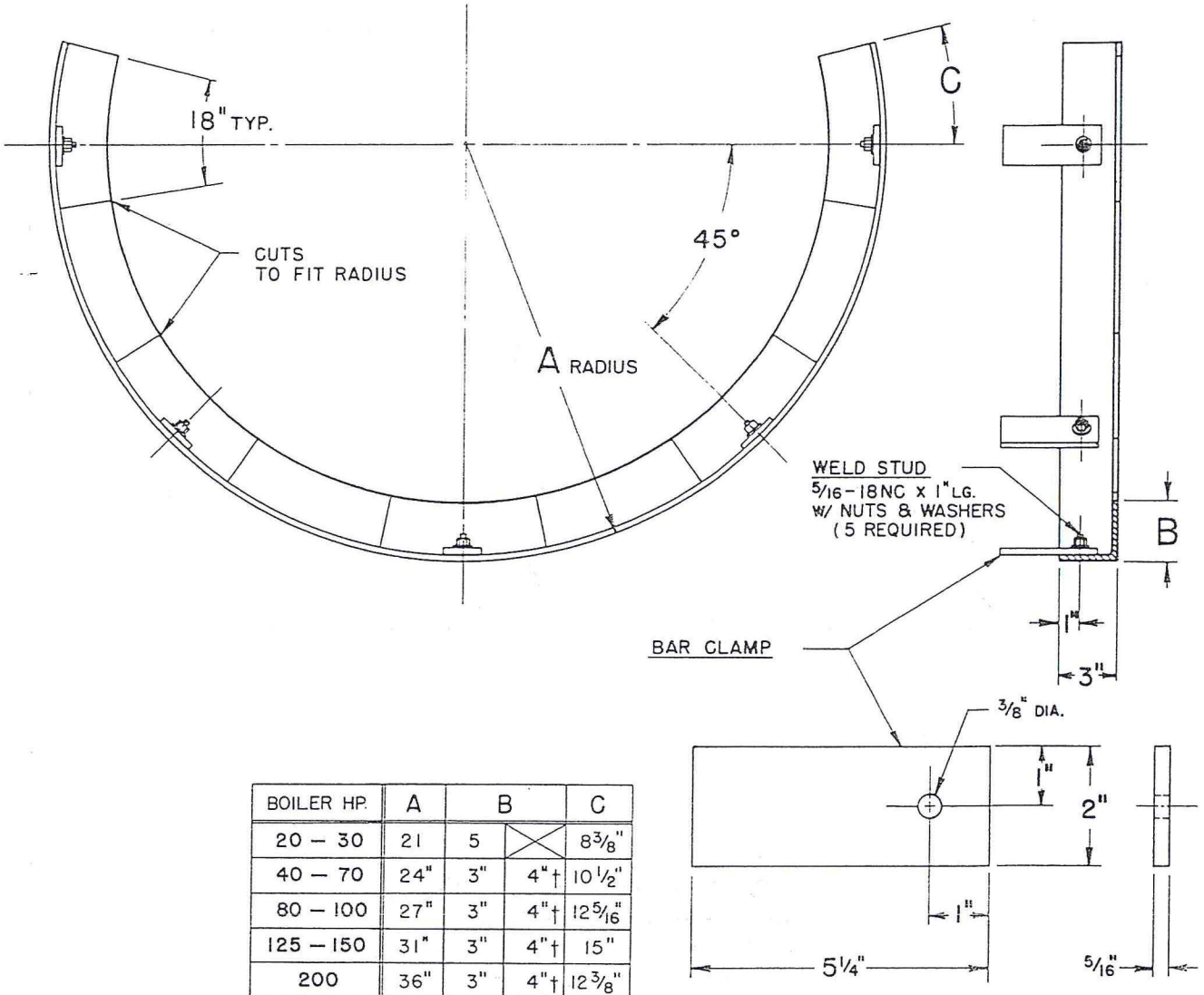
FOR 1/2" PEEP SIGHT OBSERVATION PORT – ALL HP.



FOR 1 1/2" PEEP SIGHT OBSERVATION PORT – ALL HP.
(LATER MODELS ONLY)

PEEP SIGHT FORMING PLUG
20–600 HP

B-1219

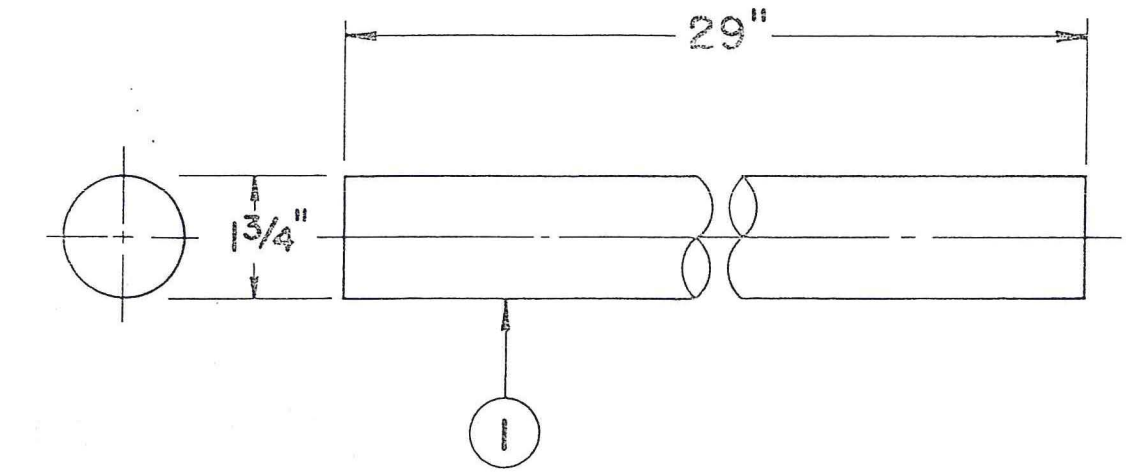


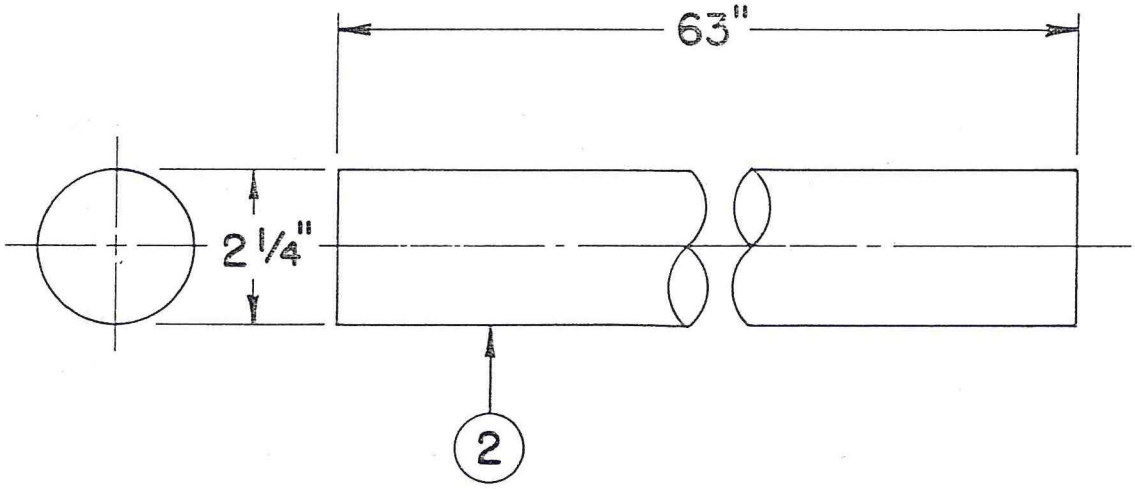
BOILER HP.	A	B		C
20 – 30	21	5		8 3/8"
40 – 70	24"	3"	4"†	10 1/2"
80 – 100	27"	3"	4"†	12 5/16"
125 – 150	31"	3"	4"†	15"
200	36"	3"	4"†	12 3/8"
250 – 300	39"	3"	4"†	14 1/16"
350	40"	3"	4"†	15 3/8"
400 – 500	47"	3 1/2"	4"†	17 1/16"
600	49"	4"		19 1/4"

† LATER MODELS

SHELL REFRACTORY RETAINING FORM
20–600 HP

C-1220

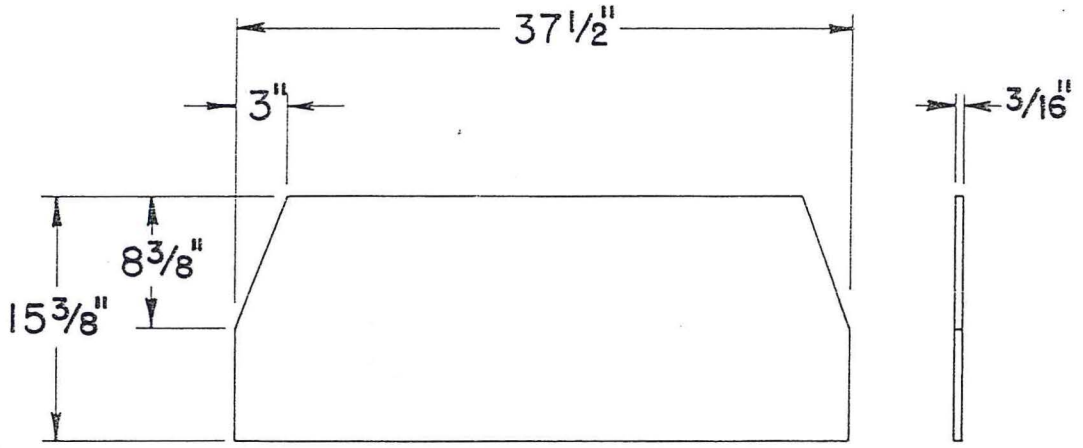




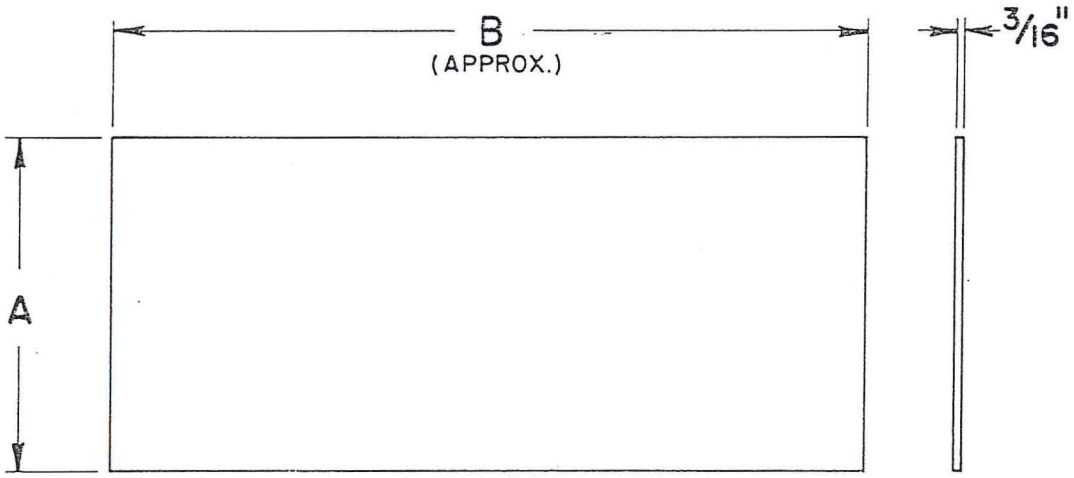
BOILER HP.	ITEM NO.	QTY.
20 – 30	1	4
40 – 70	1	6
80 – 300	2	6
350 – 500	2	8
600	2	7

ARCH SUPPORT BARS
20–600 HP

B-1221



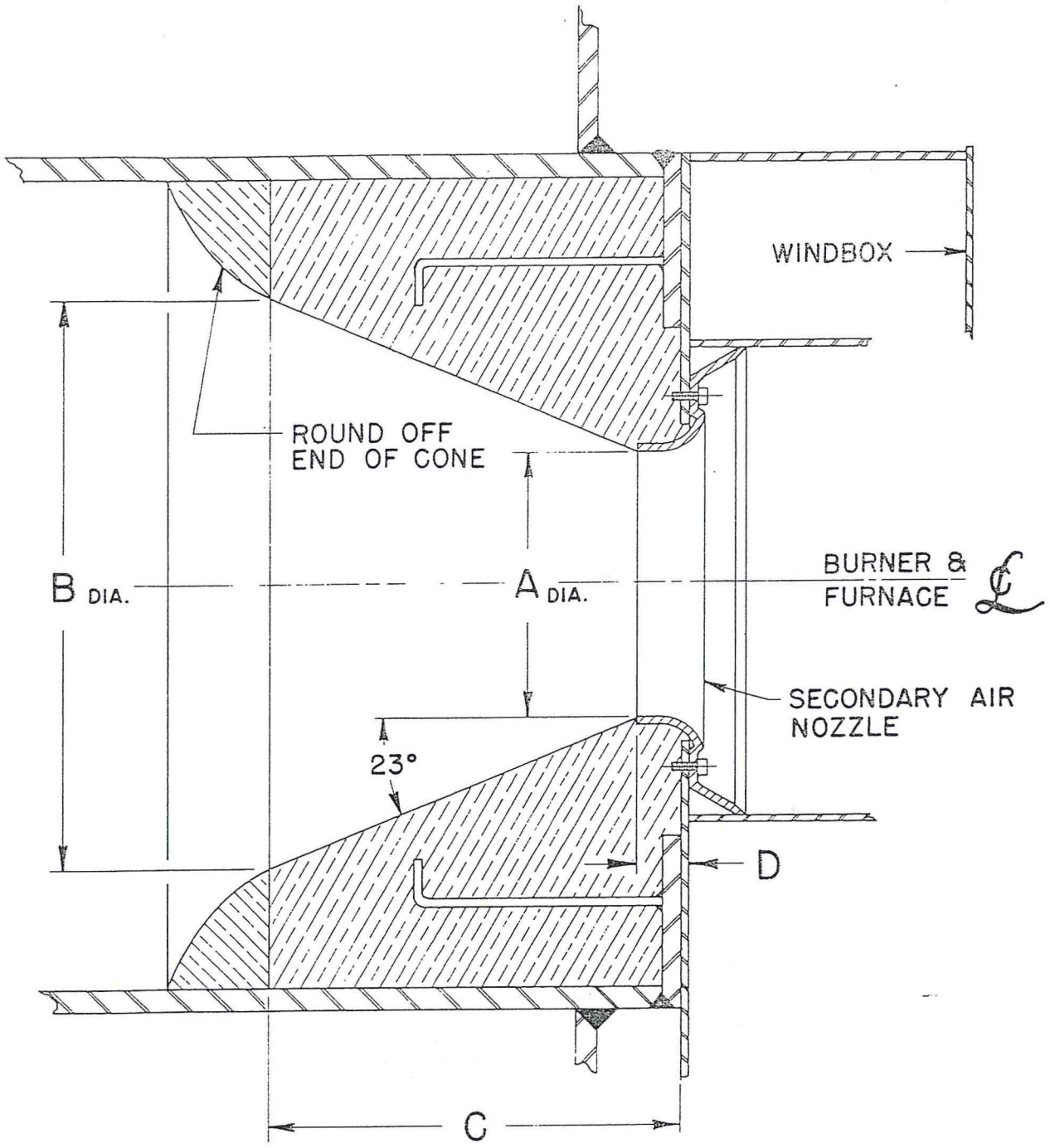
20 – 30 HP. ONLY



BOILER HP.	A	B
40 – 50	14 3/8"	41 3/4"
60 – 70	16 3/8"	41 3/4"
80 – 100	17 3/8"	47 1/4"
125 – 150	18 3/8"	55 1/2"
200	19 3/8"	65 1/4"
250 – 300	21 3/8"	70 3/4"
350	27 3/8"	72 3/4"
400	27 3/8"	85"
500	29 7/8"	85"
600	33 3/8"	87"

ARCH SUPPORT PLATE
20–600 HP

B-1222



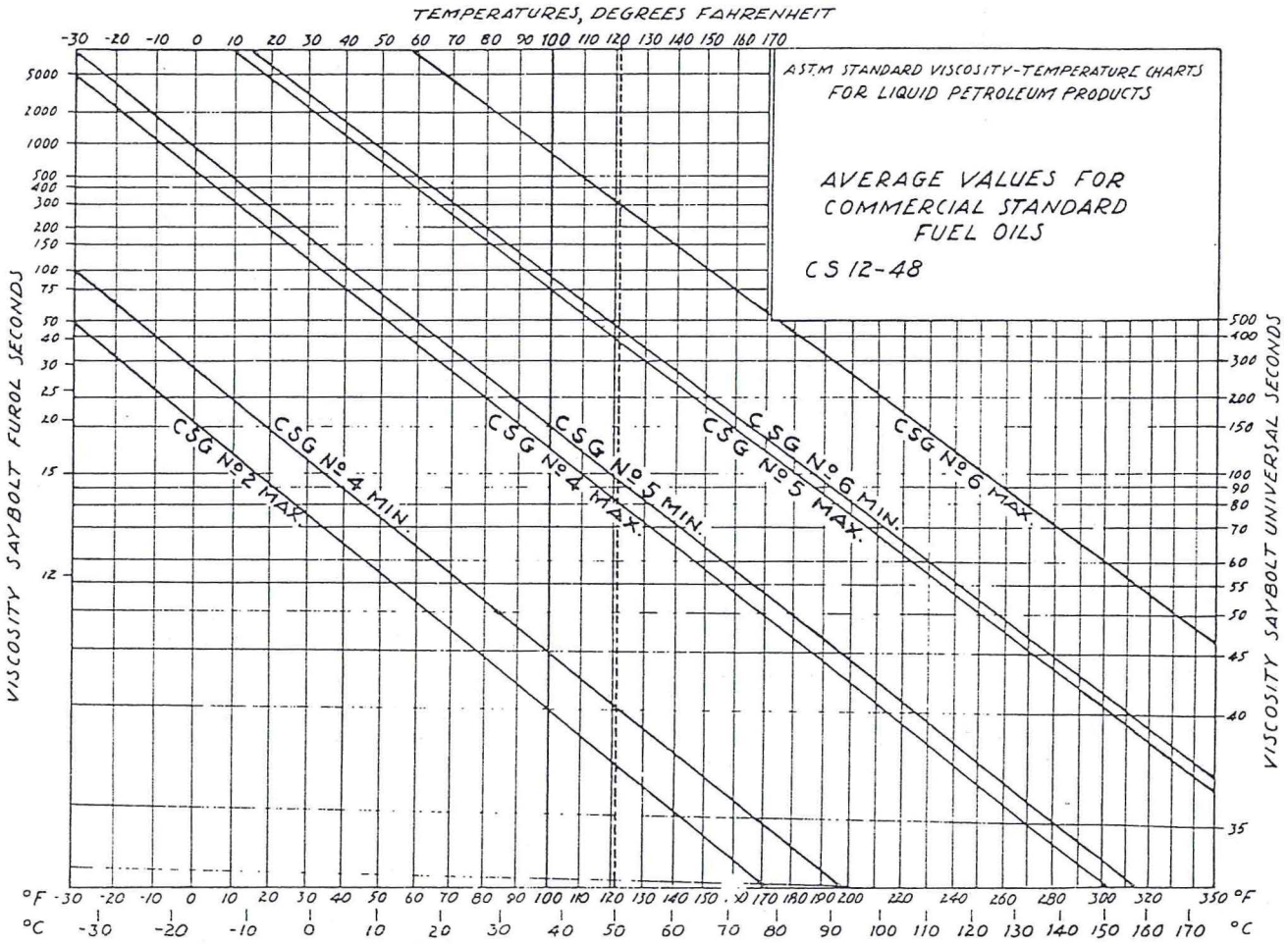
BOILER HP.	A	B	C	D
40 – 70	7 7/16"	14"	8 1/4"	5/8"
80 – 150	8 1/4"	18"	13"	1 9/16"
200 – 300	9 7/8"	24 1/4"	18"	1 1/8"

REFRACTORY CONE REPLACEMENT
"E" Burner – 40–300 HP

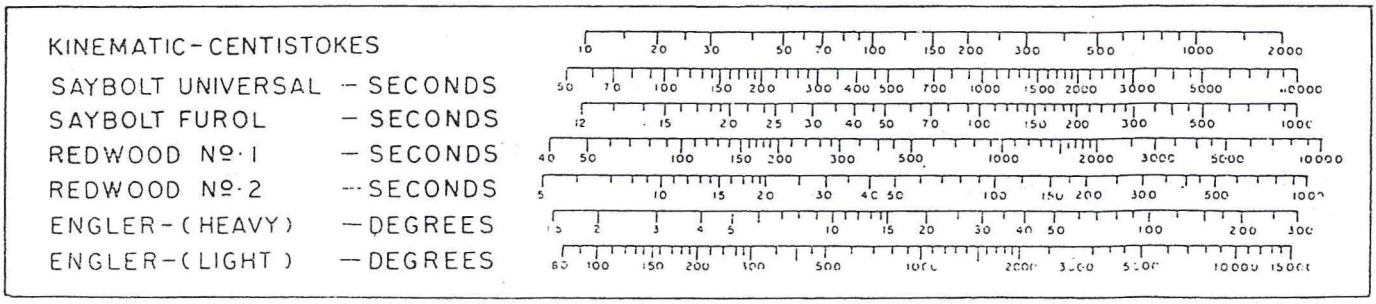
C-1223

PACIFIC COAST SPEC'S	CS 12-48 GRADE	DESCRIPTION	APPROX. GRAVITY API	APPROX. SPECIFIC GRAVITY	LBS. PER GALLON	BTU PER GALLON	BTU PER POUND	MAXIMUM VISCOSITY
100		Light Domestic Distillate	38	.84	6.96	136,500	19,600	———
	1	Light Domestic Distillate	35	.85	7.08	136,400	19,260	———
200		Medium Domestic Distillate	30	.87	7.25	138,000	19,030	SSU at 100° F--55 Sec.
	2	Medium Domestic Distillate	26	.90	7.50	140,000	18,660	SSU at 100° F--40 Sec.
DIESEL		Diesel Engine Oil, Etc.	30	.87	7.25	140,000	19,310	———
	4	Light Residual Oil	24	.91	7.60	145,000	19,070	SSU at 100° F--125 Sec.
300		Medium Residual Oil	14	.97	8.09	150,500	18,540	SSF at 122° F--40 Sec.
	5	Medium Residual Oil, Bunker B	21	.93	7.75	148,000	19,100	SSF at 122° F--40 Sec.
400		Heavy Residual Oil	10	1.00	8.33	150,000	18,000	Min SSF at 122° F--60 Sec.
	6	Heavy Residual Oil, Bunker C	11	.99	8.25	153,000	18,540	SSF at 122° F--300 Sec.
BUNKER		Heavy Industrial Oil	9	1.01	8.42	152,000	18,050	———

PROPERTIES OF COMMERCIAL FUEL OIL

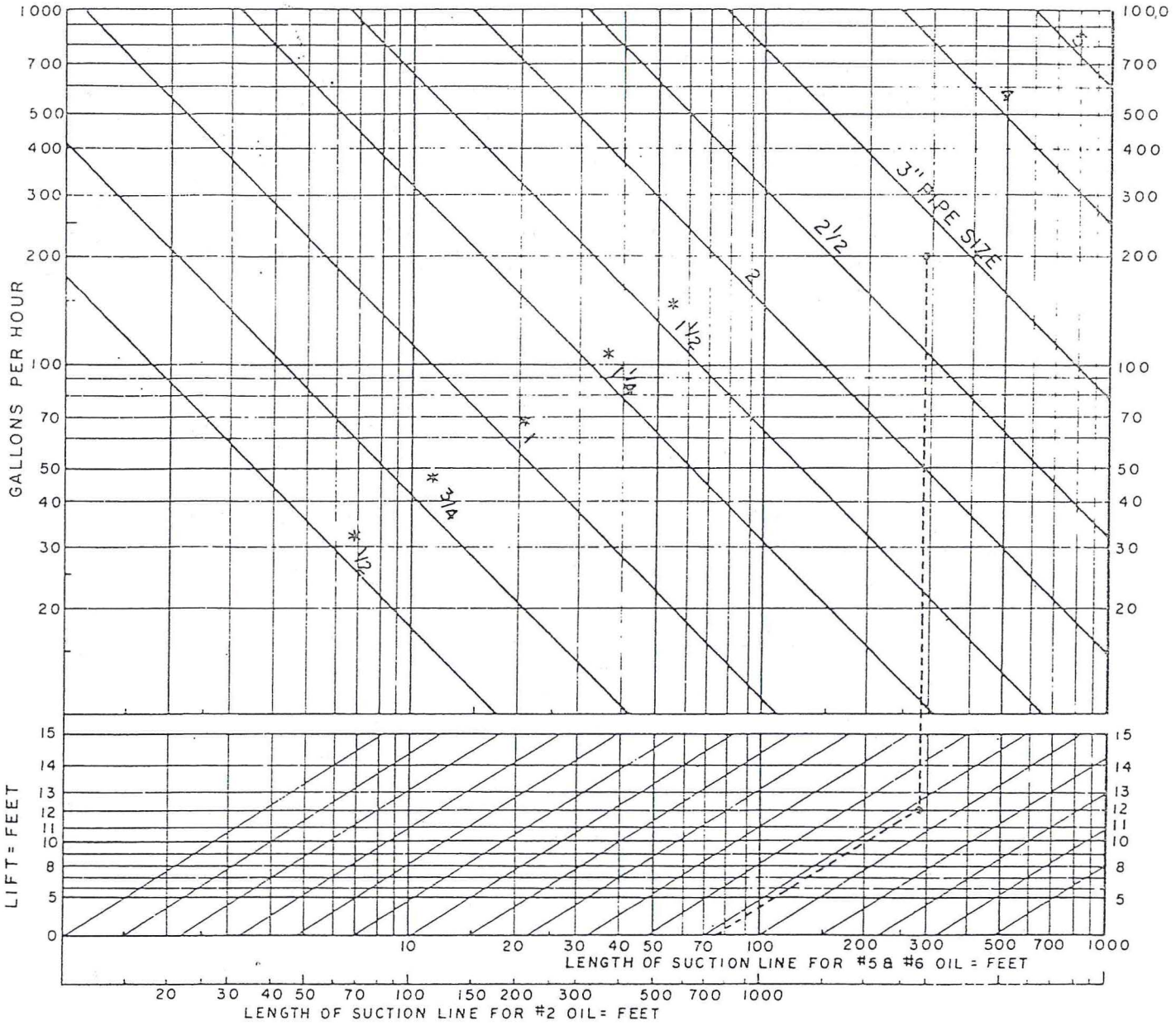


COMPARATIVE VISCOSITY CHARACTERISTICS OF FUEL OILS



VISCOSITY CONVERSION CHART

P-358



NOTES:

1. Values in this chart are based on use of oil at a viscosity of 1000 SSF, equivalent to CS 12-48 No. 6 at 95° F. or No. 5 at 45° F. and also for use with No. 2 oil.

2. By the use of the lower section of the chart, compensation may be made for suction lifts up to 16 ft.

3. Return lines and lines between pumpset and burner may usually be one size smaller than suction lines.

4. It is common practice in pumping oils of No. 5 and No. 6 grade, which carry sediment and are subject to sludging, to avoid the use of pipe sizes smaller than 2" regardless of length and capacity requirement.

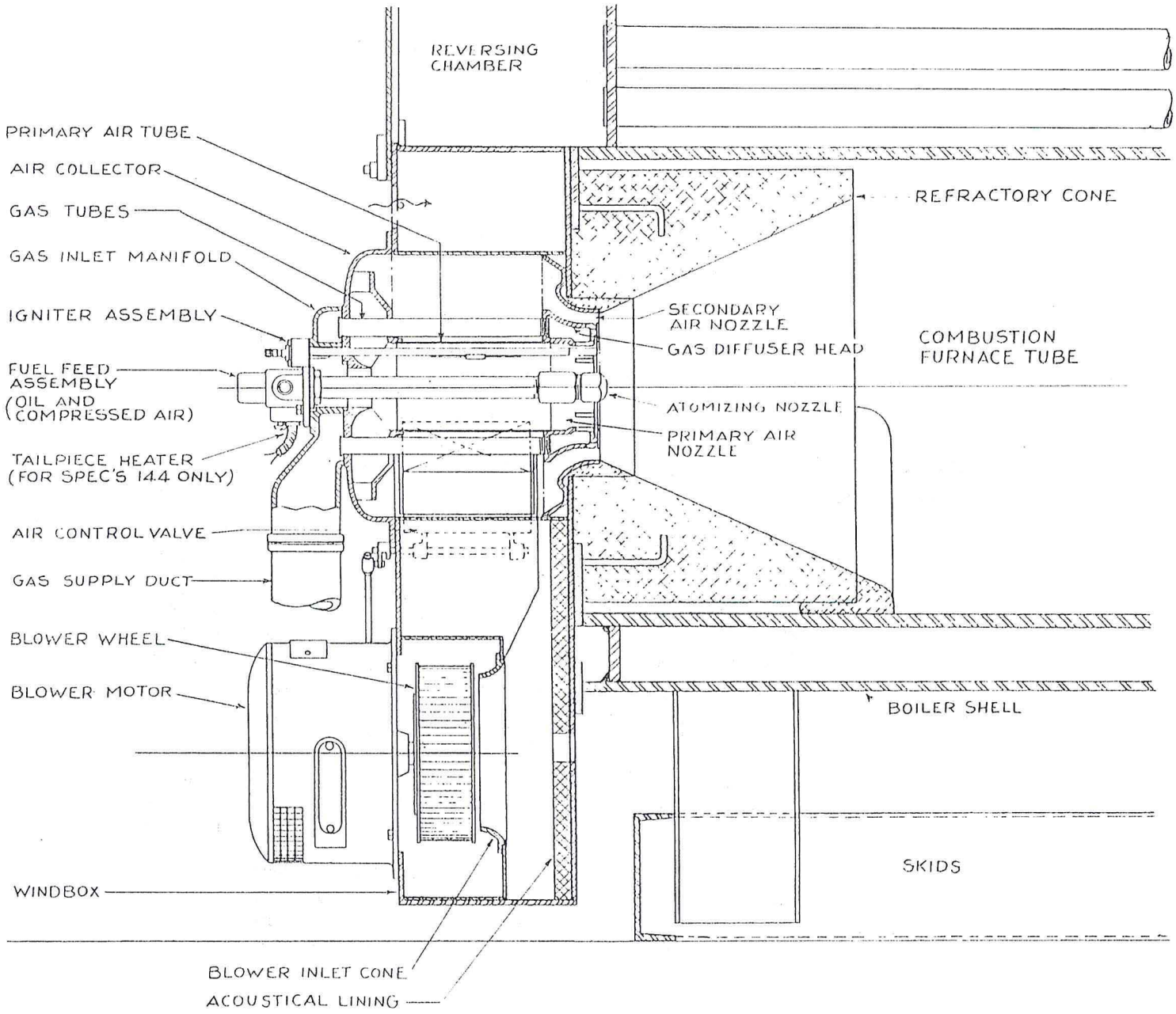
*EXAMPLE:

Length of suction lines, 75'. Height of lift (bottom of tank to burner), 12'.
Capacity required, 200 GPH.
Oil at approx. 1000 SSF viscosity.

Start at bottom of chart at 75'. Proceed up and to the right, parallel to diagonal lines to the "Lift" requirement, 12', and then vertically up to the GPH specified. Read the next larger pipe size, 3". With no lift requirement the pipe size would have been determined by moving directly upward on 75' to 200 GPH. Read approx. 2" pipe.

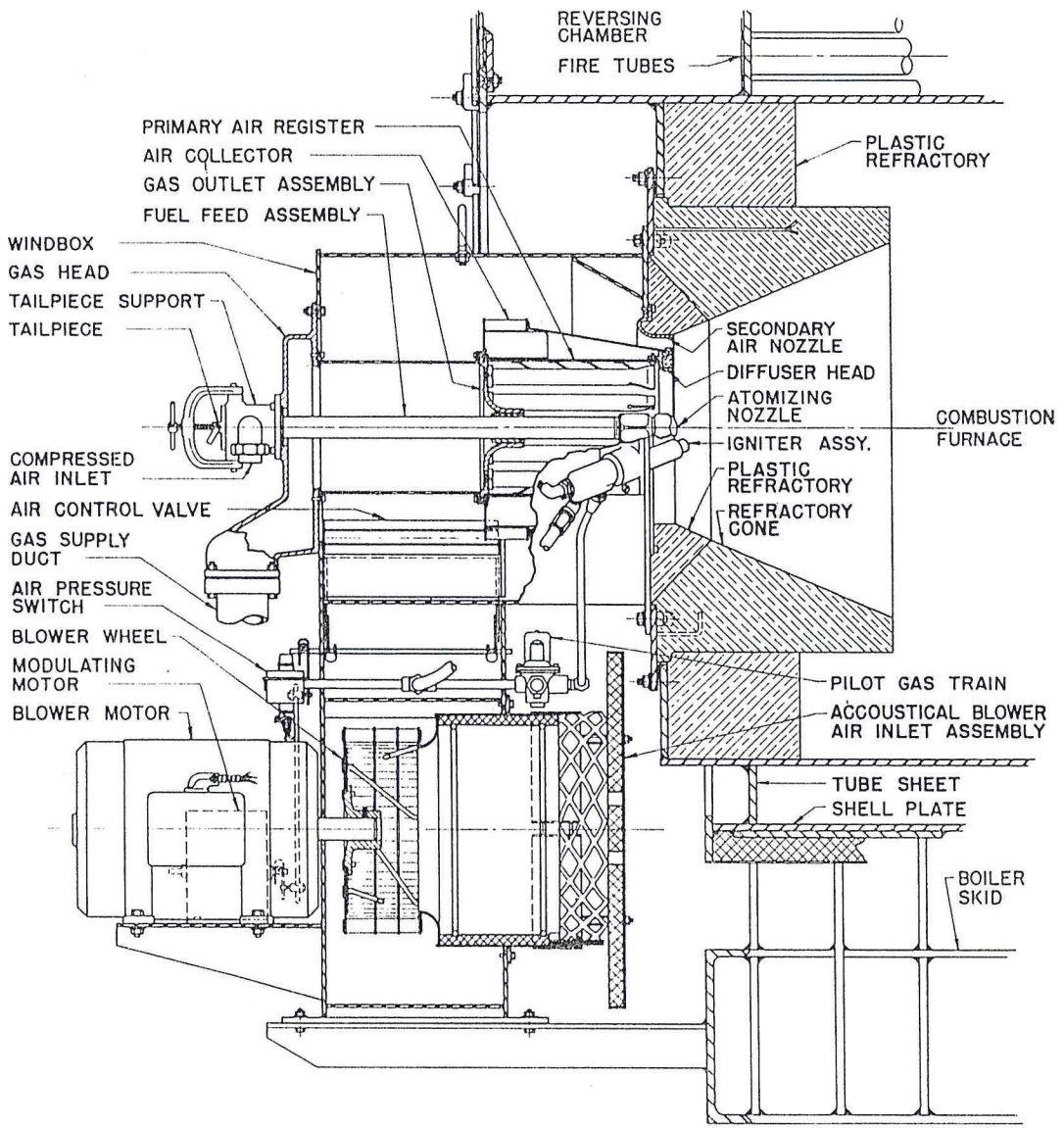
FUEL OIL SUCTION LINE SIZES

P-355



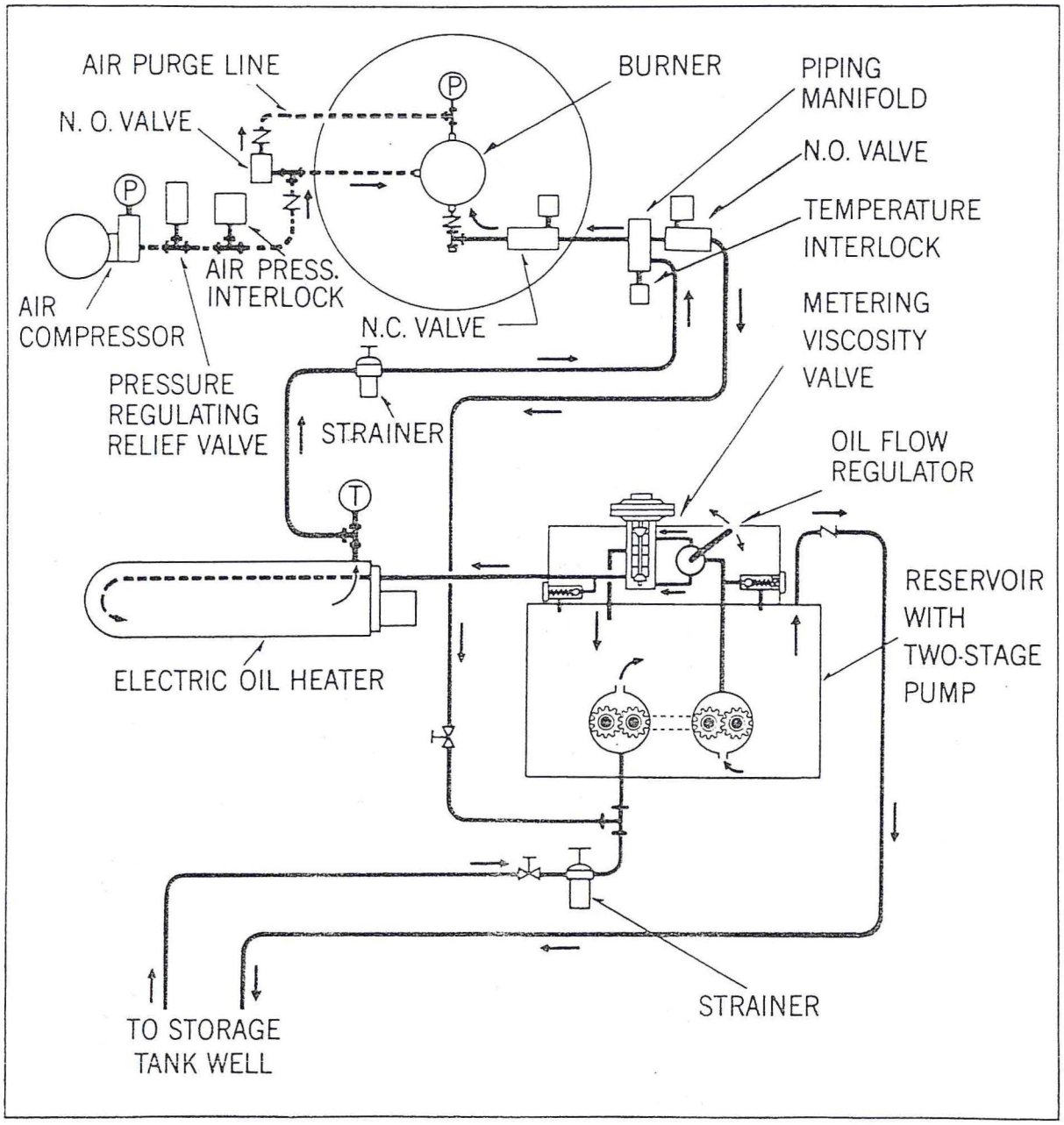
SECTIONAL DRAWING K-2456

Typical Air Atomizing Burner — Sizes 40 — 300

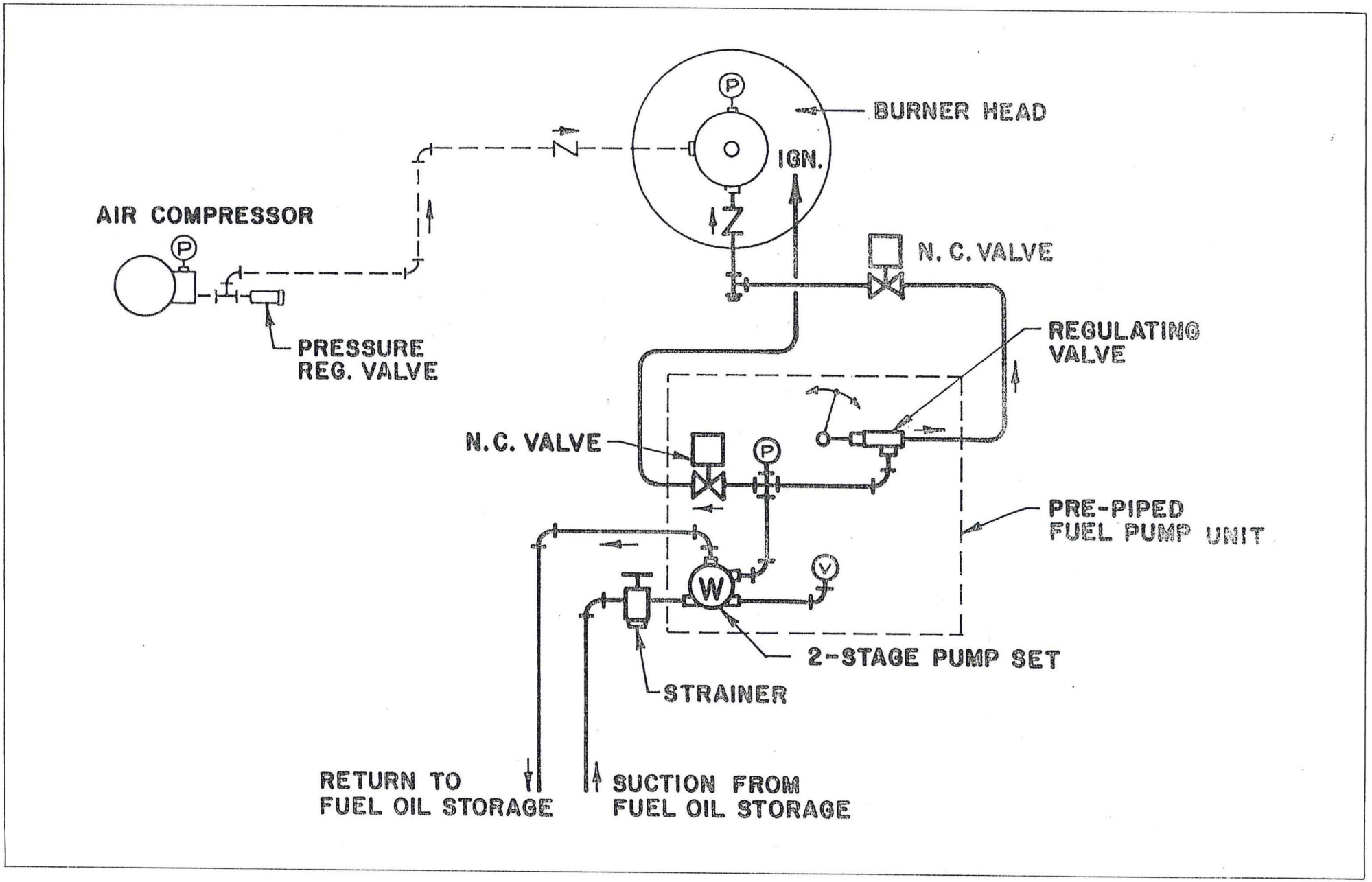


SECTIONAL DRAWING
Typical Air Atomizing Burner – Sizes 350-600

K-3047A

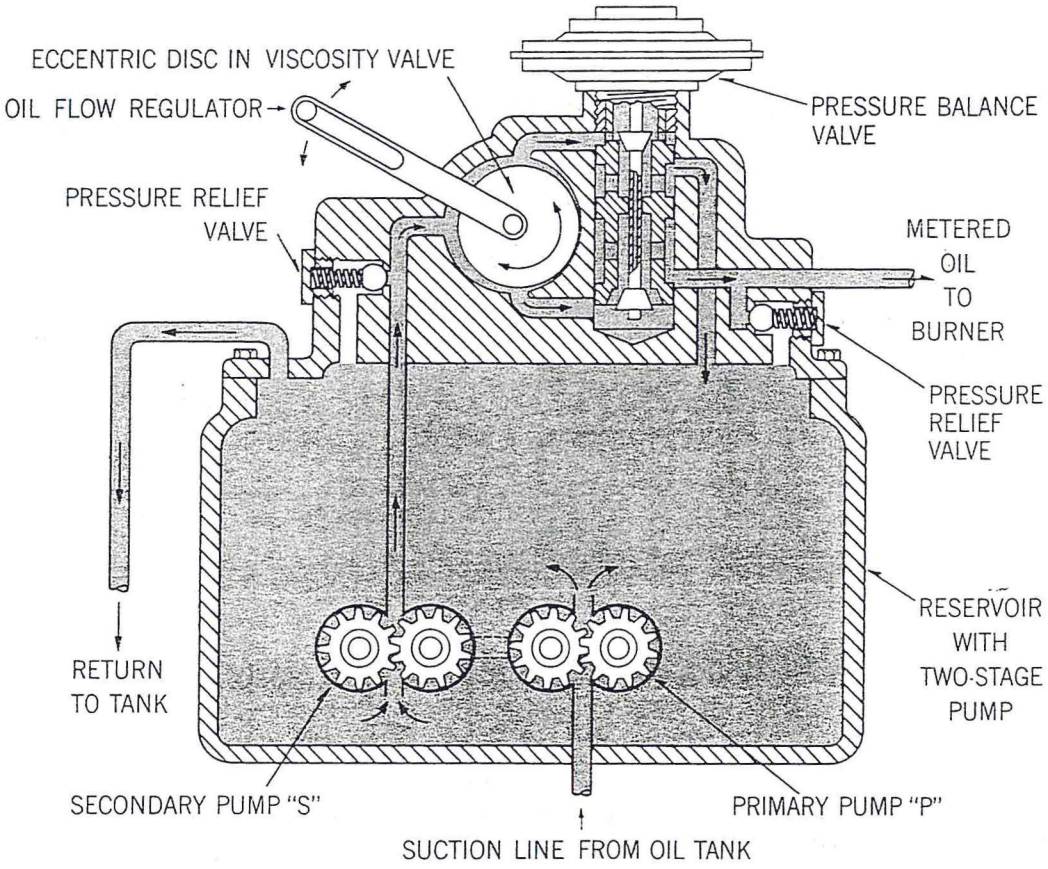


HEAVY OIL HEATING AND CIRCULATING DIAGRAM K-3062



OIL PIPING SYSTEM
Light Oil Piping System with Diesel Ignition

K-2596
REVISION B



The Viscosity Valve, in conjunction with the two-stage pump and reservoir and modulating system, automatically adjusts the fuel oil rate to match load requirements. With a single initial adjustment, this valve automatically compensates for any fluctuations in viscosity, and meters the oil at a prescribed and modulated flow rate.

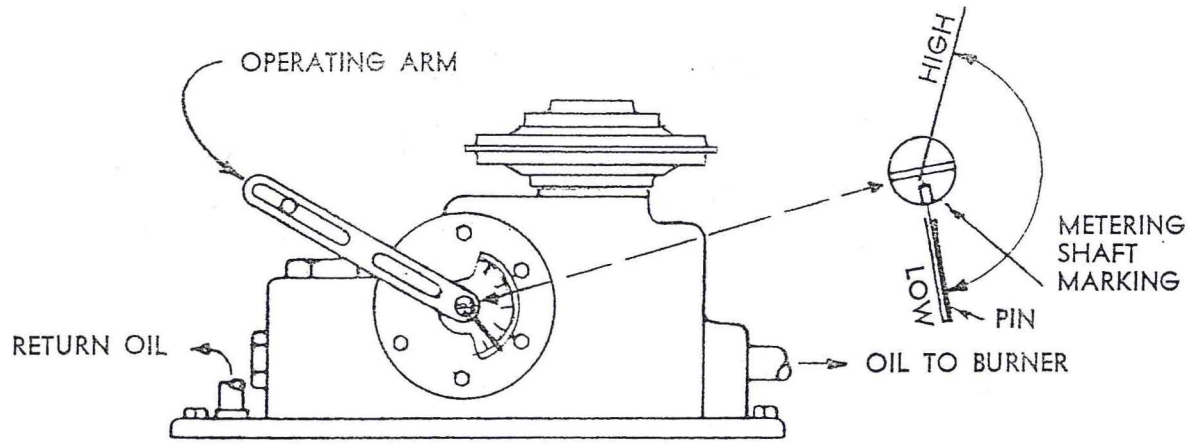
Primary pump 'P' delivers oil from the storage tank to the reservoir in excess of the pumping rate of the secondary pump 'S'. The non-variable flow of oil from the pump 'S' is delivered to the inlet port of the Viscosity Valve. The oil passes through the valve in two paths, the flow through each of which is controlled by positioning the eccentric disc in the Viscosity Valve assembly. Since the flow is viscous, the rate through each side remains constant, for a given position, regardless of oil viscosity, the pressure automatically varying to compensate for changes in flow resistance.

The oil from each path enters opposite ends of the Diaphragm Operated Valve in which the two tapered valves proportion the area of the ports, maintaining equalized pressure at both ends. This assures a viscous flow rate to the burner unaffected by changes in pressure in the return line to the tank or in the line to the burner nozzle. The metered oil from one path is delivered to the burner and the remainder, from the other path, back to the reservoir.

Two pressure relief valves, one at the pump discharge and one on the outlet to the burner nozzle, operate only to relieve excessive pressure when operating against a closed valve or in case of incorrect adjustment.

For an adjusted position of the eccentric disc, therefore, the flow rate to the burner remains constant, independent of oil temperature changes or line pressure variations.

VISCOSITY VALVE OPERATION P-643A



VISCOSITY VALVE AS VIEWED FROM
SHAFT EXTENSION SIDE

When adjusting the Viscosity Valve, it should be noted that the end of the metering shaft has a slot for screwdriver setting. There may also be a position-indicating notch in the end of the shaft or a pin indicator through the shaft. As viewed from the shaft extension side, as above, the notch or pin must operate within the arc represented; that is, approximately "one o'clock to five o'clock".

On E burners it is probably most convenient to have the operating arm in the "nine to twelve" quadrant. Its adjusted position and the length of the arm will have to be set to meet the operating requirements.

On other burners the operating arm position may be adjusted to suit the individual linkage arrangement, but the valve disc will remain in the same operating quadrant.

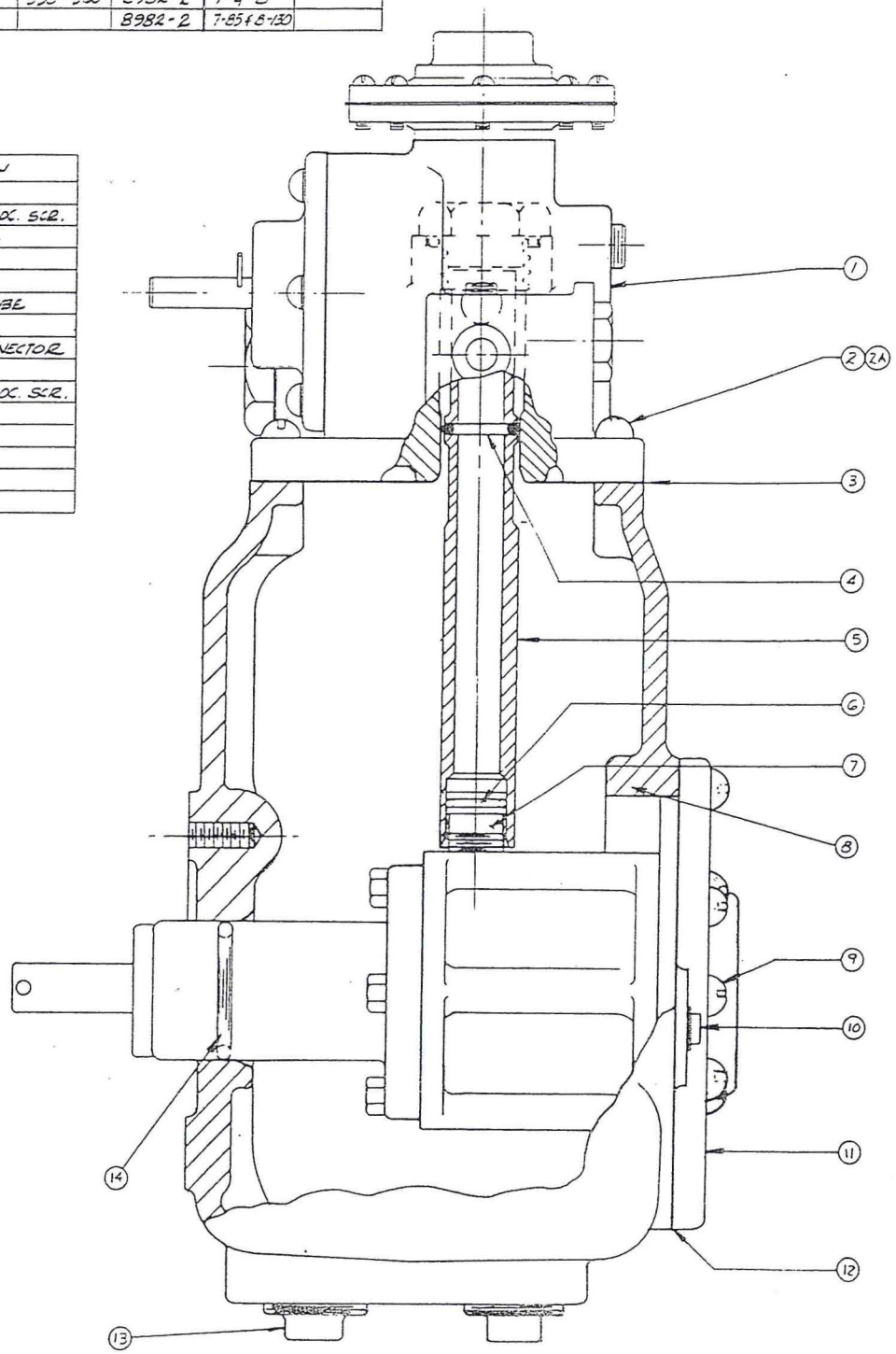
It is likely that a rotation of 60° or less will be required to obtain the high-low range desired.

There is no other adjustment to be made.

P-643 shows the general flow diagram of the oil pumping and metering unit and gives a general description of the operation.

ASSY NO.	AIR VALVE SIZE	AIR VALVE	BOILER HP E	BOILER HP EE	AE BURNER	PUMP ASSEMBLY	SPECIAL® ROTARY	SPECIAL® AE
50274-12		51825-9		40-100		2892-3		
50274-13		51825-16		125-150		2892-3		
50274-14	2	51825A-7		200-300		8982-2		
50274-15		51825-14	40-80			2892-3	0-3	40-100
50274-16		51825-11	125-150			2892-3	3-30 4-40 5-50	125-150
50274-17	2	51825A-12	200-300			8982-2	6 & 6-60	200-300
50274-18	2	51825A-15			350-500	8982-2	7 & 8	
50274-19	2	51825A-13				8982-2	7-85 & 8-130	

"EV"	AV"	PART NO.	PART DESCRIPTION
1	1	SEE TABLE	VISCOSITY VALVE
2	12		1/2-20 x 3/4 BUTTON HD SOC. SCR.
2A	12	50292	1/2 COPPER WASHER
3	1	6085	GASKET
4	1	5126	'O' RING
5	1	51832	PUMP DISCHARGE TUBE
6	1	5125	'O' RING
7	1	9787	DISCHARGE TUBE CONNECTOR
8	1	50274	RESERVOIR
9	8		1/4-20 x 3/4 BUTTON HD. SOC. SCR.
10	1		1/2 PIPE PLUG
11	1	SEE TABLE	DOUBLE PUMP
12	1	3744	GASKET
13	2		3/4 PIPE PLUG
14	1	5123	'O' RING

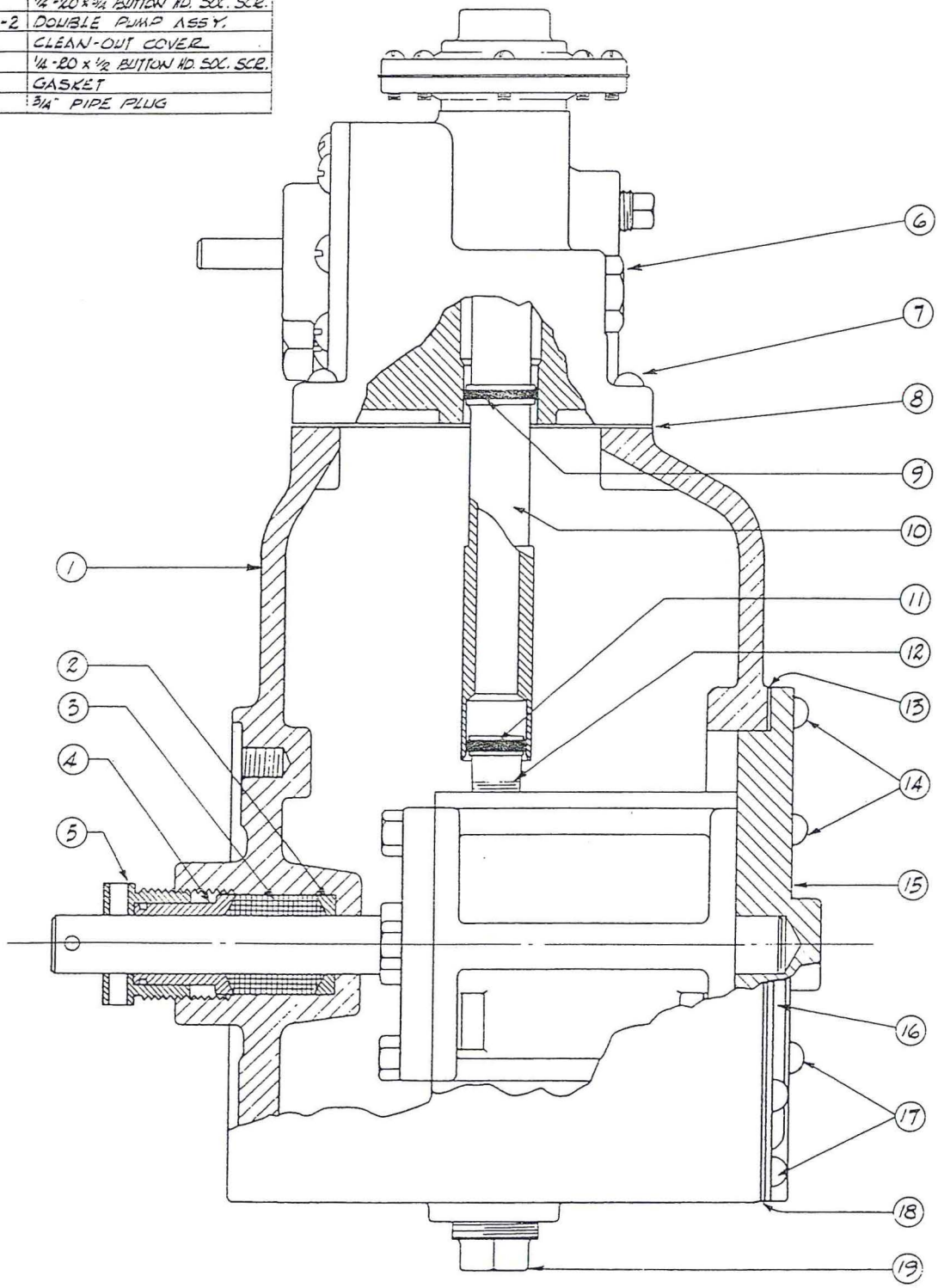


NOTE:
USED ON STANDARD - E 40 TO 300 HP
AE 350 TO 500 HP.
SPECIAL - AE 40 TO 300 HP.
ROTARY 0 TO 8-130

RESERVOIR ASSEMBLY WITH VISCOSITY VALVE
Sizes E 40 to 300 H.P. - AE 350 to 500 H.P.

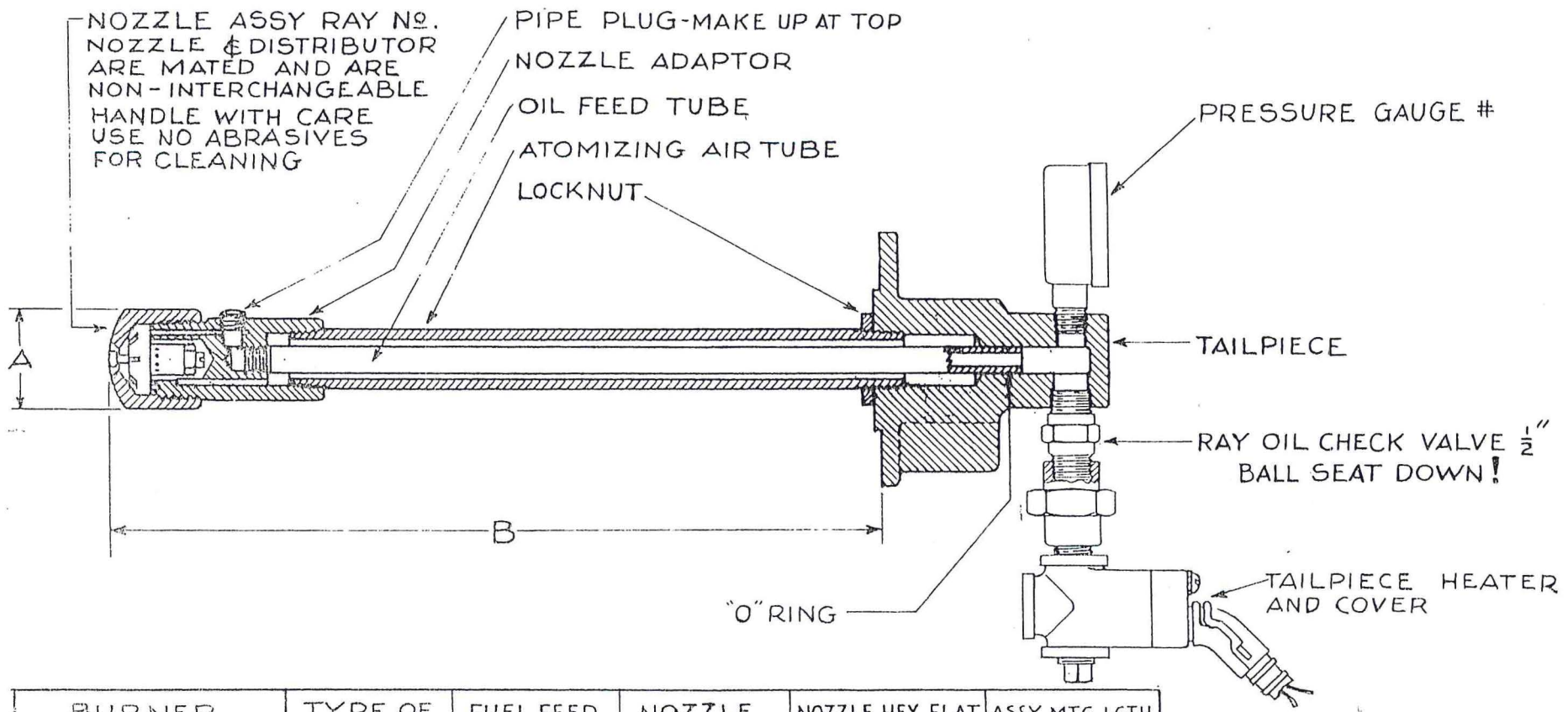
50274-12 to 19
Revision R

ITEM	ASST	PART NO.	PART DESCRIPTION
1	1	9336	RESERVOIR BODY
2	1	9458	PACKING RETAINER
3	1	9335	PACKING
4	1	50201	PACKING GLAND
5	1	50202	PACKING GLAND NUT
6	1	51825A-13	VISCOSITY VALVE ASS'Y.
7	12		1/4-20 x 3/4 BUTTON HD. SOC. SCR.
8	1	6085	GASKET
9	1	51126	'O' RING
10	1	51832	PUMP DISCHARGE TUBE
11	1	51125	'O' RING
12	1	9787	CONNECTOR
13	1	9328	GASKET
14	8		1/4-20 x 3/4 BUTTON HD. SOC. SCR.
15	1	9294-2	DOUBLE PUMP ASS'Y.
16	1	8797	CLEAN-OUT COVER
17	6		1/4-20 x 1/2 BUTTON HD. SOC. SCR.
18	1	8798	GASKET
19	2		3/4" PIPE PLUG



RESERVOIR ASSEMBLY WITH VISCOSITY VALVE
Size AE 600 H.P. only

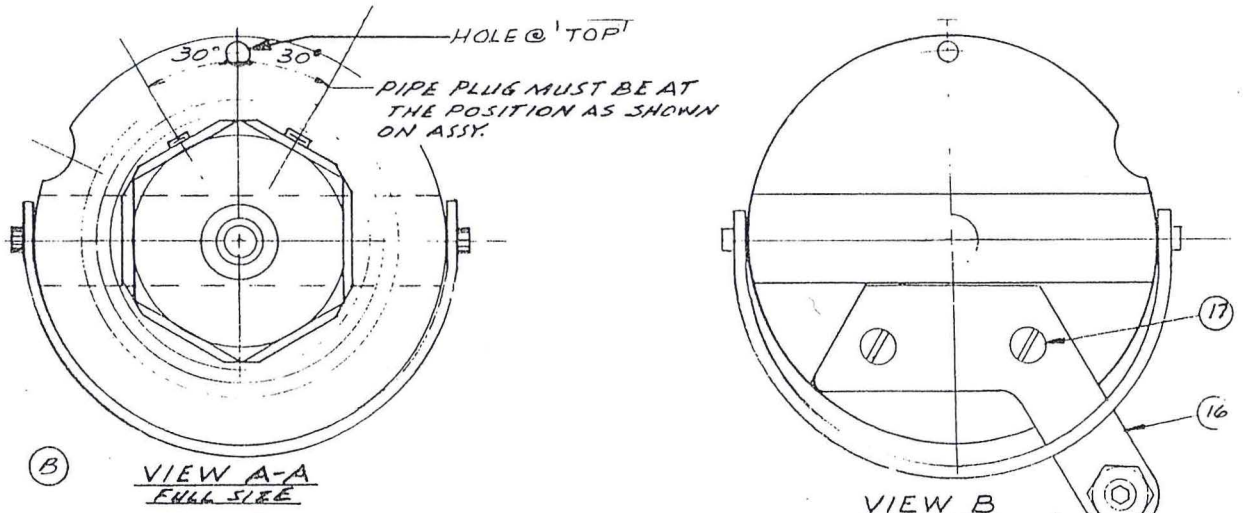
9336-6
1-23-70



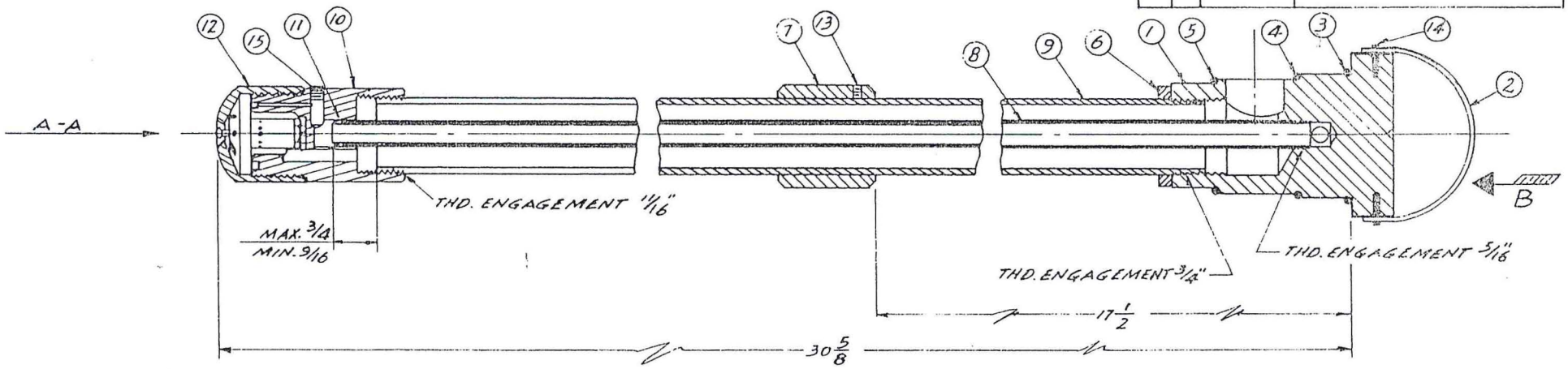
BURNER TYPE & SIZE	TYPE OF FUEL	FUEL FEED ASSY	NOZZLE RAY Nº	NOZZLE HEX FLAT A	ASSY MTG LGTH B
E 40-70	STR. OIL	51760 A-1	51907-1	1 7/16	13 1/2
	GAS-OIL COMB	51760 A-2			15 1/2
AE 40-175 | E 80-150	STR. OIL	51760-2	51761-1	1 3/4	14 7/16
	GAS-OIL COMB	51760-1			16 1/4
AE & E 200-250-300	STR. OIL	51760-3	51976-1	1 3/4	20 3/8
	GAS-OIL COMB	51760-4			22 1/2

FUEL FEED ASSEMBLIES WITH TAILPIECE HEATER
E & AE Burners, Sizes 40 to 300

P-653
Revision M



ITEM NO.	AMT.	PART NO.	PART DESCRIPTION	
1	1	52699	TAILPIECE	
2	1	52703	TAILPIECE HANDLE	
3	1	52716	'O' RING	
4	1	52715	'O' RING	
5	1	52714	'O' RING	
6	1	52712	LOCKNUT	
7	1	52717	GAS SEALING RING	
8	1	52711	OIL FEED PIPE	A
9	1	52710	AUTOMIZING AIR PIPE	A
10	1	52713	NOZZLE ADAPTER	
11	1	51127	'O' RING	
12 (C) (D)	1	53259-2	UNITIZED AIR ATOMIZING NOZZLE	A
			80° 125 GPH	A
13	1		1/4 x 1/4-20 HEX. SOC. SET SCR.	
14	2		3/16 DIA. x 3/8 LG. DRIVE-LOCK PIN	
15	2		1/8 HEX. HD. PIPE PLUG	
(E) 16	1	53527-1	STRIKER PLATE ASSY.	
17	2		10-24 x 5/8 RD. HD. SCR. + L.W.	

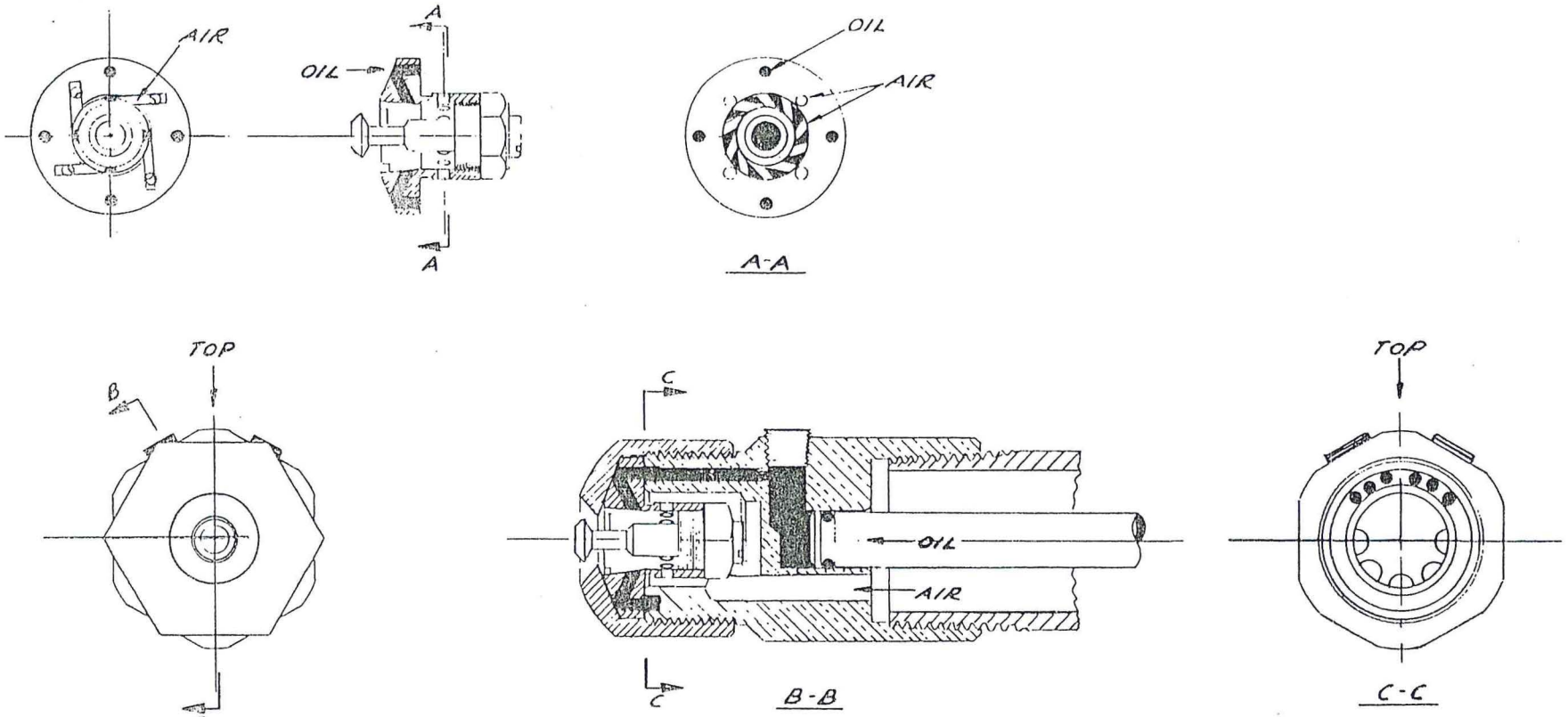


FUEL FEED ASSEMBLY

AE Burner, Sizes 350 to 600

52699-1

Revision D



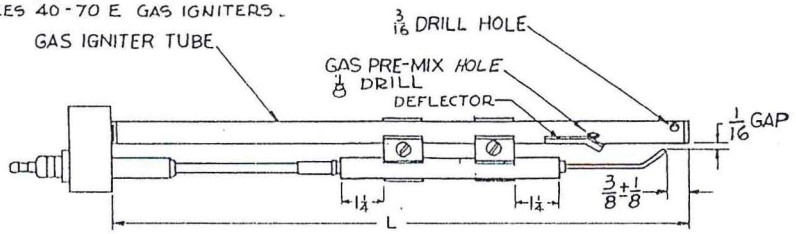
MONARCH OIL NOZZLE C-169 WA
SIZE 150 & 200 GPH

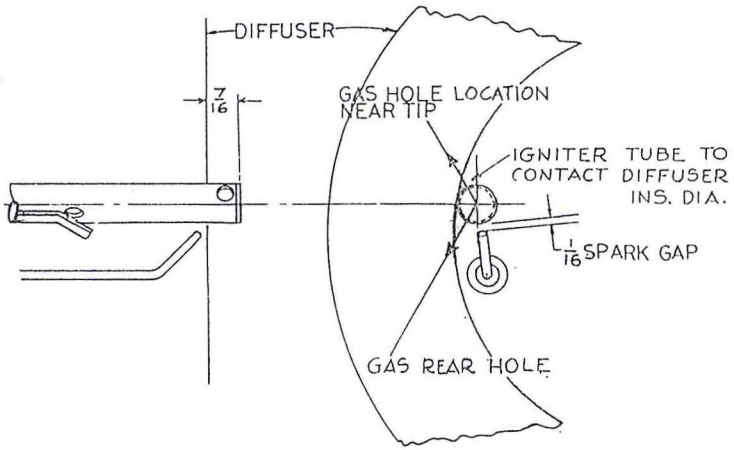
AIR ATOMIZING OIL NOZZLE
AE Burner, Sizes 350 to 600

P-728

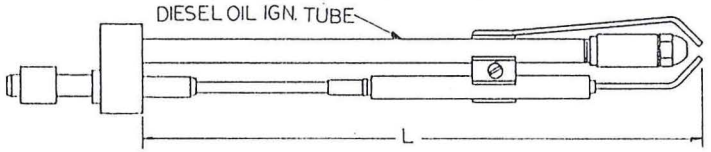
GAS, GAS-OIL COMB. & STRAIGHT OIL FIRING
GAS IGNITION

ONLY ONE CLAMP AND YOKE FOR SIZES 40-70 E GAS IGNITERS.

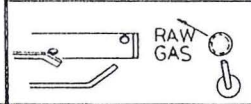
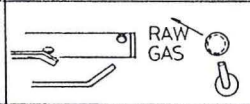
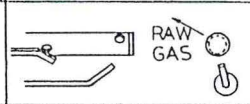
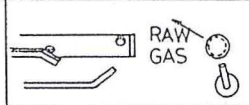
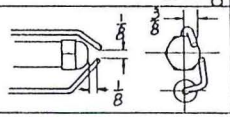
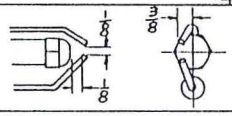
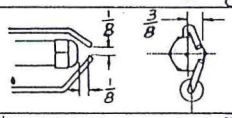
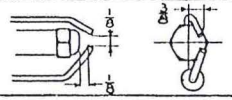




STRAIGHT OIL FIRING
DIESEL OIL IGNITION



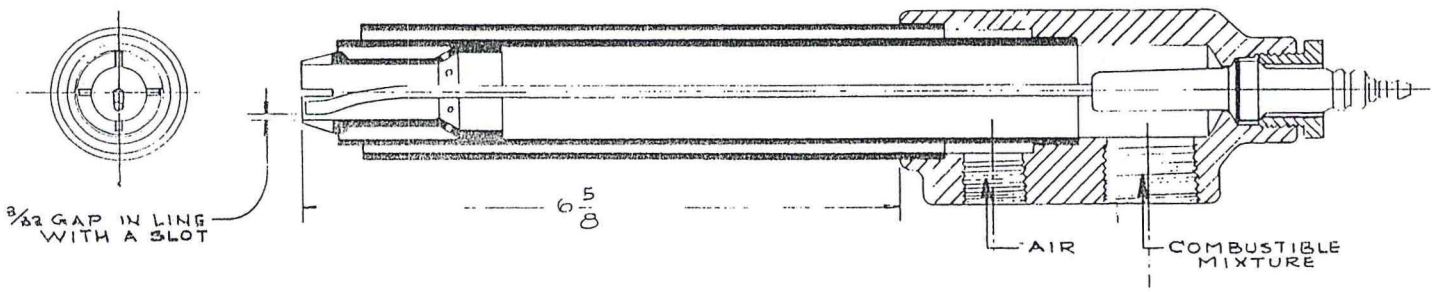
SIZE OF BURNER, IGNITER ASSEMBLY Nº'S AND MOUNTING LENGTH

TYPE OF FUEL AND IGN.	40-70 E	80-150 E & 40-175 AE	200-300 E & AE
GAS AND GAS-OIL COMB. GAS IGNITION	#51773-3 L=15 1/16 	#51773-1 L=16 3/16 	#51995-1 L=22 1/2 
STRAIGHT OIL GAS IGNITION	#51773-4 L=13 1/4 	#51773-2 L=14 5/8 	#51995-2 L=20 5/8 
STRAIGHT OIL DIESEL IGNITION	#51773-6 L=12 1/8 	#52085-2 L=13 3/4 	#51995-4 L=19 1/8 
GAS-OIL COMB. DIESEL IGNITION			#51995-5 L=21 7/8 

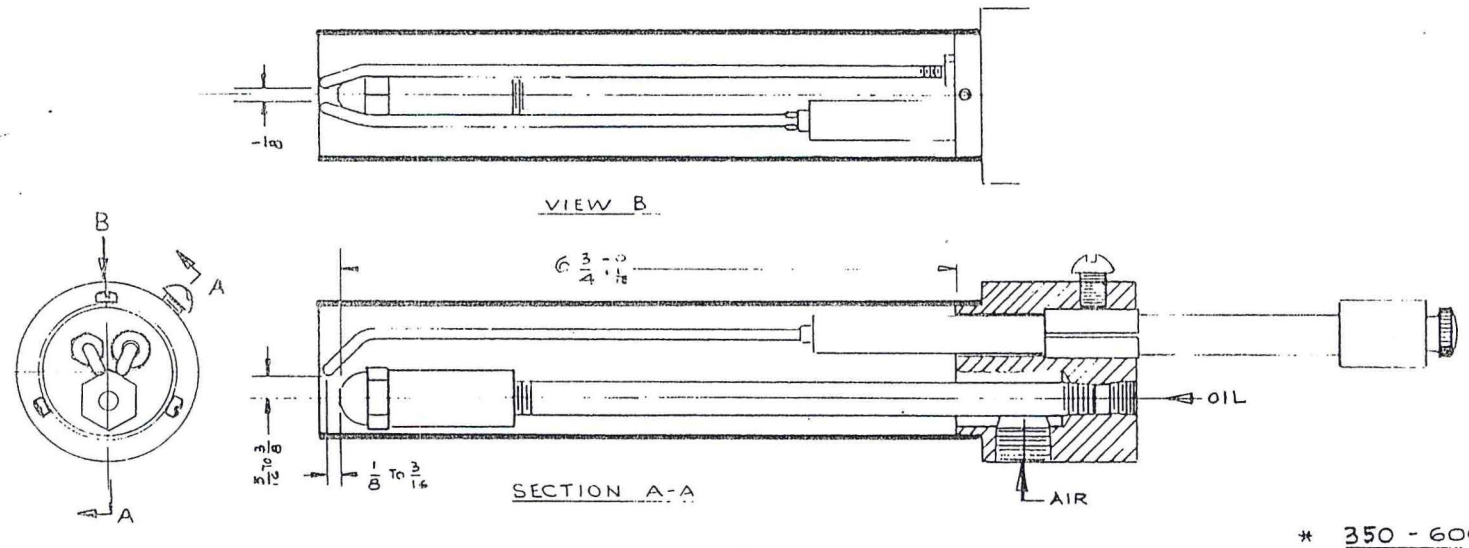
SPARK GAP DIMENSIONS

P-654
Sheet 1
Revision Q

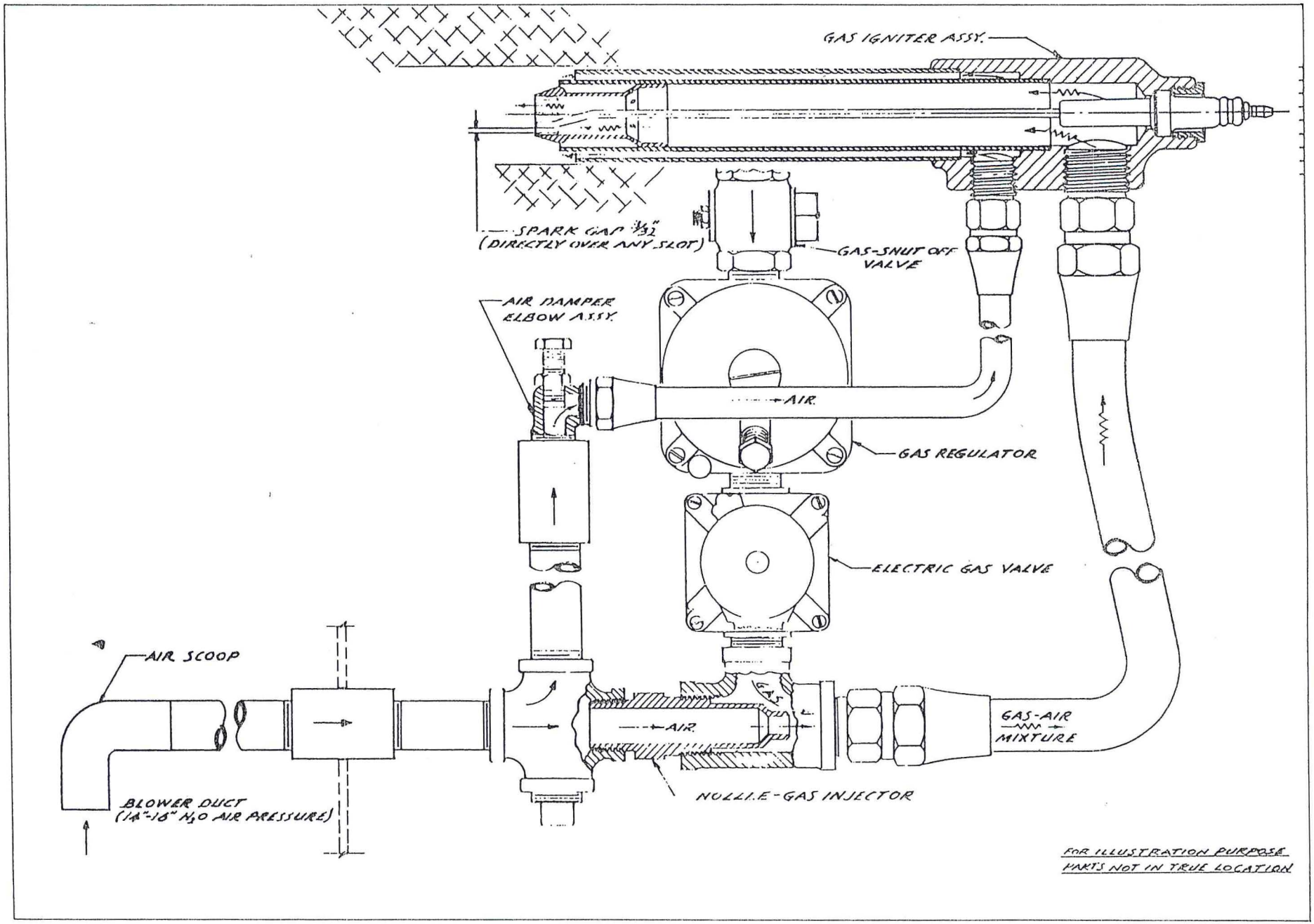
GAS, GAS-OIL COMB. & STRAIGHT OIL FIRING
GAS IGNITION



STRAIGHT OIL FIRING
DIESEL OIL IGNITION

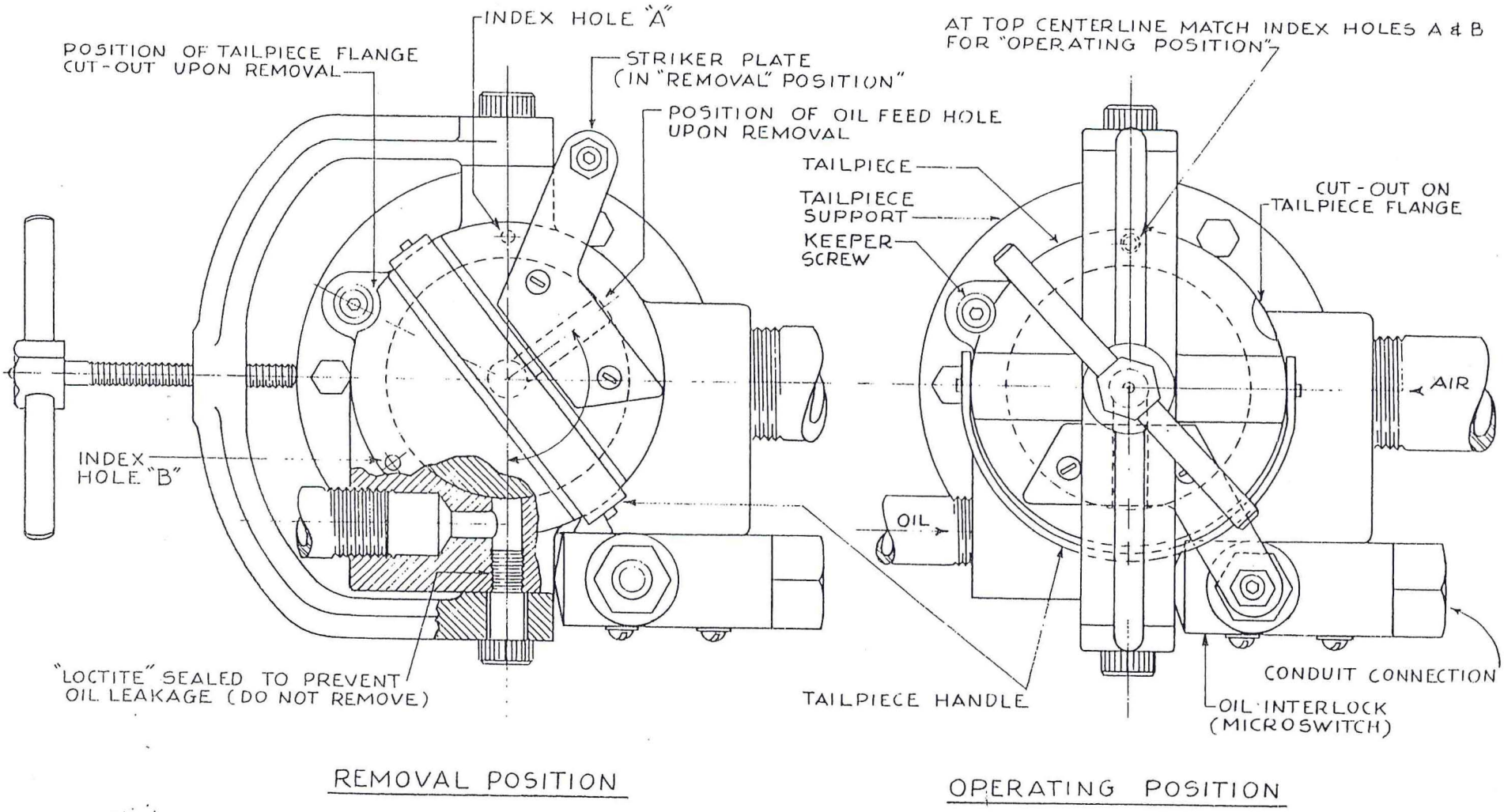


* 350 - 600 E, AE BURNERS



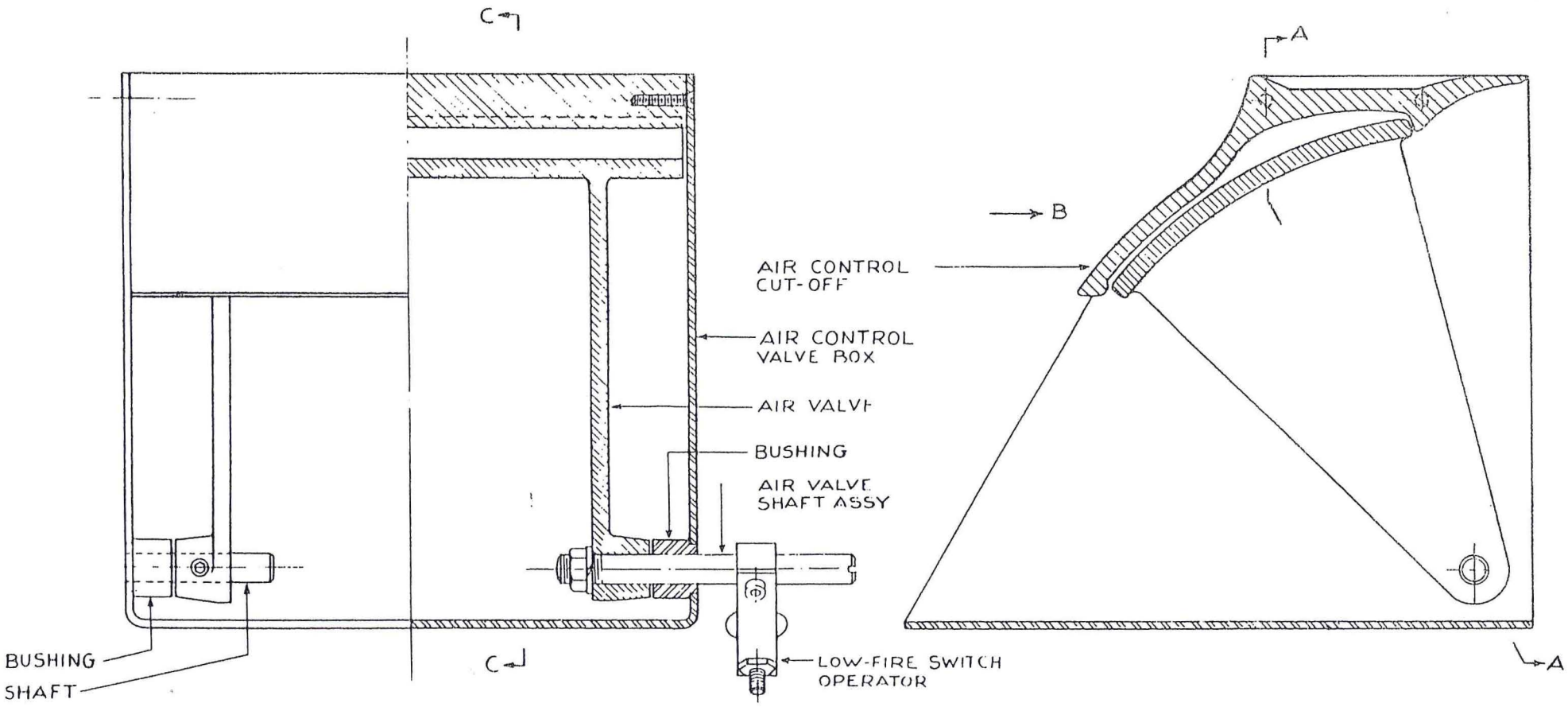
GAS IGNITER OPERATION
AE Burner, Sizes 350 to 600

P-726



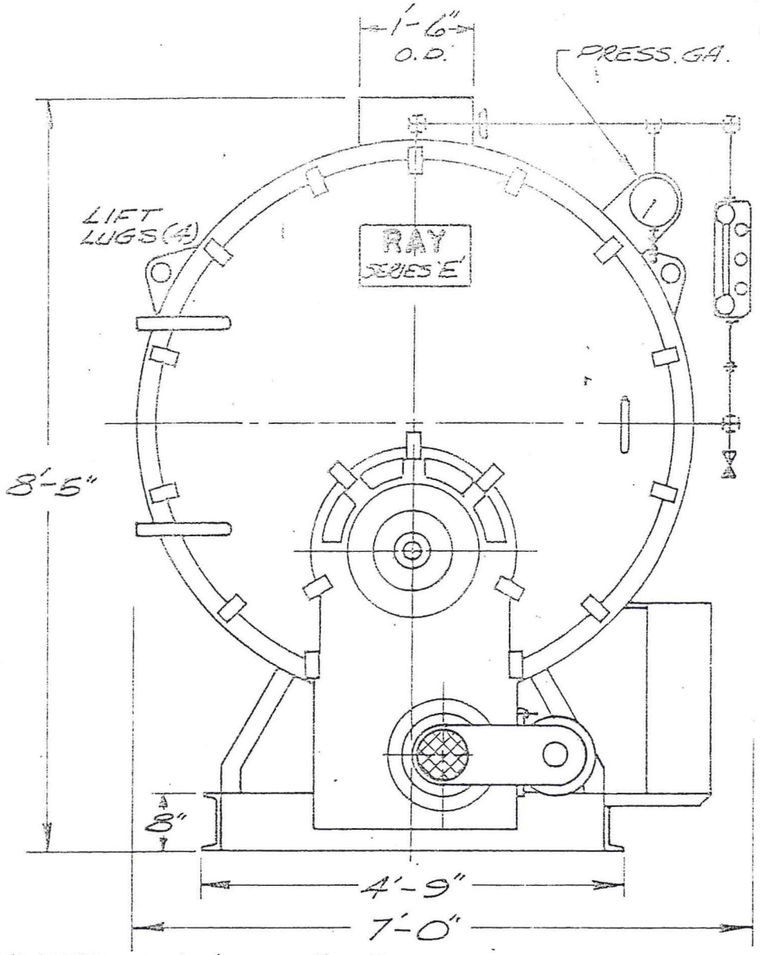
OIL TAILPIECE ASSEMBLY
Type AE — Sizes 350–600

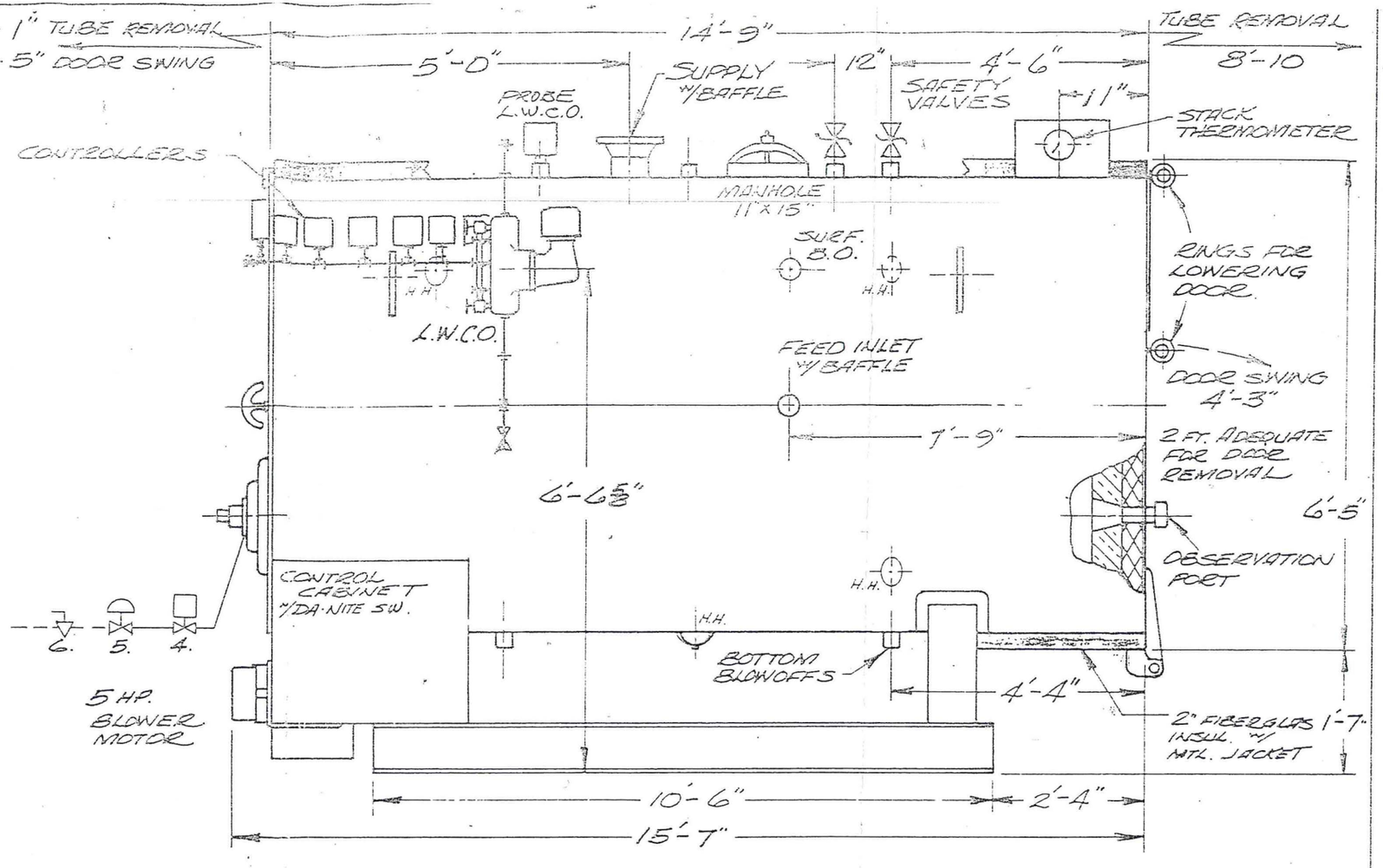
P-727
REVISION A



TYPICAL AIR CONTROL DAMPER

L-2072





* MOUNTED ON LEFT SKID

TRIM

SAFETY VALVE - KUNKLE FIG. 6000
F. 1 x 1/4" SET @ 150 PSI.
H. 1/2" x 2" SET @ 150 PSI.
L.W.C.O. - McDONNELL & MILLER #157
(W/WTR. GA. GLASS & 3-TRY COCKS)
STACK THERMOMETER - 3"ϕ (200-700°F)
PRESSURE GAUGE - 6" ϕ (0-300 PSI.)
OPERATING CONTROL - M.H. L-404A (H.P.)
HIGH LIMIT CONTROL - M.H. L-404A (H.P.)
MODULATING CONTROL - M.H. L-91A (H.P.)
* 2-STAGE PUMP & RESERVOIR (W/ 1/2 HP MTR.)
W/ VISCOSITY VALVE
* OIL PRE-HEATER - 2 x 5 KW
* AIR COMPRESSOR - 1 1/2 HP MOTOR
4) PILOT SOL. GAS VALVE - 3/8 G.C. S301AA
5) PILOT GAS PRESS. REG. - 1/2 MAX. R6C6S
6) PILOT GAS COCK - 1/2" BRASS L.H.

AUXILIARY EQUIPMENT

OPERATING CONTROL - M.H. L-404A (L.P.)
HI. LIMIT CONTROL - M.H. L-404A (L.P.)
MOD. CONTROL - M.H. L-91A (Lo. PRESS.)
AUX. L.W.C.O. - WARRICK PROBE 3E1B

LET.	REVISION	DATE	BY

SHELL OPENINGS

SUPPLY - 6" 300# W. NECK FLG.
FEED INLET - 1 1/2" IPS. X-HVY. CPLG.
BOTTOM BLOWOFF - (2) 1 1/2" X-H. CPLG.
SURFACE BLOWOFF - 1 1/2" IPS. X-H. CPLG.
HANDHOLES - 3" x 4" (FIVE)
MANHOLE - 11" x 15"

MODEL & SPECIFICATIONS

RAY SERIES 'E' PACKAGED BLR.
200 HP. 150 P.S.I. STEAM
ASME CODE CONSTRUCTED
3-PASS DRY-BACK DESIGN
HEATING SURFACE (ASME) - 1000 SQ.FT.
STEAM OUTPUT (F&A 212°F) - 6900 LB/HR.
BURNER TYPE - EOR-144
FUEL - #5 OIL
CONTROL - FPZ-6070
MOTORIZED, FULL MODULATION
POWER: 480-60-3 CONTROL: 115-60-1
FOR CONTROL & ELEC. SPECS. SEE
WIRING DIAGRAM WR-7622

JOB NAME:
FIBERLAY CORP.
DOSWELL, VIRGINIA

CERTIFIED BY:

RAY BURNER COMPANY

RAY SERIES 'E' 200 HP.
150 P.S.I. STEAM

BY:
DATE 6-16-72
SCALE NONE
80-7622-200