CHAPTER 31

Industrial Oil Burners

The term industrial oil burner as used by one authority, is "intended to designate burners intended primarily for the many and diversified forms of heat treatment and heat application in industry, such as metallurgical furnaces, drying and enameling ovens, drying kilns, ceramic ovens, furnaces, etc."

As distinguished from domestic burners, industrial burners because of their applications do not require intermittent automatic "off and on" operation, except in rare cases. Temperature control accordingly does not depend *upon intermittent* operation but upon throttling, usually manually.

Large burners such as are used for heating large buildings such as schools, apartment buildings, dairies, etc. are sometimes called commercial burners. The term industrial is here used in a broad sense and covers *all* burners, except those of the domestic class.

Classification.—Industrial burners may be classed from several points of view, as:

1. With respect to gravity of the fuel used.
   - *a.* Light industrial (No. 4 Bunker A).
   - *b.* Medium industrial (No. 5 Bunker B).
   - *c.* Heavy industrial (No. 6 Bunker C).

2. With respect to method of control, as,

a. Manual.
b. Semi-automatic.
c. Automatic.

3. With respect to the method of spraying (alleged atomizing) as,

a. Air.
b. Steam.
c. Mechanical pressure.
d. Centrifugal force (rotary cup).

4. With respect to pressure of the air, as,

a. Low pressure (up to 5 lbs.).
b. Medium pressure (up to 25 lbs.).
c. High pressure (up to 100 lbs.).

5. With respect to commercial service burners, as,

a. Horizontal rotary { with induced secondary air / with forced secondary air }
b. Mechanical.
Etc.

Fuel Oils for Industrial Burners.—As adopted by Underwriter's Laboratories and the American Petroleum Institute, the listing of fuel oils is, as before stated, as follows:

No. 4 fuel oil. Light industrial.
No. 5 fuel oil. Medium industrial.
No. 6 fuel oil. Heavy industrial.

The heat value of these oils is as follows:

No. 4 Average 145000 B.t.u. per gallon.
No. 5 Average 148500 B.t.u. per gallon.
No. 6 Average 152000 B.t.u. per gallon.

Ques. What other names are given to the No. 4, 5 and 6 oils?

Ans. Bunker A, Bunker B, and Bunker C.

Ques. What determines the grade of oils that can be used?

Ans. The design of the burner with respect to the method of spraying, and the preliminary handling of the oil.

Ques. Why are the heavier grades of oils used with industrial burners?

Ans. Because they are cheaper and have higher heating value as indicated in the table just given.

This saving is important especially because industrial burners are of large sizes, burning much more oil than the small domestic burners.

General Principles of Oil Burning.—To ignite properly, oil spray must be mixed with air so that it will vaporize and gasify.

Ques. What is the relation of temperature and gravity of the oil?

Ans. The higher the temperature and the Baume of the oil at the burner, the easier it is to spray and the air pressure may be correspondingly lower.

Ques. What is required for burning the heavy oils?

Ans. Pre-heating.

Ques. What is the limit of pre-heating?

Ans. The temperature at which the oil begins to vaporize.

The Spraying Agent.—With the exception of the mechanical and rotary cup burners, air or steam is used as the spraying (alleged "atomizing") agent. There are numerous types of burners using air or steam for spraying, a description of which follows.

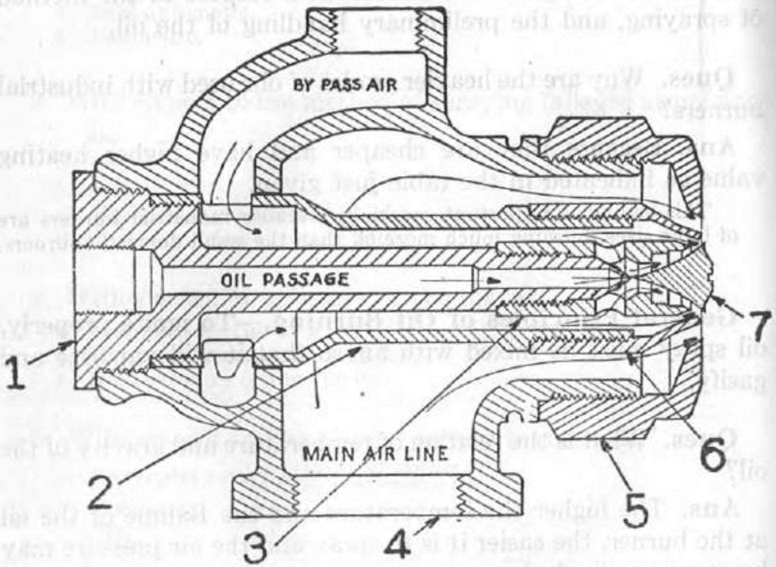
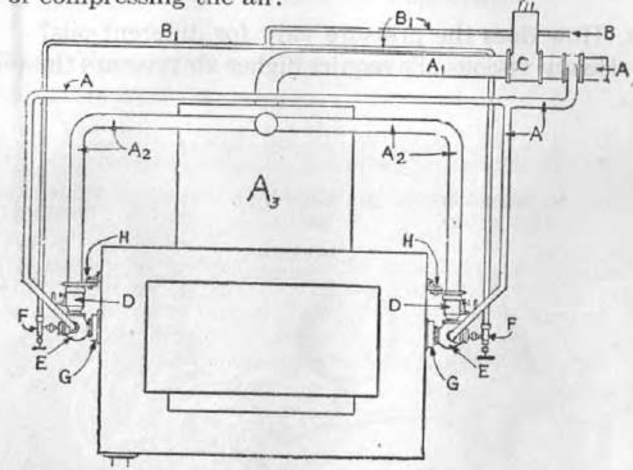


FIG. 1—Multiple spray oil burner for low pressure air. ***The parts are:*** 1, spindle; 2, sleeve; 3, spindle cap; 4, body; 5, body cap; 6, sleeve cap; 7, spreader. ***In operation,*** the oil is picked up and forced outward from the point of the oil spreader by a stream of air; then it meets a second stream of air just as it reaches the head of the spreader; a thin film of oil is thus forced outward in the form of a cone of very fine spray. The burner is provided with a cone shaped spreader which is heated by reflected heat from the furnace and receives the oil at the point of the cone. The oil is blown along the cone by air. It is expanded and thinned as it travels along the cone and leaves the cone in a finely nebulized state. As the oil issues from the oil passage, the by pass air picks it up and forces it outward on all sides from the point of the spreader (No. 7 in diagram) it meets the second jet of by pass air which is directed at an angle to strike the spreader. The thin film of oil is thus forced outward in the form of cone of very fine spray; the fineness depending on the air pressure, the viscosity of the oil, and the size of the base of the spreader. Operates on air pressure as low as 8 ounces with light oil. Only a small portion of the air passing through the burner (that part going through the by pass) is used for spraying. Less than 1/6 of the air goes through the by pass to form the spray, and it is always at full air pressure. The greater volume of the air passes through the body cap to support combustion and can be varied from off to full air pressure. The combustion air having passed through the body cap, strikes the spray one or more times, depending upon the type of burner, to change its direction and lower its velocity, thus obviating the necessity for a baffle wall or block.

Air Spraying Burners.—Different air pressures are used for different types of burners. The *low pressure* burners are most numerous, being used for a great variety of industrial applications.

The *medium pressure* type is made principally for boilers. The *high pressure* air burner is very rarely used because of the cost of compressing the air.



FIr. 2—Typical installation of a multiple spray fuel oil burner in position and piped for using pre-heated air and automatic temperature control. ***A,*** uncontrolled cold air from the main air line to the by pass opening on the burner head, the by pass piping around the butterfly air valve on the burner having been disconnected. This by pass air ***A,*** is 15 per cent of the total air which passes through the burner, and is sufficient for the low burning position when automatic control is used. This small current of cold air also serves as a blanket protector for the oil tube and spraying parts of the burner from the hot air when a recuperator is used. This protection prevents premature vaporization of the oil at these points, and also the possibility of oil being left in the burner to carbonize and block the channels. ***A1,*** controlled air from the motor operated air and oil valve ***C; A3,*** recuperator or heat exchanger which heats the air for combustion on its way to the burner, by means of heat from the waste gases from the furnace; ***A2,*** controlled hot air line to the main air opening on the burner; ***B,*** oil line from the source of supply to the automatic oil control valve and by pass at ***C; B1,*** oil supply pipe to the oil control valve ***F,*** on the multiple spray burner. All branch lines should be as nearly as possible of equal length; ***D,*** butterfly air control valve, built into the burner; ***E,*** the burner proper, which sprays the fuel oil and mixes oil and air; ***G,*** induced air control. When pre-heated air is used this control is used for lighting only, being closed tightly at all other times. ***G*** is machined to fit the body cap of the burner. ***H,*** bracket bolted to furnace holds burner in position.

Low Pressure Air Spraying Burners.—These burners require air from ½ to 5 lbs. pressure, usually supplied by blowers.

Ques. What determines the pressure to be used?

Ans. Generally the grade of oil to be sprayed and the furnace operating temperature.

Ques. How does the pressure vary for different oils?

Ans. Heavy viscous oils require higher air pressure than light fluid oils.

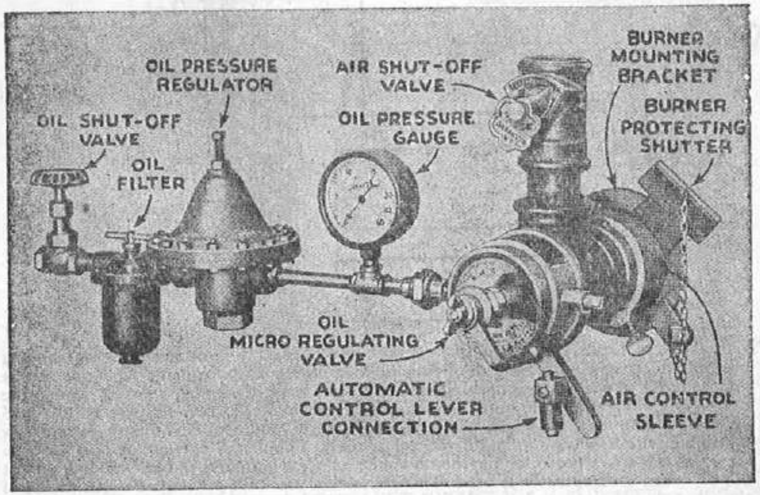


FIG. 3—Proportioning oil burner low pressure type. The moving of a single lever automatically controls the oil and air supply and simultaneously adjusts both primary and secondary air orifices in the burner. Any desired oil-air ratio once set is automatically maintained thereafter. *In operation,* it maintains the desired furnace atmosphere, consistently giving CO_2 readings between 13 and 15 per cent over the full range of the burner rating. Combines a straight line flow oil control valve with a straight line flow air control mechanism in a single, compact, rugged unit. It is adapted to industrial heating operations requiring furnaces, boilers, dryers, ovens, kilns, lehrs, retorts, roasters, stills and pre-heaters in the metal, smelting and refining, metallurgical, metal working and finishing, foundry, enameling, ceramic, glass making, cement, chemical, food and kindred industries.

Example. No. 6 or bunker C oil should have not less than 1 lb. air pressure and preferably 1½ lbs., while the light oils should have not less than ½ lb. air pressure. Intermediate oils would require intermediate air pressures.

Ques. What should be considered in selecting a pressure?

Ans. It is preferable to choose the higher rather than the low pressure in order to obtain good spraying.

Ques. Upon what does the quantity of low pressure air for spraying depend?

Ans. For proper spraying the amount of air required depends upon furnace draught, air pressure in the burner, grade and temperature of the oil to be burned and volume of the combustion space.

To prevent overloading and secure constant air pressure and volume at all times, a blower should be provided of sufficient capacity to deliver the maximum amount of air required by all burners. The following table according to Hauck, gives the average amount of low pressure air required for spraying, being subject to variations due to the actual operating conditions of the burner.

Approximate amount of low pressure air for spraying.—*Hauck.*

Air Pressure In Ounces	Percent of Total Combustion Air (1400 cu. ft. per gal.) With Balanced Furnace Pressure	With Moderate Draft
8	66	52
12	62	47
16	58	42
24	52	37
32	50	33
40	40	30
48	30	25

Forced Draught for Industrial Oil Burners.—The forced draught fan furnishes a regulated supply of combustion air to the burner with sufficient additional pressure to allow ¾ in. W.C. pressure drop through the boiler passage and breeching.

This permits Scotch Marine and other types of boilers which may be fired with a pressure in the fire box to be operated without stacks. Such boilers require only a simple vent pipe to the outside of the building. The fan, designed for forced draught use, is ruggedly built and easily accessible for service.

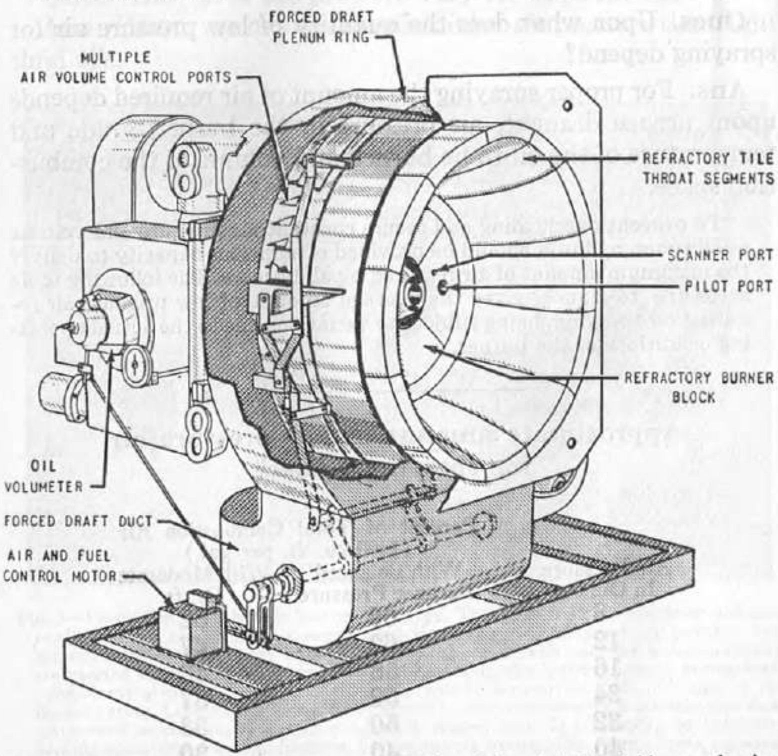


FIG. 4.—Cutaway view of Iron Fireman type RF forced draught industrial burner showing operating principle of forced draught mechanism.

An example of low pressure air spraying burner is shown in fig. 1, and a typical installation of this burner in fig. 2. This burner is of the multiple spray type and is used in many industrial heating equipment units.

Another low pressure burner of the "proportioning" type is shown in figs. 3. It burns any grade of oil and auto-

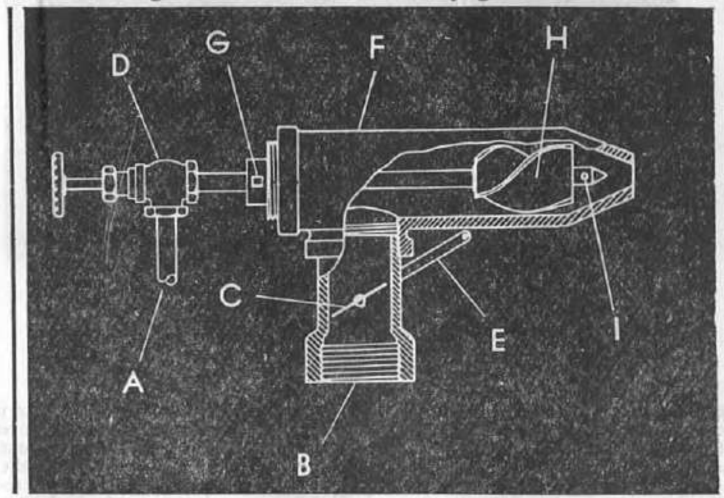


FIG. 5—Fisher model U-1½ low pressure air spraying burner. ***Applications:*** Small capacity core ovens, enameling and japanning ovens, melting and heat treating furnaces, and similar applications. ***In operation,*** air supply enters intake B, and is controlled by a butterfly blast gate, C, which is operated by lever E. Passing through the burner housing F, the air current is thrown into a whirling motion by spiral H. Oil is fed from supply line A, and governed by the needle valve D, feeding through to opening I. Upon leaving I, which is at right angles to the air current, the oil is broken into a fine mist by the shearing action of the air. Spraying is adjusted by means of a back or forth movement of I and H, which is adjusted by set screw G. Flame can be adjusted to the size and shape required in the individual combustion chamber.

matically proportions all the *primary* and *secondary* air and oil flowing through the burner from minimum to maximum capacity.

Medium Pressure Air Spraying Burners.—These burners operate on pressures ranging from 5 to 25 lbs. The particular

pressures to be used are determined by the character of the oil being burned. Evidently the more viscous the oil the more pressure required for spraying.

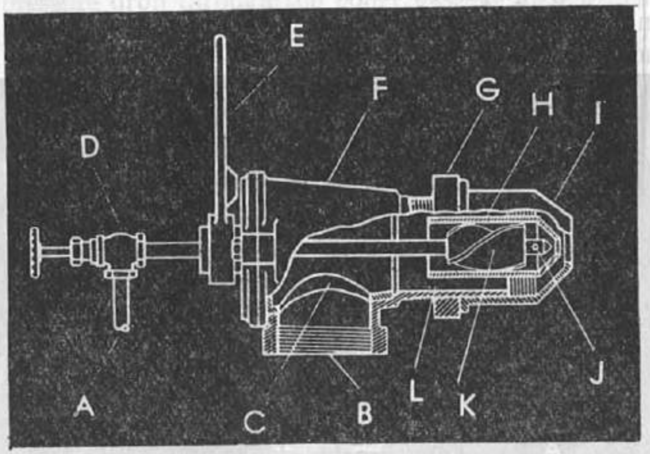


FIG. 6—Fisher model H-T low pressure air spraying burner. Adaptable to heavier fuel oils and lighter distillates. *Applications:* Heat treating furnaces, annealing ovens, forging furnaces, brick kilns, boilers, etc. B, air inlet from the blower. The amount of air used by the burner is controlled by the rotary blast gauge C, operated by handle E. Air for spraying passes through the tube H, and is given a whirling motion by spiral K, after which it cuts across oil opening J. These openings, being at right angles to the air passage, cause the oil coming in contact with the air at this point to be broken into a fine mist by the shearing action of the air. This mixture leaves tube H, in a whirling motion and again comes in contact with the air stream passing through chamber L, causing a second spraying. Adjusting of cap I, either spreads or lengthens the flame as may be required. The size and shape of the combustion chamber determines the type of flame necessary.

Ques. What are the various uses of these burners?

Ans. Principally for boiler installations, also for various industrial processes such as baking, drying and melting.

Ques. Describe the construction and operation of a typical medium pressure air spraying burner.

Ans. The external appearance of a burner of this type is shown in fig. 7 and sectional view in fig. 8.

As constructed, fig. 8, oil under pressure is fed through a duct in the

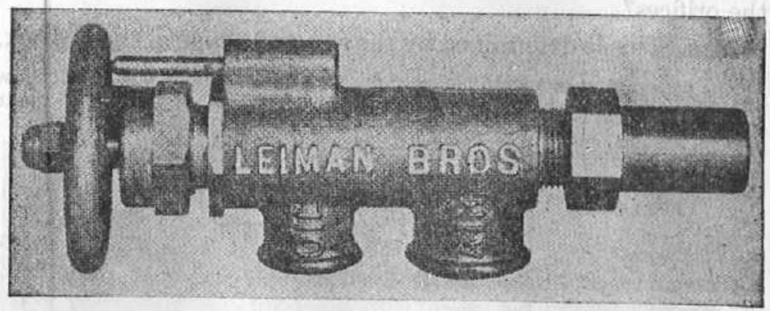


FIG. 7—External appearance of a typical medium air pressure spraying burner.

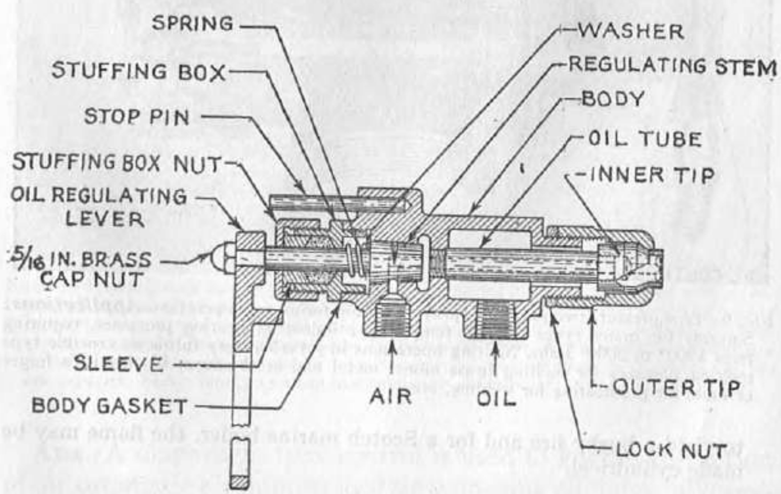


FIG. 8—Sectional view of the medium air pressure spraying burner shown in fig. 7.

oil tube up to its end at the inner tip. From there it is forced into the channels in which compressed air is flowing. Air and oil are then sent through small ports which impart to the mixture a rapid rotary motion.

Ques. What determines the angle of the tip and angle of the orifices?

Ans. This is determined by the size and shape of the fire box.

The fire may be varied by selecting a suitable tip. For boilers with low bases a flat flame may be used; for short fire boxes the tip can be made

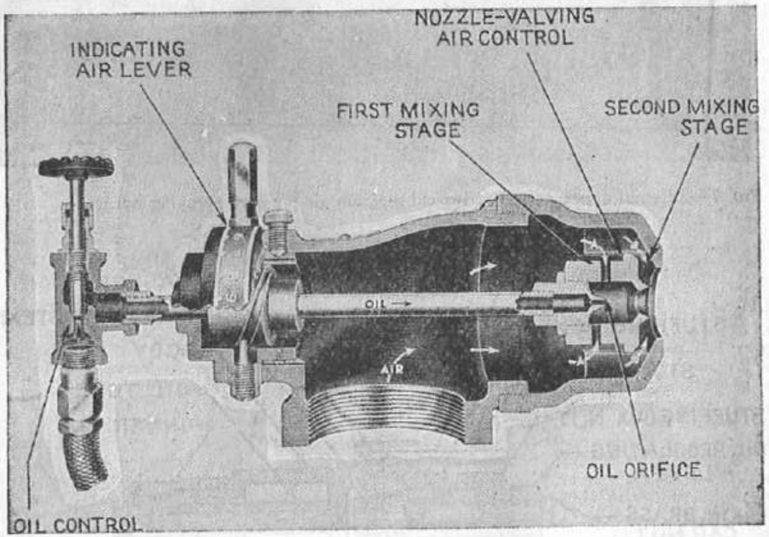


FIG. 9—Low pressure two stage air spraying burner for manual operation. ***Applications:*** Suitable for many types of high temperature industrial heating processes, requiring from 1500° to 3000° Fahr. Melting operations in reverberatory furnaces; crucible type melting furnaces for melting brass monel metal and steel alloys; blacksmith's forges or units for pre-heating for welding, etc.

to yield a bushy fire and for a Scotch marine boiler. the flame may be made cylindrical.

Ques. How is the oil and air delivered to the nozzle?

Ans. A combination oil pumping and air compressing unit is generally used.

Ques. Describe the control system and its operation.

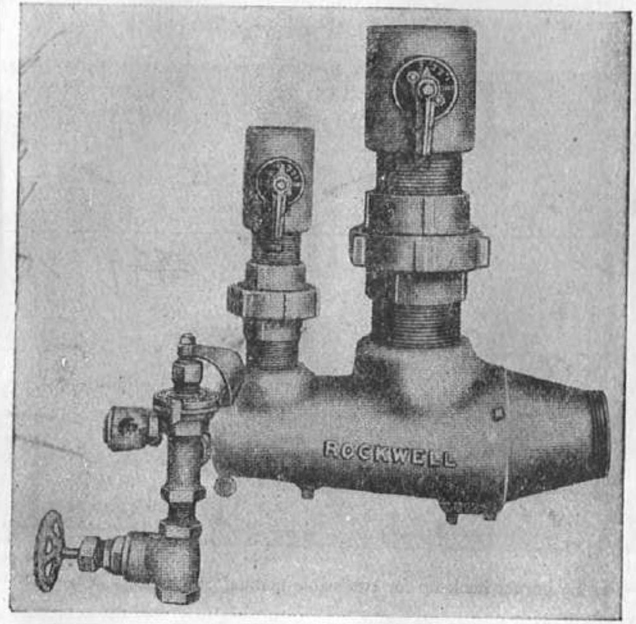


FIG. 10—Hy-Lo burner for low pressure air with air control butterfly valves, oil tube clean-out, oil control or shut off valves. ***Applications:*** For heating operations where close temperature control over a wide range of heating requirements and uniform furnace atmospheres are of primary importance. ***In construction,*** it is essentially two burners in one burner body, one burner for *high* capacity the other (known as the inner tip) for *low* capacity. Either one can be run independently or both can be run in combination.

Ans. A diaphragm type control is used to govern the action of an automatic air damper and slow opening oil valve, all operating from the same compressed air as is used for spraying.

Ques. Describe the starting action.

Ans. Under automatic starting, a needle valve slowly admits air under the diaphragm, in turn causing a gradual opening of the secondary air and similar feeding of oil to the nozzle through the oil valve.

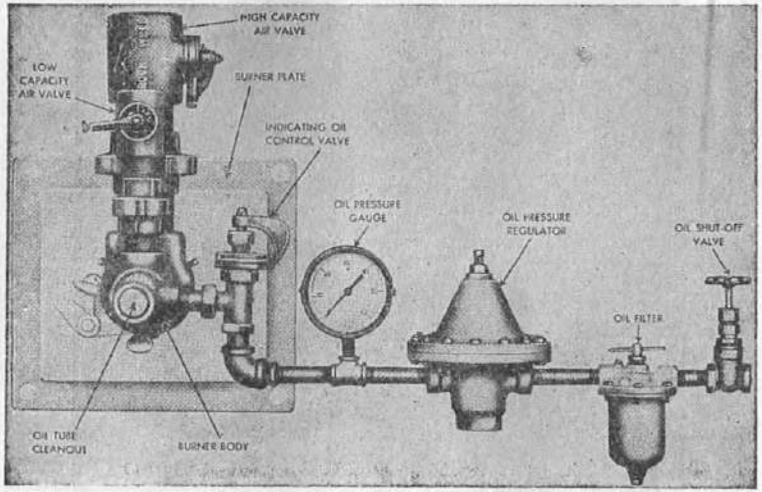


FIG. 11—Hy-Lo burner hook up for two valve manual control.

Ques. Describe the stopping action.

Ans. A spring action snaps the oil valve closed as soon as the air pressure drops.

Ques. What is the fuel range of the burner?

Ans. It will handle any grade, the more viscous of course requiring pre-heating.

High Pressure Air Spraying Burners.—The pressure range for these burners is from 25 to 100 lbs. and higher. They will ordinarily handle any grade of oil that can be delivered to the burner.

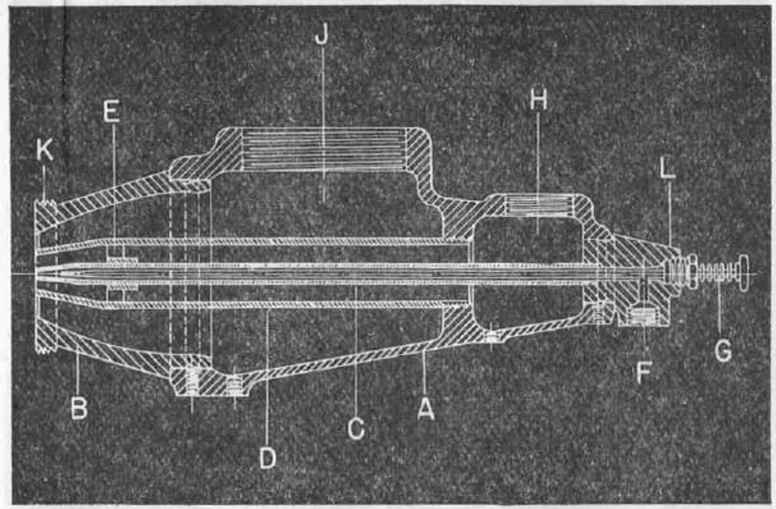


FIG. 12—Sectional view of Hy-Lo burner. ***In operation,*** for *low capacity,* air enters at H, flows through low capacity burner tip D, to spinner E, where a whirling or cyclonic motion is imparted to it. The oil entering at F, and flowing through oil tube C, is completely sprayed by the air at the nozzle. For *high capacity,* air enters at J, flows through the high capacity burner head B, to the nozzle (outer tip) where it comes in contact with the sprayed oil. Here it is intimately mixed to provide perfect combustion of the large volume of oil. The flame can be lengthened or shortened by changing the position of spinner E. The closer the spinner is to the nozzle, the shorter is the flame. Pushing in clean out rod G, cleans the orifice of the oil tube without shutting down the burner. The spring on the rod returns it to normal position after cleaning. The burner body is cleaned by loosening set screws holding castings B, A, and L together. The burner head is screwed into the burner plate with the thread shown at K. The spinner E, is adjusted on oil tube C, by removing the oil tube from the low capacity burner tip D, by loosening the set screws holding L, in place. The spinner is put on by a pressed fit and can be moved by tapping lightly with a hammer. In case the burner nose should burn off, the only part that need be replaced is the high capacity burner head casting B.

Ques. How about the amount of air required for spraying?

Ans. The same conditions obtain as for low pressure burners.

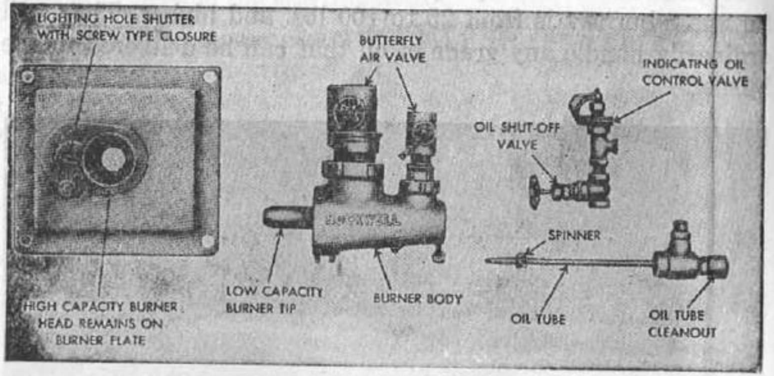


FIG. 13—Hy-Lo burner disassembly showing various parts.

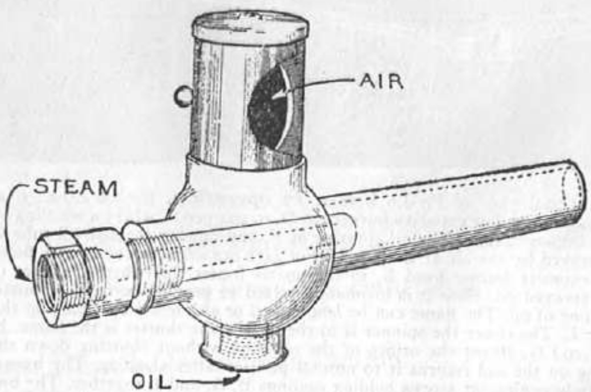


FIG. 14—Heavy duty air or steam and air spraying burner—adaptable also for gas. ***Applications:*** Designed to fire any size boiler. ***In operation,*** the incoming live steam or compressed air creates a vacuum in the large central chamber. This vacuum draws in air from one side and oil from the other. The air and oil unite with a swirling motion, and one instant later are shot from the burner. The air that enters the burner is used primarily to spray the fuel and is not enough to burn the fuel properly except with a very small fire. As the amount of fuel to be burned is increased, the amount of air admitted to the firing chamber should be increased by opening additional draught area or by a forced draught, until the fire burns perfectly clear without smoking. Care should

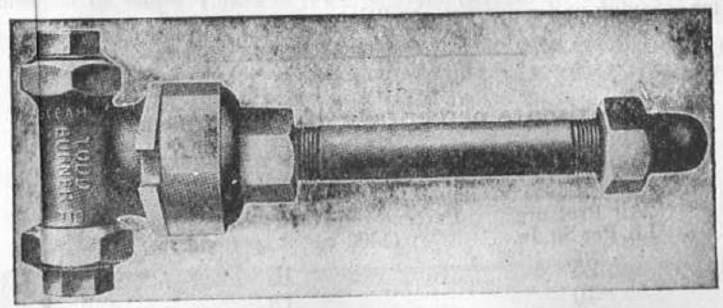
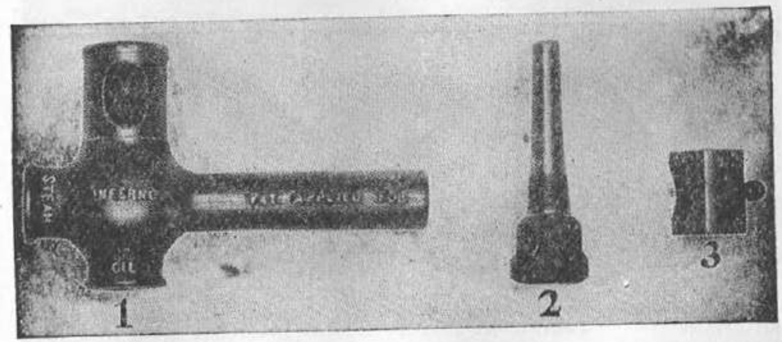


FIG. 15—Inside mixing type steam spraying oil burner. ***Applications:*** Designed to burn all grades of fuel oil, under all types of boilers, where steam or compressed air is economically available for spraying. The burner is built to operate with any steam pressure over 20 lbs. The oil is pumped to the burner as required or the burner can be arranged for gravity feed where storage tank locations so permit.



FIGS. 16 to 18—Parts of the heavy duty burner shown in fig. 14. ***The parts are:*** 1, burner body; 2, air or steam nozzle; 3, air spring valve. The air spring valve is used to vary the amount of air entering the burner through the upper opening in the body. It may be adjusted according to the requirements of the burner.

Fig. 14—*Text continued.*

be taken that no more air is admitted than is necessary to clear the fire and eliminate the smoke, as excess air only wastes fuel. The amount of steam or compressed air necessary to operate the burner varies with the volume and gravity of the fuel to be burned. In no case should more be used than is necessary to thoroughly spray the fuel.

The following table gives the amount of high pressure air necessary for spraying under average conditions.

Approximate percentage of high pressure air required for spraying.—*Hauck.*

Air Pressure Lb. Per Sq. In.	Percent of Total Combustion Air (1400 cu. ft. per gal.)
25	15
40	13
50	12
60	11
75	9
100	7

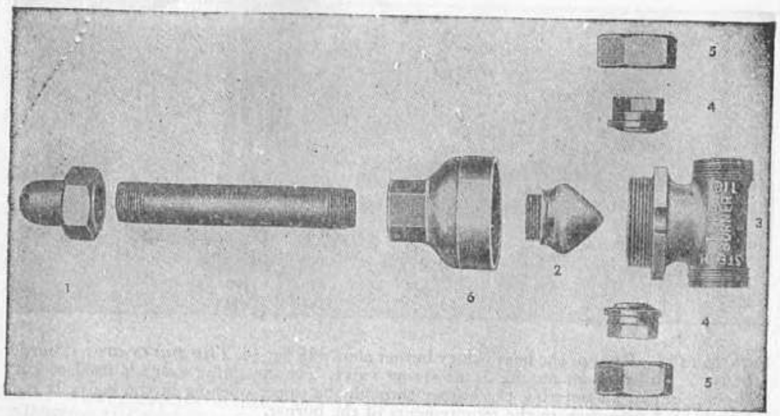


FIG. 19—Sectional view of inside mixing type steam spraying burner. *In operation,* oil enters at one side and steam at the other. These mix in the mixing chamber. The force of the steam causes the oil to spread in a thin film over the conical surface. At a point mid-way down the cone, the whirling film is joined by steam from another series of jets which impinge angularly upon it and break the fuel up into minute particles. ***The parts are:*** 1, Burner tip; 2, Mixing cone; 3, Burner body; 4, Union; 5, Union nut; 6, Coupling.

By referring to this table it will be found that the air required at 50 lbs. pressure per hour is 12% of 1400 or 168 cu. ft. per hour or $168 \div 60 = 2.8$ cu. ft. per minute. Hence, a compressed air burner operating at 10 gallons of oil per hour would ordinarily require for spraying $10 \times 2.8 = 28$ cu. ft. of air per minute approximately.

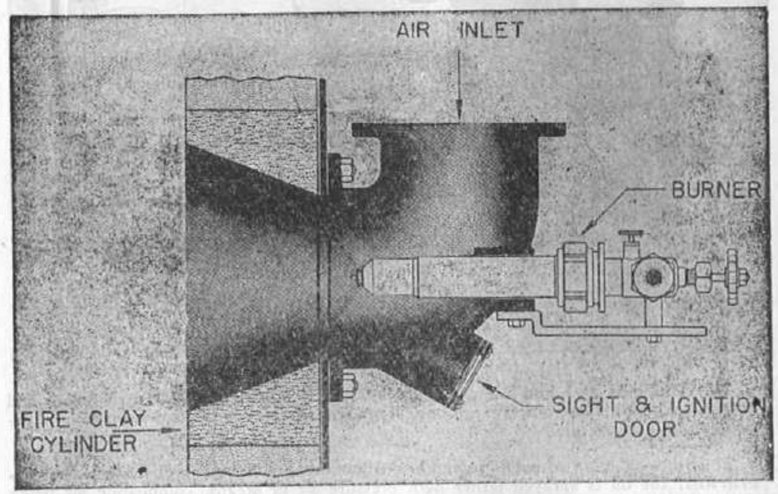


FIG. 20—High pressure air or steam wide range sprayer oil burner. ***Applications:*** Designed for steam boilers and industrial furnaces. ***In operation,*** oil is delivered to burner tip through a central passage and regulation of flow is obtained by turning the screw spindle. A micrometer valve in the oil supply line is recommended for very fine regulation. The spiral on spindle gives the oil a rotating motion producing a cone shaped spray, while the spiral in air passage gives the steam or air a whirling motion that improves atomization. Control of steam or pressure air is obtained by turning burner nozzle. A pilot valve (not shown in cut) connecting the oil space with the air or steam passage permits blowing out the inner tube and allows the burner to operate as an internal mixer at low rates. The shape of the flame is controlled by adjustment of burner nozzle and spindle. Oil is delivered at an average pressure of 75 lbs. Operating steam should be at a pressure lower than the oil pressure. Pressure air used as the spraying agent must be delivered at 10 lbs. pressure for light oils and at 20 lbs. pressure for heavy oils, equivalent to an air consumption of 15 cu. ft. per lb. of light oil or 25 cu. ft. per lb. of heavy oil.

High Pressure Steam Spraying Burners.—These burners, according to Hauck, require dry steam at 30 lbs. pressure or higher.

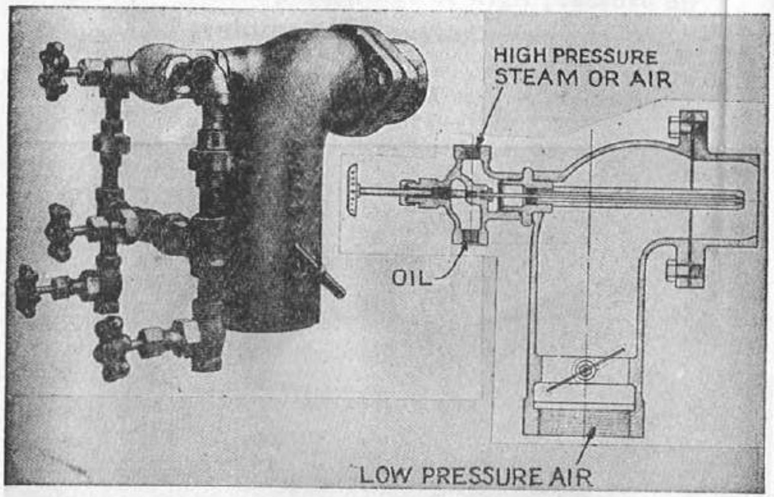


FIG. 21—Combined high and low pressure spraying oil burner complete with valves and fittings including blow out connections. ***Applications:*** For general furnace applications using heaviest oils.

FIG. 22—Sectional view of combined high and low pressure spraying oil burner. ***In operation,*** the oil is sprayed either high pressure air or steam, combustion air being supplied by means of a low pressure blower. This arrangement provides separate control on both spraying agent and the combustion air, resulting in a burner flexible in its operation, from the standpoint of character of fire desired and flame length.

Ques. What is the objection to wet steam?

Ans. If the steam be wet, oil cannot be properly sprayed, irrespective of how much steam be used.

Ques. What precautions should be taken to avoid wet steam?

Ans. The steam line should be of the proper size, well insulated and adequately drained.

Ques. Upon what does the amount of steam required for spraying depend?

Ans. It depends upon the skill and judgment of the burner operator, and furnace conditions.

Ques. What results are obtained by a good burner operator?

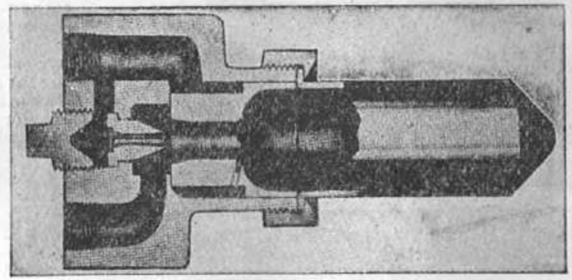


FIG. 23—Typical burner using steam or air for spraying. ***In operation,*** oil enters and surrounds a main jet of high velocity steam from an expanding nozzle. This contact causes the primary spraying of the oil. Further on in the passage, there are holes which introduce tangential jets of steam that rotate the oil in the mixing chamber, whence it passes through the nozzle in substantially a gaseous condition.

Ans. A good burner operator, under favorable conditions, can spray a gallon of oil with 2 to 4 lbs. of steam, whereas a wasteful operator may use up to 8 lbs. of steam per gallon of oil.

Ques. What do you mean by 2 or 4 lbs. or 8 lbs. of steam per gallon of oil?

Ans. Pounds ***weight***—not pounds steam pressure.

Ques. What is the usual allowance?

Ans. It is safe to allow 4 lbs. of steam per gallon to be sprayed, making allowance also for condensation loss in the steam lines leading to the burners.

Points Relating to Air or Steam Spraying Burners.—For either air or steam, the burners may be either single or multi-port.

Ques. What is a single port sprayer?

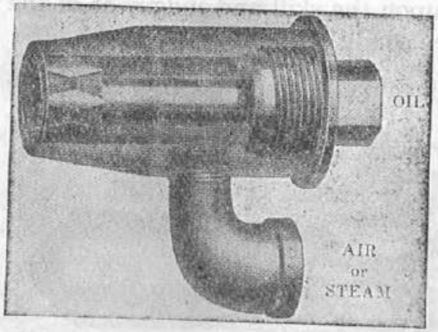


Fig. 24—Venturi high pressure oil burner (phantom view.) Designed for air or steam at 30 lbs. per sq. in. guage pressure and higher, and for oil from 5° Baume up, the heavier grades require pre-heating.

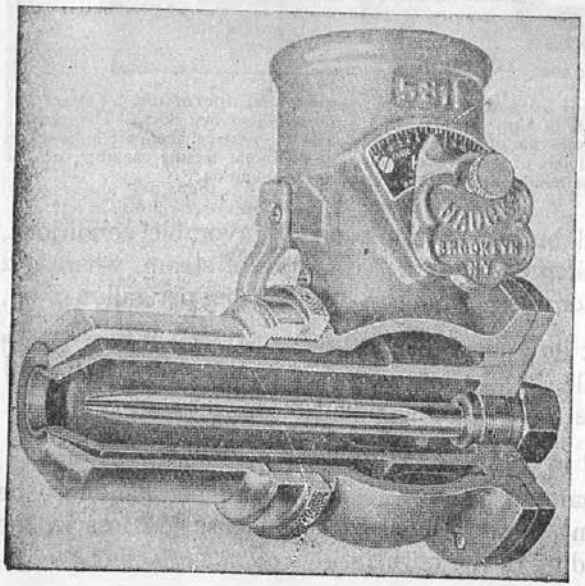
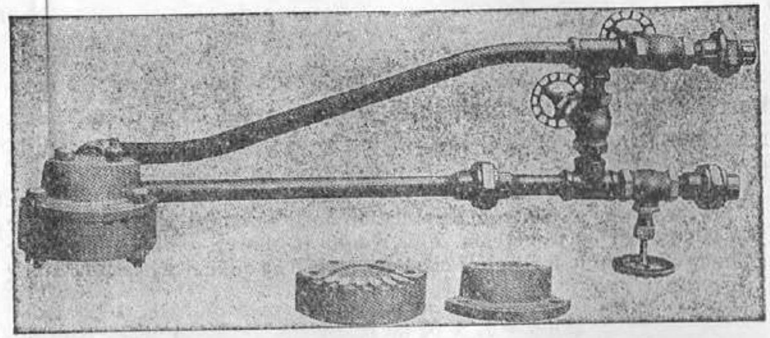


Fig. 25—Detail of venturi high pressure oil burner as shown in fig. 24. The illustration shows a venturi port where air or steam meets the oil at its greatest velocity.

Ans. One in which a jet of air or steam passes through a single large slot, whose end is a single port.

Ques. What is the complaint about this type of sprayer?



Figs. 26 to 28—Hauck Venturi "flat flame" high pressure burner. Adaptation, steam or compressed air at 40 lbs. per sq. in. and higher. It will burn oils of 19° Baume and lighter without heating, and all heavier oils, if preheated. Because of its flat flame design, it is particularly well suited to firing boilers, and large heating furnaces where a soft spreading flame is desired. All the Venturi ports are on a horizontal plane, and placed to give a flame spread of either 30° or 45° as specified. The illustration shows oil burner with piping and valves to the left of burner. Another pattern has piping and valves to the right of the burner. The burner parts show how the Venturi parts are placed to give a flame spread of 45°.

Ans. At best these sprayers give only a partial or incomplete spraying effect which makes it impossible to obtain fine and complete spraying without very large volumes of spraying agent.

Ques. What are multi-port sprayers?

Ans. They are those in which a series of ports divides the main oil stream into a number of smaller jets or streams, over which air or steam passes.

Ques. What is the effect of multi-ports?

Ans. It permits more intimate contact with the oil, resulting in better spraying with less air or steam.

Ques. For equal capacity how does air compare with steam as a spraying agent?

Ans. A shorter flame is generally produced with air than with steam.

Ques. Why?

Ans. In spraying with air, this air which is necessary for combustion, comes into immediate contact with the oil particles, resulting in quicker ignition, which shortens the flame, permitting a smaller combustion chamber than with steam.

With steam, all air from combustion must be mixed with the oil after it is sprayed by the steam. This results in slower combustion, longer flame and a limited range of capacity as well as difficulty in maintaining low capacities.

Ques. What should be noted in selection?

Ans. Don't overlook the difference in flame characteristics with air and with steam as just pointed out.

Example.—A long narrow combustion chamber, which, while suitable for a conical or cylindrical flame steam atomizing burner, would be improper for a low pressure air burner. The combustion chamber would have to be widened, to assure reasonable service from refractories and good combustion.

Ques. What is the principal application of low pressure air burners?

Ans. They are most often used in industrial heating furnaces where multiple burners, ease of automatic control, wide range of control and low operating costs are important requirements.

Comparison of Spraying Costs.—According to the noted authority, Hauck combustion engineers, the quantity of spraying agent required per gallon of oil fired per hour:

For low pressure air burners 10 to 15 cu. ft. per min.
For high pressure air burners 2½ to 3 cu. ft. per min.
For steam pressure burners 2 to 8 lbs. of steam.

Approximate power required to spray one gallon of fuel per hour is:

For low pressure air burners turbo blower 16 oz. .1 *h.p.*
For high pressure air burners 75 lbs. per sq. in. .4 *h.p.*
For steam pressure burners .12 *b.h.p.*

High pressure spraying requires over 4 times as much power as low pressure air spraying (turbo blower 16 oz.) performing the same work.

Example.—For a furnace which is to burn 50 gallons of oil per hour using high pressure air burners, the power required = $50 \times .4 = 20$ *h.p.* whereas if the low pressure air (turbo blower 16 oz.) were used, the hourly power requirements would be $50 \times .1 = 5$ *h.p.*

Ques. What are the conditions favorable for steam spraying?

Ans. In general where suitable steam quality and quantity are available for oil heating and spraying, steam spraying is the cheapest to install.

Operating Instructions

Relating to the variable capacity pressure sprayer burner of fig. 29

The sprayer must be inserted and securely clamped in the quick detachable union connections. Open the oil control valve on the burner return manifold and be sure the return line beyond this control valve is wide open.

The burner is now ready to light off. Insert the torch through the opening in the closure plate. Open air doors and place the torch flame as

close to the diffuser as possible. Open the inlet valve. Slowly close down on the return line valve until the spray ignites. It may be necessary to quickly close and open the register doors to bring the flame up to the sprayer. Remove the torch after the flame has been properly established. Closing in on the return valve increases the oil flow through the sprayer, producing a larger fire. Adjust the fire to the desired size by means of this valve. The supply pressure to the burners should be held constant.

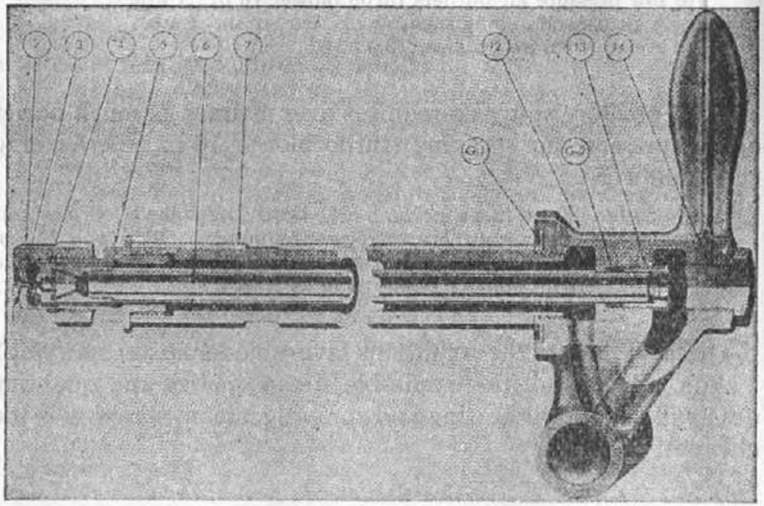


FIG. 29—Half section of variable capacity pressure sprayer burner. ***The parts are:*** 2, sprayer nut; 3, orifice plate; 4, sprayer plate; 5, nozzle body; 6, supply tube; 7, sprayer barrel; 12, handle; 13, ferrule; 14, plug; G-1, gasket; G-2, packing.

Other fires as required, should be lighted off in the same manner and all flames brought to the same size.

It is usually best to put the burners on the main control valve as soon as possible, so that all burners in operation may be controlled from one station.

This is accomplished by slowly closing the main return control valve until the size of the flame begins to increase, indicating that the oil control is now on the main valve and not on the individual burner return valves, which should be immediately opened wide so that they

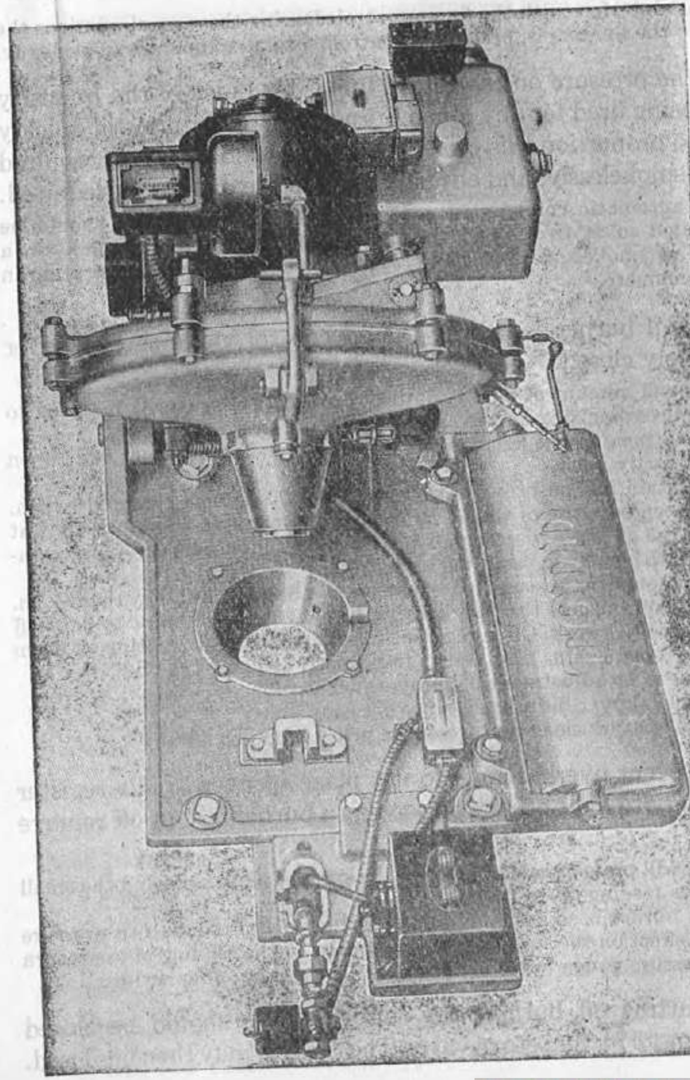


FIG. 30—Todd type RAH horizontal rotary oil burner suitable for firing all types of high or low pressure steam or hot water boilers; also applicable to industrial ovens, kilns, etc., where the furnace and general physical conditions permit such installation. View showing burner swung open.

do not interfere with the flame control. During these manipulations the air to the burners is, of course, controlled so as to operate smokelessly.

As the pressure on the return line is an index of the quantity of oil being fired for any given burner, the operators will quickly learn to proportion this pressure with the amount of air required to run smokelessly, and adjust the air to the oil flow as required.

If automatic combustion controls are being used, they should be adjusted so as to provide the proper quantity of air to maintain a trace of smoke. Most efficient results are obtained when operating in this manner.

While a burner is in use, the oil control valve should never be entirely closed.

A small amount of oil circulating through the sprayer is required to prevent carbonizing and overheating at the sprayer.

On burners in use keep valves on supply and return lines wide open —not partly open.

Maintain fuel oil pressure to burners at 300 pounds per square inch.

The temperature of the oil at the burner manifold should be that at which the oil has a viscosity of 150 SSU, and should be carefully maintained with as little variation as possible.

Use enough air pressure for smokeless combustion, but only that much.

Light off burners through lighting holes. Do not attempt to light off from hot brickwork. Close registers for an instant after lighting off, then quickly open again. This assists in properly igniting the oil.

Remember adjustment of sprayer jacket tube.

Check sprayer-diffuser distance occasionally.

Keep sprayer clean and free from grit, carbon or dirt.

To prevent overheating, do not place sprayer in idle register until ready to light off and as soon as a burner is shut off remove sprayer.

This will prevent caking of oil in the sprayer plate slots and the small passages feeding oil to them.

This burner is so designed and constructed that the return pressure has no effect on the spraying and regardless of the reading of the return line pressure gauge this does not affect the quality of spraying.

In shutting off burners the supply valves should be closed first, followed by the return valve. The register may then be closed.

The sprayer should be immediately removed from the register. Care should be taken not to allow oil to drip on the front, piping, etc.

The burner should be allowed to cool before cleaning.

When cool the sprayer nut should be removed and the sprayer and orifice plates cleaned. Extreme care should be taken so that the surfaces of these parts and the nozzle body face are kept smooth and free from dents, nicks or foreign matter.

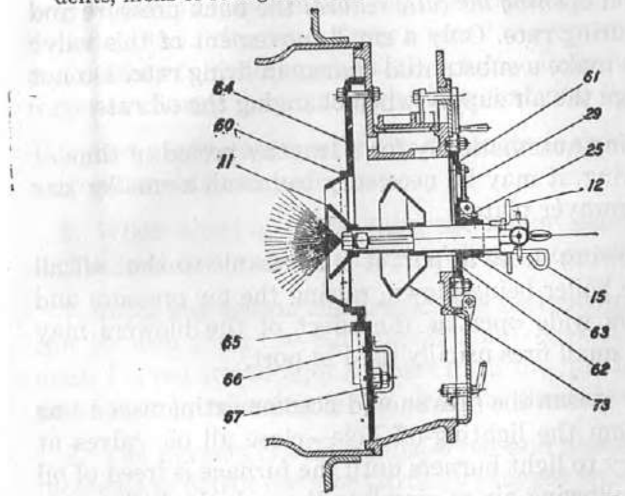


FIG. 31.—Todd furnace door and interior castings for converting Howden or similar type forced draught coal burning furnace fronts to oil burning. ***The principle parts are:*** 11, Flame cone; 12, flame cone rod; 15, air cone rod; 25, jacket tube set screw; 26, cone rod collar and set screw; 27, flexible burner tubing; 28, sight door; 29, lighting door; 60, Venturi ring.

DO NOT use steel or any other hard material in cleaning these parts.

In storing orifice and sprayer plates do not place them in bags or so that they will be shaken or thrown continuously against one another. Store so that the finished faces are protected against damage. It is important to keep them in good condition.

Port Operation

1. For low rates of firing adjust flame size to suit rating re-

required. Keep flame of sufficient volume to maintain combustion close to diffuser.

2. If operating manually, maintain the boiler pressure by using the valve on the return line. **Closing down on the valve** increases the back pressure on the return line and causes more oil *to be burned* and *opening the valve reduces* the back pressure and decreases the firing rate. Only a small movement of this valve is necessary to make a substantial change in firing rate. Do not forget to change the air supply when changing the oil rate.

3. If operating automatically for a lengthy period of time at low rates of firing, it may be necessary to install a smaller size of orifice and sprayer plate.

4. When blowing tubes in port it is advisable to shut off all burners on the boiler being blown, raising the air pressure and having registers wide open as the effect of the blowers may extinguish the small fires usually used in port.

5. If for any reason the fires should become extinguished—as can be seen from the lighting-off hole—close all oil valves at once. Do not try to light burners until the furnace is freed of oil and vapor by allowing air to circulate through the boiler.

6. The burners should be inspected and checked at frequent intervals to detect dirty or partially plugged sprayers and flame shapes should be observed to see that they are uniform and of proper contour.

7. Clean sprayers thoroughly each watch.

Operations While Under Weigh.

1. Use burners with sprayers of size and type as directed by the engineer in charge.

2. Run with registers wide open.

3. Use only sufficient air to operate at trace smoke.

4. If operating manually, maintain the boiler pressure by using the valve on the return line. *Closing down on the valve* increases the back pressure on the return line and causes more oil *to be burned* and *opening the valve reduces* the back pressure and decreases the firing rate. Only a small movement of this valve is necessary to make a substantial change in firing rate. Do not forget to change the air supply when changing the oil rate.

5. If operating automatically, the controls should be set using all register shutters wide open.

6. When blowing tubes, raise the air pressure by hand 1½ to 2 in. higher than normal. Leave oil on automatic. Blow tubes.

7. If for any reason the fires should become extinguished—as can be seen from the lighting-off hole—close all oil valves at once. Do not try to light burners until the furnace is free of oil and vapor by allowing air to circulate through the boiler.

8. The burners should be inspected and checked at frequent intervals to detect dirty or partially plugged sprayers and flame shapes should be observed to see that they are uniform and of proper contour.

Mechanical Spraying Burners.—These burners spray oil by forcing it under high pressure to pass through a specially designed fixed orifice.

As distinguished from the air or steam spraying burners, it should be understood that in the mechanical spraying burners, *no air or steam is mixed with the oil on its way to the nozzle exit. The air for combustion is forced or drawn (induced) around the spray.*

Ques. What should be noted about mechanical spraying burners?

Ans. These burners are regarded as one of the cheapest methods of spraying oil.

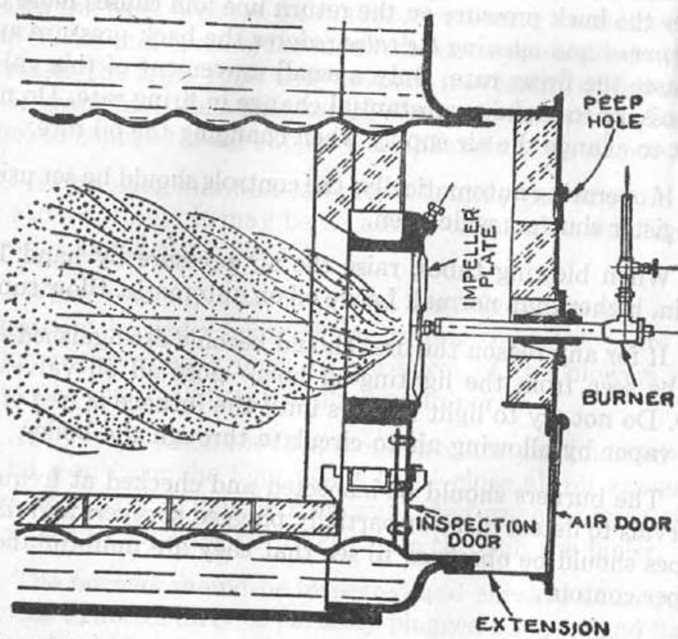


FIG. 32—Mechanical burner as applied to a Scotch marine boiler.

Ques. What is the pressure range for mechanical spraying burners and why?

Ans. The oil pressure is from 75 to 300 lbs. per sq. in. depending upon the kind of oil and the temperature required.

Ques. Why have these burners a limited capacity?

Ans. The burner sprays efficiently only at its rated capacity with limited turn down ability.

This is due to the fact that in order to reduce the oil capacity 50%, it is necessary to reduce the oil pressure 75% and, at such reduced pressure, the oil ceases to leave the burner orifice at sufficient velocity to be thoroughly sprayed.

Hauck on Oil Burner Selection.—The selection of the size and the number of burners for a furnace depend upon the nature of the heating operation, the type of furnace and the limitation

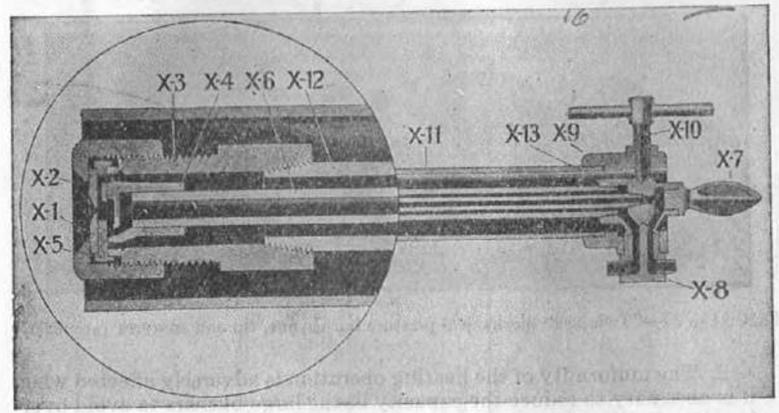


FIG. 33—"Twinplex" mechanical pressure sprayer (atomizing) burner. Wide range type. *The parts are:* X1, Tip; X2, nut; X3, body; X4, min. atoms X5, max. atom.; X6, inner tube; X7, handle; X8, union bushing; X9, housing; X10, housing screw; X11, jacket tube; X12, outer tube; X13, housing body.

of the burners in relation to the furnace space available for combustion and heat circulation.

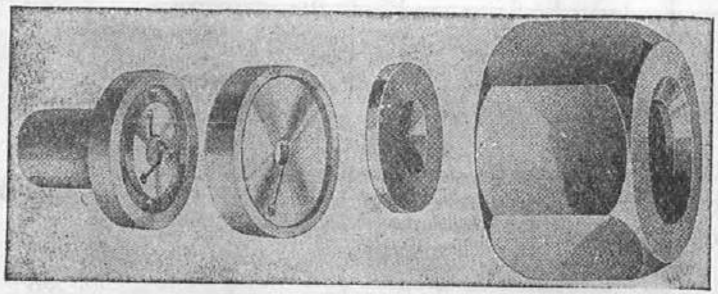
In new furnace installations, the combustion space and heat distribution can be arranged to suit any particular type of burner, whereas on existing furnace installations, the burner must be selected to fit the existing furnace design.

In any case, the analysis of the problem requires the knowledge of burner characteristics, furnace design, combustion theory and practice.

It has been developed from practical experience that the application of multiple burners to a furnace assures greater uniformity of heat distribution as well as better flexibility of temperature control.

The use of a fewer number of burners of larger capacity makes the maintenance of equal heat distribution more difficult because:

1. The distances of travel of the products of combustion from the burner to the working chamber are necessarily unequal and greater.



FIGS. 34 to 37—"Twinplex" mechanical pressure burner nut, tip and sprayers (atomizers)

2. The uniformity of the heating operation is adversely affected when it is necessary to reduce the capacity of the large burners to avoid overheating as the volume of the products of combustion is reduced to a point where the equal distribution of heat in all the passages is no longer possible.

In boilers and furnaces requiring a wide range of heat input, the use of multiple burners is especially desirable.

Example! A furnace with one large burner of 50 gals. maximum and 10 gals. minimum per hour oil burning capacity has a heat range or turn down ratio of 5 to 1, whereas on the same installation two smaller burners each with 25 gals. maximum and 5 gals. minimum per hour oil burning capacity have a

maximum turn down ratio of 10 to 1. This is because with both burners on, a maximum of 50 gals. per hour is consumed, and by shutting one burner off entirely and operating the other at its minimum, only 5 gals. per hr. are consumed.

The turn down limits of 5 to 1 have been chosen because it has been found difficult to secure a greater turn down ratio than this and maintain proper combustion in an ignition tile.

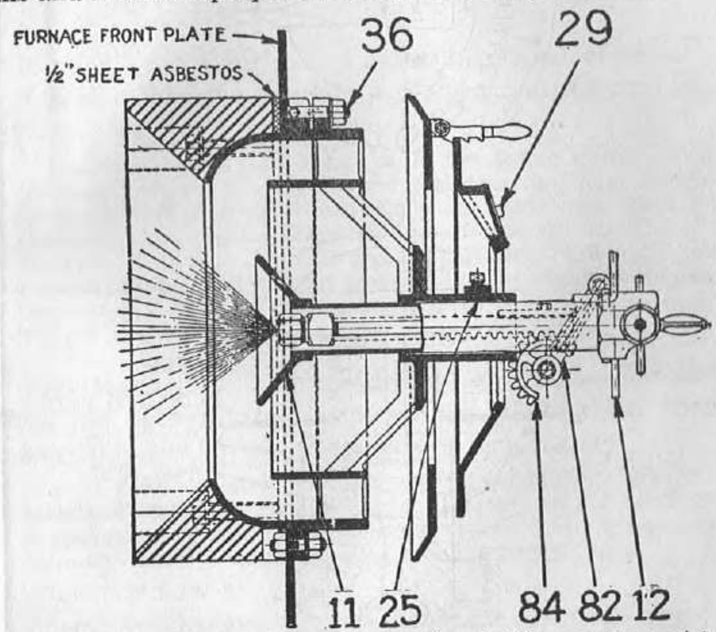
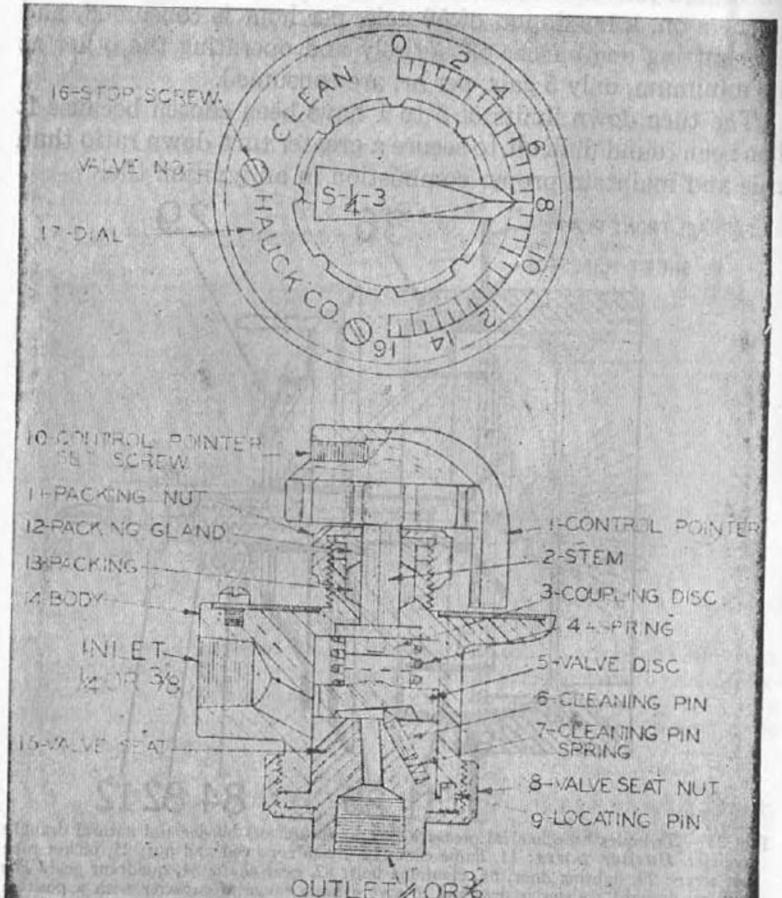


FIG. 38—"Twinplex" mechanical pressure sprayer (atomizer) burner and natural draught register. ***Burner parts:*** 11, flame cone; 12, flame cone rod and nut; 25, jacket tube set screw; 29, lighting door; 36, clamping bolt; 82, gear shaft; 84, quadrant gear. The natural draught register is designed to give a large range of capacity with a positive and wide variation between the maximum and minimum air admission. Air adjustment is accomplished by regulating the small and large ring plates on the air register by means of the handle provided for that purpose. Adjustable stops are also provided so that the best setting can be maintained at all times. The entire air register is hinged, permitting access to the furnace and all parts of the air register and burner. In common with all mechanical pressure atomizing burner air registers, all the air for combustion is admitted at the burner.



FIGS. 39 and 40—Self cleaning valve. ***In operation***, this valve is designed for controlling the flow of oil to burners so that constant accurate combustion conditions can be maintained and easily secured from day to day by setting the valve pointer at the same position. The sludge, dirt and foreign particles that normally build up in the controlling opening of the control valves to reduce the flow are automatically removed in this valve

That is, a tile which is small enough and correctly shaped to retain the heat properly for a flame of 1 gallon of oil per hour will, when the flame is increased to over 5 gallons per hour, cause the flame to be choked and forced back on the burner nozzle and carbon will be formed in the tile opening.

On the other hand, when a tile large enough for over 5 gallons per hour is used to burn less than 1 gallon per hour, the heat of the flame will be insufficient and too far away from the tile to keep it at the temperature necessary to maintain proper ignition and combustion.

Burning No. 5 and No. 6 oil at less than 1 gal. of oil per hour is difficult unless the oil be heated and circulated through the burner.

These oils require heating and, as the flow to the burner is so small, the heated oil cools off, thickens and finally ceases to flow. Also, oils of this grade have small particles of coke and foreign matter which readily clog small valve openings necessary to control small quantities of these grades of oil. In fact, this is the greatest difficulty. With lighter oils not requiring heating and with the proper burner an hourly consumption of less than ½ gallons can be easily secured.

Pre-Heating.—With all mechanical spraying burner installations, it is necessary to provide suitable equipment for heating heavy oil to the burners at the proper temperature.

No. 5 and 6 oils (also known as bunker B and bunker C) require preheating. These oils are frequently kept at temperature below 100° Fahr. in storage tanks, and by means of steam or water heaters, raised to considerably higher temperature at or near the burner.

Ques. To what temperature should the heavy oils be heated?

Ans. According to Petro the common burning temperature for best results has been found to be at or near 170° Fahr.

Figs. 39 and 40—*Text continued.*

by returning the pointer to zero and then to the stop screw beyond *clean*. Thus the valve clears itself, forcing the dirt into the outlet and on out through the burner. Setting the pointer back to the original position secures the desired flow.

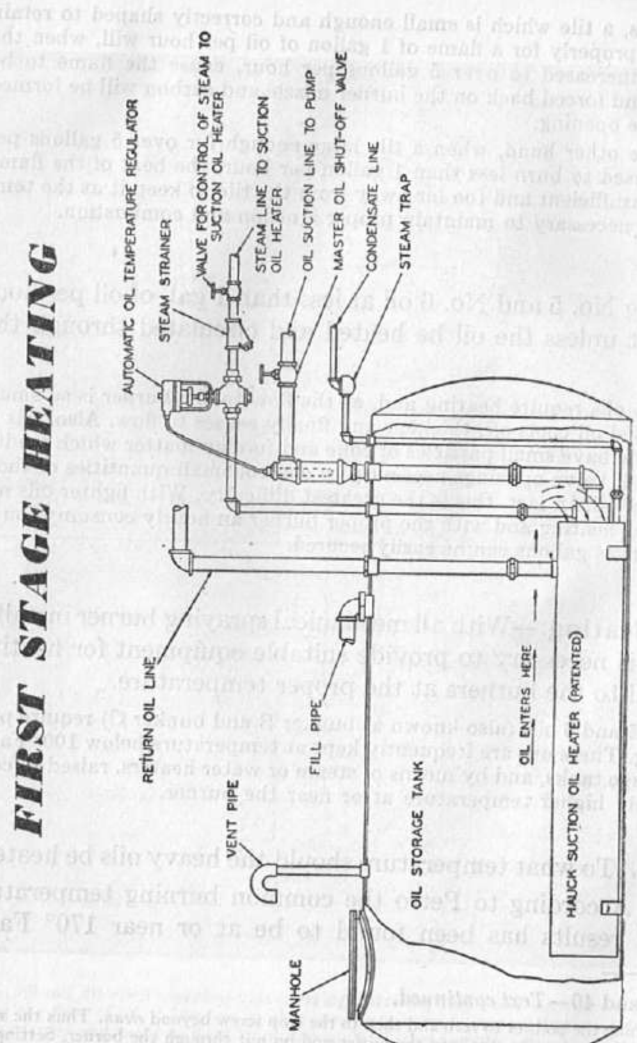


FIG. 41—Oil tank or *first stage* heater shown in the bottom of a tank, also showing such accessories as automatic oil temperature regulator, steam trap, and piping connections.

According to Schutte & Koerting a temperature of 270° Fahr. is usually sufficient for fine spraying of the heaviest oils and for their complete combustion in the boiler or furnace.

Ques. How should the oil be heated?

Ans. In ***two stages,*** that is the oil in the tank should be partially heated by a ***tank heater,*** that is, hot enough so that the pump can handle it satisfactorily and then passed through a

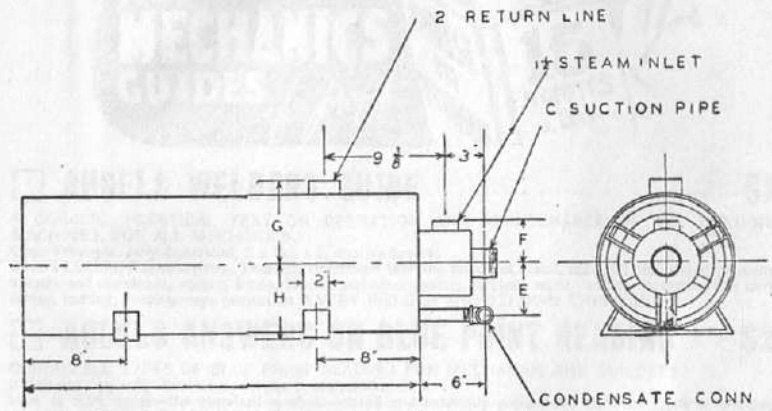


FIG. 42—*Second stage* or so called *pre-heater.* The automatic oil temperature regulator should be used to maintain the proper temperature determined by the viscosity characteristics of the oil used. A pressure relief valve should be installed at the hot oil outlet to relieve thermal oil expansion into a return or supply line, in case oil valves on both sides of preheater are accidentally closed. A steam condensate trap and an oil temperature thermometer should also be included in the pre-heater installation.—*Hauck.*

second stage or so-called ***pre-heater*** to further raise the temperature of the oil to a point where it can be most satisfactorily sprayed and burned.

Ques. How high should be the final temperature?

Ans. The temperature should be such that a slight variation will not materially affect the viscosity of the oil.

Ques. Where should the pre-heater be located and why?

Ans. As near the burner or burners as possible to avoid heat loss from the oil in transit.