available in cast-iron, steel, and non-ferrous metals. The burners are located beneath the sections, and the flue gases pass upwards between the sections to the flue collector. Some boilers are designed to provide domestic hot water through the use of tankless or instantaneous heaters.

Warm air furnaces are of two types, gravity and forced air. The former depends upon a thermal head to provide circulation of air over the heat exchanger and thence directly to the space to be heated, usually through ducts. Most gravity furnaces can be equipped with humidifiers. Forced warm air furnaces utilize a motor-driven blower to circulate air over the heat exchanger and through the ducts. A common type is quite similar to Fig. 13 except that gas burners, pilots, controls, and gas pressure regulator are substituted for the oil burner, and a draft hood is attached to the outlet of the furnace. Due to the pressure developed by the blower, ductwork becomes smaller and the location of the furnace less critical than in gravity systems. Designs of forced air furnaces vary from the conventional types that deliver heated air to overhead ductwork to the downflow types

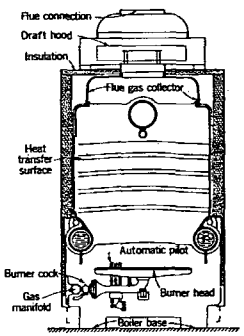

Fig. 14 .... Gas-Fired Boiler

wherein the heated air is delivered at the bottom of the furnace, this latter type being designed for perimeter or radiant-panel heating. Several types of low height horizontal furnaces are available for installation in attics or under floors of unexcavated houses. These furnaces are designed for compactness. The A.G.A. listed output at the boiler nozzle or at the bonnet for forced air furnaces is 80 percent of the approved input to the burners. The corresponding output for gravity furnaces is 75 percent.

Conversion Burners

Conversion burners are complete burner and control units designed for installation in existing boilers and furnaces. A typical gas conversion burner is shown in Fig. 15. Atmospheric conversion burners may have drilled-port, slotted-port, or single-port burner heads. Single-port types have become increasingly popular in the last few years due to their simplicity of construction and ease of installation. In rectangular or round, drilled and slotted-port burners, baffles of clay or metal are usually used to direct the products of combustion toward the side walls of the combustion chamber. In single-port burners the flame usually impinges on a horizontal cast-iron, stainless steel, or ceramic flame spreader which directs the products of combustion toward the side walls. For certain applications, particularly wet-base boilers, a horizontal single-port burner is utilized. This design produces a horizontal flame which strikes a curved baffle that spreads the flame in a fan shape.

Several power burners in domestic sizes are available. These are of gun-burner design and feature small mechanical blowers for supplying all the air required for combustion. These are particularly desirable for handling restricted flue boilers or furnaces where an atmospheric burner cannot obtain the desired output.

Conversion burners for domestic application are available in sizes ranging from 50,000 to 400,000 Btuh capacity. It should be noted that the American Standard Listing Requirements are limited at present to conversion burners having input capacities up to 400,000 Btuh. Burners of larger capacity, for use in large steel boilers, are usually engineered by a contractor specializing in this type of work, or by the local utility company. They are available in a large number of sizes and types. In some cases the burner may be an assembly of multiple burner heads filling the entire firebox. For conversion burner installation in boilers requiring more than 400,000 Btuh input, reference should be made to the current *American Standard Requirements for Installation of Gas Equipment in Large Boilers*, ASA Z21.33.

Domestic sizes of conversion burners should conform to current *American Standard Listing Requirements for Domestic Gas Conversion Burners*, ASA Z21.17. As the successful and safe performance of a gas conversion burner depends on numerous factors other than those incorporated in such equipment, installations of this kind must be made in strict accordance with current *American Standard Requirements for Installation of Domestic Gas Conversion Burners*, ASA Z21.8. Also, draft hoods conforming to current *American Standard Listing Requirements for Draft Hoods*, ASA Z21.12, should be installed (in place of the dampers used with a solid fuel) on all boilers and furnaces converted to burn gas.

Floor Furnace

The floor furnace is used to supply central heating in mild climates, or for auxiliary heating or heating of single rooms in colder climates. It is used for heating first floors, or where heat is required in only one or two rooms. A number may be used to provide heat for the entire building where

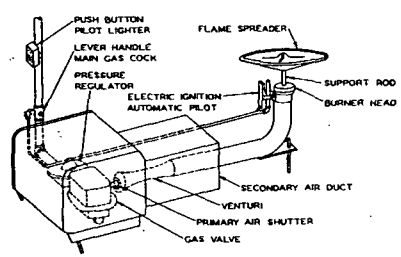

Fig. 15 .... Typical Single-Port Gas Conversion Burner

all rooms are on the ground floor, thus giving the heating system flexibility.

In floor-furnace applications, the heating element, gas piping, and flue vent piping are suspended below the floor, and the only part in the room being heated is the circulating air register which may be of the single type installed in the floor, or of the dual type installed in a partition, and heating two rooms. The A.G.A. output rating of floor furnaces is based on an efficiency of 70 percent for the gravity-type and 75 percent for the fan-type unit.

Another type of heating appliance is the vented recessed heater which is either a gravity or fan-type appliance designed for installation in or permanent attachment to a wall, floor, ceiling, or partition. Such heaters may have short stub ducts to conduct heated air to adjacent rooms. They are installed primarily in new homes, usually being plastered into the wall as a permanent part of the building. The A.G.A. heat output rating is required to be 75 percent of the approved heat input to the burners for fan-type units, and 70 percent for gravity-type units.

Space Heaters

Space heaters are defined as heating units that take the air for combustion from the space being heated. They may be broadly classified as room heaters and unit heaters.

Room heaters are used for heating single rooms or connecting rooms with good circulation between them and, except for wall-type heaters, they are semi-portable. Unvented-type room heaters should not be used unless space is properly ventilated to prevent excess moisture and to provide sufficient combustion air to prevent formation of carbon monoxide. All types of room heaters are capable of automatic control, although they are generally controlled manually. When equipped for automatic control, they must have an automatic pilot as part of the control equipment. Room heaters may be classified as follows:

Circulators, vented and unvented, that heat the room mainly by convection, although some have radiants over the burner, with windows in the front to allow some heat by radiation.

Radiant heaters, usually unvented, although some vented types are available, have a refractory directly above the burners which is heated to incandescence, and gives off an appreciable part of its heat in the form of radiant energy.

Wall heaters, vented or unvented, are usually a type of radiant heater constructed with sufficient insulation (either solid or circulating air) to prevent overheating of the casing, and are built into a wall with the front flush with the wall surface. Their heat input rating is limited to a maximum of 25,000 Btuh. Vented wall heaters equipped with air circulating fans, safety pilots, and automatic control are available for greater input.

Although an output rating is not required by A.G.A., the efficiency of a vented room heater must be not less than 70 percent when rated above 20,000 Btuh input, and 65 percent when rated at less than 20,000 Btuh input.

Unit heaters are used extensively for heating large spaces such as stores, garages, and factories. These heaters consist of a burner, heat exchanger, fan for distributing the air, draft hood, automatic pilot, and controls for burners and fan. They are usually mounted in an elevated position from which the heated air is directed downward by louvers. Some unit heaters are suspended from the ceiling, and others are free-standing floor units of the heat tower type. Unit heaters are classified for use with, or without, ducts depending on specific A.G.A. approval. When connected to ducts they must have sufficient blower capacity to deliver an adequate air quantity against the duct resistance. Heat output is required to be at least 75 percent of heat input to the burners.

Duct furnaces are usually of the unit heater type without the fan, and are used for heating air in existing duct systems where blowers are provided for moving the air through the system. Duct furnaces are tested for operation at much higher static pressures than are obtained in unit heaters.

Combustion Process and Adjustments

Most domestic gas burners are of the atmospheric injection (Bunsen) type in which primary air is introduced and mixed with the gas in the throat of the mixing tube. For normal operation of most atmospheric type burners, 40 to 60 percent of the theoretical air as primary air will give best operation. Slotted-port and ribbon burners may require from 50 to 80 percent primary air for proper operation. The amount of excess air required in practice depends upon several factors, notably: uniformity of air distribution and mixing, direction of gas travel from burner, and the height and temperature of combustion chamber. With power type burners utilizing motor driven blowers to provide both primary and secondary air, the excess air can be closely controlled while securing proper combustion.

Secondary air is drawn into gas appliances by natural draft. As with other fuels, excess secondary air constitutes a loss, and should be reduced to a proper minimum, which usually cannot be less than 25 to 35 percent, if the appliance is to meet ASA approval requirements. Yellow flame burners depend upon secondary air, alone, for combustion.

The flame produced by atmospheric injection burners is non-luminous. Air shutter adjustments for manufactured gas should be made by closing the air shutter until yellow flame tips appear, and then by opening the air shutter to a final position at which the yellow tips just disappear. This type of flame obtains ready ignition from port to port, and also favors quiet flame extinction. When burning natural gas, the air adjustment is generally made to secure as blue a flame as is obtainable without lifting of flames from burner ports. Manufacturers' instructions for burner adjustment should be followed.

Gas-designed equipment does not usually incorporate any means for varying the secondary air supply (and hence the CO_2). The amount of effective opening and baffling is determined by A.G.A. tests and cannot be varied. Gas conversion burners, however, do incorporate means for controlling secondary air to permit adjustment over a wide range of inputs according to the type of installation encountered. The manufacturer's specific instructions contained in the installation manual required to be supplied with each burner should be followed. It is possible through the use of suitable indicators to determine whether carbon monoxide is present in flue gases. For safe operation carbon monoxide should not exceed 0.04 percent (air-free basis) when operating at the maximum gas input to the burners.

During recent years, the use of fuel gas (natural, manufactured, and liquefied petroleum) has become increasingly popular for heating tourist cabins and motels. Due largely to the intermittent use of such equipment and the fact that so many of the users are entirely unfamiliar with the fundamentals governing its operation, many special and unusual problems arise. The importance of safeguarding the public interest has prompted some state and city officials to adopt and enforce legislation governing not only the manner