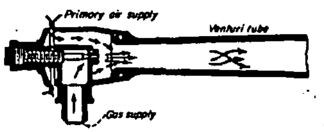
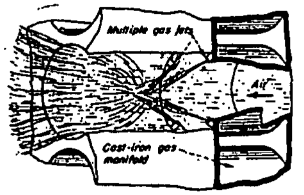
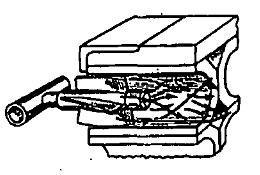
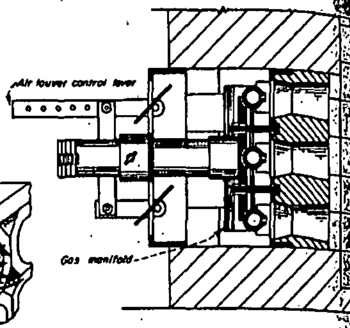
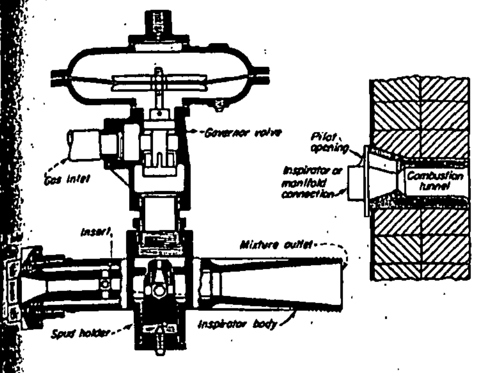


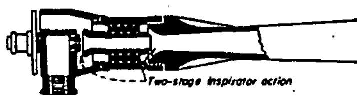
1 Atmospheric gas burners pull in their primary air for combustion by the action of a stream of low-pressure gas expanding through an orifice











6 Two-stage burner operates on high-pressure gas; passes it through two venturi sections in series. Primary air enters shutter, at left, under induction

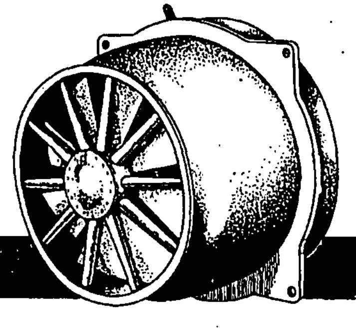
7 High-pressure gas issues from jets in the spider and reaction spins the spider to rotate the fan. Resulting turbulence gives prompt, thorough mixing

2 Premixing of fuel gas and air needed for combustion takes place in a mixing chamber outside the furnace proper

3 Vanes placed in the path of incoming air to this tunnel burner act to impart swirling motion to stream

4 Gas issues from a number of spuds connecting to vertical and horizontal manifolds. Primary air enters around the spuds

5 So called low-pressure gas-burner systems work with air under pressure and gas at atmospheric conditions. An inspirator governor, left above, delivers gas-air mixture at proper pressure to burner blocks, right above



Burning Ga[illegible]nd Oil

Knowing something about the general process of combustion and the various fuels met in power-plant practice, we're now ready to tackle the next element—firing equipment. Its job is to prepare the fuel, bring fuel and air together in proper proportions and, with the help of the furnace, ignite and burn the fuel-air mixture continuously.

GAS

On the face of it, burning gas is simple, because the fuel is ready for combustion and requires no preparation in the strict sense of the word. Nevertheless, the remaining parts of the job—proportioning, mixing and burning—can be handled in a variety of ways and *their characteristics need to be known* for sound selection of equipment and successful operation.

Atmospheric Burners. Gas burners differ mainly in the way air and fuel mix. Perhaps most familiar is the so-called *atmospheric* burner. One form appears quite generally in the ordinary household gas range. In it the momentum of the incoming low-pressure gas stream is used to draw in, or *aspirate*, part of the air needed for combustion. A shutter or similar device regulates amount of air so induced. Gas and air together pass through a tube leading *to the burner ports, mixing in the process.* The mixture burns at the ports or openings in the burner head (with a blue, nonluminous flame. Secondary air is drawn into the flame from the surrounding atmosphere. Larger counterparts of this general burner type, having ring or sectional burner heads with many ports, are used to fire small boilers and industrial equipment.

A single-port atmospheric burner is shown in Fig. 1. Needle valve controls gas flow through the spud; air is drawn in around the shutter at the end. The resulting mixture passes through the tube and burns at its end. Single-port burners may be grouped, several banks high and wide, to serve larger furnaces.

Although physically simple, such a burner must be proportioned with considerable skill to conserve the relatively *small amount of energy in the low-pressure gas stream.* It is this energy which entrains the primary air. How well this is done depends on primary-air percentage, gas-orifice size, ratio of mixer throat to burner port area and, in boilers especially, furnace draft.

Premix Percentage. With burner-port size and shape fixed, nature of burning depends largely on amount of primary air, or *premix*. With premix low, flame is long and pale blue. It may have a yellow tip, indicating, as we have seen, some cracking and presence of free carbon. Increasing primary air shortens *the flame as burning becomes* more rapid, and a greenish inner cone appears. When speed of burning, or *flame propagation*, exceeds that of gas issuing from the port, flame flashes back into mixing tube.

Operation is generally satisfactory with 30 to 70% premix; in some special designs 100% primary air is used. This premix range gives a turn down, or capacity range, of about 4 to 1. Usually premix and capacity ranges are somewhat narrower.

Secondary air is usually drawn in around the burner and the amount thus depends on the area of the opening and the draft. Control may be effected by varying draft or, sometimes, by adjusting opening area by shutters.

The so-called atmospheric burner is one example of a general class, in which *the energy of one fluid is used to* aspirate the other and in which part or all primary air mixes with the fuel in the burner body. The "high-pressure" burner uses gas at about 20 to 30 psig and air at atmospheric pressure. Another type uses compressed air, and the gas is at atmospheric pressure. The burner of Fig. 6 expands *high-pressure* gas through two venturi-sections in series to obtain thorough mixing in a short distance.

Refractory Burners. For boiler firing a somewhat different type of burner finds wide use. It depends on natural or fan draft to draw in all air required for combustion; hence draft conditions are most important. Design of Fig. 2 employs multiple gas jets, which discharge into the air stream in such a way that violent agitation results in a short *mixing tube or tunnel of refractory.* In the burner of Fig. 3, turbulence vanes impart a swirling motion to the air entering the tunnel. Each of the small jets of gas issuing from the multiple-jet orifice entrains with the air and impinges it outward against the tunnel walls. This action gives turbulent, thorough mixing.

In the burner shown completely assembled, Fig. 4, vertical manifolds connect horizontal tubes, which contain individual gas orifices for the 15 tunnel blocks forming the complete burner (3 high, 5 wide). Louvers in front of the burner assembly control air admission. Each orifice discharges into a refractory mixing tube or tunnel.

In burners of this type the refractory tunnel aids in heating the mixture for ignition and protects metal burner parts from high temperature. The flame can be made relatively luminous, for high *radiant-heat transfer.*

Large steam-generating units often employ a high-pressure (2 to 25 psi) gas burner of the gas-ring, Fig. 20, center-diffusion tube, or turbulent, Fig. 7, design. The gas-ring, Fig. 20, has an annular manifold located between air register and furnace wall surrounding burner opening. Orifices drilled in this ring spray gas angularly across an incoming air stream controlled in quantity, velocity and rotation by the registers.

Fan-Mix Burner. In the burner of Fig. 7, gas issues from jets drilled at an angle in a rotating spider. Resulting reaction spins the spider and with it the connected fan. A shutter controls air drawn in, to maintain desired fuel-air ratio. Thorough mixing of gas and air result from the turbulent interaction of jets and air stream; combustion is completed close to the burner.

Thus far we have talked of designs in which fuel and air mix in or at the individual burner. Higher burner head pressure to overcome variable furnace draft, high overload capacity, uniform air-gas mix at all loads, and single-valve control may be had in a system in which mixture is made at one point and supplied to several burners. Such a system is shown in Fig. 5. This is the low-pressure type; gas is at atmospheric pressure while air is at 1 to 2 psi.

Inspirator Governor. Heart of the system *is the inspirator governor, left,* Fig. 5. Air passes through the venturi tube at high velocity to create a low-pressure region at the end of the straight run where gas ports are located. This pulls atmospheric-pressure gas through the ports into the throat and produces mixing. As the mixture expands through the inspirator body its velocity is converted to pressure.

Gas enters the governor under pressure and flows through the governor valve. A passage through the governor valve keeps pressure at governor outlet and on the under side of the diaphragm the same. With atmospheric pressure on the other side of the diaphragm, governor delivers gas at atmospheric pressure.

The mixture leaving the inspirator governor contains all air needed for combustion. *An air valve controls the* burning rate. The complete gas-air mixture goes from the inspirator-governor to a number of individual burners, usually the tunnel type shown at the right in Fig. 5. This principle of supplying a complete mixture to a number of burner units is also found in systems operating with high-pressure gas and atmospheric air.

OIL

In addition to proportioning fuel and air, and mixing them, oil burners must *prepare* the fuel for combustion. There are *two ways of doing this, with many* variations of each: (1) The oil may be vaporized or gasified by heating within the burner, or (2) it may be *atomized* by the burner so vaporization can occur in the combustion space.

Designs of the first group, usually called *vaporizing burners*, are necessarily limited in range of fuels they can handle and find little power use.