Sept. 13, 1960 H. W. SCHRAMM ET AL 2,952,307

BURNER APPARATUS

Filed Oct. 26, 1955

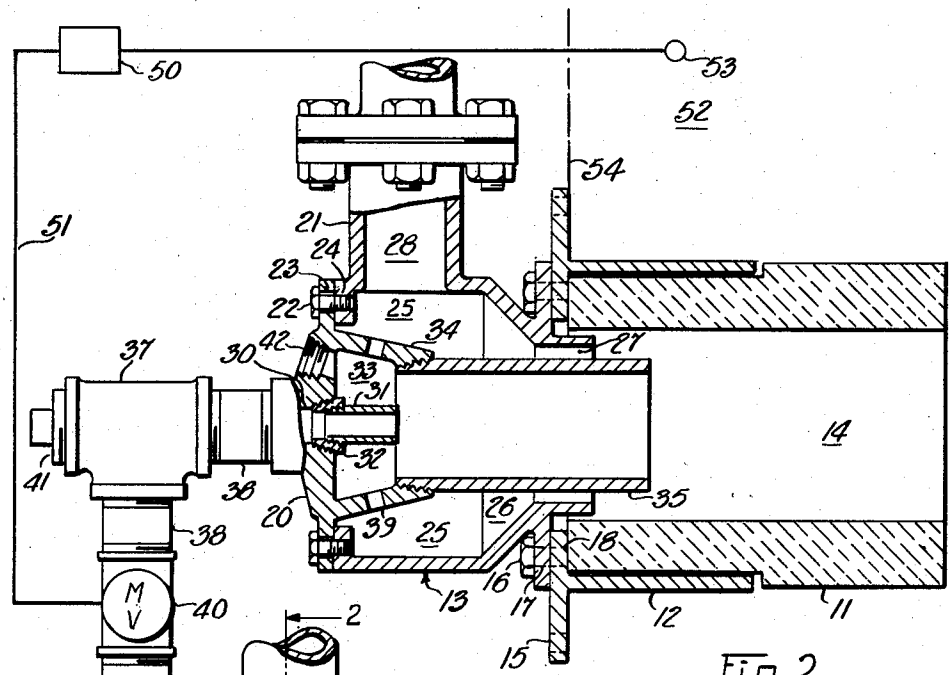


Fig. 2.

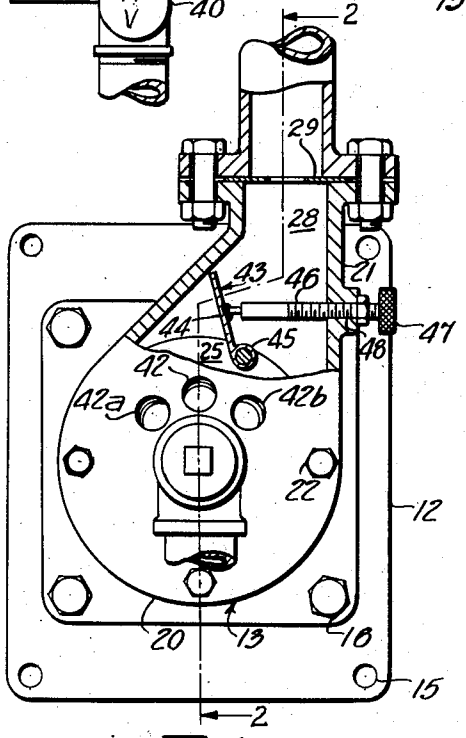


Fig. 1.

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BURNER APPARATUS

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2 Claims. (Cl. 158—7)

This invention pertains to burning of combustible fuel and has particular application to apparatus for burning fuel with which a large temperature variation may be attained.

There are a large number of applications for such apparatus. A typical example of this is a batch type furnace in which work is to be hardened and then drawn. The first operation may require a furnace temperature of 1700° F. and the latter, a temperature of 700° F. Unless the single furnace has burner equipment capable of properly operating at and maintaining both of these temperatures, two separate furnaces must be employed.

A large temperature variation has been previously attempted with a variety of apparatus. For instance, two or more separately controllable sets of burners have been employed. All sets of burners would be used when high temperatures were desired and one or more sets would then be turned off when lower temperatures were to be maintained. This system, although relatively inflexible, worked reasonably well but resulted in a higher first cost for such furnace installations due to the extra number of burners necessary. The extra burners also result in extra controls, extra fuel, additional piping, and additional space. Also, these burners did not create comparatively large temperature ranges in the furnace chamber even when several sets of burners were employed.

As an alternate to this system, a single set of larger burners has been used in place of the above and are operated at their full firing rate at higher temperatures and in an on-off manner at lower temperatures. However, such burners are incapable of maintaining a steady temperature particularly below 1000° F. when controlled by a thermocouple and temperature control instrument. With this system, the burners are turned off when the temperature of the chamber slightly exceeds the control temperature and are likewise turned on when the temperature falls slightly below this control temperature. However, the heating effect from the burners continues, at these lower temperatures, to raise the temperature of the chamber even after the burners are shut off with the result that the control temperature is overridden and large temperature variations occur—the lower the temperature desired to be maintained, the larger the variation in temperature actually attained. During the period the burners are not firing temperature differences within the chamber also result due to lack of circulation. This will be more fully discussed subsequently. Furthermore, these burners generally rely on pilots for ignition when turned on, and should the pilots be extinguished, the

combustible air-gas mixture would be fed directly into the furnace chamber with an explosion hazard resulting. This is not a danger at higher temperatures, above 1400° F., since the tunnel walls of the burner will be maintained, due to heat from the furnace chamber, at temperatures that will ignite the air-gas mixture on contact if the pilot is extinguished.

A third means of attaining a large temperature range in a furnace chamber was by variation of the firing rate of the burners in place of operating them in an on-off manner. However, such burners must have a very large range of turndown to fire properly at the very low firing rates required for low furnace temperatures. Burners are designed to fire at certain capacities, however, and will only operate properly within certain variations from this capacity, most burners having a turndown range of less than 4 to 1. To produce a temperature range in a furnace of, for example 700° F. to 1700° F., a much larger range of turndown is required.

In such cases, at the required very low rates of firing, the volume of air and gas passing through the burner nozzle is reduced and the velocity thereof is likewise decreased. However, the rate of flame propagation will be constant with the result that, as the velocity of the air-gas mixture is decreased, the flame moves back through the nozzle. The velocity of flow back of the nozzle is, of course, less than that through the nozzle with the result that the flame, once having penetrated back through the nozzle, spreads quickly through the remaining air-gas mixture up to the point where the air and gas are combined. This explosion, or backfiring, may damage the apparatus, particularly if there is a large volume of the air-gas mixture. Even without damage occurring, there is danger involved since the explosion generally extinguishes the flame with the result that the subsequent unignited mixture is emitted into the furnace chamber.

To overcome this, a burner may be supplied mixture through separate air and gas conduits whose outlets lie behind, and adjacent to, the nozzle. Any backfiring occurring here, then, merely extends to this point of mixing with very little ignitable volume involved. A small backfiring occurring here, however, is still sufficient to extinguish the flame which again results in the mixture being fed, unignited, into the furnace chamber. If backfiring will not extinguish the flame, an unstable flame front may nevertheless occur that causes inefficient combustion and generally unsatisfactory operation of the burner.

Furthermore, particularly in burners of this nozzle mixing type, the air-gas mixture is very difficult to proportion at very low firing rates. Thus the correct stoichiometric mixture to give complete combustion for high flows may result in a rich or lean mixture at low flows. This not only causes inefficient combustion, but may be serious enough to form an unignitable mixture that will result in an extinguished flame.

In view of the aforementioned difficulties and many others, a burner and method of operation have been developed that will operate effectively at full rates and very low rates of firing with none of these problems. Furthermore, this burner is capable of producing a temperature range in a furnace chamber of 400° to 2400° F.

For further consideration of what is novel and our in-

vention, reference is made to the accompanying drawing, subsequent specification, and claims.

In the drawing:

Figure 1 is a partially sectional end view of apparatus embodying our invention, and

Figure 2 is a side view shown partially in section as taken on line 2—2 of Figure 1.

The burner of Figure 2 comprises a tunnel block **11** and a holder **12** attached to burner body **13**. Tunnel block **11** is of refractory composition and square configuration with a cylindrical tunnel chamber **14** extending longitudinally therethrough. The portion nearer the holder **12** is offset to accommodate the holder which is generally made of cast steel and is adapted to be installed in a furnace wall and fastened to the outer casing thereof by means of bolts through bolt holes **15**. Burner body **13** is attached to holder **12** by means of bolts **16** extending through bolt holes **17** and **18**, located in body **13** and holder **12** respectively, and so positioned that the body is properly aligned with respect to cylindrical chamber **14**.

Burner body **13** has cast portions **20** and **21** united by bolts **22** extending through bolt holes **23** and into tapped holes **24**. This forms a cylindrical chamber **25** and a sharply tapered chamber **26** that tapers toward tunnel chamber **14**. It also forms a smaller cylindrical chamber **27** that extends slightly into tunnel chamber **14** and an air inlet passage **28** which tapers outwardly from chamber **25**. Air volume to this inlet is controlled by orifice plate **29**.

Cast portion, or rear wall, **20** has a fuel port **30** drilled through it in axial alignment with chamber **25**, tapered chamber **26**, small chamber **27**, and tunnel chamber **14**. A fuel nozzle **31** is axially aligned with this port **30** and threaded thereinto by means of fitting **32**. A frusto-conical chamber **33** is formed around nozzle **31** by wall **34** which is integrally connected with portion **20**. Wall **34** has four equally spaced air ports **39** drilled therein. In addition, it is suitably threaded at its outer portion to receive tube **35** which is axially aligned with nozzle **31** and extends into tunnel chamber **14** past small chamber **27**.

Fuel port **30** is supplied fuel through pipe nipple **36**, **T 37**, and pipe **38** which lead to a source of fuel (not shown). A valve **40** is disposed in pipe **38** to control fuel flow therethrough; it is an electrically-operated, motor-driven valve in the preferred form of application. **T 37** contains a plug **41** at its unused outlet which is periodically removed and a brush or other suitable cleaning means is extended thereinto to clean port **30** and nozzle **31** in which carbon and impurities in the fuel may gradually be deposited.

Three tapped holes **42**, **42*a***, and **42*b*** are provided in portion **20**. The axes of these holes intersect the superimposed axes of port **30**, nozzle **31**, tube **35**, and the various chambers at some point within tube **35**. A commercially available flame rod safety device may be placed in one of these holes to shut off a valve upstream of valve **40** should the flame in tube **35** become extinguished. A sight glass may be installed in the second hole to permit limited observation of the internal operation. In the third hole, an ignition means may be placed to initially light the fuel-air mixture.

A movable air vane **43**, which is somewhat similar to one in a Patent Number 1,943,590 to Carroll Cone, may be placed at the entrance of air inlet passage **28** into chamber **25**, and directs the air in a tangential or radial direction into chamber **25**. The vane consists of a metal sheet **44** rotatably attached to a pin **45** which is horizontally disposed in chamber **25**, parallel to the axis thereof, and secured at its ends to portions **20** and **21**. A threaded shank **46**, having a knurled head **47**, extends through a tapped hole **48** in portion **21** and is rotatably secured to vane **44**.

When an electrically-operated, motor-driven valve **40** is employed in fuel pipe **38**, it is controlled by a temperature controller **50** through line **51**. This controller **50** is responsive to temperature in furnace chamber **52** by a thermocouple or temperature bulb **53** which extends through the furnace wall as represented by dotted line **54**.

In operation, air is supplied through inlet **28** with the majority flowing through tapered chamber **26**, small chamber **27**, and into tunnel chamber **14**. A smaller portion of this air enters air ports **39** to subsequently mix with a portion of the fuel emitting from nozzle **31**. The air entering ports **39** is sufficient to create a combustible mixture with a portion of the aforementioned fuel when ignited. This burning mixture, along with the raw fuel, passes out of tube **35** where the unignited fuel mixes with the additional air, forms a combustible mixture, and is ignited by the former burning mixture. When the burner is firing at its full capacity, orifice plate **29** is sized to allow entry of sufficient air to form a stoichiometric mixture with the fuel that permits complete combustion with no residual air resulting. This is the preferred method of operation with air being turned on and off by a valve upstream of the orifice. The burner will thus operate at stoichiometric proportions of fuel and air as long as it is operating at capacity which will be maintained until the temperature of the furnace chamber reaches that desired. At this point, temperature controller **50** will tend to close valve **40**. An excessive amount of air will then be supplied to the burner for the amount of fuel input and this excess will increase for lower furnace temperatures where the fuel input is further decreased. However, the burner will still operate efficiently and with a positive, stable flame for any air-fuel ratio that may be created. This is achieved for two principal reasons: The flame emitting from tube **35** forms a constant point for ignition of the air and unburned fuel that initially mix at this point; this helps assure a stable flame front. Secondly, the air and fuel emerging from separate points tend to mix slowly enough to prevent excessive dilution of the fuel in the air before ignition can occur and thus form an unignitable mixture. This is true regardless of the amount of excess air encountered since, upon emission from tube **35**, the combination fuel and burning mixture immediately begin to mix with the air, with additional combustion occurring constantly. Such mixing prohibits excessive dilution since this additional burning constantly occurs as soon as a portion of the unburned fuel mixes with sufficient air to support combustion. Furthermore, the raw fuel in tube **35** is heated by the ignited portion of fuel and air therein. This heated fuel then tends to expand as it emits from the relatively confined volume defined by tube **35**. The expansion hastens mixing of the fuel and air sufficiently to prevent the possibility of excessive air from lowering the temperature of the air-fuel mixture to the point where the flame will be extinguished.

When very low temperatures of approximately 400° to 600° F. are desired in the furnace, the fuel supplied will be decreased to a point where all the fuel is burned with the air entering ports **39** and no burning occurs in tunnel chamber **14**. Again, there is a stable flame produced with efficient burning. This occurs because the air entering ports **39** is directed toward the rear of chamber **33** to prevent any possibility of its velocity blowing off the flame. The air will thus properly support combustion for even the smallest amount of fuel emitting from nozzle **31**, and, of course, for higher rates of fuel flow the uncombusted fuel is combusted with the air emitting from small chamber **27**. Therefore, it may be seen that efficient combustion and a stable, positive flame occurs for any rate of fuel flow.

The use of excess air at all but full firing rates has several advantages, particularly for lower furnace temperatures. This air, upon leaving chamber **27**, mixes with the products of combustion and thus decreases their temperature which permits an even lower furnace temperature to be attained. Of more importance, however,

is the fact that this air circulates the heat through the furnace chamber and thus affords greater heat distribution than otherwise possible. If the burner, at low rates of firing, were to operate with no excess air, this heat, due to lack of volume for circulation, would tend to be limited to a relatively hot area adjacent the burner. At full rates of firing, the volume of products of combustion are large enough to supply the necessary circulation but for lesser firing rates the excess air must provide this. Furthermore, the use of excess air permits the furnace pressure to be maintained above ambient whereas normally with low firing rates, the volume of combusted products is insufficient to effectively provide such pressure. Without this positive furnace pressure, relatively cool, ambient air tends to enter through various furnace openings such as at charge and discharge ports. This, of course, develops areas of cooler temperatures which further vary temperature distribution.

Additional versatility is provided in our invention due to vane **43**. Sheet **44** of the vane may be moved from the position shown in Figure 1 to a middle position in air inlet passage **28**. In the former position, all the air enters chamber **26** tangentially and is thereby spun around tube **35** and wall **34**. This air, still spinning, is pushed out through tapered chamber **26** and small chamber **27** into tunnel chamber **14** where it mixes with unburned fuel from tube **35**. The total mixture of fuel, air, and combusted products is thereby spun and, as it emits from the confines of tunnel chamber **14**, expands both forward and radially, the exact direction depending on the degree of spin imparted to the mixture. This flame emitting from tunnel chamber **14** thus appears as a cone, the apex angle of which varies with the spin as heretofore mentioned. Such a flame configuration is useful in a variety of applications as, for instance, where work being heat treated is situated in front of the burner and it is desirable for the burner flame not to impinge this work. For lower firing rates, of course, the flame will not extend beyond the chamber **14**, but the hot mixture of combusted products and air will do so and spinning in this case helps create greater heat distribution.

In the latter position of sheet **44**, air enters chamber **25** substantially equally on both sides of tube **35**. Tendency to spin is thus counteracted and the air moves through tapered chamber **26**, small chamber **27**, and tunnel chamber **14** in substantially straight flow. This air mixes more slowly with the fuel and products of combustion from tube **35** and results in a somewhat longer flame. Furthermore, this flame tends to emit straight outward from tunnel chamber **14** in an axial direction which results in a long, directional flame that likewise has various applications, as where the burners are placed below or above the work being heat treated.

Vane **43** is adjusted by screwing threaded shank **46** in or out by turning knurled knob **47**. Once this vane is adjusted, it is seldom necessary to move it unless the physical conditions under which the burner is operated vary.

Typical data showing the range of turndown and the variation in flame length when using oil for fuel are presented below:

Air Input, c.f.h.	Oil Input, g.p.h.	Air Pressure, Oz. S.I.	Oil Pressure, p.s.i.	Air Direction	Flame Length, Feet
14,225	10.60	9.8	75.0	Straight	9
14,225	10.60	9.8	75.0	Spinning	6
14,225	8.48	9.8	48.0	Straight	9
14,225	8.48	9.8	48.0	Spinning	4
14,225	6.35	9.8	27.5	Straight	8
14,225	6.35	9.8	27.5	Spinning	3
14,225	4.24	9.8	13.0	Straight	4
14,225	4.24	9.8	13.0	Spinning	2
14,225	2.12	9.8	3.4	Straight	1
14,225	2.12	9.8	3.4	Spinning	0.8
14,225	0.706	9.8	0.42	Straight	[1]
14,225	0.706	9.8	0.42	Spinning	[1]

[1] Flame within tunnel.

For gas fuel, the burner is even more effective as evident in the following representative data:

Air Input, c.f.h.	Gas Input, c.f.h.	Air Pressure, Oz. S.I.	Gas Pressure, Inches of Water	Air Direction	Flame Length, Feet
15,000	1500	11.0	0.6	Straight	8.5
15,000	1500	11.0	0.6	Spinning	3
15,000	1200	11.0	0.4	Straight	8
15,000	1200	11.0	0.4	Spinning	2
15,000	900	11.0	0.3	Straight	4
15,000	900	11.0	0.3	Spinning	2
15,000	600	11.0	0.15	Straight	3
15,000	600	11.0	0.15	Spinning	1.5
15,000	300	11.0	0.08	Straight	2
15,000	300	11.0	0.08	Spinning	1
15,000	100	11.0	0.05	Straight	[2]
15,000	100	11.0	0.05	Spinning	[2]
15,000	25	11.0	[1]	Straight	[3]
15,000	25	11.0	[1]	Spinning	[3]
		Inches of Water			
3000	300	5.0	[4]	Straight	3
3000	300	5.0	[4]	Spinning	8″
3000	250	5.0	[4]	Straight	2.5
3000	250	5.0	[4]	Spinning	7″
3000	200	5.0	[4]	Straight	2.5
3000	200	5.0	[4]	Spinning	6″
3000	150	5.0	[4]	Straight	2
3000	150	5.0	[4]	Spinning	6″
3000	100	5.0	[4]	Straight	1.5
3000	100	5.0	[4]	Spinning	6″
3000	50	5.0	[4]	Straight	6″
3000	50	5.0	[4]	Spinning	4″
3000	5	5.0	[4]	Straight	[2]
3000	5	5.0	[4]	Spinning	[2]

[1] Not measurable.
[2] Flame within tunnel.
[3] Flame within inner tube.
[4] Not measured.

It may be seen then, that the versatility of our burner is extended not only over a large range of temperatures, but also over a variety of flame lengths and flame shapes, the latter ranging from linear to conical.

It may be noted here that whether air enters chamber **25** radially or tangentially, the volume of air entering ports **39** is not substantially varied. This is true since, regardless of the mode of air entry, pressure in chamber **25** remains relatively constant due to the restriction afforded by tapered chamber **26** and small chamber **27**, and thus forces a relatively constant volume through ports **39**.

The foregoing disclosure is the best mode known to the inventors of carrying out this invention, the scope of which is limited only by the appended claims.

We claim:

1. Burner apparatus for burning fuel at a wide range of inputs in a furnace chamber comprising: a refractory block containing a cylindrical tunnel chamber extending longitudinally therethrough; a holder for attaching said block to a wall of said furnace; first wall means attached to said holder and forming a small cylindrical chamber extending into said tunnel chamber, a tapered chamber with the smaller end thereof meeting the end of the smaller cylindrical chamber away from said tunnel chamber, and a larger cylindrical chamber with one end thereof meeting the larger end of said tapered chamber, the three chambers being substantially axially aligned with said tunnel chamber; rear wall means forming a closed end for said large cylindrical chamber at the other end thereof; an air inlet to said large cylindrical chamber located at one side thereof; nozzle means extending into said large cylindrical chamber, in substantially axial alignment with, and directed toward, said tunnel chamber; pipe means connecting a source of fuel to said nozzle means; and second wall means forming a cylindrical combustion chamber extending from said rear wall means, around said nozzle means, and into said tunnel chamber, said combustion chamber being in substantially axial alignment with said tunnel chamber and forming a series of equally spaced air ports for emitting air from said large cylindrical chamber substantially radially to said com-

bustion chamber at a point upstream of the outlet of said nozzle means, and said small cylindrical chamber forming a restricted annular passage with said second wall means for the passage of air therethrough from said air inlet and said large cylindrical combustion chamber.

2. Apparatus according to claim 1 characterized by an electrically operated valve in said pipe means, and control means responsive to the temperature of the furnace chamber for operating said valve to vary the rate of gas flow therethrough, said air inlet containing a constant restriction whereby the flow of air therethrough will remain unchanged.

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